The transmission of Western science into China 1840-1900

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Abstract

This thesis examines the process,practice and issues surrounding the transmission of Western science into China 1840-1900. It opens with a discussion of the previous (Jesuit) transmission of Western science,and the nature of the Chinese paradigms which the Jesuits tried to displace.

The nineteenth-century Western chemical paradigms which were to be transmitted are then considered,together with the rapidly changing nature of the subject and the consequent problems for the translators and their readers.

The context of the transmission in China is discussed,especially the nature of the *kaozheng* 考證 [evidential research] scholarly community in the Jiangnan region of China which,I hope to show,played an important role in the reception of science.

The special problems of translation from Western languages into Chinese are then dealt with,including the transliteration of terms and the creation of new characters. Parallels are drawn with the methods of the Buddhist translators and of the early nineteenth-century Chinese geographers.

There follow studies of the translation of chemical terminology,of a selection of important science textbooks,and of two Western agents of transmission,John Fryer and Calvin Mateer.

The lives of Chinese scientists Li Shanlan 李善蘭,Xu Shou徐壽,Xu Jianyin 徐建寅 and Hua Hengfang 華衡芳 are studied,followed by a chapter on the new institutions which they and the Westerners created. The remarkably rich popular science literature such as *Gezhi Huibian* 格致彙編 is then analysed,and conclusions drawn about the nature of

popular interest in science in this period.

The intellectual impact of Western science in the last decade of the century is considered, especially the effects on the thinking of Tan Sitong 譚嗣同 and Kang Youwei 康有為.

Finally, general conclusions are elaborated and the significance of the transmission is assessed.

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I shall always remember the generous help and hospitality I received in California from Jane and Christopher Lamb; and the guidance of the Fryer scholar Dr F.Dagenais,who,as well as sharing his detailed knowledge of Fryer's life and work,also showed me Mountain View Cemetery,the place to which John Fryer was finally translated.

I owe special debts of gratitude to Professor T.Barrett,who first allowed me to make this late start in the field of historical research; to Richard King,Richard Wang and especially to Wing-Commander R.F.Sloss,who in 1976-77 gave me the opportunity for full-time study of the language of transmission; and to Liu Bingchen for teaching me to read Chinese handwriting. To my supervisor,Dr Christopher Cullen,without whose support and help it would never have been finished,I owe thanks not only for the many hours of stimulating conversation and encouragement,which allowed me eventually to make the final conversion of the material I had gathered into something resembling a thesis,but also for his careful reading of previous drafts. I alone am responsible for any errors and omissions which remain.

Finally,I would like to express my gratitude to my parents; and to my wife Mai and my children Tom,Emma and Adam,for their forbearance of my long preoccupation with nineteenth-century China,when I could have been giving my time to them.

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Articles included with this thesis

David Wright,'Tan Sitong and the ether reconsidered' in *BSOAS* **lvii**(1994),551-575

David Wright,'Careers in Western science in nineteenth-century China: Xu Shou and Xu Jianyin' in *JRAS* **5**,1(1995),49-90

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Acknowledgements of permission to reproduce these illustrations are given beneath each figure. I have endeavoured to trace the copyright-owners of all figures,and apologise to those whom I have been unable to contact.

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Chapter 1. The scope and argument of the thesis [1]

This thesis examines the processes and results of the transmission of nineteenth-century Western science into China during the period 1840-1900. One of the aims will be to show the complexity of this process,which involved the Western science of the period,the motives of the Western agents of transmission,the actual process of transmission, the Chinese matrix into which Western science was transmitted,and the responses which Western science evoked in the Chinese themselves.

1.0 Western science and its varieties

The transmission of Western science to China during the nineteenth century has been given little scholarly attention,and the little it has received has been from a general historical and sinological standpoint rather than as an aspect of the history of science.[2] The assumption has generally been that transmission occurred through translated science textbooks,with Chinese people reading and understanding(or misunderstanding) them: a slow,painful process,but not in itself problematic.

The reality turns out to be more complex and more interesting. The complexity of the transmission process derives partly from the multivalency of the component elements : 'Western science' was not a single entity,but a collection of ideas,processes,techniques and institutions,sharing only a 'family resemblance' of disciplined,cumulative inquiry into the natural world. Within this 'science',the individual disciplines were

[1] I have found useful on the general issues of transmission: R.G.A.Dolby,'The transmission of science' in *HS* **15**(1977),1-45; Patrick Petitjean,Catherine Jami and Anne Marie Moulin (eds.)*Science and empires*(Dordrecht:Kluwer Academic Publishers,1992).

[2] For instance James Reardon-Anderson,*The science of change: chemistry in China 1840-1949*(Cambridge:Cambridge University Press,1991).

actually at quite different stages of development,and were progressing at quite different rates during the period in question.

Some of the theoretical concepts employed in nineteenth-century Western science (such as the ether) had at least something in common with traditional Chinese thought,whilst other notions (such as current electricity,or the atomic theory) had no Chinese counterpart. The interaction between the traditional Chinese concepts and the Western models was relatively slight(outside the realm of medicine[3]),but,where it occurred,it is revealing of the unexpected ways in which the same ideas can be developed in different cultural contexts,and of how within the process of transmission the object of transmission was subtly altered by the recipient culture.

Chemistry was in many respects at the leading edge of Western science during the nineteenth century. Following the clarification of the nature of combustion and of the nature of chemical elements towards the end of the eighteenth century through the work of Antoine Lavoisier(1743-1794),Joseph Priestley(1733-1804),Joseph Black(1728-1799),Carl Scheele(1742-1786),Humphry Davy(1778-1840),and others,there was rapid progress in the inorganic and organic fields of chemistry,with spectacular growth in the numbers of new compounds synthesised,some of which found applications in the new industries centred around the manufacture of textiles. William Whewell,writing of the Great Exhibition in 1851,contrasted the products of mining with those of the new science-based industries:

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[3] This will be a proviso which will be frequently made in the course of this discussion. Chinese medicine and Western medicine have followed parallel courses of development,and although modern Chinese medicine has been influenced by the Western paradigms it has not been absorbed by them.

> In the former class [Mining and Mineral Products] art existed before science; men could shape,and melt,and purify,and combine the metals for their practical purposes,before they knew anything of the chemistry of metals; before they knew that to purify them was to expel oxygen or sulphur; that combination may be definite or indefinite. But in the second class[Chemical Processes and Products] science has not only overtaken art,but is the whole foundation,the entire creator of the art. Here art is the daughter of science. The great chemical manufactories which have sprung up at Liverpool,at Newcastle,at Glasgow,owe their existence to a profound and scientific knowledge of chemistry. These arts could never have existed if there had not been a science of chemistry; and that,an exact and philosophical science.[4]

These new chemical industries were proof that science was able to generate completely new technologies. One result of the rapid growth of chemical science,pure and applied,was a need for new systems of nomenclature which would reflect deepening theoretical understanding . In transmitting the complex of ideas called 'chemistry',some of which had been clarified,with others remaining in a state of confusion,it was inevitable that the results of transmission would themselves be in some disarray.

1.1 Aspects of the Western scientific paradigm

In Chapter 3 I shall describe those aspects of mid-nineteenth century chemistry which were particularly

[4] William Whewell,'The general bearing of the Great Exhibition on the progress of art and science' in *Lectures on the results of the Great Exhibition of 1851*(London: David Bogue,1852),1-34 pp.28-29

problematic,particularly the ideas of atomic and equivalent weights and the notations in use for representing chemical formulae.

I shall also show in Chapter 6 that some of the modern criticisms of the Chinese chemical translations are due to a misunderstanding of the state of contemporary Western chemistry,and that they can only be understood in terms of the persistence of the use of dualistic and equivalent formulae in the source-texts chosen by the translators.

1.2 The intellectual matrix of early nineteenth-century China

Within the Chinese tradition there had been a number of brilliant individual scholars who had turned their attention to aspects of natural science,but there was no field of knowledge which was co-extensive with 'science' as understood in the West.[5] China had of course its own intellectual traditions which were themselves distinctive and various,and not susceptible to a simplistic,anhistorical summary of 'Chinese thought',but nevertheless I risk a brief account of the chief ideas of Chinese natural philosophy in Chapter 2,in order to explain how attempts were made either to refute them or to incorporate them within the Western paradigm.

By the early nineteenth century,the influence of the early Jesuit missionaries in stimulating interest in native Chinese mathematics and astronomy had waned. This was however a time of great intellectual change within China(quite apart from the so-called 'responses' to the West),and some of these changes proved favourable towards the reception of natural science. In particular,the *kaozheng* 考證[evidential research] movement in late Qing

[5] Nathan Sivin,'Why the Scientific Revolution did not take place in China --or didn't it?' in *CS*(1982,5),45-66 p.48

China in preparing the ground for the early modern scientists such as Xu Shou 徐壽(1818-1884),and the revival of Buddhism,another foreign implant,played an important role in the late Qing eclecticism of Kang Youwei 康有為 (1858-1927)and Tan Sitong 譚嗣同(1865-1898).

1.3 The political context of transmission

The political context of the transmission was a country large areas of which were in rebellion for much of the period,whilst at the same time its eastern coastal regions and northern borders were being increasingly threatened by foreign aggression. In Chapter 4,I have described the shifts in the political circumstances within China,and how they affected the nature and rate of the process of transmission: the decades following the First Opium War and the Taiping Rebellion(the 1840s and 1860s) were times of relative openness to Western techniques,yet the 1850s,1870s and 1880s saw a resurgence of conservative opposition,with the final decade of the century seeing a dramatic rise of interest in the *ideas* as well as the techniques of science in the aftermath of the defeat by Japan in 1894-95.

1.4 The foreign agents of the transmission of Western science

The foreigners who brought Western science to the attention of the Chinese did so for many reasons,but whatever their personal motives they were agents of a process of cultural invasion which lasted throughout the nineteenth century and which has continued to the present day. The political and economic motives of the West for opening China's doors to Western trade have been extensively studied. The primary missionary motive was quite plain: the conversion of 'China's millions' to Christianity. Yet these factors do not in themselves explain why Westerners,including missionaries,should have thought science worthy of transmission. The China market did not depend on the Chinese understanding how goods were being manufactured in Lancashire; nor could souls be saved by revealing the true nature of combustion. Yet from the earliest political,economic and missionary contacts with China,Western science played a central role in the Westerners' view of themselves as possessors of a higher civilisation,which in part validated their invasion of a culture which had in previous centuries been seen by many European intellectuals as superior to their own.

1.5 Missionaries and the transmission process

Many of the early Western translators and compilers of science textbooks were Christian missionaries or ex-missionaries. Like the Jesuits two centuries earlier,many of these men hoped that the wonders of Western science would convince the Chinese of the validity of the Christian message,but a more sanguine view of the connection began to appear towards the end of the century,reflecting the sharpening of the already ambivalent relationship of science and Christian doctrine in Europe and the United States.

In contrasting the lives and work of the 'secular missionaries'[6] John Fryer[Fulanya 傅蘭雅][7](1839-1928),translator and journalist and the Presbyterian missionary educator Calvin Mateer[Dikaowen 狄考文] (1836-1908) in Chapter 8,I have studied the manner in which these two Westerners attempted to influence the Chinese in favour of science,and how their differing circumstances and personalities formed their work.

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[6] This term was used in *North China Herald*(26th December,1872),548-549.

[7] There being no general rule about the romanisation of the transliterated names of foreigners in Chinese,I have transcribed them all as single terms,thus *Fulanya* rather than *Fu Lanya* or *Fu Lan Ya*.

1.6 The translation of texts

In Chapter 5 the general problems of scientific translation into Chinese are discussed in some detail,followed in Chapter 6 by consideration of chemical nomenclature and chemical theory,and in Chapter 7 by an examination of some of the textbooks themselves,including a comparison of two of the most influential chemical works (*Huaxue jianyuan* 化學鑑原 and *Huaxue chujie* 化學初階),both of which derived from the same source-text.

The assembly of lists of titles of translated books can easily give the misleading impression that transmission via translation was a quantifiable diffusion-like process,with each volume completed representing gradually accumulating knowledge in the minds of the recipient culture,its very quantifiability being an attractively objective historical datum. It is thus easy to imply that,because textbooks were produced,transmission actually took place,but the (somewhat scant) evidence of what actually occurred seems to suggest that such a presumption needs to be viewed with some caution: users of the textbooks,even when they were well-versed in the ideas,sometimes seem to have found them indigestible - like 'chewing wax'. The content of the books was also sometimes of questionable value: the rapid changes in nineteenth-century science meant that some books were already at least a decade out of date when they were first translated,and as I show in Chapter 7,the lag between new ideas arriving and their transmission tended to increase rather than decrease during the later years of the century.[8]

[8] The Periodic Table of the elements for instance was not mentioned in Chinese texts until 1900,31 years after its discovery by Mendeleev; Darwin's evolutionary ideas were given their first extended treatment in Chinese in 1898,nearly forty years after the publication of *The origin of species*.

1.7 The Chinese scientists

The Chinese scholars who,somewhat eccentrically,devoted themselves to the cultivation of 'Western studies'[*Xixue* 西學]after 1840 were,in the main,talented men who had failed to advance via the orthodox route to success through the literary examinations. In Chapter 9,I have studied the lives of Li Shanlan 李善蘭(1811-1882),Xu Shou 徐壽,his son Xu Jianyin 徐建寅(1845-1901),and their colleague Hua Hengfang 華衡芳(1833-1902). These men had,as far as can be discovered,no background in the Chinese-paradigm sciences such as traditional Chinese medicine,alchemy,or *fengshui*風水[geomancy or 'siting']. They seem to have viewed themselves not as innovators but as revivers of a moribund *Chinese* tradition through the agency of the foreign sciences. These men played a vital role as 'bilinguals',in understanding both the Chinese and Western paradigms well enough to be able to create adequate translations of Western terminology which served to introduce science,at a popular level at least,to the next generation.

1.8 The institutions and journals propagating natural science

The brilliant individual Chinese scholars who made their own studies of science were not able to propagate the richness of its content. It was the new schools - government,independent and missionary-run - which sprang up from the 1860s which played a key role in this aspect of the transmission process. In Chapter 10 I have studied some of these institutions,such as the Beijing Tongwenguan,the Shanghai Polytechnic and Dengzhou College to show how their successes and failures charted the problematic development of modern education in a society still largely indifferent to the concerns of science.

The institutional developments show great variety of purpose and calibre. The government schools(Tongwenguans) played an important role in giving science respectability in the eyes of the *literati*,but the missionary schools also made important contributions to widening the public awareness of and interest in Western science. The development of these was not easy,and led to much disappointment amongst the enthusiasts for science,who turned to popular journalism as a means of reaching a wider audience.

Chapter 11 is devoted to the journals which carried scientific material - a surprisingly large number - with *Gezhi Huibian* 格致彙編[The Chinese Scientific and Industrial Magazine] being given particular attention,although there were several other journals and newspapers which regularly carried science articles,such as *Jiaohui Xinbao* 教會新報,*Wanguo Gongbao* 萬國公報 [The Chinese Globe Magazine] and,in the last years of the century,the earliest Chinese-run science journal *Gezhi Xinbao* 格致新報[Science News]. These journals,and in particular their readers' letters,are a rich source of information about the transmission and reception of Western science in China.

1.9 The Chinese origins of Western science and the attempts at a synthesis

An important current of thought,sustained right through the nineteenth century,was the theory that Western science was actually Chinese in origin. The proponents of this theory came to see Mo Zi 墨子 (ca.479-ca.381 B.C.)as the most likely Chinese source of scientific ideas,but they also pointed to such figures as the late Tang alchemist Dugu Tao獨孤滔 and the Song Neo-Confucian philosopher Zhu Xi朱熹(1130-1200). The ancient Chinese theories of *wuxing* 五行,*qi* 氣,the hexagrams of the *Zhouyi* 周易 and so on were also seen as examples of scientific thought. This may have been a conservative,anti-foreign reaction to Western science,but was sometimes an attempt by the liberal-minded to make it easier for Chinese conservatives to accept Western ideas by demonstrating that the Western concepts were not essentially foreign,but had their roots in the China of high antiquity.

It seemed to follow that,if Western science were really Chinese,a new synthesis between Western and Chinese ideas could be created. This synthesis received largely unintentional encouragement through the use of texts such as *Tiandao suyuan* 天道溯原['Seeking the origin through the Way of Heaven',usually known as *Evidences of Christianity*](1867) by W.A.P. Martin and *Gewu tanyuan* 格物探原 ['Seeking the origin through the investigation of things',usually known as *Natural theology*](1876) by Alexander Williamson,both direct descendants of William Paley's attempt to show how the phenomena of Nature accorded with Christianity. The first signs of science being taken seriously by intellectuals outside the government schools was,as I attempt to show in Chapter 12,a direct result of the reading of missionary works with a natural-theological message. The reform group including Kang Youwei,Liang Qichao 梁啓超(1873-1929),Tang Caichang 唐才常 (1867-1900) and Tan Sitong all read translations of Western science textbooks,and were all to different degrees impressed by the power of the new ideas,and led Tan Sitong to his unparalleled synthesis of Western science,Buddhist and Confucian ideas in *Renxue* 仁學.

1.10 The general framework

In arriving at the model which I have in the end found most fruitful for understanding these complex issues,I have relied upon the work of Joseph Needham,Nathan Sivin,Ho Peng Yoke and Shigeru Nakayama in providing a conspectus of the achievements of traditional Chinese science,and an appreciation of the matrix into which Western science was transmitted.

In understanding the *change* involved during the process of transmission,the work of Thomas Kuhn,especially his notion of scientific paradigms as developed in *The structure of scientific revolutions* and modified in 'Second thoughts on paradigms',has been of great importance. The issue of 'incommensurability' of new and old theories seems quite apposite when evaluating the task of translation into a culture which has an existing set of paradigms.[9] The translation of Western science into Chinese is inevitably to some degree filtered through the already-existing 'matrix' of language used in Chinese for talking about natural phenomena. Daiwie Fu's[10] notion of 'bilinguals' interpreting the new paradigm has also been helpful in clarifying the problem of how men like Xu Shou came to understand,accept and then transmit Western science so effectively.

I have also found the ideas of Ludwig Wittgenstein on the role of language-games and their application to the process of translation stimulating,as has the work of Mi Gyung Kim on the 'layers of language' in nineteenth-century chemistry.

Finally,the debt I owe to the work of Benjamin Elman on the *kaozheng* 考證 movement in the Jiangnan 江南 region will be obvious especially in Chapter 4 and 9.

1.11 Sources of evidence

I have drawn upon a wide variety of sources directly concerned with the science transmission,both Chinese and

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[9] Thomas Kuhn,*The structure of scientific revolutions* 2nd edition(Chicago:University of Chicago Press,1970),200-204

[10] Daiwie Fu,'Problem domain,taxonomy and comparativity in histories of science - with a case study in the history of "optics" ' in Cheng-hung Lin and Daiwie Fu(eds.)*Philosophy and conceptual history of science in Taiwan*(Dordrecht:Kluwer Academic publishers,1993),123-147

Western. Of prime importance have been the translated science texts themselves, especially *Bowu tongshu* 博物通書[Chinese almanac](1851)[11], *Bowu xinbian* 博物新編[A new account of natural philosophy](1855)[12], *Gewu rumen* 格物入門[An introduction to the investigation of things](1868)[13], *Huaxue chujie* 化學初階[First steps in chemistry](1870) and *Huaxue jianyuan* 化學鑑原[The mirror of chemistry: a source-book](1871)[14], *Huaxue zhinan* 化學指南[A guide to chemistry](1873)[15], and *Gewu tanyuan* 格物探原[Seeking the origin through the investigation of things](1875)[16] with their original Western source-texts, where these were known and accessible.

The Chinese journals of the period containing some articles on popular science, such as *Wanguo Gongbao* 萬國公報[The Chinese Globe Magazine], *Zhong-Xi Wenjian Lu* 中西聞見錄[The Peking Magazine], *Gezhi Xinbao* 格致新報 [Science news] and above all *Gezhi Huibian* 格致彙編 ['The Chinese Scientific Magazine'; later, 'The Chinese Scientific and Industrial Magazine'], whilst English-language newspapers such as *North China Herald*, *The Celestial Empire*, and contemporary English and French journals including the *Chinese Repository*, *Chinese Recorder*, *T'oung Pao* and the *Journal of the Royal Asiatic Society* provide scattered but indispensable pieces of relevant data.

I have also studied unpublished writings and letters

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[11] Section 7.4

[12] Section 7.5

[13] Section 7.6

[14] Section 7.7

[15] Section 7.8

[16] Section 7.9

of Calvin Mateer held by the Presbyterian Historical Society and the Yale Divinity Library; and letters and writings of John Fryer held by the East Asian Library and the Bancroft Library in the University of California,Berkeley[17] and the University of Birmingham.

Biographies of the Chinese scientists and translators were consulted in Zhao Erxun 趙爾巽(ed.) *Qingshigao* 清史稿[Draft history of the Qing dynasty],Min Erchang 閔爾昌 (ed.)*Beizhuanji bu* 碑傳集補[A supplement to the *Collection of Epitaphs*],Yang Mo 楊模 (comp.) *Xi-Jin sizhe shishi huicun* 錫金四哲事實彙存[A collection of facts about the four philosophers of Wuxi and Jinkui],together with the indispensable compilation by Yang Gen 杨根,*Xu Shou he Zhongguo jindai huaxueshi* 徐寿和中国近代化学史[Xu Shou and the history of modern Chinese chemistry].

Contemporary sources which,though not dealing directly with science,contain scattered references to it,and throw fascinating light on the attitudes of the official class to science,and to the movements of some of the personalities involved in the transmission,include the diaries of Wang Tao 王韜(1828-1897),Zeng Guofan 曾國藩(1811-1872),Xue Fucheng 薛福成(1838-1894) and Yung Wing[Rong Hong] 容閎 (1828-1912). Of especial interest is the account of the embassy to the West of Liu Xihong 劉錫鴻,who,as an enemy of Westernisation,can be relied on to give a more jaundiced view of scientific developments than the more enthusiastic modernisers such as Guo Songtao 郭嵩燾(1818-1891).

For official memorials on Self-Strengthening projects,such as ship-building and languages schools,I have referred to the collected works of Zeng Guofan,Li Hongzhang 李鴻章(1823-1901),Zhang Zhidong 張之洞(1837-1909),Ding Baozhen丁

[17] During a field trip to the USA during Easter,1993.

寶楨(1820-1886) and the collections *Chuanzheng zouyi huibian*船政奏議彙編[A collection of memorials on shipbuilding] and *Yangwu yundong* 洋務運動[The 'Foreign Matters' Movement],as well as articles by Thomas L.Kennedy,Quan Hansheng and Liu Kwang-ching.

In the Hundred Days' Reform period,the writings of Kang Youwei,Liang Qichao,Tan Sitong and Tang Caichang,together with the collection *Wuxu bianfa* 戊戌變法[Materials on the Hundred Days' Reform period],and translations such as *Zhixin mianbingfa* 治心免病法[Method for avoiding illness [through] control of the mind] provide the basis for Chapter 12.

1.12 Other works on the nineteenth-century transmission of Western science to China

Despite the existence of a considerable number of authoritative monographs and articles in English,Chinese and Japanese,touching on various personalities and institutions involved in,and various aspects of,the transmission[18],there has been to my knowledge only one full-length book on the subject,James Reardon-Anderson's *The study of change: chemistry in China 1840-1949*,which in its early chapters covers some of the same ground as this thesis,and was published about a year after I began the present work. I discovered its approach to be rather different from my own. Reardon-Anderson views the actual transmission of chemistry to China as essentially unproblematic - from the Western end of things at least - ,saying little about the confused state of Western

[18] The writings of A.A.Bennett,Knight Biggerstaff,Chan Sin-wai,Gideon Chen,Paul A.Cohen,John K.Fairbank,Charlotte Furth,Keizō Hashimoto,Hsiao Kung-chuan,Thomas L.Kennedy,Luke Kwong,Li San-po,Joseph Needham,Richard Shek,and Nathan Sivin in English; and those of Pan Jixing 潘吉星,Quan Hansheng 全漢昇,Wang Bing 王冰,Wang Shuhuai 王樹槐 ,Wang Yangzong 王扬宗,Yang Gen 杨根 and Zhang Zigao 張子高 in Chinese.

chemistry during much of the century,and tends to blame the Chinese themselves for misunderstanding what they were told. He also in my view understates both the degree of Chinese practical involvement in the transmission process,regarding it as 'almost exclusively a literary affair'[19],and - in my view - misinterprets the Chinese intellectuals' eclectic applications of science as a 'failure to understand science at all'.[20] The present study goes into much greater detail on the precise nature of the transmission,its problematics,the textbooks compiled,and in particular stresses the complex and ambiguous nature of the process at both its Chinese and Western poles.

1.13 Conclusion: the translation of Western science

The present study does not attempt to be a complete account of this vast subject,but rather sets out to make a preliminary survey of the terrain - some parts of which other scholars have already explored - from a vantage-point more sceptical than hitherto. On the level of the history of ideas,it seeks to show that what might be thought of as a rather dull period in the history of Chinese science has a great deal to tell us both about the Chinese and Western paradigms and their mutual interaction during the process of transmission,the process which in the end I have elected to call 'translation'. It is to the pre-history of this great translation we now turn.

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[19] James Reardon-Anderson,*The study of change*,15

[20] *ibid.*,16

Chapter 2. : The pre-nineteenth-century transmission of Western science to China and the existing Chinese paradigms

In this chapter I shall firstly consider the Jesuits' attempt to transmit Western chemical knowledge,and then describe the nature of the chief concepts within the Chinese paradigm which they attempted to overthrow. Finally I briefly describe the scientific aspects of the Macartney mission to China in 1792-94,which seemed at the time to confirm Chinese disinterest in Western science.

2.0 Chinese alchemy before the Jesuits[21]

The Chinese alchemists developed a complex and subtle view of the transformations of matter. Although by the mid-nineteenth century this tradition was dying,it was an important aspect of the Chinese background to the acceptance of modern chemistry.

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[21] For background on Chinese alchemy,see Obed.S.Johnson,*A study of Chinese alchemy*(Shanghai:Commercial Press,1928); Arthur Waley,'Notes on Chinese Alchemy' in *BSOAS* **6**(1930),1-24; Homer H.Dubs,'The beginnings of alchemy' in *ISIS* **38**(1947),62-86; Yuan Hanqing 袁翰青,*Zhongguo huaxueshi lunwenji* 中國化学史論文集 [A collection of essays on the history of chemistry in China](Beijing:Sanlian shudian 三聯書店 ,1956); Joseph Needham and Ho Ping-yu,'The laboratory equipment of the early medieval Chinese alchemist' in *Ambix* **7**,2(June,1959),57-115; Joseph Needham,'Theories of categories in early medieval Chinese alchemy' in *Journal of the Warburg and Courtauld Institute* **22**(1959),173-210; Nathan Sivin,*Chinese alchemy: preliminary studies*(Cambridge,Mass.:Harvard University Press,1968); Ge Hong 葛洪,*Alchemy,religion and medicine in the China of A.D.320* J.R.Ware trans.(Cambridge,Mass.:The M.I.T. Press,1966); Li Qiaoping 李喬苹,*Zhongguo huaxueshi* 中國化學史[The history of chemistry in China](Taibei:Taiwan shangwu yinshuguan 臺灣商務印書館,1976); Lu Gwei-djen,'The Inner Elixir(*nei tan*):Chinese physiological alchemy' in Mikuláš Teich and Robert Young(eds.)*Changing perspectives in the history of science*(London:Heinemann,1973),68-84; Joseph Needham,*SCC* Vol.5 Pt.2(Cambridge:Cambridge University Press,1974);Joseph Needham,*SCC* Vol.5 Pt. 3(Cambridge:Cambridge University Press,1976); and Ho Peng Yoke,*Tuku T'ao's* Tan-fang chien-yüan:*a 10th century Chinese alchemical source-book*(Hongkong:Centre of Asian Studies,1980).

They developed many chemical techniques such as sublimation,distillation,amalgamation,filtration,solution in water and acids[22] and a wide range of chemical apparatus[23],to the extent that few of the methods (with the important exception of electrolytic techniques)described in the first translated chemistry texts would have been entirely alien to Sun Simiao 孫思邈 (A.D.581-682) or Dugu Tao 獨孤滔 [24]

An impressive range of chemical substances were familiar to them,and their description and classification probably reached as high a level of sophistication as was possible before a proper understanding of the nature of chemical compounds was in place,and was certainly no more arbitrary and unsystematic than contemporary European nomenclature. [25]

2.1 The Jesuit introduction of Western chemical science to China[26]

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[22] Yuan Hanqing,*Zhongguo huaxueshi lunwenji*,208ff.

[23] Joseph Needham and Ho Ping-yü,*The laboratory equipment of the early medieval Chinese alchemist.*

[24] An alchemist who probably lived in the late Tang dynasty. See Ho Peng Yoke *Tugu T'ao's* Tan-fang chien-yüan.

[25] Joseph Needham,*SCC* Vol.5 Part 3,154ff

[26] Sources consulted on the Jesuit transmission of Western science include: Henri Bernard,*Matteo Ricci's scientific contribution to China*(Beiping:Henri Vetch,1935); Henri Bernard,'Notes on the introduction of the Natural Sciences into the Chinese Empire' in *Yenching Journal of Social Studies* **3**(1941),220-241; Pasquale M.D'Elia,*Galileo in China:relations through the Roman College between Galileo and the Jesuit scientist-missionaries (1610-1640)* (Cambridge,Mass.:Harvard University Press,1960); George H.C.Wong,'China's opposition to Western Science during late Ming and early Ch'ing' in *ISIS* **54**,1(1963),29-49; Nathan Sivin,'On "China's opposition to Western Science during late Ming and early Ch'ing' in *ISIS* **56** (1965),201-205; Nathan Sivin,'Copernicus in China' in *Colloquia Copernicana*

The mathematical and astronomical aspects of the Jesuit transmission are not considered here,but there is evidence that although they did encourage something of a renaissance in Chinese mathematics and mathematical astronomy[27],in chemistry they were able to add little to existing knowledge,and this in part accounts for the relative indifference of the Chinese.

The Jesuits were at first regarded by some Chinese as alchemists: Qu Rukui 瞿汝夔 ,one of Ricci's collaborators,originally joined him hoping for instruction in alchemy[28],and Chinese alchemists came to Ricci with examples of strange or unusual minerals[29]. Nearly four centuries later,the missionary Karl Gützlaff(1803-1851) was to find similarly arcane arts attributed to the English.[30]

II (Warsaw,1973),63-122; Nathan Sivin,'Biography of Wang Hsi-shan' in *DSB*,159-168.

[27] See A.Hummel,*ECCP* for biographies of Xu Guangqi 徐光啓 (1562-1633)(ibid.,316-319) and Mei Wending 梅文鼎 (1633-1721)(ibid.,570-571); also Nathan Sivin 'Biography of Wang Hsi-shan' (1628-1682).

[28] Henri Bernard,*Matteo Ricci's scientific contribution to China*,44

[29] *ibid.*,43

[30] According to Karl Gützlaff:

They were still desirous to know more information about dollars,and requested me to teach them the art of making them of tin or lead; for many of them believe that the English are able,by certain processes,to change these metals into silver. As they considered me an adept in every art,except divinity,they were much disappointed when I told them,that I neither understood the secret,nor believed there was any mortal who did. This statement they discredited,and maintained that the English,as they had many great ships and splendid factories in Canton,and had no means of obtaining riches except by this art,must of necessity be able to change the inferior metals into gold. This same strange notion is believed in Siam; and I have been earnestly importuned by individuals to teach them this

In 1584,two years after his first arrival in China,Matteo Ricci[Limadou 利瑪竇](1552-1610)expressed admiration(albeit in rather condescending terms) for Chinese scientific accomplishments:

> In their sciences the Chinese are very learned: in medicine,moral physics,mathematics and finally all the liberal or mechanical arts. It is admirable that a nation,which never had any relations with Europe should have reached by its own means almost the same results as we with the collaboration of the whole universe.[31]

Thirteen years later,after some success but many disappointments in his attempts to impress the Chinese with the advanced state of Western science,he was,Kurtz-like,to come to a more gloomy conclusion:

> The Chinese do not possess any sciences: one may say,only mathematics are cultivated and the little they know of that is without foundation,they borrowed it from the Saracens; only the king's mathematicians teach the science to their sons. They just manage to predict eclipses,and even in that make many mistakes.[32]

It was in mathematics and astronomy that the most famous and significant transmissions were made,but these lie outside the scope of this thesis. Here I shall only

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valuable art; silver ore has been sent to me also with the request,that I would extract the silver and turn it into dollars.(Karl Gützlaff,'Journal' in *CRP* **1**,4(August 1832),129)

[31] Henri Bernard,*Matteo Ricci's scientific contribution to China*,39

[32] *ibid.*,52

consider an unsuccessful attempt to introduce the European Four Element theory of chemistry.

In his tract 'Si yuanxing lun' 四元行論 [On the Four Elements],part of a longer work *Qian-kun tiyi* 乾坤體義[On the forms of Heaven and Earth] Ricci attacked the *wuxing*五行[Five Phases] theory,rather skilfully using an ancient Chinese form of argument to prove that the traditional view of *wuxing* 五行 contained logical inconsistencies,and - rather less convincingly - that the Greek Four Element theory was superior.

Ricci began by arguing that the *wuxing* 五行 (especially Metal and Wood)were not pure elements,and that the ancient *wuxing* 五行 were never intended to be 'elemental'(in the Greek sense of the term: in Ricci's time the modern conception of the chemical elements had not yet been developed):

> I venture to suggest that in China the theory of the Five Elements was different in antiquity and modern times. The so-called elements (*xing* 行)[33] are whence Myriad Phenomena arise,and hence,being 'elements' are actually 'Primal Elements'(*yuan xing* 元行): they are extremely pure,properly are not mixed together,and do not include one another. Whilst Water,Fire and Earth[34] may be [properly] called elements,it is hard to understand how Metal and Wood can [also] be regarded as Primal Elements. [For] if you observe the formation of the Myriad Things,most do not involve Metal or

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[33] I translate *xing* 行 as 'element' here because it is clearly what *Ricci* intended by the term. Sinologists generally prefer to use the expression 'phase'. See Section 2.2 below.

[34] Three of the Five Phases.

> Wood: humankind,insects,birds and beasts do not involve Metal and Wood as constituent elements(*da xing* 達行). Who does not know that Metal and Wood are really mixtures of Water,Earth and Fire,and,being mixtures,cannot be regarded as Primal Elements? Mixtures such as grass,stones,etc. might be classified as 'elements',but then there would not be just five elements. Why should Metal and Wood be singled out? I have read that [Emperor] Shun 舜 of Tang唐 exploited material things and [Emperor] Yu 禹 the Great set out his plan by arranging these [five] along with grain to make the Six Treasuries(*liu fu* 六府),but these were only said to be [materials] essential to the life of the people; it was not that Water,Fire,Metal,Wood and Earth were the primary material elements and the origin of the Myriad Things. [35]

Ricci then moved on to criticise the supposed Mutual Production(*xiang sheng* 相生) relationship between the *wuxing*五行,which Dong Zhongshu 董仲舒 (?179-?104 B.C.) had characterised as that of father and son[36]. Ricci uses an argument similar to that deployed centuries earlier by the great sceptic Wang Chong 王充 (A.D.27-?100)in *Lunheng* 論衡[Weighing the arguments] [37],by showing first that the *wuxing* 五行 must have been interdependent,and could therefore not have come into existence sequentially; and then how the father-child analogy led to internal inconsistency:

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[35] Matteo Ricci,'Si yuanxing lun' in *Siku quanshu* 四庫全書[A complete library of the Four Treasuries],787.761a

[36] Joseph Needham,*SCC* Vol 2,249,quoting Dong Zhongshu.

[37] Joseph Needham,*SCC* Vol.2,265-266. Wang Chong's argument is that the animals associated with the *wu xing* 五行 do not prey upon one another in accordance with the mutual destruction order.

> In latter days,[Chinese]scholars have said that Water gives rise to Wood,Wood to Fire,Fire to Earth,and Earth to Metal. That is to say,Wood is born from Water,Fire from Wood,Earth from Fire,Metal from Earth and Water from Metal. This theory is hard to accept. For Wood contains Earth and Fire[38],how can it be that it is born only from Water and yet when Earth and Fire had not [yet even] been born,how could Wood have been born of itself. If when Wood had been born Earth had not yet been born,where would the first tree have been planted?[39][...]Water gives rise to Wood,and Wood to Fire,so Water is the grandfather and Water the grandson. How can the grandfather be so unloving as constantly to wish to destroy his grandson? [40]

Having refuted the *wuxing* 五行,Ricci then explained the Western theory:

> The Western scholars say that the Elements do not give birth to one another and are not contained within one another. The Elements are what constitute the Myriad Phenomena. Everything in the universe that has form has its substance made of the Four Elements,which are Fire,Air,Water and Earth. Their number cannot be increased or decreased. The basic characters(*ben qing* 本情) of the Elements are combined as four: namely,Hot,Dry,Cold and Wet. The Primal Characters(*yuan qing* 元情) of the Four Elements are paired to form their Natures(*xing* 性). As,for instance,Cold and Hot,Dry and Wet are directly mutually antagonistic and cannot coexist,then [the

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[38] According to the Aristotelian scheme: this explained how Wood burned,giving rise to Fire and ash(= Earth).

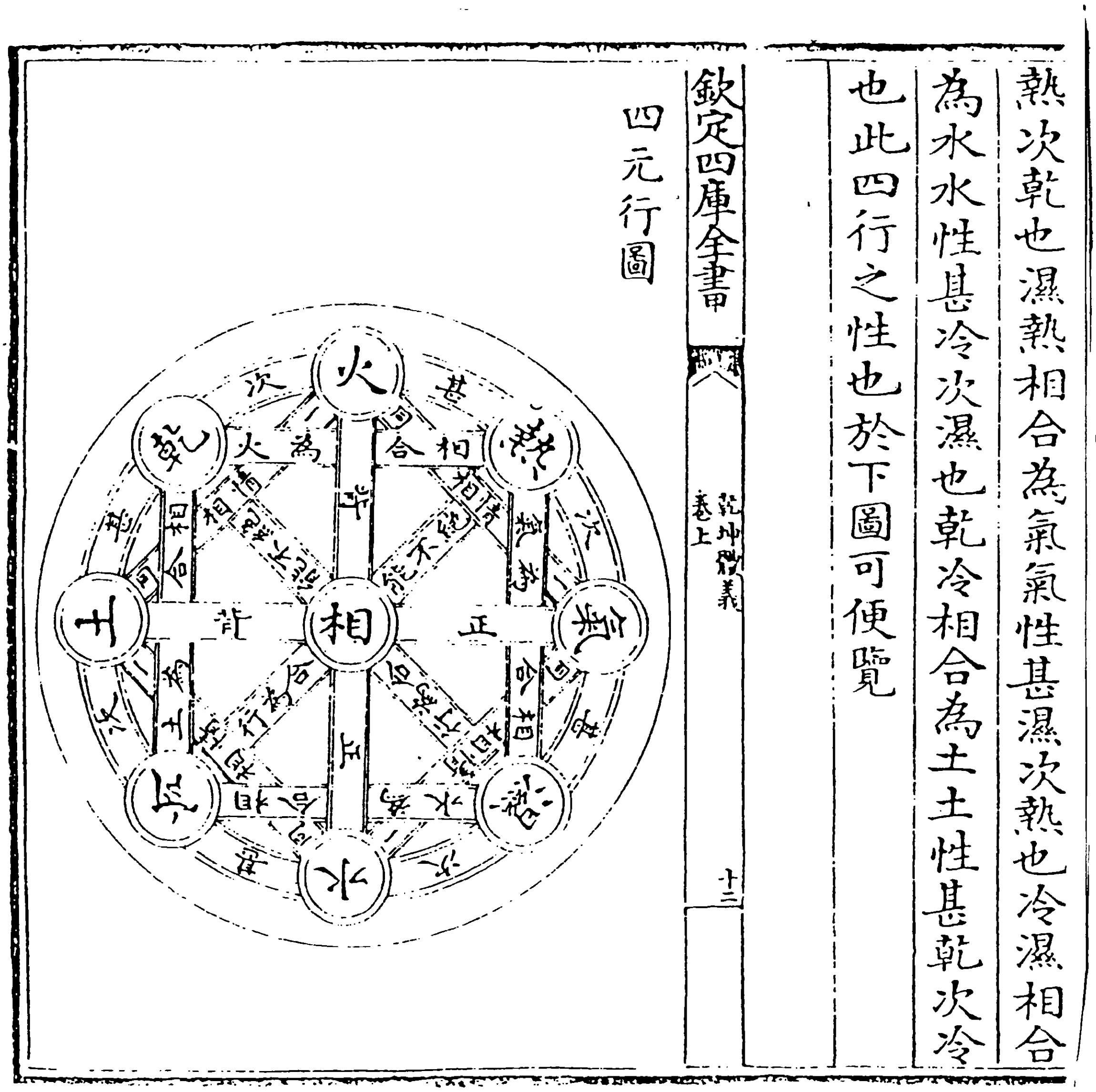
[39] Ricci assumes a single act of creation.

[40] Ricci,'Si yuanxing lun',787.761b

poles of each pair] must be regarded as [pertaining to] two [separate] Elements. Hot and Dry are combined as Fire: the nature of Fire is primarily Hot and,secondarily,Dry. Cold and Wet are combined as Water: the nature of Water is primarily Cold and secondarily Wet. Cold and Dry are combined as Earth. The nature of Earth is primarily Dry and secondarily Cold. The natures of the Four Elements are shown in the following diagram.[Figure 1]

When the Creator wished to create the Myriad Things in the first chaos of the universe,he created the Four Elements and then according to their characters(*qingshi* 情勢) he distributed them in their basic places(*ben chu* 本處). Fire is by character extremely light and it therefore rose until it stopped beneath the Ninth Celestial Sphere. Earth is by character extremely heavy,and it thus it fell and congealed between Heaven and Earth. Water is by character lighter than Earth and thus it came to rest floating on Earth. The nature of Air is neither light nor heavy,and it mounted the Water and Earth,bearing the Fire above it. Earth is the most turbid of the Four Elements and Fire the most pure. Fire is by its basic position close to Heaven and it follows it and rotates,every day performing one rotation. This is the original Fire,[and is] thus extremely pure and very hot,with no light in it.[41]

[41] Ricci,'Si yuanxing lun',787.761b-762b



熱次乾也濕熱相合為氣氣性甚濕次熱也冷濕相合
為水水性甚冷次濕也乾冷相合為土土性甚乾次冷
也此四行之性也於下圖可便覽

欽定四庫全書

乾坤體義 卷上

十二

四元行圖

Figure 1. The Greek Four Element theory as illustrated in Matteo Ricci's 'Qian-kun tiyi 乾坤體義' in *Siku quanshu* 四庫全書 787.762a

Later, another Jesuit, Alphonsus Vagnoni (1566-1640) [Gaoyizhi 高一志] wrote on the Four Elements in his book *Kongji gezhi* 空際格致 [The science of the atmosphere] using virtually identical arguments.[42]

Neither tract had much effect on the Chinese view of *wuxing* 五行, which they could see no good reason to abandon[43]. The Jesuits' polemics missed the point: the *wuxing* 五行 never were regarded by the Chinese as 'elements' in the Greek sense of 'pure materials from which all other substances are made'. The supposed inconsistencies in the *wuxing* 五行 system were also not, in the Chinese view, a sufficiently serious enough problem to make it untenable, and they already had experience of at least one other foreign system, the Four Element theory of the Buddhists, which had coexisted comfortably enough with the *wuxing* 五行, never seriously threatening the dominance of the latter[44]. From a Chinese point of view, what was to be gained by accepting the Western Four Element theory? It could explain some phenomena but not others, just as the *wuxing* 五行 did. It could not make predictions nor, most significantly, did it underlie a new technology. To accuse the Chinese of 'complacency' in not accepting it seems at the least unfair if not positively arrogant. It was after all nearly two centuries before the West could offer anything in chemical

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[42] Liu Zhaomin 刘昭民, 'Zui zao chuanru Zhongguo de Xifang qixiangxue zhishi' 最早传入中国的西方气象学知识 [The earliest knowledge of Western meteorology to enter China] in *ZGKJSL* **14**, 2 (1993), 90-94.

[43] See Fang Yizhi 方以智, *Wuli xiaozhi* 物理小識 [Notes on the principles of things] (preface dated 1664; reprinted Shanghai: Wanyou wenku 萬有文庫, 1937) 1.10-11.

[44] Sun Simiao for instance mentions the Buddhist Four Element theory, but it had little influence on the concept of *wuxing*. See Paul U. Unschuld, *Medicine in China: a history of ideas* (Berkeley: University of California Press, 1985), 150.

theory to the Chinese which provided a really satisfactory explanation of phenomena such as burning in terms of elements,and then only by abandoning the old speculativė notion of the Four Elements in favour of an empirical definition which would allow a substance to be termed an element only if it could not be disintegrated by any known method. It is clear in hindsight that it was only the discovery of electrolysis that made it possible by the late 18th century to begin to have a reliable sense of what was and was not an element,as so many compound substances(such as common salt and water) are extremely stable under normal conditions with respect to their constituent elements,and could not have been shown to be compounds before the chemical effects of electric currents were known.

The most important difference between the Jesuit transmission and the 19th century missionary transmission was not intellectual,religious or organisational but military. There were no steamships behind Matteo Ricci and his colleagues: it was the very practical possibility that the Chinese Empire might be overwhelmed by the military technology of the West in the nineteenth century that led to the sciences of the Westerners eventually being taken seriously.

2.2 The existing Chinese paradigms

What were the paradigms which Ricci and his colleagues attempted to displace? In order to understand the process of the transmission of Western science into China,it is necessary to look briefly at the already-existing paradigms for natural philosophy in China.

language

the world of phenomena (*qi* 氣, *wu xing* 五行, *yin-yang* 陰陽) .... underlying pattern (*li* 理, *Dao* 道)

the world of human relations (*li* 禮)

Figure 2 A diagram showing some of the connections between the concepts of Chinese natural philosophy

The view of nature which Ricci and his colleagues discovered the Chinese to hold was coherent yet radically different from that generally held by European natural philosophers of that period. The concepts through which the Chinese perceived and described the natural world, such as *dao* 道, *qi* 氣, *yin-yang* 陰陽, *wu xing* 五行 and *li* 理 were capable of providing a pattern which could embrace most phenomena in the natural world, and which showed how these phenomena connected human beings with an ethical but impersonal cosmos. The philosophers who formulated and deployed these theories were engaged in what Robin Horton has called:

> a quest for unity underlying apparent diversity; for simplicity underlying apparent complexity; for order

> underlying apparent disorder;for regularity underlying apparent anomaly.[45]

which is,in the broadest sense,scientific.

2.21 *Dao* 道 [46]

The flux of the universe was intrinsically One,but unified and organised in a particular way,the Way of the *Dao* 道 . The *Dao* 道 was indescribable,impersonal and purposeless,yet intrinsically ethical,saturating the whole natural world,which,by and large followed the *Dao* 道,just as water spontaneously flows along the path of least resistance down a mountainside. The *Dao* 道 was not a conscious regulator of nature,yet human beings who chose a course of action contrary to the *Dao* 道 courted disaster. The ethical,political and physical aspects of *Dao* 道 were inseparable. All human beings were subject to the *Dao* 道,even the Emperor,in whose person and in whose virtue the fate of the (Chinese) world resided. An ideal ruler was one who followed the Kingly Way *Wang Dao* 王道. From the earliest records it seems that the term *Dao* 道 meant 'speech' as well as 'way': the Way,as well as being a path could also be the locus of a social relationship,mediated through language.[47]

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[45] Robin Horton,'African traditional thought and Western science' in *Africa* **37**(1967),50-71 and 155-187, p.51

[46] Excellent accounts of the fundamental ideas of Chinese science are to be found in: Joseph Needham,*SCC* Vol.2,216-345 and Nathan Sivin,*Traditional medicine in contemporary China* (Ann Arbor:Center for Chinese Studies,University of Michigan,1987). This section is not intended to do more than emphasise certain key ideas in so far as they are relevant to the nineteenth century Western transmission.

[47] See Chapter 1 of Arthur Waley,*The Way and its Power*(London:George Allen and Unwin,1934,reprinted 1949), translating the opening verse of the first chapter of the *Daodejing* 道德經 as 'The Way that can be told of(*dao* 道)is not an unvarying Way'.

One of the characteristics of the Chinese natural philosophers was their relatively relaxed view about anomalous,unexpected or novel phenomena.[48] The anomalies were never seen as a threat to the underlying philosophy of the *Dao* 道,because the *Dao* 道 was all-encompassing and unitary without being defined by a set of rules,and 'simple' only in the sense that Nature is simple and unadorned. *Dao* 道 was the Word,but did not itself have to be expressible in words.

The beginning of natural science is careful observation of and curiosity about the natural world,and there is evidence from the earliest Chinese written records,the inscribed shells and bones(*jiaguwen* 甲骨文)of the Shang Dynasty that they took great interest in celestial phenomena such as solar eclipses,as these were believed to be correlated with changes in the terrestrial political environment[49].

The connections between language and the ideas of natural science in ancient China are very deep: in the visual form of communication,going to the roots of the Chinese script itself,and for the spoken language associating the terms used to describe phenomena with the *qi* 氣 from which the phenomena arise.

For the accumulation of knowledge,accurate observation requires the recording of data in a form accessible to

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[48] See Daiwie Fu,'A contextual and taxonomic study of the "Divine Marvels" and "Strange Occurrences" in *Mengxi bitan*' in *CS* **11**(1993-94),3-35.

[49] See Wen Shaofeng 温少峰 and Yuan Tingdong 袁庭栋(eds.)*Yinxu buci yanjiu:kexue jishupian* 殷卜辞研究科学技术篇 [Research on Shang divinations: science and technology chapter](Chengdu:Sichuan sheng shehui kexueyuan chubanshe 四川省社会科学院出版社,1983)

later observers. The development of writing was thus a key step in the development of natural science as a social enterprise. The earliest myths of the creations of writing in China show how close the connection between the written word and the patterns of Nature was thought to be. Of the legendary creator of the Chinese script Cang Jie 倉頡 it was said:

> He studied the metamorphoses of Heaven and Earth; he looked up and gazed at the convoluted outline of the constellation *kui* 奎[sacred to literature];he looked down and observed the scales of fish and birds' feathers; he noted the contours of hill and stream,and [out of these] he created writing.[50]

The characters which appear in the oldest known written records in China are already of impressive complexity,and suggest that other,considerably older examples may await discovery,as such a sophisticated system must surely have developed over a considerable time.

Characters which are pictographic in origin are termed *wen* 文,[51] a character which originally indicated 'markings' or ,'streaks',a meaning which was preserved in the term for astronomy *tianwen* 天文 'the markings of Heaven'.Thus the written word,the *wen* 文,connected the patterns of Nature with the patterns of the script,which were in turn markings denoting both the sounds of language and the meanings inherent in the sounds.

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[50] Charles Aylmer,*Origins of the Chinese script* (Cambridge:East Asia Books & Arts,1981),3

[51] As distinct from *zi* 字,which are compounds of radical and phonetic,and do not attempt to depict an object.

The spoken language was one expression of the entity *qi* 氣 [52],originally associated with the breath,whose passage through the throat,mouth and nose caused the sounds through which communication might be effected. Thus,in communication,*dao* 道,*qi* 氣 and *wen* 文 became interconnected.

According to the Song Neo-Confucian philosopher Cheng Yi 程頤 (A.D.1033-1108):

> The names [*mingzi* 名字] of all things are themselves in mutual communication[*xiang tong* 相通] with [their] sounds,[their] meaning,[their] *qi* 氣 and [their] *li* 理.(Apart from other substantial things which can be named just by pointing.) For instance,the sky is taken as 'sky': before it had been named,it had no name,it was just blue(*cangcangran* 蒼蒼然). How then did it have this name? Its natural principle [*ziran zhi li* 自然之理] appeared,and [as] the sound issued forth within its own *qi* 氣,it had this name. (It is like those people nowadays who are able to judge whether someone has a good character from their voice,or diviners who know people's names [by looking at them]: [these phenomena also] derive from this principle.)[53]

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[52] See Section 2.22.

[53] Zhu Xi 朱熹 (ed.) *Henan Chengshi yishu* 河南程氏遺書 [The writings of Cheng Yi and Cheng Hao](Shanghai:Commercial Press,1935),10.

The importance of the relation of names to the things they represent can be traced back to Confucius himself,with the theory of the 'rectification of names(*zheng ming* 正名)' and was elaborated further by Dong Zhongshu. See Fung Yu-lan,*History of Chinese philosophy* (Princeton:Princeton University Press,1953; reprinted 1973)Vol.1,59-63 and 302-311,and Vol.2,85-87.

The observation of the *Dao* 道 was thus by the Song Dynasty connected with the markings by which it is communicated,and the sounds of the names of the things themselves. The markings developed into one of the most highly developed non-alphabetic scripts in the world,a script which,from its beginnings in divination,still holds a position in Chinese culture which is of great significance,and which despite several attempts at script reform[54] appears unlikely ever to be replaced as the principal medium of written communication in China.

The concept of *Dao* 道 as both a natural and an ethical principle permeated the whole of Chinese philosophy,and was seen as a fundamental of Chinese culture which set them apart from the barbarians. As the West began to gnaw at the coastal cities of China in the nineteenth century,and Western technical superiority in guns and steamships became undeniable,some writers contrasted China and the West through their different emphases: China emphasised *Dao* 道,whereas the West emphasised *qi* 器. This *qi* 器,not to be confused with the 'vapour' *qi* 氣, meant primarily 'vessel' or 'tool',but contrasted with *Dao* 道 [55] meant something like 'material

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[54] Including the development of auxiliary phonetic scripts such as *zhuyin fuhao* 注音符號 and *Hanyu pinyin* 漢語拼音,and simplification of the characters themselves(in 1956 with the *Hanzi jianhua fang'an* 汉字简化方案 [Proposal for the simplification of Chinese characters]and the abortive *Di er ci Hanzi jianhua fang'an(caoan)*第二次汉字简化方案 (草案) [The second proposal on the simplification of Chinese characters(draft)]. For the latter,see *Renmin Ribao* 人民日报 [People's Daily](20th December,1977),4.

[55] See *Yijing* 易經 : 'That which transcends form(*xing er shang zhe* 形而上者)is *Dao* 道,that which is subject to form(*xing er xia zhe* 形而下者) is *qi* 器 '(See Z.D.Sung, *The text of Yi King*(Shanghai,1935; reprinted New York,Paragon Books,1969),303(my translation)). The Neo-Confucian philosophers made much of this contrast. See Fung Yu-lan,*A history of Chinese philosophy* Vol.2,510.

objects and their uses'. The contrast is telling,for *qi* 器 had always,even in Confucius' time,been used in a somewhat derogatory sense,implying 'mere mechanical use' : 'The accomplished scholar(*junzi* 君子) [said the Sage] 'is not a utensil (*qi* 器)'[56],meaning that the gentleman is not a mere artisan or tool of those in power but possessed of an ethical nature not constrained by a specific task.[57]

The *qi* 器 of the West were,however,deadly effective,and by the mid-nineteenth-century some leading scholars recognised that the *qi* 器 would have to be mastered if the Chinese Empire were not to be a victim of internal rebellion or foreign invasion or both.

2.22 *Qi* 氣 [58]

Qi 氣 is probably the most important physical concept running through Chinese natural philosophy,with a history stretching back to the Shang dynasty.[59] Its fundamental meaning is 'breath' or 'vapour': Dong Zhongshu 董仲舒 in Chapter 81 of *Chunqiu fanlu* 春秋繁露[Abundant dew of the

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[56] James Legge,*Analects* Book 2 Chapter 12 in James Legge(trans.)*The Four Books*.

[57] See Section 12.1.

[58] On the origins of the term *qi* 氣 see Nathan Sivin, *Traditional medicine in contemporary China*,46-59; A.C.Graham,*Yin-yang and the nature of correlative thinking*(Singapore:Institute of East Asian Philosophies,1986); and Hu Weijia 胡維佳,'Yin-yang,wu xing,qi gainian de xingcheng ji qi yiyi - xian Qin kexue sixiang tixi shitan 阴阳五行气概念的形成及其意义 - - 先秦科学思想体系试探' [The formation of the concepts of *yin-yang*,*wu xing*,and *qi* and their significance -- a study of the pre-Qin scientific thought system] in *ZRKXYJ* **12**,1 (1993),16-28,on which this section draws heavily.

[59] See Yu Shengwu 于省吾,*Jiagu wenzi shilin* 甲骨文字释林 [A glossary of shell-and-bone characters](Beijing:Zhonghua shuju 中华书局,1979),79-83.

Spring and Autumn Annals] attempted a synthesis of the previous ideas about *qi* 氣,putting forward the notion of the existence of a primal *qi* [*yuanqi* 元氣],from which all things had originated.[60] Developed further by the Neo-Confucian Song philosophers such as Zhang Zai 張載 (A.D.1020-1077),it reappeared towards the end of the nineteenth century,in the hands of Kang Youwei and Tan Sitong,as *yitai* 以太 or the ether. According to Zhang Zai

> The Great Void(*taixu* 太虛)cannot be void of *qi* 氣 ; *qi*氣 cannot but congeal and make the Myriad Things. The Myriad Things cannot but disperse and make the Great Void[...][61]

Zhang Zai's *qi* 氣 was both material and spiritual.As Nathan Sivin has pointed out[62],*qi* 氣 was regarded as both the cause of phenomena and the vector of the cause,the condensate which is what Western philosophers call 'matter' *and* the cause of the changes which matter undergoes. It never lost its transcendental and ethical aspect.

Qi 氣 was not regarded as residing only in living things. Everything,including the 'supernatural' entities such as ghosts and spirits were made of *qi* 氣. Nevertheless,*qi* 氣 was essential for life. The *Zhuangzi* 莊子 records the sage stoically reflecting upon the death of his

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[60] Fung Yu-lan,*History of Chinese philosophy* Vol.2,19-22 and He Zhama 何乍麻,'Yuanqi xinjie' 元气新解 [A new explanation of primal *qi*] in *KJSWJ* **12**(1984),35-41.

[61] Wang Fuzhi 王夫之,*Zhang Zi Zhengmeng zhu* 張子正蒙註[Annotations to Zhang Zai's *Correcting Youthful Ignorance*] (Beijing:Zhonghua shuju 中華書局,1975),5

[62] Nathan Sivin,*Traditional medicine in contemporary China*,47

wife:

> Having investigated the origin [of things,I find that] in the beginning there was no life(*sheng* 生).Not only was there no life,but in the beginning there was no form(*xing* 形).And not only was there no form,but in the beginning there was no *qi* 氣. Everything was in a state of chaos. Then it changed,and there was *qi* 氣. The *qi* 氣 changed and there was form. The form changed and there was life. Now this too has changed,and [her] death is like the movement of the seasons,spring,summer,autumn and winter.[63]

The association of breath with sound,with life and with *qi* 氣,and the equation of the cessation of breathing and the stilling of the *qi* 氣 with death was natural,and reinforced the powerful connection which existed between the individual's *qi* 氣 and the cosmos to which it returned on his or her death.

2.23 *Yin-yang* 陰陽 [64]

By the nineteenth century,it was the Neo-Confucian unitary view of *yin-yang* 陰陽,as part of the evolution of *qi* 氣,which had become the most influential,following the teachings of the Neo-Confucian philosopher Zhu Xi 朱熹 (1130-1200),who said:

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[63] *Zhuangzi* 莊子 6.10a-10b. This passage is translated in Arthur Waley,*Three ways of thought in ancient China*(London:George Allen & Unwin,1939),21.

[64] See Bernhard Karlgren,*The book of odes* (Stockholm: Museum of Far Eastern Antiquities,1950); Joseph Needham,*SCC* Vol.2,273ff ; Nathan Sivin,*Traditional medicine in contemporary China,*59-70; Vitaly A.Rubin,'The concepts of *wu-hsing* and *yin-yang*' in *Journal of Chinese Philosophy* **9**(1982),131-157 and A.C.Graham,*Yin-yang and the nature of correlative thought.*

> *Yin* 陰 and *yang* 陽 are a single *qi* 氣. The withdrawal of *yang* 陽 is the birth of *yin* 陰 . It is not that *yang*陽 has to withdraw for the *yin* 陰 separately to be born. *Yin* 陰 and *yang* 陽 may be regarded as single [aspects] or as two [aspects]. If regarded as two,they are *yin*陰 and *yang* 陽,the two exemplars [*yi* 儀] being established. If regarded as one,there is just the waning and waxing of the one. *Yin* 陰 and *yang* 陽 are clear and turbid,oblique and straight. The principles of *yin*陰 and *yang* 陽 include gathering and division. All things are like this.[65]

Thus the natural world was seen as essentially unitary,produced by the interaction between *yin* 陰 and *yang*陽 aspects of *qi* 氣,an interaction in which *yang* 陽 disperses everything into the Great Void,but is unceasingly re-created,as the *yin* 陰 aspect of *qi* 氣 again encourages its coalescence,and these evolutions of *qi* 氣 (*qihua* 氣化) result in the constant flux of the phenomenal world.

Even in the writers of the late Qing such as Kang Youwei and Tan Sitong,influenced though they were by Western science,the assumption remained that the human,physical and supernatural worlds were still intimately interconnected through *qi* 氣,and that the study of science would not offer any fundamental contradiction to the traditional Chinese ethical imperatives,of which human beings were conscious through the flow of *qi* 氣 between Heaven and Earth.

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[65] Zhu Xi 朱熹,*Yulei* 語類[Classified sayings] 65.1a Translation partially based on that of Nathan Sivin,*Traditional medicine in contemporary China*,64.

2.24.The Five Phases or wu xing 五行 [66]

The terms known as *wuxing* 五行 are defined in the Great Norms[*Hongfan* 洪範] section of the 'Declaration at Gan'[*Gan shi* 甘誓] in the Book of Documents[*Shangshu* 尚書]:

> [...]first,Water,second,Fire,third,Wood,fourth,Metal ,and fifth,Earth. Of Water it is said that it soaks and goes downward;of Fire it is said that it flames and goes upward;of Wood it is said that it bends and straightens;of Metal,it is said that it conforms and can change[shape];of Earth it is said that it accepts seeds and gives forth crops.[67]

These Norms were natural categories correlating the processes described to the five substances which epitomise them. The processes were regarded as those essential for the universe to flow in the proper way. There is,as with *qi* 氣,no distinction between *substance* and *process*.

By classical times,the *wuxing* 五行 had come to be seen as varieties of the transformation of *qi* 氣,allowing physiological and chemical phenomena to be explained in terms of the mutual control systems which the five *xing* exerted over one another,but they were never 'elements' in the Western sense of the term.

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[66] See Joseph Needham,*SCC* Vol.2,216ff; Nathan Sivin, *Traditional medicine in contemporary China*,70-80; A.C.Graham,*Yin-yang and the nature of correlative thought*; John S.Major, 'Substance,process,phase: *wuxing* 五行 in the *Huainanzi*' in Henry Rosemont(ed.)*Chinese texts and philosophical contents: essays dedicated to Angus C.Graham*(La Salle,Illinois:Open Court,1991),67-78

[67] Nathan Sivin,*Traditional medicine in contemporary China,*71

2.25.Li 理 :the principle and pattern of Nature[68]

The term *li* 理 originally meant 'veins in jade' or 'to dress jade'.[69] The *li* 理 of nature was the underlying pattern or unchanging principle of things,which Wing-tsit Chan calls 'the specific principle of what a thing should be'[70]. This was not merely an abstract pattern like a scientific law,but also partook of the nature of the *Dao*道 - an ethical as well as a physical ordering of the cosmos.

2.26 Gewu zhizhi 格物致知 'the extension of knowledge lies in the investigation of things'[71]

The term which nineteenth-century translators used for 'science' was *gezhi* 格致(or sometimes *gewu* 格物,although this seemed to be used increasingly just for 'physics'). The term *gezhi* 格致 comes from the Confucian text *Daxue* 大學 [Great learning] "the extension of knowledge lies in the investigation of things". This phrase was emphasised by the Song Neo-Confucian philosophers,but less in the sense of an empirical study,than of the spiritual contemplation of the Principle(*li* 理)of things.

Nineteenth-century translators had at least a ready-made term for 'science' even though *gezhi* 格致 had very little to do with empirical studies: at least they did not have to

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[68] See A.C.Graham,*Two Chinese philosophers: Ch'eng Ming-tao and Ch'eng Yi-ch'uan* (London:Lund Humphries,1958),8 and Wing-tsit Chan,*Neo-Confucian terms explained*(New York:Columbia University Press,1986),112-113.

[69] Graham,*Two Chinese philosophers*,8

[70] Wing-tsit Chan,*Neo-Confucian terms explained*,112-113

[71] See Lin Wenzhao 林文照,'"Gewu zhizhi" xueshuo jiqi dui Zhongguo gudai kexue fazhan de yingxiang' "格物致知"学说及其对中国古代科学发展的影响[The theory of the "extension of knowledge through the investigation of things" and its influence on the development of Chinese science] in *ZRKXYJ* 7,4(1988),305-310.

invent a new term. No-one starting to read a science text would have thought for long that it was a Confucian exercise in self-cultivation. The necessity for antiquity in terms and the supposed antipathy of the Chinese to linguistic novelties was one of the great obstacles to the transmission of science,to some degree it was a problem created by the foreign translators as much as by the Chinese themselves.

2.3 Science and the Macartney mission(1792-1794)[72]

The Macartney mission to China took with it a remarkable quantity of scientific equipment with which it was hoped the Chinese would be impressed,including even a full-scale planetarium. There were also more exalted aims of the transmission of knowledge: 'The great hope of commercial intercourse is to improve human knowledge,and to bring it to the greatest possible perfection.',as Sir George Staunton wrote.[73] Yet the extraordinary array of philosophical instruments did not as far as we can tell impress the Chinese,who saw them as baubles possessing no real novelty,nor of any significance beyond demonstrating the ingenuity of their makers.

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[72] The Chinese documents relevant to the mission are collected in *Zhanggu congbian* 掌故叢編[Historical documents],3rd collection(Beijing:Palace Museum,1928-30).

For secondary sources,see J.L.Cranmer-Byng(ed.)*An embassy to China: being the journal kept by Lord Macartney during his embassy to the Emperor Ch'ien-lung 1793-1794*.(London:Longmans,1967); J.L.Cranmer-Byng and T.H.Levere,'A case study in cultural collision:scientific apparatus in the Macartney Embassy to China,1793' in *AS* **38**(1981),503-525; Harriet T.Zurndorfer,'Comment la science et la technologie se vendaient à la Chine au XVIIIe siècle' in *Études Chinoises* 7,2(1988),59-90; and Alain Peyrefitte,*The collision of two civilisations:the British expedition to China in 1792-4* Alfred A.Knopf trans.(London:HarperCollins,1993).

[73] J.L.Cranmer-Byng and T.H.Levere,'A case-study in cultural collision',508

The mission was in any case hardly capable of doing more than show these objects,and was in the circumstances prevailing quite unable to transmit anything of significance about contemporary Western science to the Chinese. It seems only to have reinforced attitudes on both sides: the Europeans came away convinced of Chinese conceit and indifference to science; the Chinese of European arrogance and barbarity,and that the Westerners had nothing - material or intellectual - to offer the ruler or the peoples of the Celestial Empire.

2.4 Conclusion

The Chinese system of natural philosophy provided a flexible intellectual framework in which most phenomena would fit,and which could be adjusted to suit the changing emphases in the broader areas of Chinese philosophical thought. Its strong emphasis on the indissoluble connection between the physical and the ethical contrasted strongly with the more materialistic aspects of Western natural science in the nineteenth century,although as we shall see there were other currents of Western thought which were by no means completely inimical to concepts such as *qi* 氣 and *Dao* 道.

It may be seen that a thread running through the concepts of *qi* 氣 and *Dao* 道 is communication: *qi* 氣 was originally the cloudy medium through which the *di*帝 communicated with mortals,and the path of the *Dao* was speech. The cosmos was communicating with itself through the things,living and non-living,of which it was made. Language,the phenomenal world,and the underlying pattern were in some sense connected with one another,the sounds of the words we use,and the marks we trace on paper - the *wen* 文 or characters - were thus not merely ciphers but correlates of things beyond themselves,of the markings of heaven and earth,and of the human relations which form the social harmony of *li* 禮. Figure 2 above illustrates the interconnection with human relations,which are governed by *li* 禮. [74]

In this chapter we have seen how the basic concepts of traditional Chinese natural philosophy inter-relate,and how the Jesuit mission and the embassy of Lord Macartney failed to convince the Chinese that these concepts were seriously inadequate in any way. In the next chapter we move on to look at the Western ideas - and the technologies which employed them - ideas which seemed to leave no room for *li* 理,*qi* 氣 or *Dao* 道,and would eventually displace traditional Chinese natural philosophy completely(with the significant exception of the field of Chinese medicine).[75]

[74] *Li* 禮 was the harmony between one's behaviour and the social situation in which one found oneself,a harmony in which music played a vital role. See Fung Yu-lan,*A history of Chinese philosophy* Vol.1,337-341.

[75] I say 'seemed' because as I show in Chapter 12,there were some connections which were not entirely inimical to traditional Chinese philosophy.

Chapter 3: The Western chemical paradigm 1840-1900[76]

3.0 Introduction

In order to appreciate the problematics of the transmission of Western science,it is necessary to spend a little time examining the state of the Western chemical paradigm: the atomic theory,the system of chemical notation,and the use of dualistic formulae which can make chemical texts of this period seem puzzling or obscure even to a modern reader with a good chemical background.

3.1 Science and industry

> What Art was to the ancient world,Science is to the modern: the distinctive faculty. In the minds of men the useful has succeeded to the beautiful. Instead of the city of the Violet Crown,a Lancashire village has expanded into a mighty region of factories and warehouses. Yet,rightly understood,Manchester is as great a human exploit as Athens.[77]

And,having given Science its accolade,Benjamin Disraeli goes on to describe his hero Coningsby's excitement at his first sight of the new Athens:

> It was to him a new world,pregnant with new ideas,and suggestive of new trains of thought and feeling. In this unprecedented partnership between capital and science,working on a spot which Nature had indicated as the fitting theatre of their exploits,he beheld a great source of the wealth of nations which had been reserved for these times[...][78]

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[76] See Aaron Ihde,*The development of modern chemistry*(New York:Dover Publications,1984).

[77] Benjamin Disraeli,*Coningsby or the New Generation*(1844; reprinted London:Penguin Classics,1989),177

[78] *ibid.*,180

The Great Exhibition of 1851 was the concrete symbol of this 'unprecedented partnership',the unity of science,technology and manufacture[79]. For the first time in history,natural philosophy - which by this time had already divided into the fields of physics,geology,chemistry and so on - was able to interact directly with the work of the artisans and manufacturers to make machines and products which could not have existed before.

At a popular level,people became more aware of the nature of science through exhibitions,lectures and popular science journals which opened to the lay public the more dramatic outcomes of the work of the scientists.[80]

At the same time,science was developing as a social system,with its own societies,journals and academies. The universities were beginning to take the natural sciences seriously,as the first chairs in natural philosophy and chemistry were founded.

3.2 The science of chemistry

The great breakthrough in the late eighteenth century in understanding the nature of chemical combination and of the chemical elements meant that chemists were able to determine the nature of the substances they were using by

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[79] J.D.Bernal,*Science in history* 3rd ed. Vol.2 (1965; reprinted London:Pelican Books,1969),553; and J.A. Bennett *Science at the Great Exhibition*(Cambridge:Whipple Museum of the History of Science,1983).

[80] Richard D.Altick,*The shows of London*(Cambridge,Mass.:Harvard University Press,1978),363-374; Jan Golinski,*Science as public culture: chemistry and enlightenment in Britain,1760-1820*(Cambridge:Cambridge University Press,1990)and Larry Stewart,*The rise of public science: rhetoric,technology and natural philosophy in Newtonian Britain,1660-1750* (Cambridge:Cambridge University Press,1992).

exact,quantitative methods,and thus to comprehend the reactions they carried out in unprecedented detail. New industries,manufacturing old products in new ways,and synthesising new and unknown substances.[81] As the century progressed,even the immensely complex carbon skeletons of the organic substances began to be better understood. It became clear that there was no essential difference between 'organic' substances (such as urea) derived from living things,and 'inorganic' compounds (such as ammonium cyanate[82]) which could be made in a laboratory: the distinction between things which possessed 'vital energy' and those which did not,began to dissolve.[83]

3.21 The chemical elements and their compounds

The nature and existence of 'elements' had been disputed since the ancient Greeks first attempted to reduce the material world to a small number of 'elementary' substances from which all others derived. The Four Element theory of Empedocles(c.492-432 B.C.)was that all matter was made of Four 'Roots': Earth,Air,Fire and Water,and that actual substances were made of mixtures of the Four Roots[84]

This theory was adopted by Aristotle[85] and became the

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[81] Maurice Crosland,*In the shadow of Lavoisier: the Annales de chimie and the establishment of a new science*(London:British Society for the History of Science,1994),34-5.

[82] Friedrich Wöhler(1800-1882)showed the 'organic' substance urea to be identical with the 'mineral' substance ammonium cyanate in 1828. See Ihde,164-165.

[83] See Section 6.83.

[84] W.K.C.Guthrie,*A history of Greek philosophy* Vol.2(Cambridge:Cambridge University Press,1980),212

[85] See Aristotle,*Meteorologica* H.D.P.Lee trans. (London W.Heinemann,1952),7 on the nature of the elements,and *ibid.*,319 on the compounding of the elements to form substances like milk or blood. For the Greek theory of compounds,see Marius,*On the elements* Richard C.Dales trans.(Los Angeles: University of California Press,1976); H.H. Joachim,'Aristotle's conception of chemical combination' in *Journal of Philology* **29**(1904),72-86 and

orthodox view of chemical combination until the time of Paracelsus(1493-1541),who proposed salt,sulphur and mercury as the *tria prima*.[86]

In the seventeenth century the existence of these so-called 'elements' within the substances they were supposed to inhabit was being questioned[87],but during the late eighteenth century the work of Antoine Lavoisier on the true nature of combustion was for the first time to produce a reliable concept of a 'chemical element',a term which was

> to express our idea of the last point which analysis is capable of reaching[......][Thus we shall consider as elements] all the substances into which we are capable of,by any means,to reduce bodies by decomposition.[88]

By the 1840s about 60 chemical elements had been identified,and more were discovered as sensitive new analytical techniques such as spectroscopy were invented. It became accepted that all the millions of diverse *chemical compounds* are the result of the combination of two

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J.E.Bolzan,'Chemical combination according to Aristotle' in *Ambix* **23**,3(November 1976),134-144.

[86] See H.M.Leicester *The historical background of chemistry*(New York:John Wiley and Sons,1956),97-98.

[87] See Robert Boyle,*The sceptical chymist*(London: F.Crooke,1661):

> And indeed I scarcely know any one mineral from which by fire alone chymists are able to sever any substance simple enough to deserve the name element or principle(*ibid.*,65)

[88] Antoine Lavoisier,*Elements of chemistry in a new systematic order* Robert Kerr trans. (Edinburgh:William Creech,1790),xxiv

or more of these elements in well-defined proportions.[89]

As we have seen in Chapter 2,there was nothing equivalent to the concept of the unchanging irreducible chemical element in the Chinese system. All phenomena were viewed as evolutions of *qi* 氣,and chemical reactions - with which the Chinese alchemists were very familiar - showed that *qi* 氣 could take many different forms: inconstancy was part of its nature. Chemical *change* was perfectly familiar to the Chinese point of view: if anything,it was the idea of unchanging elements which might have proved problematic. In fact,there were very little argument over the new system of chemistry,probably because it was so very practical,and the chemical ideas could be shown to correspond with actual experience,as in the analysis of mineral ores and the extraction of metals.

3.22 Atoms

The theory of atoms also derives from the pre-Socratic philosophers Leucippus(fl.430 B.C. and Democritus(born c.460 B.C.),who used them to explain the immense variety of natural substances,but curiously also thought that there would be an infinite number of different types of atom.[90] They were the first to use the analogy of letters of the alphabet to explain how two types of atom could produce new substances by combining in different ways. (It seems likely that the use of an alphabetic script leads naturally to

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[89] This theory was not universally accepted. Hegel claimed that the elements were 'universal natural essences'; that water was not a combination of hydrogen and oxygen; and that air was not composed of nitrogen and oxygen as they were 'merely the forms in which the air is posited'. See *Hegel's* Philosophy of Nature M.J.Petry trans.(London:George Allen and Unwin,1970)34.46-47,187

[90] Simplicius,*Commentary on the* Physics *28.15-27*,quoted in Jonathan Barnes,*Early Greek philosophy*(London:Penguin Books,1987),249

speculations of this kind,and the possible connection between the complete absence of any kind of atomic theory in the Chinese cultural area,is suggestive.[91])

The atomic theory had a very long dormant period of some two thousand years,when it was rescued by the Newtonian chemists,who saw in the concept of hard,massy particles a way of restoring the unity of nature in the face of the apparent diversity of substances,regarding all matter as composed of particles essentially the same but with different degrees of porosity or compaction.[92]

This elegant,unitary picture was shattered by the theory of the chemical atom proposed by John Dalton(1766-1844),who was able for the first time to determine the relative masses of the atoms of some of the elements.[93] He assumed that the atoms of different chemical elements were actually quite <u>different</u> from one another,and he further postulated that his 'chemical' atoms would combine in the simplest possible proportions to make binary compounds such as water(HO),ammonia(NH),and so on. Although his latter hypothesis proved to be incorrect,the empirical techniques he pioneered opened up a completely new field of quantitative understanding of chemical combination. Arnold Thackray credits him with

> the establishment of valid rules of chemical combination and the realization of the utility of

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[91] See Section 5.311 for a brief account of the Chinese script; and Lucretius,*De rerum natura* W.H.D.Rouse trans.(Cambridge:Cambridge University Press,1975),175 and p.68 note a.

[92] Arnold Thackray,*Atoms and powers: an essay on Newtonian matter-theory and the development of chemistry*(Oxford:Oxford University Press,1970),23,25,69

[93] Ihde,101-111

relative particle weights.[94]

The Daltonian 'chemical' atom was by no means universally accepted by chemists and philosophers[95],and even towards the end of the century there were attempts to rescue the aesthetically more pleasing unitary scheme by positing vortex-atoms in the ether or even by denying the existence of 'chemical atoms' altogether.

The language of chemistry,with terms such as 'particle',atom' and 'molecule' used in different senses by different chemists proved to be a complex web of misunderstanding and a source of much argument and uncertainty.[96] Textbook writers of this period consequently avoided much discussion of the atomic theory,emphasising instead the safely empirical notion of *equivalents*.

3.23 Atomic weights and equivalent weights

The combining masses of the elements could be determined by a skilled experimenter,and their relative combining masses with respect to hydrogen or oxygen were called *equivalents*. However,to convert these combining masses into ratios of combining *atoms* required knowledge of their relative atomic masses,or,as chemists then called them,*atomic weights* or simply *atoms*. Unfortunately the determination of reliable atomic weights proved to be problem not fully resolved until after the Karlsruhe

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[94] Arnold Thackray,*John Dalton: critical assessments of his life and work*(Cambridge,Mass.:Harvard University Press,1972),62

[95] A.H.Brock (ed.)*The atomic debates: Brodie and the rejection of the atomic theory*(Leicester:Leicester University Press,1967).

[96] See My Gyung Kim,'The layers of chemical language,I: Constitution of bodies *v*. structure of matter' in *HS* **30**(1992),69-96 and My Gyung Kim,'The layers of chemical language,II: stabilizing atoms and molecules in the practice of organic chemistry' in *ibid.*,397-437.

Congress of 1860.[97] Dalton's assumptions of the simplicity of the combining ratios turned out to be seriously mistaken, and the whole question of true atomic weights led many eminent chemists to avoid the issue altogether, and to use instead the empirically determined *relative combining masses* or *equivalent weights*.[98] The great advantage of the latter was that, being empirically determined, they required little theoretical speculation about the existence or properties of invisible particles.

After the clarification of the 1860 Congress, atomic weights were increasingly widely used, but many chemists still regarded the atomic theory as unproven, and persisted with equivalents[99]. One result of this was that the

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[97] Ihde, Chapter 6 and 226-230.

[98] Ihde, 153-154.

[99] It must be observed that we are utterly ignorant of the nature, size, form, or actual weight of the atoms of elementary bodies, and of the mode in which they are grouped or arranged; all we know is their actual weight.

(Henry M. Noad, *Lectures on chemistry* (London: Simpkin, Marshall & Co., 1843)

Twenty-four years later, Charles Loudon Bloxam could still write

> In explaining chemical changes by equations, I have, as a general rule, emphasised symbols representing combining weights (or equivalents), and not the atoms [i.e. atomic weights], of the elements. Had the work been intended for advanced students, I should have hesitated to incur the reproach of obstinate conservatism, or of being behind the chemical spirit of the time, though even then, which of the more advanced systems was to be adopted would have been very formidable question, for at present the different modes of representing chemical changes are almost as numerous as chemical writers.

(Charles Loudon Bloxam, *Chemistry inorganic and organic, with experiments and a comparison of equivalent and molecular formulae* (London: John Churchill & Sons, 1867)

It was not only conservative British writers who felt happier with equivalents: as late as 1877, Berthelot (1827-1907) still preferred to use the equivalent system. (See Joshua C. Gregory, *A* majority of the chemistry texts translated in China before 1900 used the system of equivalents and equivalent formulae rather than the atomic weights and atomic formulae with which we are nowadays familiar.

Another remarkable feature of the chemistry textbooks which were translated into Chinese before 1900 is their *lack* of discussion of the atomic theory,and the relatively small attention that is given to theoretical questions. The structural atomic formulae which we are accustomed to see in our elementary texts are completely absent. This reflects what one writer has called the 'astounding infertility' of the atomic hypothesis in chemistry before the 1860s.[100]

3.24 Berzelius and the dualistic theory of compounds

The success of electrolysis in decomposing compounds,and in making new elements led naturally to the idea that the attraction between positive and negative electricity held the key to the nature of chemical affinity,and Jakob Berzelius(1779-1848) proposed that all chemical combination was electrical in nature. Compounds consisted of positive and negative components,metal oxides being electropositive,and non-metal oxides electronegative.[101] The reaction of copper oxide and sulphuric acid to make copper sulphate could therefore be explained as

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short history of atomism(London: A.& C.Black,1931),93 and Mary Jo Nye,'Berthelot's anti-atomism - a matter of taste?' in *AS* **38**(1981),585-590)

[100] David M.Knight,*Atoms and elements: a study of theories of matter in England in the nineteenth century*(London:Hutchinson,1967),25

[101] Ihde,132-133

$$\overset{+}{CuO} \quad + \quad \overset{-}{SO_3}\text{[102]} \quad \text{-------->} \quad CuO.SO_3$$

Thus in the Berzelian system the formulae of all salts were given as if they were combinations of oxides(a practice until recently followed by mineralogists,and still used when giving the percentage of potash in fertilisers). This system was followed by John Fryer in giving the formulae of salts in the Jiangnan Arsenal chemistry texts,and by Anatole Billequin in *Huaxue zhinan* 化學指南(1873) and *Huaxue shanyuan* 化學闡原(1882).[103]

3.25 Symbols of the equivalent weights of the elements

The pictograms which Dalton invented were not popular with other chemists,and in 1813 Jakob Berzelius invented a system of representing the combining masses of the elements by means of *letters*.[104] This was then developed,with first superscripts[105] and then later subscripts being used to indicate the 'equivalent numbers' when for instance one equivalent of sulphur combined with three equivalents of oxygen,it was written SO^3. Berzelius attempted to 'simplify' his system by using small circles above the element to indicate oxygen. Thus the above oxide could also be written

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[102] The convention of the time was to write the anhydrous oxide as the symbol for the acid.

[103] See Chapter 7.

[104] The idea of symbolising the *elements* using letters was not new,having been proposed by Hassenfratz and Adet as part of Lavoisier's reform of nomenclature. (See Maurice P.Crosland,*Historical studies in the language of chemistry*(New York:Dover Publications,1978),245ff.) The novelty of Berzelius' proposal was the use of letters to stand for *equivalent weights*. (See Jakob Berzelius,'Experiments on the nature of azote,of hydrogen and of ammonia' in *Annals of Philosophy* **2**(1813),359-360 and 'On the cause of chemical proportion' in *Annals of Philosophy* **3**(1814),51.)

[105] Berzelius initially placed the superscript directly above the symbol,but it was later moved slightly to the right,in the same manner as the power notation used in mathematics.

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S .

This was the method adopted for the nomenclature of oxides by Anatole Billequin in *Huaxue zhinan* 化學指南 (1873) and *Huaxue shanyuan* 化學闡原(1882) .

3.26 Acids,bases and salts

Antoine Lavoisier had assumed that all acids contained oxygen(hence the German term for oxygen *Sauerstoff*,which is still in use today[106]),but by the mid-nineteenth century this theory had been abandoned. The term 'acid' was still applied rather differently to the modern usage. The anhydrous oxide was usually used to represent the acid,and so 'sulphuric acid' was represented as SO^3 and 'nitric acid' as NO^5

As Berzelius' ideas were gradually abandoned,the dualistic system was replaced by the 'modern' or unitary notation,but like the system of equivalents the dualistic notation survived for many decades after it had outlived its apparent usefulness. Of the early translators in China,only John Kerr used the unitary system,and his book *Huaxue chujie* was less influential than the Jiangnan Arsenal and Beijing Tongwenguan texts.

3.27 The periodic classification of the elements

The greatest achievement in theoretical inorganic chemistry was undoubtedly the periodic classification of the elements discovered by Dmitri Mendeleev(1834-1907),and first published in 1869[107]. He was able to make

[106] The English word 'oxygen' is also derived from the Greek for 'acid-former'.

[107] Ihde,243-249

predictions about the properties of unknown elements which were strikingly confirmed by the discoveries of gallium,scandium and germanium in 1875,1879 and 1886 respectively,yet its earliest mention in China seems to have been in *Yaquan Zazhi* 亞泉雜志[Yaquan journal] in 1900.

3.28 Organic chemistry

During the late nineteenth century it was in organic chemistry that the greatest strides were made. The early confusion caused by trying to apply the Berzelian dualistic theory to carbon chemistry was over,and after the Karlsruhe Congress in 1860,it became possible to determine molecular formulae with some confidence,and the problems of the structures of the carbon skeletons of the molecules such as benzene became soluble.

The organic chemists also developed a wide range of synthetic methods,which led to the first artificial dyes such as the mauve discovered by William Perkin(1838-1907)in 1856. A greater understanding of the structures of the compounds involved led to the synthesis of dyes such as alizarin [108],and synthetic pharmaceuticals such as aspirin.

3.3 Conclusion

The translation of 'Western science' to China was an immense undertaking. It involved the delivery of actual examples of working technology,the translation of textbooks,the creation of intelligent appreciation of science through journals and science classes,and the nurturing of talented scientists through an education system which took science seriously. In 1840,none of these conditions prevailed,yet as the following chapters will show,by 1900 the situation had changed utterly.

The assimilation of Western technology into the coastal areas of China during the late nineteenth century

[108] Ihde,456

stimulated interest in science,even though the concern was often vague and unfocussed. The interest discovered by Young J.Allen and John Fryer was sufficient to encourage them in their efforts to translate articles and textbooks on science to give access to those Chinese(the vast majority) who knew no Western languages.

Far from being a single,majestic stream,science often appeared as a confusion of different currents,with some of its most fundamental concepts,such as existence of atoms,the stability of species,and the nature of the ether,being held in question. It was the nature of textbook science to avoid difficult issues,and to present science as an accumulation of certainties,within a process of steadily increasing 'useful knowledge',yet the rapid changes meant an increasing tension between the building of libraries of translated works(with consistent terminologies and theoretical frameworks) and the need to keep up with new discoveries and theories.

There was also the problem of nomenclature - reflecting the theoretical background to science - which could cause students great difficulties if it were constantly revised. There was the risk of confusion and archaism in the Western terms being imported into China as 'scientific confectionery': translators often faced serious problems in knowing *which* nomenclature to present to their Chinese readers.[109]

Science was admitted to China very late in the nineteenth century: only when all technology-based attempts to strengthen the dynasty by imitating Western weapons had failed was the basis of that technology given the importance it deserved,and it is to how this transmission

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[109] G.Schlegel,'Scientific confectionery' in *T'oung Pao* **5**(1894),147-151.

was effected we now turn.

Chapter 4. The transmission of Western science into China 1840-1900[110]

4.0 Introduction

The Chinese had always regarded themselves as living at the centre of the world, *tianxia* 天下, 'all under heaven'. The countries surrounding the Middle Kingdom were suppliers of tribute and of exotic products - even, exceptionally, new

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[110] The Self-Strengthening movement and its activities have been studied by many scholars in China, Japan and the West. Although a number of interesting questions remain, I do not propose here to do more than sketch an outline of the political background to the influx of Western science from the 1840s onwards, and am therefore relying heavily on secondary sources.

Secondary works I have consulted include: Joseph R.Levenson, '"History" and "Value": the tensions of intellectual choice in modern China' in Arthur F.Wright(ed.)*Studies in Chinese thought*(Chicago:University of Chicago,1953),146-194; John K.Fairbank,*The influence of modern Western science and technology on Japan and China*(Rome:X Congresso Internazionale di Scienze Storiche,1955),241-269; Mary C.Wright,*The last stand of Chinese conservatism: the T'ung-chih Restoration 1862-1874*(Stanford:Stanford University Press,1957;reprinted Atheneum,1967); *Yangwu yundong* 洋務運動[The 'Foreign Matters' Movement] Vols.1-8(Shanghai:Shanghai renmin chubanshe 上海人民出版社,1960-1); Immanuel Hsü,*China's entrance into the family of nations: the diplomatic phase 1858-1880*(Cambridge,Mass.:Harvard University Press,1960); Thomas L.Kennedy,'Self-strengthening: an analysis based on some recent writings' in *CSWT* 3,1(November 1974),3-35; K.H.Kim,*Japanese perspectives on China's early modernization: the Self-Strengthening Movement 1860-1895 . A bibliographical survey* (Ann Arbor:Center for Chinese Studies,University of Michigan,1974); Immanuel Hsü,*The rise of modern China*(New York:Oxford University Press,1975); Ye Xiaoqing,叶晓青 'Jindai Xifang keji de yinjin ji qi yingxiang' 近代西方科技的引进及其影响[The introduction of modern Western science and its influence]in Zhang Mingjiu 章鳴九(ed.)*Yangwu yundong shi lunwen ji* 洋物运动史论文集[A collection of essays on the history of the 'Foreign Matters' Movement](Beijing: Renmin chubanshe 人民出版社,1985),354-377; John K.Fairbank,*The great Chinese revolution*(London:Chatto and Windus,1987); and Kuo Ting-yee and Liu Kwang-ching 'Self-strengthening: the pursuit of Western technology' in D.C.Twitchett and J.K.Fairbank(eds.)*CHC* Vol.10 Late Ch'ing 1800-1911(Cambridge:Cambridge University Press,1978),491-542.

religions - but the moral centre of the universe was always China. Mencius is supposed to have said,'I have heard of the Chinese converting barbarians to their ways,but not of their being converted to barbarian ways.'[111] The Chinese world had always regarded itself as morally and intellectually self-sufficient,teacher rather than taught. The aim of this chapter is to describe the political struggles which led to the gradual introduction of Western science into China,a 'learning from barbarians' for which the only real model was the influx of Buddhism nearly two millennia earlier,and which was in its technical aspects completely unprecedented.

4.1 The precedent of the transmission of Buddhism

Buddhism came to China via Central Asia during the first century A.D.,meeting a hostile reception both from the Confucians,who regarded its emphasis on celibacy as unfilial,and from the native religion of Daoism with which it had certain philosophical characteristics in common and therefore contested similar religious space[112]. Despite the coming of Buddhism, China remained a civilisation apart,regarding the rest of the world as barbaric,and as having little to teach it in respect of what we would now call science and technology,and still less in the spheres of morality and civil culture.

4.2 The desire for Western military technology

The men who eventually decided that Western science <u>had</u> to be studied were upright Confucian scholars,who would never have seen themselves as 'Westernisers': they were attempting to save the dynasty by devotion to their duty as

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[111] *Mencius* D.C.Lau trans.(London:Penguin Books,1970; reprinted 1976),103.

[112] See Arthur F.Wright,*Buddhism in Chinese history* (Stanford:Stanford University Press,1959) and E.Zürcher,*The Buddhist conquest of China*(Leiden:E.J.Brill,1972).

officials of the Emperor[113]. Yet in doing so they were also admitting that China could not ignore the technologies of the Westerners,and - finally - that only Westerners could teach them how to resist the West.

It was the *military technologies* of the West which the Chinese wanted: the scientific principles on which the technologies were grounded were at first hardly discussed by the officials who promoted 'Self-Strengthening'. Only gradually did students of the technologies come to realise the significance of the immense gap which separated the Chinese paradigms from those of modern Western science,and that radical changes in the institutions of the education system were needed for China to become technologically self-reliant.

We shall now examine some of the internal factors which made the translation of science into China possible.

4.3 The kaozheng movement in Jiangnan[114]

A tradition of imperial bureaucracy which never entirely divorced itself from the world of technology,and the late Qing *kaozheng* 考證 [evidential research] movement were both important factors in the translation of Western science to China.[115] The *kaozheng* tradition was particularly a feature of the Jiangnan 江南(Lower Yangzi valley) region of South China,where a network of academies had built up scholarly communities,which were centred on

[113] Mary Wright,*The last stand of Chinese conservatism*,45

[114] See Chapter 9 on the Chinese scientists working in the *kaozheng* tradition.

[115] I am heavily indebted to the work of Benjamin Elman,*From philosophy to philology: intellectual and social aspects of change in late imperial China*(Cambridge,Mass.:Harvard University Press,1984) for many of the remarks in this section.

libraries[116]. The Jiangnan scholars shared certain methods and emphases,such as the keeping of notation books[117],the collection of numerical data[118],the precise citation of sources[119],the accurate reconstruction of the past[120] - in all,*the systematic accumulation of objective knowledge*. They thus shared many characteristics with the scientific communities which had formed in the West.[121] The study of phonology and etymology also gave the *kaozheng* scholars insights into the best way of forming new technical terms from a language which some foreigners claimed was utterly unsuited to the expression of scientific exactitude. The *kaozheng* emphasis was on the restoration of the purity of diction of the past - what Michel Foucault calls,in the context of pre-Classical European history, 'the [restoration] to language [of] all the words that had been buried' and '[pronouncing] afresh so many words that had been muffled'[122]. Such studies also encouraged research for instance into mathematical acoustics - one of the key sciences of ancient China - at a time when the first translations of Western texts on sound were becoming

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116 *ibid.*,143ff

117 *ibid.*,174ff

118 *ibid.*,180ff

119 *ibid.*,184ff

120 *ibid.*,182ff

121 Yet another characteristic may have been a certain openness of mind,which regarded some change as inevitable and did not see the present as always more degraded than the past. See for instance Wei Yuan's remarks in *Wei Yuan ji* 魏源集[A collection of the writings of Wei Yuan](Beijing:Zhonghua shuju 中華書局,1976),47-48,quoted in Jacques Gernet,'Space and time: the encounter between China and Europe' in *CS* **11**(1993-94),93-102 p.101.

122 Michel Foucault,*The order of things: an archaeology of the human sciences*(London:Routledge,1989),131

available.[123]

4.4 The periodization of the transmission of Western science into China from 1840 to 1900

I propose the following scheme:

(i)1840-1860 This was the period of the first imitation of Western ships and guns; of the earliest Protestant missionary attempts to explain Western science; and of experiments by Chinese scientists based upon their readings of the early missionary texts. The leading Chinese figures of this period were,in the 1840s Lin Zexu 林則徐(1785-1850),Ding Gongzhen 丁拱振 (c.1800-c.1875) and Gong Zhenlin 龔振麟; in the 1850s Li Shanlan,Xu Shou and Hua Hengfang; the foreign agents of transmission principally Alexander Wylie[Weilieyali 偉烈亞力] (1815-1887),Alexander Williamson[Weilianchen 韋廉臣] (1829-1890),and Daniel Jerome Macgowan[Maogaowen 瑪高溫](1814-1893).

(ii)1861-1875 During this period there was the founding of the first modern Chinese arsenals; the establishment of Chinese government schools(*Tongwenguan* 同文館)[124] teaching foreign languages and Western science; and the founding of an official translation bureau for scientific books at the Jiangnan Arsenal. During this period the leading Chinese figures in the transmission were Zeng Guofan,Prince Gong(1833-98),Zuo Zongtang 左宗棠 (1812-1885),Li Hongzhang,Li Shanlan,Xu Shou and Hua Hengfang; the chief foreign agents missionaries or ex-

[123] See my article 'Careers in Western science in nineteenth-century China' in *JRAS* 5,1(April 1995),49-90.

[124] The term *Tongwenguan* comes from the phrase *tongwen tongzhong* 同文同種 [of one language and one race],which implied the equality of all the Emperor's subjects.

missionary educators such as John Fryer,Carl T.Kreyer[Jinkaili 金楷理],W.A.P.Martin [Dingweiliang 丁韙良](1827-1916) and Calvin Mateer.

(iii)1876-1893 This period was marked by attempts at popularising science through popular science articles in journals and the founding of the Shanghai Polytechnic; and by the development of Western-style factories,ironworks and shipyards. The leading figures were Li Hongzhang,Xu Shou,Xu Jianyin and Zhang Zhidong; key foreigners were Young J.Allen[Linyuezhi 林樂知](1836-1907),Anatole Billequin[Biligan 畢利幹](1837-1894) and,again,John Fryer,Calvin Mateer and W.A.P.Martin.

(iv)1894-1900 Following the Sino-Japanese War,there was increasing interest amongst reformist intellectuals in the practical,political and philosophical aspects of Western science,together with the formation of many scholarly societies and journals with scientific connections. The leading intellectual figures were Kang Youwei,Liang Qichao,Tan Sitong; Zhang Zhidong led the Self-Strengthening movement after the disgrace of Li Hongzhang; and John Fryer taught at the Shanghai Polytechnic in its brief heyday before finally leaving China in 1896.

4.41 The period 1840-1860.

The First Opium War(1839-1842) stimulated an interest in the deadly effectiveness of Western technology,as Lin Zexu and his supporters attempted to imitate the ships and guns of the Westerners. Lin's disgrace after 1840 discouraged those who would have liked to continue his work,and although the geographies of Wei Yuan 魏源(1794-

1856)[125] and Xu Jiyu 徐繼畬 (1795-1873)[126] at first allowed a more informed debate on the technology of the West,by the late 1840s an increasingly conservative atmosphere tended to discourage further experimentation with foreign methods.[127]

From 1850 the dynasty was increasingly preoccupied by the Taiping Rebellion,whilst with the Second Opium War(1856-1860) and the advance of Russia on the Empire's northern and north-western borders [128],China moved into a period of increasing humiliation by foreign powers.

<u>4.411 The early geographies</u>

It was the coming of steamships and accurate guns that made the Chinese decide that the Western techniques could no longer be ignored. Yet when they began to study these matters,they realised how little they knew about the countries whose armed forces they were resisting. During the 1840s there were several important attempts were made to bring geographical knowledge up-to-date,but these geographies were not solely or even mainly about the West,regarded as but one ocean region (*Daxiyang* 大西洋(Great Western Ocean)) amongst others: they principally revived an older Chinese interest in the *Nanyang* 南洋 (Southern Ocean) region,what we should now call South-East Asia and

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[125] Hummel,850-2.

[126] Hummel,309-310. Xu was for a short time one of the officials in change of the Beijing Tongwenguan. See Su Jing,蘇精,*Qingji Tongwenguan ji qi shi-sheng* 清季同文館及其師生 [The Qing dynasty Tongwenguans,their teachers and their students](Taibei:Su Jing 蘇精,1985),21.

[127] Immanuel Hsü,*The rise of modern China*,249-259

[128] *ibid.*,271-274

its adjacent sea areas[129]. The Great Western Ocean was far away and,at that time,of only limited significance from a Chinese perspective. The Westerners only deserved attention because of their activities within the *Nanyang*,incursions which had already caused the Empire serious embarrassment,but which did not yet,like the Taiping rebellion,threaten its disintegration.

The most notable attempts to describe the lands from which the foreigners came were the geographies written or compiled by Lin Zexu[130],Wei Yuan and Xu Jiyu[131]. Commissioner Lin compiled his *Sizhouzhi* 四洲志 [Account of the Four Continents](1841) during his time at Guangzhou,and many excerpts from it were included by Wei Yuan in his *Haiguo tuzhi* 海國圖志 [Illustrated gazetteer of the maritime countries](1844-1852). Xu Jiyu's *Yinghuan zhilüe* 瀛環志略 [Brief account of the maritime circuit] (1848)included more accurate maps but very little on foreign technology.

Haiguo tuzhi included several chapters on Western ships and guns. In the second *juan*,a passage ascribed by Gideon Chen to Lin Zexu runs:

> Let us now in this time of peace adopt the superior skill of the barbarians in order to control them with greater effect,as we would before have employed

[129] According to Jane Kate Leonard in *Wei Yüan and China's rediscovery of the maritime world*(Cambridge,Mass.:Harvard University Press,1984)the Manchus regarded the coasts as 'harbouring pirates and rebels' rather than as frontiers,as their main concerns had been land incursions from the north and west(See *ibid.*,1).

[130] Hummel,514

[131] See Fred W.Drake,*China charts the world: Hsü Chi-yü and his geography of 1848* (Cambridge,Mass.:East Asian Research Center,Harvard,1975) and Fred W.Drake,'Protestant geography in China: E.C.Bridgman's portrayal of the West' in Suzanne Wilson Barnett and John King Fairbank(eds.)*Christianity in China* (Cambridge,Mass.:Committee on American-East Asian Relations of the Department of History,Harvard,1985),89-106.

> barbarians to fight against barbarians. The barbarians are superior in three ways: firstly,warships; secondly,firearms; and thirdly, methods of military training and discipline of soldiers[132]

We now turn to the steamships,which were such a formidably effective part of the Westerners' force of aggression.

4.412 Early attempts at imitating foreign ships [133]

The Chinese were far from novices at shipbuilding, indeed,as Joseph Needham has pointed out,they had long experience of constructing ocean-going ships which had many features which the Western ships only developed in the nineteenth century,including hulls with almost flat bottoms - ideal for going close to shore - ,hulls protected by metal or leather,and watertight compartments.[134]

Lin Zexu,as Imperial Commissioner at Guangzhou during the First Opium War,had good reason to know the power of the foreign vessels,and was at the forefront of attempts to build Chinese ships to match them. He had schooners built on Western models in 1840[135],and in 1841 a wheeled paddle-ship was constructed.[136] Deng Tingzhen 鄧廷楨 (1776-

[132] Gideon Chen,*Lin Tse-hsü: pioneer promoter of the adoption of Western means of maritime defense in China*(Beiping:Department of Economics,Yanjing University,1934),4-5

[133] See Gideon Chen,*Lin Tse-hsü*; Gideon Chen,*Tseng Kuo-fan: pioneer promoter of the steamship in China*(Beiping:Department of Economics,Yanjing University,1935);Gideon Chen,*Tso Tsung-t'ang: pioneer promoter of the modern dockyard and the woollen mill in China*(Beiping:Department of Economics,Yanjing University,1938)

[134] *SCC* Vol.4 Part 3,695-696

[135] Gideon Chen,*Lin Tse-hsü*,19

[136] *ibid.*,21.

1846)[137] set up a shipyard at Amoy during the First Opium War where the British forces discovered 'a good-sized frigate junk,of about three hundred tons,in course of building,in a regular dry dock something after the European model'[138] It was due mainly to the skill of an extraordinary engineer,Gong Zhenlin [139] magistrate of Jiaxing 嘉興,who according to Gideon Chen was 'transferred to Ningbo to assist in military affairs at the camp in the summer of 1840' [140] that paddle-wheeled craft powered by manpower were constructed.

Even more remarkably,Ding Gongzhen [141] author of *Yanpao tushuo* 演圖說[An illustrated description of gunnery] 礮 (1843) built a small steamship[142] twenty years before the much better-known attempts of Xu Shou and Hua Hengfang led to what is usually described as the first all-Chinese steam-powered vessel at the Anqing Arsenal of Zeng Guofan.[143] Pan Shicheng 潘仕成 also built steamships,using

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[137] Hummel,716-7.

[138] Chen,*Lin Tse-hsü*,32

[139] *ibid.*,34

[140] Chen,*Lin Tse-hsü*,14-15 and *Haiguo tuzhi* 18.1a

[141] Ding's distant ancestors were Arabs who arrived during the Yuan dynasty,and his family were Hui Muslims. In his youth,Ding travelled in South-East Asia and the Middle East as a merchant,and it would seem that this is when he obtained his knowledge of ships. See Joseph Needham,*SCC* Vol.5 Part 7,364; Li Bin 李斌 ,'Zhongguo gudai wenxian zhong de tandaoxue wenti' 中国古代文献中的弹道学问题(Problems of ballistics in ancient Chinese literature) in *ZRBZFTX* **16**,3(1994),56-57; and Li Chongzhou 李崇州,'Zhongguo zhigan huojian xitong yanjiu' 中国直杆火箭系统研究 [Research on Chinese centre-stick-mounted rocket systems] in *ZRKXSYJ* **13**,2(1994),164-172.

[142] Gideon Chen,*Lin Tse-hsü*,46. See the brief account by Yishan 奕山(d.1878) in *Haiguo tuzhi* 89.12a. Yishan was disgraced after the Treaty of Nanjing.See Hummel,391-3.

[143] See Chapter 9.

American ships as models.[144]

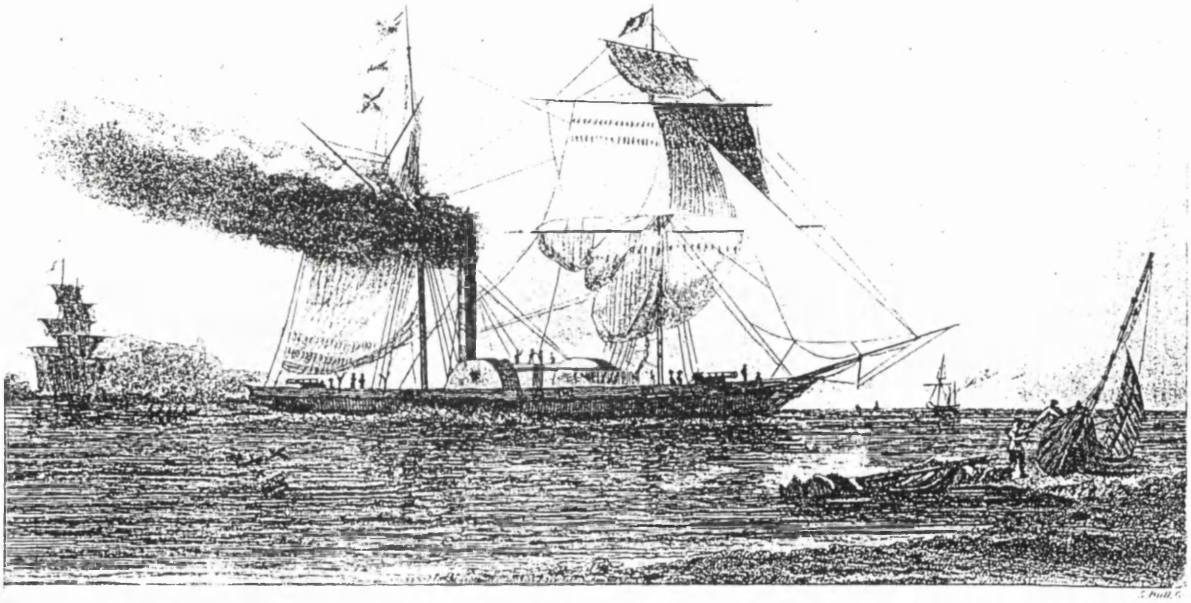

Figure 3. The steamship *Nemesis*, from William H.Hall and W.D.Bernard, *Narrative of the voyages and services of the "Nemesis" from 1840 to 1843*, frontispiece. [Reproduced by kind permission of the Syndics of Cambridge University Library]

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[144] See Chen, *Lin Tse-hsü*, 36-37 and the memorial by Yishan and others in *Haiguo tuzhi* 84.5a-8b and 18b-19a and 24a-25a, and Zheng Fuguang 鄭復光, 'Huolunchuan tushuo' 火輪船圖説 [An illustrated account of steamships] in *ibid.*, 85.1a-14b; and articles by 'a Westerner', 'Huolunzhouche tushuo' 火輪舟車圖説 [An illustrated account of steamships] *ibid.*, 85.10a-11b and 'Huolunchuan shuo' 火輪船説 *ibid.*, 85.12a-14b

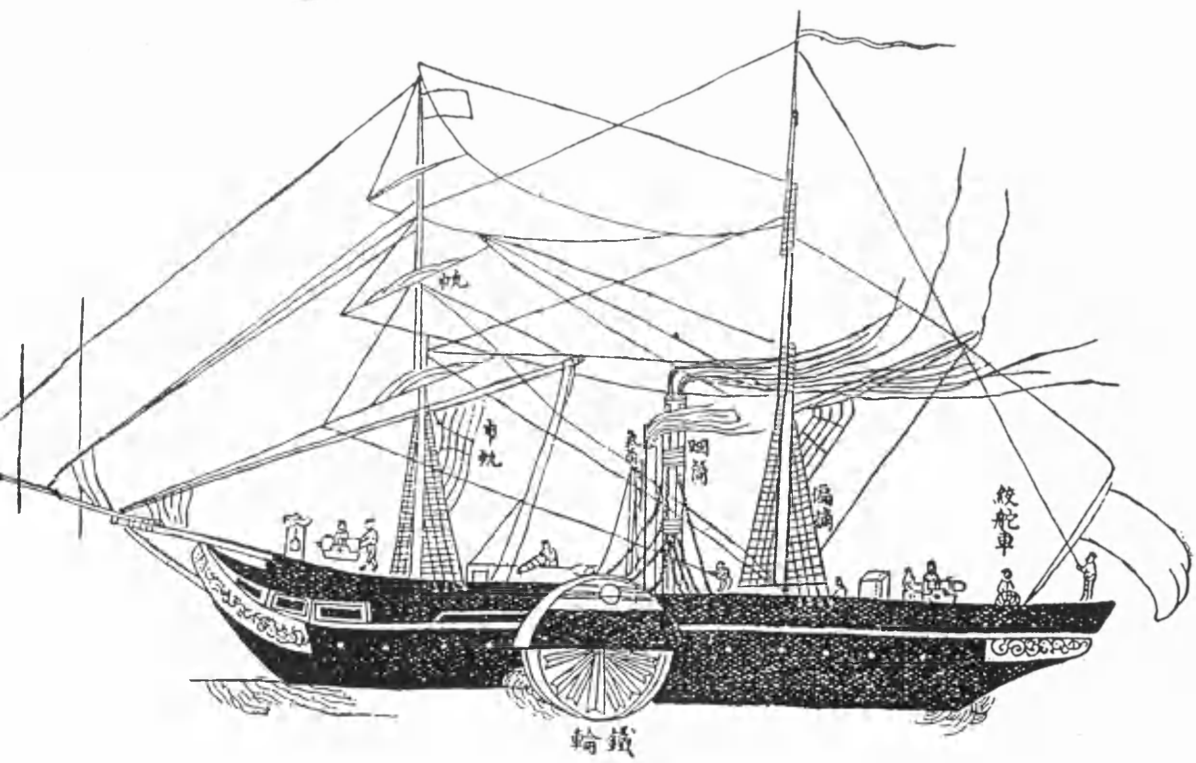

Figure 4. A drawing of a steamship by Ding Gongzhen in *Yanpao tushuo* [From Gideon Chen, *Lin Tse-hsü*, 48]

4.413 Pre-1860 guns, mines and explosives

The extraordinary accuracy of the foreign guns was what so impressed the Chinese: Lin Zexu bought about two hundred pieces to defend Guangzhou[145], and directed attempts to imitate them.[146] In the section of *Haiguo tuzhi* by Ding Gongzhen [147] entitled *Xiyang yongpao celiangshuo* 西洋用礮測量說[On the setting of Western guns],he shows a detailed understanding of the corrections need to make the guns fire accurately,the sliding gun carriage(*huache* 滑車)[148],the angled gun emplacement[149],and also how to make gunpowder for them.[150]

Gong Zhenlin also invented an iron cast for gun-making,although this was actually a re-invention of a technique known two thousand years earlier by the Han Dynasty ironsmiths.[151] Experiments were also made on

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145 Chen,*Lin Tse-hsü*,11

146 *ibid.*,15-17

147 He seems later to have director of an arsenal in Fujian.(ibid.,42). See for instance Ding Gongzhen,'Zhu zao yangpao tushuo' 鑄造洋礮圖說 [An illustrated description of the casting of guns]in *Haiguo tuzhi* 86.15a-19b.

148 Ding Gongzhen,'Da pao xuyong huache jiaojia tushuo' 大須用滑車絞架圖說 An illustrated account of why large guns need sliding carriages and cradles] in *Haiguo tuzhi* 87.18a-27b; and Ding Gongzhen,'Yong pao celiangfa' 用礮測量法 *Haiguo tuzhi* 89.1a-14a,especially p.13a

149 Ding Gongzhen,'Xiyang dihou quzhe paotai tushuo' 西洋低後曲折礮臺圖說 [An illustrated account of the Western low-backed curved gun-mounting] in *Haiguo tuzhi* 90.1a-6b

150 See the memorial by Yishan in *Haiguo tuzhi* 89.12a-14a

151 *ibid.*,43 and Gong Zhenlin,'Zhu pao tiemo tushuo' 鑄礮鐵模圖說[An illustrated account of the iron mould for casting guns] in *Haiguo tuzhi* 86.1a-14b. Gong's invention is mentioned on p.2b. See also Joseph Needham,*SCC* Vol.5 Part 7,411-412 on the ancient Chinese antecedents of Gong's technique.

land-mines[*dilei* 地雷][152] and submarine mines[*shuilei*水雷].[153] *Haiguo tuzhi* also contains fairly detailed accounts of Western metallurgical techniques,including the use of acid[*qiangshui* 強水][154] to make silver fulminate-based explosives.[155]

4.414 The Taiping Rebellion

With the beginning of the immense upheaval that was to become the greatest peasant uprising in history,the court was involved in ensuring its survival,and the acquisition of Western technology yielded priority to apparently more pressing issues. The Taiping rebels showed themselves to be surprisingly adept at obtaining and using Western technology,particularly in the matter of steamships[156],and this played a part in their rapid progress in the early years of the rebellion. As they moved through Hunan,their use of the lakes and rivers in the area put the imperial

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[152] See Huang Mian 黃冕,'Dilei tushuo' 地雷圖說 [An illustrated account of land-mines] in *Haiguo tuzhi*,90.14a-18b and Ding Shoucun 丁守存,'Ji fu yong dilei fa' 計覆用地雷法 [Using land-mines] in *Haiguo tuzhi*,90.19a-21a.

[153] See Pan Shicheng,'Gong chuan shuilei tushuo' 攻船水雷圖說[An illustrated account of the use of submarine mines for attacking ships] in *Haiguo tuzhi*,92.1a-17a,and Yishan's mention of his work in *ibid.*,89.13b. Note that *shuilei* can refer to submarine mines or,later,to torpedoes,the latter being known unambiguously as *yulei* 魚雷.

[154] *ibid.*,91.2a

[155] Ding Gongzhen,'Xiyang zhi huoyao fa' 西洋製火藥法 [Methods of making Western gunpowder] in *ibid.*,91.11b-13a; Ding Gongzhen,'Xiren zhiyao yongyao fa' 西人製藥用藥法[The methods the Westerners employ to make and use gunpowder] *ibid.*91.13a-15a;

[156] Hong Ren'gan 洪仁玕 (1822-64)was a relative of the Taiping leader Hong Xiuquan 洪秀全 (1814-64),and worked with James Legge(1815-97)in Hongkong,where he learned about Western technology. In 1856 he became Prime Minister of the Taiping Kingdom. Hong Ren'gan proposed the building of railways and steamships. See Teng and Fairbank,*China's response to the West*,56-9.

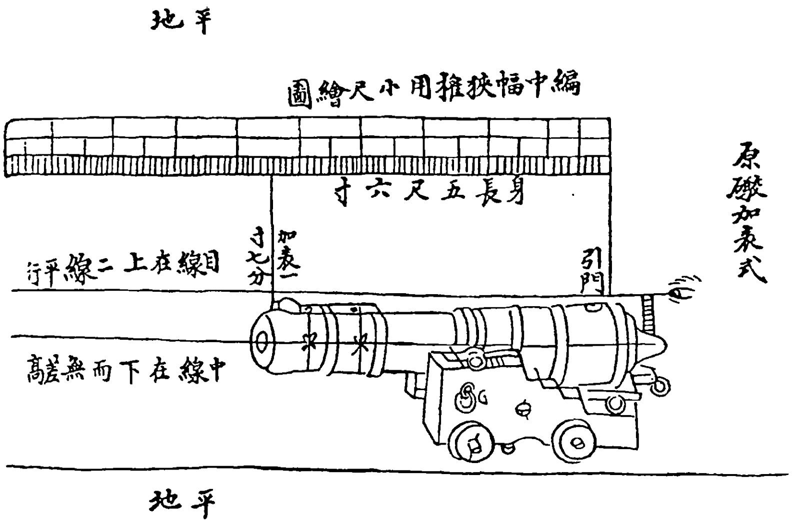

Figure 5. Ding Gongzhen's drawing of a foreign gun showing the use of a sight(from Gideon Chen,*Lin Tse-hsü*,41)

troops at a serious disadvantage as the latter possessed no naval forces in the province.[157]

Zeng set up shipyards at Hengzhou 衡州 and Xiangtan 湘潭 [158],but the early attempts at manufacturing were somewhat unsuccessful,even though he employed the son of Gong Zhenlin to cast guns,[159]and he was forced to purchase a number of foreign firearms. The Taiping rebels were becoming very successful at fending off attacks,and in 1854 Zeng attempted to drown himself after defeats at Yuezhou 岳州 and Jinggang 靖港 [160],but gradually events turned in his favour,and during the latter stages of the rebellion he was able to set up more ambitious ventures at Anqing,Nanjing and Shanghai.

4.415 Early missionary journals and science textbooks

The Chinese journals even of the earliest Protestant missionaries show some attempts to impart knowledge of Western science. William Milne(1785-1822) published a journal in Malacca *Chashisu Meiyue Tongjizhuan* 察世俗每月統紀傳[A general monthly record,containing an investigation of the opinions and practices of society],which by 1819 was selling 1,000 copies per month in Siam,Cochin-China and part of China itself.[161]

Tianxia Xinwen 天下新聞[News of the World] edited by

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[157] Chen,*Tseng Kuo-fan*,14

[158] *ibid.*,15

[159] *ibid.*,18

[160] *ibid.*,17

[161] Roswell S.Britton *The Chinese periodical press 1800-1912*(Shanghai: Kelly & Walsh,1933),18-19.See also 'Life and labours of the late Rev. William Milne D.D. in *CRP* **1**,8(December 1832),316-325.

Samuel Kidd in Malacca 1828-1829 also included some science[162]. The Pomeranian missionary Karl Gützlaff(1803-51) published his *Dong-Xi Yangkao* 東西洋考[The Chinese Magazine] from 1833,first in Java and then Siam,but it was suspended after five issues[163],being restarted in 1837-38 in Singapore under the auspices of the Society for the Diffusion of Useful Knowledge in China which had been founded in 1834.

After the First Opium War,the Treaty of Nanjing(1842)opened the 'treaty ports'(Guangzhou,Xiamen 厦門 (Amoy),Fuzhou 福州,Ningbo 寧波 and Shanghai)[164] to foreigners,and it became possible for missionaries to work in some areas of the mainland of China,and thus during the 1850s the focus of missionary activity in the transmission of science shifted to Shanghai and Ningbo.

The earliest modern science textbook in China seems to have been *Bowu tongshu* 博物通書 published in Ningbo by Daniel Jerome Macgowan in 1851. From 1854 Macgowan also published a journal,*Zhong-Wai Xinbao* 中外新報[News from China and abroad] in Ningbo,including some scientific material,and it was continued there until 1861 by Elias B.Inslee.[165] The most important science textbook of this period was *Bowu xinbian* 博物新編 by the medical missionary Benjamin Hobson [Hexin 合信] (1816-73),published in Shanghai in 1855. It was to be reprinted many times and was published in Japan.

The Mohai shuguan 墨海書館 [Inkstone Press] was set up

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[162] Britton,25

[163] Britton,22-23

[164] Hsü,*The rise of modern China*,243

[165] Britton,51. I have not been able to trace a copy of this.

in Shanghai by the London Missionary Society in 1857,and as well as publishing a number of translated textbooks,a journal *Liuhe Congtan* 六合叢談 [Shanghae Serial]was published from January 1857 to February 1858,and edited by Alexander Wylie[166],with help from William Muirhead[Muweilian 慕維廉](1822-1900),Alexander Williamson and Joseph Edkins [Aiyuese艾約瑟](1823-1905)[167].It regularly included articles on scientific topics,mainly by Alexander Williamson,intended to demonstrate the ways in which God is manifest in Nature.

4.42 1861-1875:The first modern arsenals,government schools and the Jiangnan Arsenal translation bureau[168]

As the Taiping Rebellion moved to a close,Feng Guifen 馮桂芬(1809-74)[169] pressed for the study of Western sciences and mathematics in his collection of essays *Jiaobinlu kangyi* 校邠廬抗議[Personal protests from the Jiaobin Studio][170],and presented them to Zeng Guofan in 1861. Feng,who was probably the first to use the term *ziqiang* 自強[self-strengthening],proposed that mathematics and science be studied,and that bureaux be set up in Guangzhou and

[166] See Alexander Wylie,*Chinese researches*(Shanghai: n.p.,1897) for biographical accounts of Wylie by James Thomas(ibid.,1-6)and H.Henri Cordier(ibid.,7-18).

[167] Joseph Edkins' quality of Chinese scholarship is in some doubt. See T.H.Barrett,*Singular listlessness: a short history of Chinese books and British scholars*(London:Wellsweep,1989),76-77

[168] The period 1862-1874 is sometimes known as the Tongzhi Restoration *Tongzhi chongxing* 同治重興. For a discussion of the military industry during the early part of this period see Thomas L.Kennedy,'The establishment of modern military industry in China 1860-1868' in *BIMH* **4**(1974),779-823

[169] See Hummel,241-3. Feng,an able mathematician,was the inspiration of the founding of the Shanghai Tongwenguan.

[170] Jian Bozan(ed.)*Wuxu bianfa* Vol 1,1-38.

Shanghai for books on these subjects to be translated.[171]

Zeng took these proposals seriously,and,as his diaries show,he took an intelligent interest in technology[172] By 1861 he had established at Anqing 安慶 an arsenal where the first sustained attempts were made to understand the principles behind the new steamships and guns.

The year 1861 was marked by a coup by Prince Gong and the Dowager Empress Cixi 慈禧 (1835-1908)[173],bringing to power the boy emperor who was given the reign-title Tongzhi 同治 'return to order'.[174] The Tongzhi Restoration period(1862-74) has been described as an 'Indian summer'[175],a 'reinvigoration of an ailing dynasty by the revival of traditional learning,and the winning back of the sympathy of the literati and the peasantry'.[176] It also marked a turning-point in attitudes to Western science. The disastrous Taiping Rebellion had shaken some sections of the ruling classes out of their complacency enough to realise that simply copying steamships was clearly no longer enough: the principles of their operation had also to be studied.

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[171] Teng and Fairbank,*China's response to the West*,51-2.

[172] See for example *Zeng Wenzhenggong shoushu riji* 曾文正公手書日記 (Zhongguo tushu gongsi 中國圖書公司,1909) **13**,73a-73b dated 2nd June,1862[Tongzhi 1.5.6] for his views on the importance of learning to make guns and steamships,and his use of the term *ziqiang* 自強[self-strengthening]; *ibid.* **29**,7b-8a dated 8th October,1867[Tongzhi 6.9.11] for his description of a Western gun factory,with a power-driven saw 'cutting timber like bean-curd'. [Note: I have given my own pagination for this diary.]

[173] Hummel,295-300.

[174] Wright,*The last stand of Chinese conservatism*,18.

[175] *ibid.*,45

[176] *ibid.*,44

By 1861 the foreign threat had become even more obvious than before,with defeat in the Second Opium War. The Treaty of Tianjin(1858) allowed freedom of movement for all Christian missionaries in China[177],and the permanent establishment of foreign legations in Beijing. The direct foreign influence on policy began to be clearer than before,as political figures such as the Inspector-General of Imperial Customs Robert Hart [Hede 赫德] (1835-1911),moving in the highest official circles,encouraged pro-Western reforms,which included the setting up of modern shipyards,arsenals and schools.[178] The Jiangnan Arsenal was set up in Shanghai in 1865 by Zeng Guofan and Li Hongzhang,followed in 1866 by the Fuzhou Shipyard under Zuo Zongtang,and the Jinling Arsenal in Nanjing in 1867.

The first new-style government school or Tongwenguan was founded in Beijing in 1862,followed by similar ventures in Shanghai(1863) and Guangzhou(1864). 'Learning from the barbarians' provoked fury amongst sections of the official class led by Grand Secretary Woren 倭仁(1804-1871)[179]. Threatening the pre-eminence of Confucian learning,the Western techniques were bound to undermine the status of those who had obtained their positions through the traditional route of literary examinations.As long as the 'techniques' were confined to purely military enterprises,the concern was muted,but when attempts were made to set up schools of Western learning in the capital it provoked a furious debate about China's future direction. There were even experiments with foreign education,sending Chinese boys to study in the USA with

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[177] Hsü,*The rise of modern China*,266

[178] Richard J.Smith,J.K.Fairbank and Katherine F.Bruner(eds.) *Robert Hart and China's early modernization*(Cambridge,Mass.:Council on East Asian Studies,1991),164.

[179] Hummel,861-3 and Chang Hao,'The anti-foreignist role of Wo-jen(1804-1871)' in *POC* **14**(1960),1-29.

Yung Wing from 1872,whilst other students were sent to study in Britain,France and Germany.[180]

It was only because the chief promoters of the new ideas - such as Zeng Guofan - were of such unimpeachable rectitude that they were allowed by a suspicious court to go ahead. The new 'modern' schools were given grudging assent,and foreigners - virtually all missionaries or ex-missionaries - were allowed to teach there on the strict understanding that only foreign languages and *techniques* were to be taught,and not their religion.

4.421 The Anqing 安慶 Arsenal

The Taiping Rebellion disrupted immense areas of southern China,and virtually destroyed a the tradition of *kaozheng* [evidential research] scholarship which had existed in the Jiangnan region,and many scholars fled to the relative safety of Shanghai and other cities not yet in rebel hands. Zeng Guofan invited several of them to join his *mufu* 幕府[private secretariat] at Anqing,a Yangzi port in southwestern Anhui.[181] In 1861,originally from the city of Wuxi 無錫 came Xu Shou,his second son Xu Jianyin,Hua Hengfang,and Gong Zhitang 龔之堂,the son of Lin Zexu's great engineer Gong Zhenlin.[182] They were joined in 1863 by Li Shanlan,a mathematician of prodigious ability. There they built a steamship,a vessel which was to be the prototype of the first ships to come out of the Jiangnan Arsenal. Though small and slow,this vessel nevertheless represented a great achievement,and gave its makers

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180 *ibid.*,351. See Yung Wing,*My life in China and America*(New York:Henry Holt & Co.,1909; reprinted Arno Press,1978),180-190 on the educational mission to the USA.

181 Kennedy,'The establishment of modern military industry in China',788-790.

182 Yang Mo 楊模(comp.)'Xi-Jin sizhe shishi huicun' 錫金四哲事實彙存 [A collection of facts about the four philosophers of Wuxi and Jinkui](1909),23 and Chen,*Tseng Kuo-fan*,18

confidence that China was capable of emulating the technologies of the West. The Anqing Arsenal also built explosive shells,air-bursting shells and large guns up to thirteen thousand *jin* 斤[about 6,500 kilos] in weight.[183] The achievements at the Anqing Arsenal were remarkable,but it was soon clear that the ships they had built were not adequate to match the navies of the Western powers.

In 1863 Yung Wing,the first Chinese graduate of Yale,arrived in Anqing,and Zeng asked him to purchase machinery so that they could begin making armaments for themselves. Yung Wing told Zeng that the imitation of the foreigners' technology was not a simple task,and that foreigners would have to be employed in order to make the vessels they needed.

> They ought to have a machine shop that would be able to create or reproduce other machine shops of the same character as itself; each and all of these should be able to turn out specific machinery for the manufacture of specific things.[184]

The machines which Yung had purchased arrived in 1865 and were to form the basis of the Jiangnan Arsenal,the most ambitious of all the Self-Strengthening industrial ventures.

4.422 The Jiangnan Arsenal[185]

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[183] Kennedy,'The establishment of modern military industry in China',789

[184] Yung Wing,*My life in China and America*,149

[185] See Gan Zuolin 甘作霖,'Jiangnan zhizaoju jianshi' 江南製造局簡史 in *DFZZ* **11**,5(November,1914),46-48 and **11**,6(December,1915),21-25; Quan Hansheng 全漢昇,'Qingji de Jiangnan zhizaoju' 清季的江南製造局[The Qing dynasty Jiangnan Arsenal] in *BIHP* **23**(1951),145-159; 'Jiangnan zhizaoju ji' 江南製造局記[A record of the Jiangnan Arsenal] in *Yangwu yundong* Vol.4,73-

By 1865 Zeng was able to move the Anqing operation to the Hongkou 虹口 district of Shanghai,where he and Ding Richang,*daotai* 道臺[intendant] of the Su-Song-Tai circuit,set up the Jiangnan Arsenal(*Jiangnan zhizao zongju* 江南製造總局).[186] It was established with the experience of the Anqing Arsenal,and of the Suzhou Arsenal established under Li Hongzhang and Halliday Macartney [Mageli 馬格理] (1833-1906)[187] in 1864[188],and two other small arsenals in Shanghai,one already run by Ding Richang[189].

A contemporary foreign description of the Arsenal ran:

> The Kiangnan[Jiangnan] Arsenal,situated on the left bank of the Wongpoo[Huangpu 黃浦][...] cannot fail to engage the attention of those who pass that way in making excursions up the country. The tall chimneys,the residences of the foreign engineers,the college just completed,the little town where the native mechanics live,the rows of workshops,foundries and godowns,the dockyard where the steamers are being built,and the wharf with vessels loading and unloading present a scene not unlike our own establishments at

175; Thomas L.Kennedy,'The Kiangnan Arsenal 1895-1911: the decentralised bureaucracy responds to imperialism' in *CSWT* **2**,1(October 1969),17-37; Thomas L.Kennedy,'The Kiangnan Arsenal in the era of reform 1895-1911' in *BIMH* **3**(1972),269-346; Thomas L.Kennedy,'The establishment of modern military industry in China 1860-1868' in *BIMH* **4**(1974),779-823; Thomas L.Kennedy,'The coming of war at the Kiangnan Arsenal' in *BIMH* **7**(1978),659-682; Thomas L.Kennedy,*The arms of Kiangnan: modernization in the Chinese ordnance industry 1860-1895*(Boulder,Colorado: Westview Press,1978)

[186] Hummel,721

[187] Hummel,438-439.

[188] Kennedy,'The establishment of modern military industry in China',795

[189] *ibid.*,796

home.[190]

The Jiangnan Arsenal from the beginning proved unsatisfactory. The machinery was defective in various ways,and the production of ammunition and arms was very slow. The foreigners who worked there seem to have included some at least who had little knowledge of arms production.

The Hongkou site possessed many disadvantages,both strategic and practical:it was vulnerable to naval attack,far from sources of iron and coal,and too close to the foreign concessions. There were attempts to move it inland,notably at the suggestion of Zhang Zhidong,but for Li Hongzhang it represented an important power-base in Shanghai and so it remained.[191]

The most able of the Chinese scientists,Xu Shou,Xu Jianyin and Hua Hengfang,were involved more in the translation of books more than in practical matters,and the root of the problem was that there was no-one competent to manage the enterprise. Huge sums of money were spent on the Jiangnan Arsenal - more than any other military enterprise in China - yet there was often little to show for it. In shipbuilding it was disastrously slow:between 1868 and 1885,only eight ships were built[192],and by the 1880s the high cost and low productivity of the Jiangnan operation forced Li Hongzhang to spend millions of silver taels on foreign(mainly German) ships in order to build his Beiyang Fleet.

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[190] *NCH*(11th January,1870),22

[191] Quan Hansheng,'Qingji de Jiangnan zhizaoju',153

[192] Even these were of poor quality and involved huge sums of capital.(Quan Hansheng,'Qingji de Jiangnan zhizaoju',155). See also *Celestial Empire*(4th September,1875),239-240 for an account of the launch of the first iron-clad steamship from the Jiangnan Arsenal.

4.423 Other arsenals

In 1865-1866 the Jinling 金陵 Arsenal was set up at Nanjing to produce small arms for the pacification of the Nian 捻 rebellion(1853-68)[193],but the urgent need for armaments in North China encouraged Chonghou 崇厚 (1826-1893)[194],Governor-General of Zhili,to set up the Tianjin Powder Bureau(*Tianjin huoyaoju* 天津火藥局) and the Tianjin Arsenal in 1867.[195] Zuo Zongtang set up an arsenal at Lanzhou in 1871 or 1872[196],and a woollen mill in the same city around 1879 to 1883.[197]

Listing these arsenals,it may appear that a good deal of modernisation was taking place,but as we have seen in the Jiangnan Arsenal,appearances were often misleading. For instance,Ma Xiangbo 馬相伯(1840-1939),the elder brother of Ma Jianzhong 馬建忠(1844-1900)[198],discovered in 1877 when he visited the Shandong Arsenal that they were only making one

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193 Kennedy,'The establishment of modern military history',807-809

194 Hummel,209-211.

195 Kennedy,'The establishment of modern military industry',809-819

196 Chen,*Tso Tsung-t'ang*,49-56

197 *ibid.*,57-72

198 See Hummel,950 and Paul A.Cohen,'Littoral and hinterland in nineteenth-century China' in John K.Fairbank,*The missionary enterprise in China and America*(Cambridge,Mass.: Harvard University Press,1974),197-225. Ma Xiangbo(*ibid.*,204ff) became a Jesuit priest,but developed an interest in science and technology in the 1870s; Ma Jianzhong(*ibid.*,203ff)was an expert on foreign affairs in the *mufu* of Li Hongzhang.

gun every ten days.[199] He also found that the officials of the Hubu 户部 [Board of Revenue and Population] were so ignorant of Western technology that he could avoid censure for over-expenditure on raw materials by changing the Chinese unit of weight *jin* 斤 [about 0.5 kg] to *bang* 磅[pound] in his reports to them,in the certainty that they would have no idea what *bang* meant. [200]

In Self-Strengthening,appearance was often more important than reality. Millions of taels were spent but China's ability to make armaments improved only marginally. New techniques and materials meant that,relative to the Western nations,and its neighbour Japan,China's military position was becoming dangerously weak.

4.424 The translation of scientific books.

The Translation Bureau at the Jiangnan Arsenal was set up in 1867,with the aim of providing the texts for which the next generation of technicians could be trained. John Fryer was its director,with a number of other foreigners such as Alexander Wylie,Daniel Jerome Macgowan and Carl Kreyer. Yet there was no overall plan of what types of books should be translated[201],and although many scientific works were translated,their quality and importance varied widely. More seriously,there is little evidence that the books were much used in the arsenals for which they were supposedly produced: and it seems unlikely that the

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[199] Zhang Ruogu[Chang Jo-ku] 張若谷,*Ma Xiangbo xiansheng nianpu*馬相伯先生年譜 [A biography of Ma Xiangbo](1939; reprinted Taibei:Wenhai chubanshe 文海出版社,c.1972),118-119

[200] *ibid.*,119-120

[201] There was originally an ambitious plan to make a Chinese version of the *Encyclopedia Britannica*. See John Fryer 'An account of the Department for the Translation of Foreign Books at the Kiangnan Arsenal,Shanghai' in *NCH*(29th January,1880),78.

translations had much direct practical effect on the manufacturing work of the Arsenals. (In fact the Jiangnan Arsenal seems in the early days at least to have employed its own translator Wang Ronghe 王榮和).[202]

The Beijing Tongwenguan also produced some scientific translations which,though far fewer in number than those of the Jiangnan Arsenal,were of good quality,with more emphasis on academic learning than manufacture.

4.425 The Fuzhou Shipyard [203]

Zuo Zongtang had been deeply impressed by the work of Lin Zexu,Gong Zhenlin and Pan Shicheng during the First Opium War[204],and he himself experimented with guns,casting a cannon called *pishanpao* 劈 山 礮 (mountain-splitting cannon)[205]. He also attempted to build a small steamship in Hangzhou 杭州 in 1864,which he showed to his French advisers Prosper Giquel[Riyige 日意格](1835-1886) and Paul d'Aiguebelle [Dekebei 德克碑](1831-1875). The vessel was slow and Zuo had no time to develop it further.[206] By 1866 he was memorialising the Emperor on the need for a shipyard,and on 14th July,1866 the Court agreed to his

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[202] Wang Ronghe had grown up in Singapore. See Ding Richang's memorial dated 30th August,1869(Tongzhi 8.7.23) in *Yangwu yundong* Vol.4,22-23. Wang later became part of the Management Committee of the Shanghai Polytechnic.(See Section 10.2).

[203] See Prosper Giquel,*The Foochow Arsenal and its results* (Shanghai:Shanghai Evening Courier,1874); Gideon Chen,*Tso Tsung-t'ang*; Fang Aiji 方人吉,'Woguo zuizao de zaochuan zhuanke xuexiao --- Fuzhou chuanzhengju qianxuetang' 我国最早的造船专科学校 ---- 福州船政局前学堂 in *ZGKJSL* 6,5(1985),57-62; Steven A.Leibo, *Transferring technology to China: Prosper Giquel and the Self-strengthening movement*(Berkeley:Institute of East Asian Studies,1985).

[204] Chen,*Tso Tsung-t'ang*,4

[205] *ibid.*,6

[206] Zuo Zongtang,*Zuo wenxianggong zougao* 18.1a-6b(dated 25th June,1866[Tongzhi 5.5.13]),5b-6a and Chen,*Tso Tsung-t'ang*,12

request. He enumerated seven difficulties which he faced:

> 1.the choice of a suitable site
>
> 2.the finding and purchase of machinery
>
> 3.the employment of foreign mechanics and ships' masters
>
> 4.the assembly of sufficient money
>
> 5.the inexperience of the Chinese in running boats,and their reliance on foreign ships' captains
>
> 6.the expense of the coal,salaries and wages needed to run them and of repairing the ships from time to time
>
> 7.in such an extraordinary enterprise,slanders and belittling of those who promote new ideas are commonplace,so that whilst one person directs matters,another looks on,whilst a third faces public and private ruin.[207]

Zuo then went on to explain his plan for industrial development:

> As far as the purchase of machinery is concerned, we should first buy one set of machinery,and when [all the parts],great and small,are ready,we should seek and hire foreign seamen and mechanics for it,and having gathered them all together,use these machines to make more machines,'gathering the small to make the great'(*ji wei cheng ju* 積微成鉅),one becoming a hundred. The machines can then make the engine of a steamship; this can be made into a ship. Having made

[207] *Zuo Wenxianggong quanji*. *Zougao* 1b-2a. Translated in Ssu-yü Teng and John K.Fairbank,*China's response to the West: a documentary survey,1839-1923*(Cambridge,Mass.:Harvard University Press,1979),52.

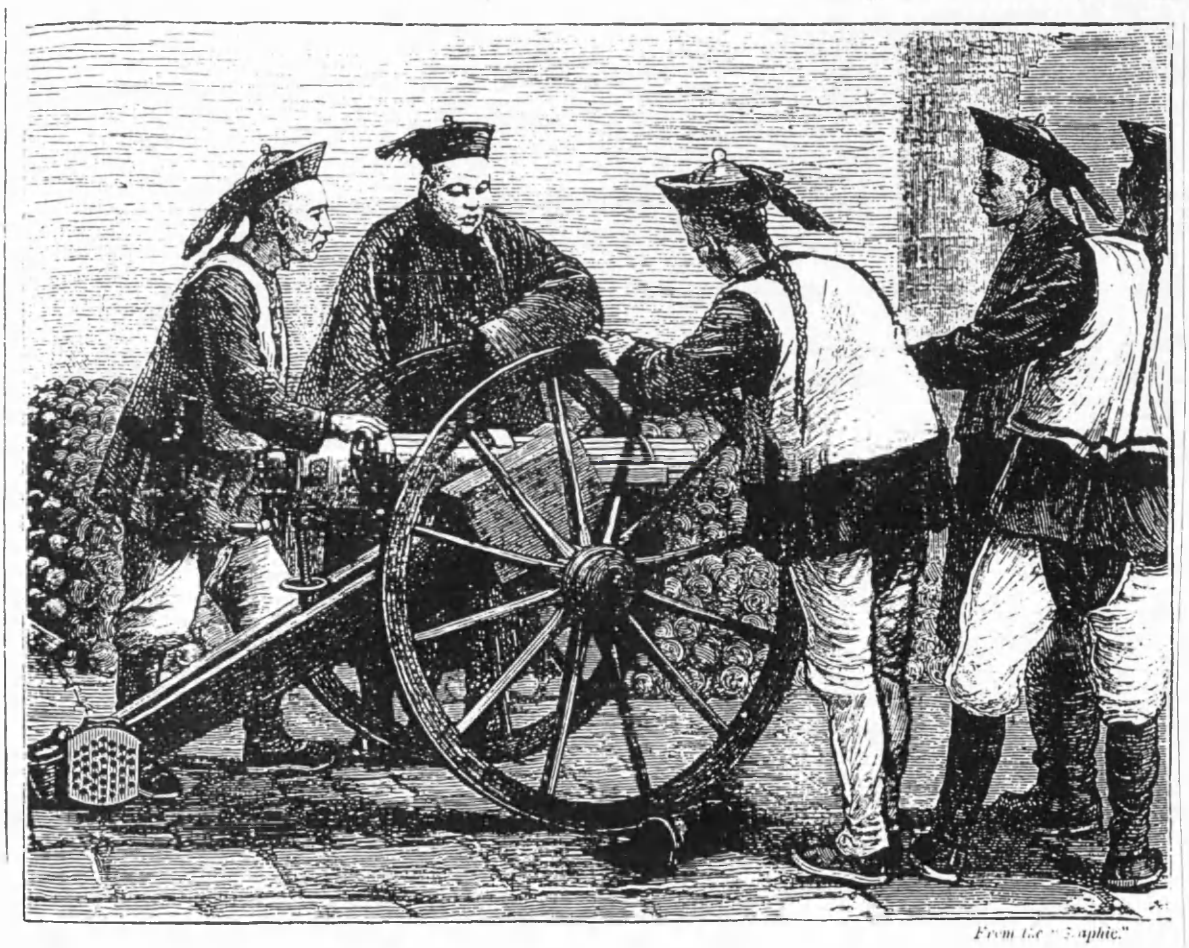

Figure 6.The Jinling Arsenal,from J.Hudson Taylor(ed.) *China's Millions*(1875-6),26

> a ship,we can then train the soldiers for the ship,and after five years,when the number of ships has increased,we can set up long-range guards on the coasts of every province to protect Tianjin and Dagu,and then we can set up all kinds of machines alongside them. We can then institute the making of guns and cannon,bullets,minting currency,irrigation,and other things which are beneficial to the people....[208]

The first shipment of machinery arrived in December 1867,and the buildings began on a "naked rice-field"[209] and the first steamer,the *Wannianqing* 萬年青,was launched in June 1868.

The difficulties which Zuo encountered were at least as great as those which he had foreseen,but he was not able to see the project through,being transferred to Shaanxi and Gansu to deal with the Muslim rebellion in 1866,so that the Arsenal passed to the control briefly of Ding Richang[210],then from 1866-75 to Shen Baozhen(1820-1879) 沈葆楨 [211],and by the turn of the century was being run by the Manchu Yulu 裕祿(d.1900).

4.426 The setting up of government schools teaching science and mathematics

The growth of industrial ventures made it obvious that simply imitating foreign ships and guns was not

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[208] *Zuo Wenxianggong quanji.Zougao* 18.2b. Translation based on Chen,*Tso Tsung-t'ang*,20-21,but translating slightly more.

[209] Giquel,*The Foochow Arsenal*,11

[210] Hummel,722

[211] Hummel,643 and David Pong,*Shen Pao-chen and China's modernization in the nineteenth century*(Cambridge:Cambridge University Press,1994),Chapters 5-11.

enough,and,as Ding Richang put it,the techniques were 'secret and have not been made known [to us]'(*mi er wei xuan* 秘而未宣)[212]. The foreigners' own technology was changing too fast,and mere imitation made the Chinese too dependent on Western suppliers and Western engineers. It was essential that some Chinese should be conversant with the principles which lay behind the running of the machines.

4.427 The Tongwenguans

The early modern government schools in Beijing,Shanghai and Guangzhou were at first constituted as language schools - in order to stress their continuity with past institutions such as the Ming *Siyiguan* 四夷館[Four Barbarians' College][213] - but all eventually widened their curricula to include some Western science. Their contribution to the transmission of science will be considered in Chapter 10.

4.428 Early popular science journals

During this period,Young J.Allen's *Jiaohui Xinbao*[Church News] in Shanghai and *Zhong-Xi Wenjian Lu* [The Peking Magazine] both carried regular articles on science,sometimes serialising science textbooks.[214]

4.43 The period 1876-1893

After the death of Zeng Guofan in 1872,the main advocates of Self-strengthening were Li Hongzhang,Zuo Zongtang and,from the 1880s,Li's great rival and critic Zhang Zhidong. In 1872 Li had supported the *guandu-shangban*

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[212] Ding Richang's memorial of 30th August,1869 in *Yangwu yundong* Vol.4,22.

[213] Su Jing,5-6.

[214] See Chapter 11.

官督商辦 'government supervised merchant undertaking' China Merchants' Steam Navigation Company[215],which from 1873 was run by Tong King-sing(Tang Jingxing 唐景星)(1832-92) a former comprador with Jardine,Matheson.[216] Li Hongzhang developed coal mines at Kaiping 開平 near Tianjin (1877)[217],gold mines at Mohe 漠河 in Heilongjiang(1887)[218],whilst Zhang Zhidong opened iron mines at Daye 大冶(1890) and coal mines at Pingxiang 平鄉(1890)[219]. In the same year Zhang established ironworks at Hanyang 漢陽. A textile mill in the remote city of Lanzhou was started by Zuo Zongtang in 1878,the same year as Li Hongzhang started the Shanghai Cotton Cloth Mill. The first telegraph line between Dagu 大沽 and Tianjin opened in 1879,and 1881 saw the founding of the Imperial Telegraph Administration,and the opening of the first telegraph line between Shanghai and Tianjin.

Several groups of students were sent to France,Britain and Germany from Fuzhou to study mining,shipbuilding and navigation. During this period many Chinese travellers went to the West and recorded their impressions in journals. The most controversial was Guo Songtao,who had been minister in Britain and France (1876-1878). In his diary he praised Western culture and even suggested that Western political institutions were worthy of study,and as a result suffered bitter criticism and disgrace on his return to China.[220]

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215 Hsü,*The rise of modern China*,353 and Liu Kwang-ching,*Anglo-American steamship rivalry in China*(Cambridge,Mass.:Harvard University Press,1962).

216 Liu,*Anglo-American steamship rivalry*,142ff and Paul A.Cohen,'Littoral and hinterland',205.

217 *ibid.*,113-144

218 *Yangwu yundong* Vol.7,313-346

219 *ibid.*,203-312

220 Hsü,*The rise of modern China*,359

The loss of the traditional tributary state of Burma to the British in 1885 was yet another confirmation of China's weakness. China faced Japanese encroachment on Taiwan 1871-1874[221],Russian advances in Xinjiang 1871-1881[222],and French aggression in Vietnam(Annam)1884-1885[223]. A particularly disastrous setback during the war with the French was the destruction of the Fuzhou Arsenal,which had ironically been built largely with French help.

None of these defeats were sufficient to press China into a serious reassessment of its policies on science and technology. Growth of new industries was slow and on such a small scale as to make little difference to the overall situation.Even Li Hongzhang did not attempt a more radical solution.

4.431 The popularisation of science

1876 saw the beginning of the *Gezhi Huibian* of John Fryer,of all the foreign journals the most completely devoted to science and technology. In 1875 the *Jiaohui Xinbao* changed its name to the more secular *Wanguo Gongbao*,and paid even more attention to scientific matters than before.

In 1887,the formation of the Society for the Diffusion of Christian and General Knowledge among the Chinese(*Guangxuehui* 廣學會)in Shanghai,which included Alexander Williamson,Young J.Allen,Timothy Richard and W.A.P.Martin led to a renewed determination to publish science textbooks suitable for missionary schools.

[221] *ibid.*,386-390

[222] *ibid.*,390-397

[223] *ibid.*,398-403

4.432 The Shanghai Polytechnic[224]

In 1874 Walter Medhurst had suggested a Reading Room for the Chinese in Shanghai,and by 1876 a building,the 'Shanghai Polytechnic Institution and Reading Rooms' was opened. Intended to bring science and technology before the Chinese public,it had a chequered and 'not very prosperous' history which will be dealt with in Section 10.2.

4.433 The development of Western-style industries [225]

Li Hongzhang and Zhang Zhidong led the establishment of modern industrial enterprises,such as a textile mill at Guangzhou(1886),four cotton mills at Wuchang 武昌(1893),the Guizhou 桂洲 ironworks in 1891,and in 1894 in Hubei a textile company was started as a *guandu-shangban* enterprise. Yet in general these ventures were relatively small and made little impact on China's relative economic weakness.

4.434 Zhang Zhidong and the Hanyang 漢陽 Arsenal[226]

Zhang Zhidong's experiences in fighting the French in Annam led him to see that China's industrialisation programme was hopelessly inadequate to face the threats. He had planned a new Guangdong Arsenal,but in 1889 he was made governor-general of Hubei and Hunan. The destruction of

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[224] See Section 10.2

[225] See Albert Feuerwerker,'Economic trends in the late Ch'ing Empire 1870-1911',in D.Twitchett(ed.)*CHC* Vol.11,1-69.

[226] Thomas L.Kennedy,'Chang Chih-tung and the struggle for strategic industrialisation: the establishment of the Hanyang Arsenal 1884-1895' in *HJAS* **33**(1973),154-182.

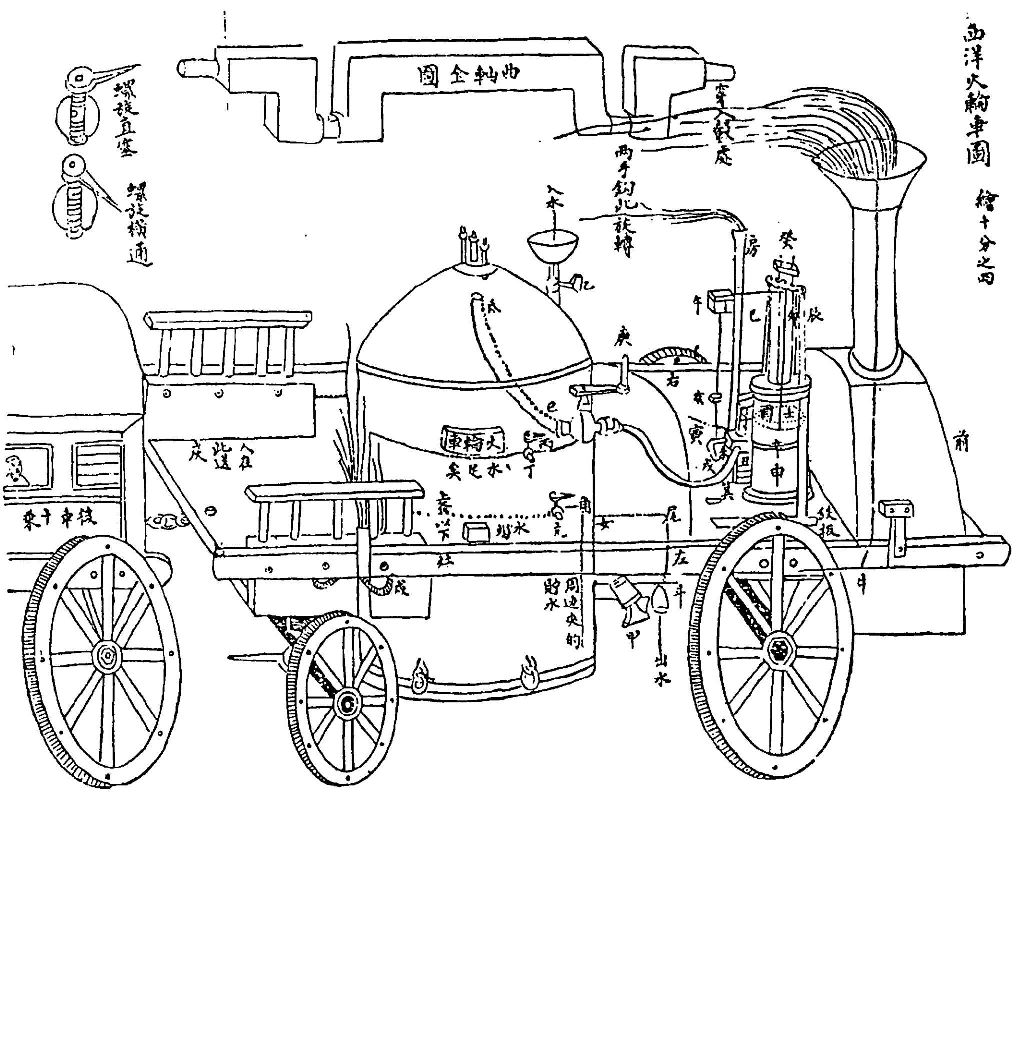
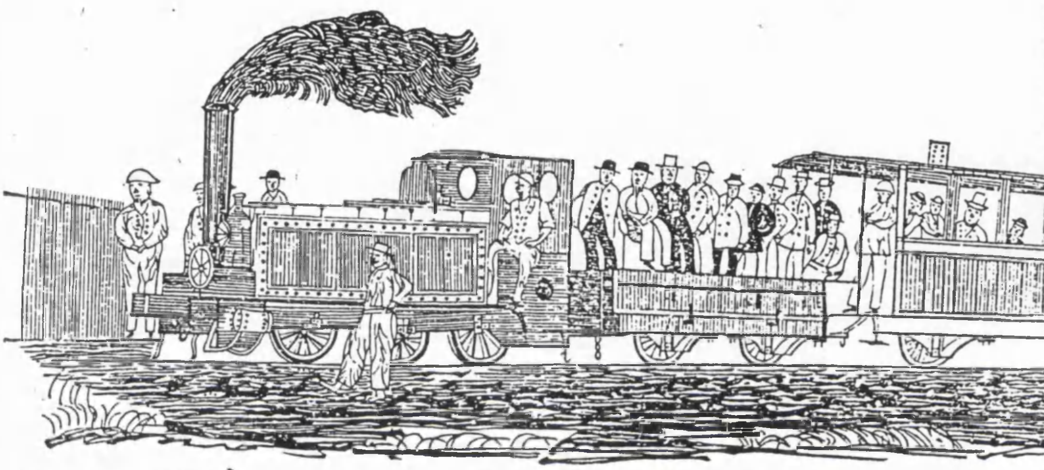


Figure 7. A railway engine drawn by Ding Gongzhen, from Gideon Chen, *Lin Tse-hsü*, 47

新造鐵路輪車之圖



但疑者無人阻者無人且以國中
來天下各大國無一國無鐵路
千八百七十四年間計共鐵路
車載客計共四百五十五兆六十
輪車所行里數計共九十六兆
英里其載貨與煤鐵等車計共行
百三十九英里每一英里中國
馬而代輪車馬行須一點鐘輪車
三倍矣合英國輪車載客之數計
萬年之數此一百五十萬年餘功
是英國水道有輪船陸地有輪車
但英國有然各西國亦復如是西
國於一千八百七十四年計共鐵
英里其次德國計共鐵路一萬一
國計共鐵路一萬零八百七十一
零五百六十英里他如奧國鐵路
印度鐵路計共六千英里推之各
以南北亞美利加洲各國之鐵路
各國之鐵路統計八萬英里有
計八千英里有奇阿非利加洲
有奇澳大利亞洲各國之鐵路計共一千英里有奇總而計之十七萬英里有奇

Figure 8. The opening of the Wusong to Shanghai railway in *Wanguo Gongbao* **9**,401(19th August,1876),8b [Reproduced by kind permission of Oriental and India Office Collections,British Library]

the Fuzhou Shipyard had shown how vulnerable coastal arsenals were to naval attack,and Zhang began plans for a new strategic approach to self-sufficiency in military materials. One of the difficulties of the Guangdong Arsenal was the scarcity of iron ore.[227] In 1889 he began developing new coal and iron mines at Daye 大冶,and in 1890 set up an ironworks at Hanyang.

The Hanyang Arsenal was sited at the foot of Dabieshan 大别山 adjacent to the ironworks[228],and was established 1890-1895. Yet not a single rifle had been turned out before the end of the war with Japan in 1895.[229] Supply problems such as shortages of bricks were less serious than the lack of trained personnel,which Zhang had tried to remedy by founding the Ziqiang Xuetang 自強學堂[Self-Strengthening Academy] in 1893 in Wuchang.[230]

4.44 The period 1894-1900[231]

The outbreak of the Sino-Japanese War was a turning point for Chinese public opinion. Whereas previous disgraceful defeats had been at the hands of the Western powers,now even the 'dwarf pirates' of Japan were able to destroy the Beiyang Navy on which so much time,effort and many millions of taels had been lavished. This event finally demonstrated that the path the Japanese had been following - a wholehearted commitment to military

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[227] Kennedy,'Hanyang Arsenal',163

[228] Kennedy,'Hanyang Arsenal',171

[229] Kennedy,'Hanyang Arsenal',173

[230] *ibid.*,176. Hua Hengfang was one of the lecturers at the Ziqiang Xuetang.

[231] See Jian Bozan 翦伯贊 (ed.)*Wuxu bianfa* 戊戌變法 [The Hundred Days' Reform Movement](Shanghai: Shenzhou guoguangshe 神州國光社,1953); Daniel H.Bays,*China enters the twentieth century: Chang Chih-tung and the issues of a new age 1895-1909*(Ann Arbor:University of Michigan Press,1978)

modernization - was needed for China if it were not to be destroyed by foreign invasion. The events of the war were also a personal disaster for Li Hongzhang,who had been the leader of the Self-Strengthening movement since Zeng Guofan's death. Li's piecemeal approach had failed utterly,and he had the humiliation of seeing the navy into which he had poured so much money and effort sunk within a few days.

The Treaty of Shimonoseki(1895) instigated the first serious attempts to reconsider the *status quo* in China. Zheng Guanying 鄭觀應(1842-1923),entrepreneur and sometime student of John Fryer,wrote his *Shengshi weiyan* 盛世危言[Warning to a seemingly prosperous age],which expressed the deep frustration felt at the slow pace of technological innovation and political change,a feeling which was beginning to be shared by the more progressive intellectuals.

4.441 The intellectual impact of science[232]

During this period the political aspects of the West began to be more widely known,and the intellectual impact of Western science began to be felt through the reading of journals such as *Wanguo Gongbao* 萬國公報 and translated Western works,especially Kang Youwei and Tan Sitong. There was an intellectual ferment,marked by the appearance of many new academic societies and science-based journals.[233] Although the scientific aspects of the post-Boxer rebellion reforms fall outside the scope of this thesis,the educational reforms of 1901-1905 were apparently a reversal of previous intransigence,yet they were too little and too

[232] See Chang Hao,'Intellectual change and the reform movement 1890-8' in D.Twitchett(ed.)*CHC* Vol.11,274-338,and Chapter 12.

[233] Hsü,*The rise of modern China*,499-538

late to save the dynasty from disaster.

4.5 Conclusion

Throughout the latter half of the nineteenth century,the motivation to introduce science was driven by the perceived urgency of the threat of foreign technology,whether wielded by foreigners or - even more dangerously - by the internal enemies of the dynasty. In periods of great upheaval: around 1840(First Opium War),around 1860(Second Opium War),the mid-1880s(war with France),and during mid-1890s(war with Japan),there were sudden surges of interest in the principles lying behind the technology,but between these peaks there were troughs of relative apathy,which account for the slow rate of the transmission during this period.

Yet the odds against the acceptance of the Western barbarians as teachers were very great,and the achievement of those who struggled to translate Western science has to be measured against the unwelcoming circumstances within China - the 'naked rice-fields',the public indifference and official hostility they faced,quite apart from the conceptual and linguistic difficulties which lay in the path of this great translation.

Chapter 5. On translation[234]

Things which have nothing in common with each other cannot be understood through each other. - Baruch Spinoza(1632-1677)[235]

<u>*5.0 On translation*</u>

This chapter opens with a discussion of the general issues surrounding translation,and then moves on to discuss the specific problems relating to the translation of science texts. The methods of translation employed by the Chinese Buddhists are then discussed and compared with those of the nineteenth century translators.Finally,the problems specific to the translation of foreign languages into Chinese are considered,and the linguistic techniques used by the scientific translators to handle the transmission of Western science are exemplified,with particular reference to the problem of transliteration.

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[234] See Fryer 'An Account of the Department for the Translation of Foreign Books',77-81; 'Methods of imparting Western knowledge to the Chinese' in *JCBRAS* **21**(1886),1-21; Rev.J.Jackson, 'Objects,methods and results of Higher Education in our Mission Schools' in *CR* **24**(January 1893),7-12; Che Shancheng 車善呈,'Taixi gezhi zhi xue yu jin ke fanyi zhu shu xiang lüe de-shi he zhe wei zui yao lun' 泰西格致之學與近刻翻譯諸書詳略得失何者為最要論 [On Western science and the most important successes and failures of the recent translations of books] in Wang Tao 王 韜 (ed.)*Gezhi keyi huibian* 格致課藝彙編[Prize essays on scientific themes](1896),28a-32b; Liang Qichao 梁啓超,'Lun yishu' 論譯書[On translation] in *Yinbingshi heji* 飲冰室合集[The Ice-Sipping Studio Collection](Shanghai: Zhonghua shuju 中華書局,1932)Vol.1 ,64-76; Eugene A.Nida,*Towards a science of translating* (Leiden: E.J.Brill,1964); Tsien Tsuen-hsuin,'Western impact on China through translation' in *FEQ* **13**(1954) ,305-327; Li Xingmin 李醒民,'Kexue geming de yuyan genyuan' 科学革命的语言根源[The linguistic origins of scientific revolution] in *ZRBZFTX* **13**,4(1991),11-19;Keizô Hashimoto 橋本敬造 ジョン=フライヤー" 江南製造局翻沢事業記" 注 Jon Furaiyâ "Kônan seizô kyoku Honyaku Jigyôki" yakuchû [Annotated translation of *An Account of the Department of the Translation of Foreign Books at the Kiangnan Arsenal,Shanghai(1880)* by John Fryer] in 關西大學主編社會學部紀要 **23**,2(1992),1-29.

[235] Baruch Spinoza,*Ethics.Treatise on the emendation of the intellect.Selected letters* Seymour Feldman (ed.)(1677,reprinted Indianapolis:Hackett Publishing Company,1992),32

5.1 What is translation?

Translation may be defined as the 'expression of the sense of a word or sentence in or into another language'[236]. The act of translation is one of the primary means of communication between different cultures(including that between different subcultures within a society,such as specialists and laymen,and between specialists of one kind and another).

The Chinese term for 'to translate' *fanyi* 繙 譯 is built of *fan* 繙 [237],meaning 'to flutter in the wind,like a pennant'[238]; 'to turn over'; and *yi* 譯 meaning 'to change'[239], 'to collect intelligence on' and finally 'to interpret or explain'[240].

The Song Buddhist Fayun 法雲,in discussing the issues of translation in the introduction to his glossary of Buddhist terms,wrote

> 'Translation' is the rendition of the language of Brahma[Sanskrit] into the language of the land of Han: although the sounds may seem different,the meaning is largely the same.

The *Biography of the Song Monks* says that it is

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[236] J.B.Sykes(ed.)*The Concise Oxford Dictionary* 6th ed.(Oxford:Clarendon Press,1976),1232

[237] Also written 翻,with the additional meaning 'to soar'. 繙 is more common in the period considered.

[238] *Cihai* 辭海(Hongkong:Zhonghua Shuju 中華書局,1947 ;reprinted 1977),1059

[239] Homophonous with *yi* 易 'to change'.

[240] The graph *yi* 譯,with the speech radical,means 'to spy'. According to *Cihai* the Zhou dynasty interpreters for the Northern barbarians were called *yi* 譯.

> like turning over a piece of brocade: the front and back are both [equally] splendid,yet they differ[just as do] the left and right [hands]. The meaning of 'to translate'(*yi* 譯)is 'to change'(*yi* 易). This means taking what is [already there] and exchanging it for what is not [to accord with the meaning of the original]. Thus [we] use the Classics of China(*ci fang zhi jing*此方之經) to reveal the Dharma of another land(*bi tu zhi fa* 彼土之法).[241]

In the case of the transmission of the Western *Dharma* of science to China in the nineteenth century,translation played just as essential a part; in fact,to a large extent,the earliest phase of the transmission *was* translation. This chapter will consider first some of the general issues surrounding translation and then look at the specific nature of the challenges faced by the translators of Western science into China.

5.11 Equivalence and semantic space

The total translation of an utterance in one language L1 into another language L2 is impossible,even in principle. This is the case even at the crudest level,that of lexical equivalence: a glance at any bilingual dictionary reveals that for most words which are equated in L1 and L2,the equivalence relation

L1(W1) ----> L2(W2)[242]

is of quite a different kind to

$$3 \times 2 = 6.$$

or even

[241] Fayun 法雲,*Fanyi mingyi ji* 翻譯名義集 [A collection of [Buddhist] translated terms] (1878 edition. Preface dated 1157.),1.1a

[242] L1(W1) means 'a word W1 in language L1'.

(Beijing) = (the capital of China in 1995)

This is partly because(for all except the most specific and artificial of terms) L1(W1) is usually only approximately equivalent to L2(W2),and indeed may have a whole range of meanings within L1,only some of which may be even approximately equated to L2(W2),and then only within a certain domain of meaning. (Even if the terms were identical in meaning,it does not necessarily follow that two given utterances L1(W1) and L2(W2) would be equivalent. That would depend on the types of usages prevailing in the two language communities,the presuppositions they held,and the particular situations in which they were spoken.[243])

The impossibility of total translation obviously does not mean that communication itself is impossible between speakers of two different languages,but the non-equivalence of terms raises the question of how and to what extent communication is achieved.

It seems that there is a domain or range of situations in which L1(W1) and L2(W2) may be safely equated within a corresponding range of linguistic environments.

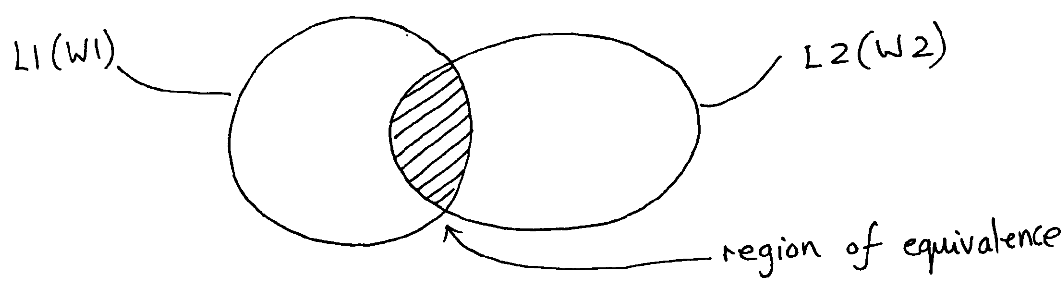

Figure 9 The region of equivalence between two utterances in L1 and L2

[243] 'whether a word of the language of our tribe is rightly translated into a word of English depends upon the role this word plays in the whole life of the tribe.'(Ludwig Wittgenstein,*The Blue and Brown Books* (Oxford:Basil Blackwell,1960),103)

The shaded area in Figure 9 shows the region or domain in which the equivalence holds. The regions L1(W1) and L2(W2) are regions in what I shall call *semantic space*,and each point of the semantic space corresponds to a shade of meaning of the term. The shaded area thus corresponds to a region in which the meanings may be 'tallied' satisfactorily without necessarily being identical.

A more satisfactory picture is

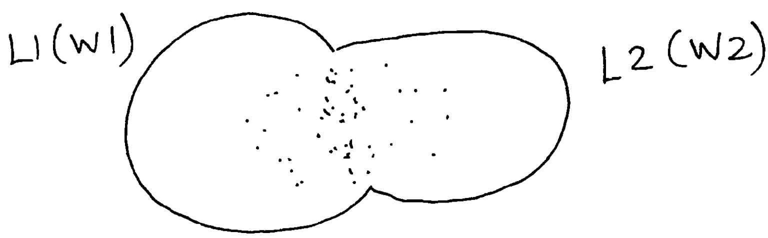

Figure 10 The semantic space between two utterances

In Figure 10,the region of equivalence is represented by a cloud or 'nebula',rather than a region with sharp boundaries as in Figure 9 [244]. Within this nebula there are certain points in which the equivalence is (almost) exact,that is the terms L1(W1) and L2(W2) occupy almost the same semantic space,shading out to regions in which the pairing is more and more imprecise and uncertain,until areas are reached in which there is no equivalence at all.

The consideration of the equivalence or non-equivalence of two terms in L1 and L2 is only the first

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[244] See Karl.R.Popper,'Of clouds and clocks' in *Objective knowledge: an evolutionary approach*(Oxford:Oxford University Press,1972),206-255 for a discussion of the 'cloudiness' of all objective knowledge about the world,and Du Houwen 杜厚文,'Mohu yuyi dingliang fenxi' 模糊语义定量分析[A quantitative analysis of the fuzziness of meaning] in *YYJXYYJ*(1995,1),64-81.

stage in the translation of sentences in L1 and L2. Even if the terms L1(W1) and L2(W2) are closely equivalent,it does not follow that the significance of the sentence S1 in L1 will be captured by S2 in L2.

This is because the significance of S1 is by definition its significance to a *native speaker* of L1. The sentence S2 cannot have the identical sense for a speaker of L2,not only because the speakers of the two languages have different cultures,world-views,and even logics,but because L1 and L2 themselves are *different*. Whilst obvious,this is also of great importance. For the presuppositions entailed in the linguistic forms of L1 and L2 themselves impose a world-view and insinuate a philosophy.

Ostensive definition,that is,the pointing to and naming of a particular material object,would seem to be a particularly clear-cut case for the equivalence of two terms in L1 and L2.[245] Surely if the speaker of L1 points to an object and says 'W1.',and the speaker of L2 looks at the same object as it is being indicated,realises what it is called in L2,and says 'W2.',there is total equivalence between W1 and W2? Yet,even here,the equivalence cannot always be regarded as exact.

5.12 The translation of terms

In this section,I shall discuss the translation of terms from English(L1) into Chinese(L2).

Consider the following relations:

(1) L1(book) ----> L2(*shu* 書)

[245] St.Augustine of Hippo(A.D.354-430),*Confessions* R.S.Pine-Coffin trans.(London:Penguin Books,1961,reprinted 1968),29

(2) L1(vanadium) -----> L2(*fan* 釩)

Of these two relationships,only (2) could be said to be an exact equivalence. The English term 'book' can include 'exercise book',whereas in Chinese *shu* 書 does not; *shu* 書 in Chinese can also include the meanings 'document'(as in *zhengmingshu* 證名書 [certificate]),'style of calligraphy' (e.g.*kaishu* 楷書 [standard form Chinese calligraphy]) which 'book' cannot.

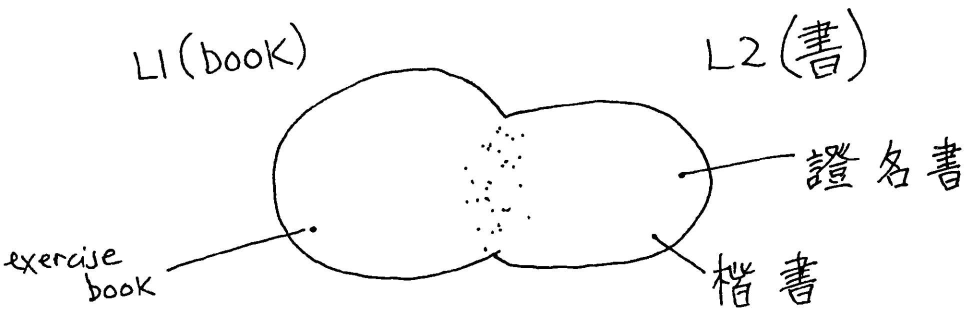

Figure 11. The relationship of 'book' to '*shu* 書 '

For 'vanadium' and *fan* 釩 the situation is quite different. The semantic spaces they occupy in the two languages are identical.

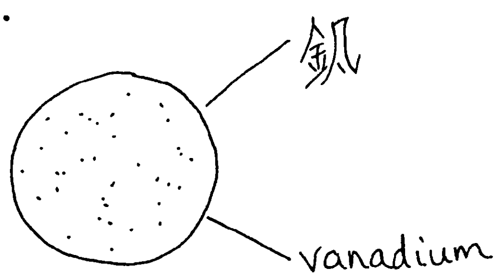

Figure 12. The relationship of 'vanadium' and '*fan* 釩'

The fit is perfect because '*fan* 釩 'is a neologism,coined <u>specifically</u> to fill the same semantic space as 'vanadium' in English,in the sense that,before the term *fan* 釩 was invented,no such word (no such semantic space) existed in Chinese at all. The space for *fan* 钒 was hewn out by the inventors of a chemical terminology,and the term may therefore be seen as a true novelty,a rare species in Chinese,which is amongst the major world languages peculiarly resistant to foreign loan-words[246].

The perfection of the fit also derives from the fact that the speakers using L1(vanadium) and L2(*fan* 钒)are usually engaged in the same type of language-game,that which refers to natural science. The term 'language-game' here is used in the sense in which it was introduced by Ludwig Wittgenstein,who defined it as a 'system of communication'[247]. Wittgenstein viewed the language-games of science as 'more-or less clear cut language-games' surrounding 'the nebulous mass of language [...the] mother tongue'[248]. The act of translation itself is of course also another and perhaps more complex type of language-game,straddling two natural languages,and coordinating two different ways of verbalising the world.[249]

The process of finding a 'good' translation for a statement in natural science is an evolutionary one which is therefore conditioned by external factors such as the state of scientific theories of matter as well as linguistic questions.[250] What marks scientific language out from the rest of natural language is that some or even most

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[246] Jerry Norman,*Chinese*(Cambridge:Cambridge University Press,1988),20

[247] Wittgenstein,*The Blue and Brown Books*,81

[248] *ibid.*,81

[249] See Ludwig Wittgenstein,*Philosophical investigations*(Oxford:Basil Blackwell,1968),12 for the reference to translation as a language-game.

[250] For instance,'oxymuriatic acid',an obsolete name for 'chlorine',and the German term *Sauerstoff* for 'oxygen',are both 'living fossils',as vestiges of Lavoisier's theory that all acids must contain oxygen.

of its propositions are in principle at least testable(verifiable or falsifiable),depending on what Wittgenstein called the 'scaffolding of facts'[251]. The language of science is 'impersonal,in its essence is untinctured by the particular linguistic medium in which it finds expression'[252],and it would appear that its message 'may be as readily delivered in Chinese as English'[253]. 'The proper medium of scientific expression',wrote Edward Sapir,'is therefore a generalised language that may be defined as a symbolic algebra of which all known languages are translations.'[254]

This view of scientific language,as transcending ordinary language,implies that the ideal language of science would be mathematics,free (perhaps) from all the confusions and ambiguities of natural language.However,in practice science cannot be reduced to mathematical formulae; mathematical statements have to be translated back into 'ordinary' object-language before they can be

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[251] Ludwig Wittgenstein,*Zettel*(Oxford:Basil Blackwell,1967),64e:

> "It is as if our concepts involved a scaffolding of facts". That would presumably mean: If you imagine certain facts otherwise,describe them otherwise than the way they are,then you can no longer imagine the application of certain concepts,because the rules for the application have no analogue in the new circumstances.

These 'facts' include mundane matters such as the relative constancy of shape of objects,human reactions to certain stimuli, the regularity of patterns such as day and night,birth and death... (See Patrick Sherry,*Religion,truth and language-games* (London:Macmillan,1977),71)

[252] Edward Sapir,*Language: an introduction to the study of speech*(London:Rupert Hart-Davis,1970),223

[253] *ibid.*,223. See Michel Foucault *The archaeology of knowledge* A.M.Sheridan Smith trans.(London:Tavistock Publications,1972; reprinted 1992),85-86.

[254] Sapir,223

tested empirically. Yet even this operational 'ordinary' language is highly specialised,and carefully shaped by the scaffolding of which Wittgenstein speaks. It is the verifiability/falsifiability of statements in this generalised language which give it its universal properties[255],and which allow translation of science texts into other languages to be carried out with such precision,and the reference to the external world which allows scientific translators to overcome the formidable theoretical and practical problems of translation.

For scientific (or any other type of)language does not only *picture* reality;it also *creates* it. [256] as Hilary Putnam puts it 'The mind and the world jointly make up the mind and the world.' [257] The dialectical relationship between the external world,the mind and the language in which mind's thoughts are expressed,is the created reality of human consciousness. The grammar(the 'rules of use' of language) which shapes the relationship between language,thought and reality is itself subject to change in the light of new discoveries[258] . When the facts change,so do the meanings of words[259].

5.13 The translation of scientific language

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[255] See John Wilkins,*An Essay towards a Real Character and a Universal Language*(London:S.Gellibrand,1668); and M.M.Slaughter *Universal languages and scientific taxonomy in the seventeenth century*(Cambridge:Cambridge University Press,1982)

[256] See Derek L.Phillips,*Wittgenstein and scientific knowledge: a sociological perspective*(London:Macmillan,1977 reprinted 1979),83 and Karl R.Popper,'On the theory of the objective mind' in Karl R.Popper,*Objective knowledge*,153-190.

[257] Hilary Putnam,*Reason,Truth and History* (Cambridge:Cambridge University Press,1981),xi

[258] Wittgenstein,*Zettel*,12e

[259] Wittgenstein,*On certainty*(New York:J.& J.Harper,1969),10e

Even with the possibility of ostension,the translation from L1 to L2 is still problematic. The 'same' substance may be *sanxiandan* 三仙丹 [Three Immortals Elixir] in Chinese but 'mercuric oxide' in English[260]. Can we therefore say

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260 See *Huaxue jianyuan* 化學鑑原(Shanghai:Jiangnan Arsenal,1872),2.2b.

sanxiandan 三仙丹 --------> mercuric oxide?

There is an equivalence,but it is nebular rather than exact.

Sanxiandan <u>is</u> analytically mainly mercuric oxide,but under the conditions in which it was made it was not pure mercuric oxide. The two referents are therefore not identical chemically. Furthermore,the term 'mercuric oxide' presupposes ideas of chemical elements,chemical synthesis and chemical purity which are absent in *sanxiandan*.

Sanxiandan was made by heating a mixture of nitre,alum and mercury. According to Frederick Porter Smith

> The nitre is put into a small boiler and melted,the alum being afterwards melted and incorporated with it. The mercury is put into the middle of the mass,and after covering it over with a dish,the whole is heated for about an hour and a half. No woman,dog or fowl may look on during the operation.[261]

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[261] Frederick Porter Smith,*Contributions towards the materia medica and natural history of China for the use of medical missionaries and native medical students*.(Shanghai:American Presbyterian Press,1871),147

It can be seen from the last sentence that its production had some magical significance which could be endangered by,or was perhaps dangerous to,women,dogs or fowl; this was not normally the case for mercuric oxide.

Even in translations of the object language there were therefore pressures to avoid such ambiguities by adopting a radically new nomenclature,its very novelty avoiding the associations of the older 'host' language.

Despite these difficulties,the problems which the gloomier forecasters saw as insurmountable proved to be quite soluble without any radical measures,especially as Chinese students began to take part in the practical study of science,and it stopped being merely a linguistic exercise[262].

5.2.The organisation of translations

5.21 The Buddhist translators

Buddhism probably entered China in the first century A.D.,carried by missionaries from Central Asia. Their knowledge of Chinese was often weak or non-existent,and they relied heavily on interpreters,and on Chinese Buddhists who knew no Indian or Central Asian languages[263].

By the time the great translator Kumarajiva arrived in

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262 See Charles F.Hockett,'Chinese versus English:an exploration of the Whorfian theses' in Harry Hoijer(ed.)*Language in culture*(Chicago:University of Chicago Press,1954),106-123,especially p.123:

> Scientific endeavour can be carried on in any language the speakers of which have become the participants in the world of science,and other languages can be modified with little trouble[...]

263 Wright,*Buddhism in Chinese history*,35

Chang'an in A.D. 401 the translation enterprise had become far more sophisticated,with a large number of translators,checkers and revisers,and with improved access to the original sutras. The translation hall(*yichang*譯場)included monks who recited the original texts (*zhiben*執本),translators(*yiyu* 譯語 or *chuanyi* 傳譯) who carried out the actual oral translation,or,if the Dharma-master had a sufficient knowledge of Chinese he would give an oral transmission *koushou* 口授. Copyists(*bishou* 筆授/受) wrote down the first draft,which could then be elaborated (*yan* 演)to give it the correct literary style[264]. The supervising monk,the Dharma-master(*fashi* 法師),would elucidate and commentate upon obscure passages. If the supervisor could not speak Chinese,this first version would then have to be translated back to him by an assistant for his comments,and further revisions made.There would then be checks and further revisions,again referred back to the Dharma-master for his approval[265] The trouble taken is an indication of the seriousness with which correctness of the translation was viewed,as false or inadequate teaching could irreparably harm the chances of the adherents to achieve their religious goals.

5.22 The nineteenth-century scientific translators

The early translators[266] of scientific works in the

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[264] Walter Fuchs,'Zur Technischen Organisation der Übersetzungen Buddhistischer Schriften ins Chinesische' in *Asia Major* 6 (1930),84-103 and E.Zürcher,*The Buddhist conquest of China*,31.

[265] Tang Yongtong 湯用彤,*Han-Wei-Liang Jin-Nanbeichao Fojiaoshi* 漢魏兩晉南北朝佛教史 [A history of Buddhism under the Han,Wei,Jin and Northern and Southern dynasties](Beijing:Zhonghua shuju 中华书局,1963),408-411; and Hurwitz,48-50.

[266] I include compilers of scientific works in Chinese as well as those who actually translated a named text. The compilers generally in effect translated sections of existing English or French texts rather than actually writing their own versions.

19th century faced difficulties similar to those of the early Buddhist missionaries.[267] Working in isolation,with Chinese collaborators who often knew no foreign language and who sometimes had little knowledge of natural science,they had to select suitable texts,and then laboriously construct a lexicon in Chinese which could transmit a natural philosophy totally different in its assumptions from that of traditional China. It is not surprising that some of the earliest examples of compilations such as *Bowu tongshu* 博物通書 (1851) and *Bowu xinbian* 博物新編(1855) avoided technical and theoretical discussions as far as possible,keeping to topics which could be explained relatively simply,and relying on diagrams of experiments rather than any attempt to explain what was going on.

The earliest centre for scientific translation was the Inkstone Press (*Mohai Shuguan* 墨海書館) in Shanghai run by Protestant missionaries such as Alexander Wylie from 1847,and later succeeded by the American Presbyterian Press. The Chinese government itself set up the Translation Department of the Jiangnan Arsenal in 1868.

As with the Buddhists a millennium before,and the Jesuits two centuries earlier,the scientific translators employed the technique of oral translation by a foreigner who knew enough Chinese to transmit the gist of the meaning(*kouyi* 口譯). This was then written down by the Chinese scribe(*bishu* 筆述) into acceptable Chinese. This first draft was then revised and corrected by a proofreader

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[267] Japanese translators of scientific texts sometimes wrote in the style of a Buddhist sutra,beginning with the formula: *Ru shi wo wen* 如是我聞 [Thus have I heard....]. See Togo Tsukahara,*Affinity and shinwa ryoku*(Amsterdam: J.C.Grieben,1993),55 and 118-9. I am grateful to Bridie Andrews for drawing my attention to this point.

(*jiaodui* 校對)before being prepared for printing[268].

The following is an account written in 1880 by John Fryer,chief translator of scientific books at the Jiangnan Arsenal in Shanghai between 1868 and 1896.

> The foreign translator,having first mastered his subject,sits down with the Chinese writer and dictates to him sentence by sentence,consulting with him whenever a difficulty arises as to the way the ideas ought to be expressed in Chinese,or explaining to him any point that happens to be beyond his comprehension. The manuscript is then revised by the Chinese writer,and any errors in style,& c,are corrected by him. In a few cases the translators have been carefully gone over again with the foreign translator,but in most instances such an amount of trouble has been avoided by the native writers,who,as a rule,are able to detect errors of importance themselves,and who,it must be acknowledged,take great pains to make the style as clear and the information as accurate as possible. A fair copy having been made,the work is placed in the hands of the foreman of the printing department,who causes it to be written out on sheets of thin transparent paper in the large bold block-characters of the "Sung[Song 宋]" pattern,and pasted on blocks ready for the engraver.[269]

This description grossly devalues the role of the

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[268] Tsien,305-307

[269] John Fryer,'Science in China' *Nature* (May 19,1881),55 See also T.Carter,*The invention of printing in China and its spread westwards* 2nd edition (New York:The Ronald Press Co,1955),34 for a description of the preparation of the wood block.

Chinese writer who did far more than simply transcribe the words 'dictated' to him by the foreigner. The foreign *kouyi* 口譯 was speaking in colloquial Chinese(sometimes of doubtful quality),whereas the Chinese *bishu* 筆述 was in effect translating the foreigner's colloquial into literary Chinese,a very different language,and this demanded of him a thorough understanding of the scientific issues being transmitted. In some cases(such as those of Li Shanlan and Xu Shou) the Chinese collaborator was intellectually considerably more distinguished than the foreign translator.

According to Hua Hengfang,there were several drafts prepared before the final version went to press. Hua calls them the *gaoben* 稿本 'rough draft',the *gaiben* 改本 'revised draft' and the *qingben* 清本 'fair copy'[270]. It seems likely from Fryer's account that the bulk of the redrafting could only be done by the Chinese translator. The early Chinese translators had after all no knowledge of any foreign tongue,so that the transition from the English syntax to literary Chinese was often tortuous. [271]

Fryer went on to explain why wood blocks were used rather than movable metal type which had,after all,been invented in China.

> It may seem strange that with such facilities for printing in Chinese by metal type as exist in Shanghai,and with a complete fount of such type as well as a good cylinder press on the premises,these books are nevertheless cut on wooden blocks and printed by hand,in the old-fashioned way that existed in China for so many

[270] Hua Hengfang,Preface to *Dixue qianshi* 地學淺釋,1a

[271] Hua Hengfang,*ibid.*,1a

> ages before printing was known in Europe. The fact is,however,that as a matter of economy and convenience the old system is preferable. The blocks are all about the same size,about eight inches by twelve inches,and about half an inch thick. Each block represents two leaves or four pages of the book,being engraved on both sides. The blocks for a complete work can this be stowed away in a very small compass. The cost of engraving a page of these wooden blocks is said to be but little more than the expense of setting up a page of Chinese type and preparing it for the press. An edition of one copy can be printed if no more are required,and thus the expense of keeping a large stock of printed books on hand,some of which might eventually have to be sold as waste paper when they grew out of date or revisions had to be made,as is the case ourselves,is entirely avoided. Any errors or misprints that may be discovered can as a rule be corrected on the blocks with but little trouble.a skilful printer can print by hand five thousand leaves of two pages each in a day,using no press or machinery whatever. He supplies his own tools and receives as wages about twenty-five dollars a day.The paper ordinarily used is white and of the best quality,although a yellowish kind is also made use of at a reduction of 20 per cent. on the selling price. The books are bound in the usual Chinese style and fastened with white silk thread. They present an appearance which satisfies the taste of the most fastidious native.[272]

It may be seen that the organisation had not altered

[272] Fryer,'Science in China',55.

materially since the days of Kumārajīva,although it would appear from the passage quoted above that Fryer had a more casual attitude towards the checking of his work than the Buddhist translators.

An article written over forty years earlier gave a less sanguine view of the advantages of block printing over lithography and typography. 'Typographus Sinensis',writing in the *Chinese Repository* of October 1834,estimated that printing an octavo edition of 2000 copies of the Bible would cost £1900 to be block printed,£1261 to be lithographed,and £1498 to be printed by movable type. The long term advantage of metal type was the immense numbers of copies that could be produced.[273]

The difference between these views can be easily resolved: the scientific books the Jiangnan Arsenal was publishing sold relatively small numbers. In the period 1871-1879 only 83,454 *juan* in total were sold of a total of 98 works[274],so that it is clear that the print runs were on average below 1,000 copies,and many were probably much less. The advantages of block printing for such small runs were probably overwhelming,whereas for the missionary distributing tracts the blocks were slow to produce and were unreliable after 10,000 impressions. Typographic production could generate millions of tracts from a single setting,and economies of scale would then play a larger role than the initial cost of the type and cost of setting.

5.3 Methods of translation:strategy

5.31 Features of the Chinese language

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[273] *CRP* **3**,6(October 1834),246-252. See also *CRP* **1**,10(February 1833),414-422 on Chinese printing methods.

[274] Fryer,'Science in China',57

It was seriously suggested by some 19th century commentators that the translation of science into literary Chinese was impossible. The reasons given were usually the alleged 'vagueness' of Chinese,a reference to the fact that it is uninflected,the nouns shows no change according to number,and so on.[275] The nature of the Chinese language certainly posed the translators difficulties which they would not have faced in translating between European languages.

Most *wenyanwen* 文言文 words are monosyllabic monomorphemes[276],that is to say they are simultaneously *quanta of meaning,quanta of sound,*and *quanta of visual symbolism.*

This means that,for instance,the graph 钒 is a single syllable */fan/* and is also a morpheme 'vanadium'. This triadic relationship

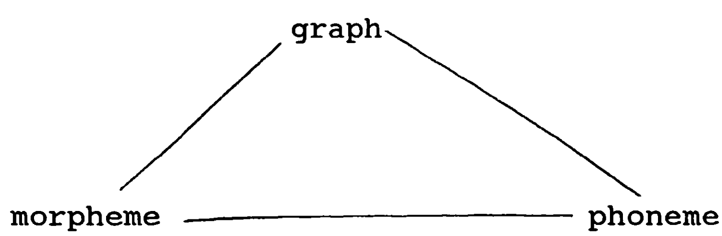

Figure 13. The triadic relationship of graph to morpheme to phoneme

[275] The Chinese language being yet in a state of vagueness,makes it impossible to enter into scientific details with sufficient exactness to convey definite notions. A term-question-dragon is lurking in all deep waters ready to bring woe unto him who enters into the depth of any subject.Happy are those diffusers of Western knowledge in Chinese language that keep in shallow waters.

(Ernst Faber in 'Methods of imparting Western knowledge to the Chinese' in *JCBRAS* **21**(1886),15)

[276] M.A.French,'Observations on the Chinese script and the classification of writing systems' in W.Haas,*Writing without letters*(Manchester:Manchester University Press,1976),103

makes the problems of translation into Chinese almost unique.

The script has had many effects on Chinese culture,including a strong resistance to phonetic loans,which has reinforced the relative weakness of foreign influences on Chinese culture[277]. It may even have affected the way in which the Chinese viewed the material world,as a phonetic script leads one naturally to the idea that all substances may be ultimately built of the same few building blocks,just as all words are built of a small number of basic letters. However,the claim that the script was a block to scientific thought seems to be amply refuted by the brilliance of Chinese scientific achievements.

The disadvantages of such a script - the enormous number of characters to be remembered,the great difficulty of compiling indexes,and above all the enormous time and effort required to become proficient in it - were for some

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[277] There have of course been some striking contrary instances such as the influx of Buddhism,but nevertheless the point stands that Chinese civilisation,as a whole,probably owes less to foreign influences than most other great cultures.

On the question of loan-words see: Wang Lida 王立達,'Xiandai Hanyu zhong cong Riyu jielai de cihui' 現代漢語中從日語借來的詞彙[Japanese loan-words in modern Chinese vocabulary] in *ZGYW*(1958,2),90-94; Zhou Youguang 周有光,'Wailaici pinyinfa wenti'外來詞拼音法問題 [The problem of romanising foreign loan-words] in *ZGYW*(1959,3),106-113; Shi Shenghan 石聲漢,'Shi lun woguo cong "Xiyu" yinru de zhiwu yu Zhang Qian de guanxi 試論我國從西域引入的植物與張人的關系 [A tentative discussion on the connection between plants introduced from the "Western Regions" and Zhang Qian] in *KXSJK* (1963),16-33; Zdenka Novtná,'Linguistic factors of the low adaptability of loan-words to the lexical system of modern Chinese' in *MS* **26**(1967),103-118.

foreign missionaries so exasperating that they proposed that China should abandon characters altogether for a phonetic script.

5.311 The structure of the Chinese script

Traditionally,Chinese characters have been categorised into five major types[278]:

(a)pictographs(*xiangxingzi* 象形字):

mu 木 'tree;wood',originally written  ;*shui* 水 -'water',originally  .

(b)compound characters(*huiyizi* 會意字):

ming 明 'bright',built of 'sun' and 'moon'; *sen* 森 'forest' built of three 'wood' characters.

(c)indicative characters(*zhishizi* 指事字)
ben 本 'root'

(d)radical-phonetic characters(*xingshengzi* 形聲字)*tong*銅 'copper' is made of the metal radical 金 and the element *tong* 同 'same',which indicates the pronunciation[279].

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[278] A sixth category *zhuanzhu* 轉注 seems to be of dubious status.

[279] The status of phonetics is controversial. Some authors have claimed that they are not only phonetic symbols,but also the metaphors,which relate to the meaning of the whole character. This view was put forward by Liang Qichao 梁啓超 in his article 'Cong fayin shang yanjiu Zhongguo wenzi zhi yuan' 從發音上研究中國文字之源 [Research into the phonetic aspects of the origin of the Chinese script] in *Yinbingshi heji* 飲冰室合集 Vol.4 [Collected works from the Ice-Sipper's Studio],37-47. The hypothesis,though attractive,seems far from being proved. See also Arthur Cooper, *The creation of the Chinese script*(London:The China Society,1978)

(e)false borrowings(*jiajiezi* 假借字). Characters of this type were used to stand for a word which previously had no written form,but which had the same pronunciation. For example *wan* 萬 'scorpion' was used for 'ten thousand'. This technique tended to be used for more abstract terms which could not be given a pictograph,and for grammatical particles(such as the sentence final particles *ye* 也 and *er* 耳,originally meaning 'vessel' and 'ear' respectively.)

<u>5.32 The translation of foreign terms</u>

In translating terms from L1 to L2 there are five(or,strictly,four) alternatives:

(i)Not translating the term at all,leaving it as a piece of L1 embedded as a *xenologue*[280] in the matrix of L2.[281]

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for a poetic interpretation of the same idea. The ideal of a phonetic which matched both the sound of the foreign word and related to the meaning of the whole character certainly influenced the creators of some new chemical terms.See below,Section 5.35.

[280] I propose this neologism to mean 'a piece of the written form of language L1 embedded unchanged,*recognisably foreign*,in a matrix of another written language L2',by analogy with the term 'xenolith' in petrology. Such xenologues are commonplace in European languages: *Schadenfreude,savoir faire,pizza,anorak,*etc. All xenologues are loan-words,but in Chinese not all loan-words are xenologues: many words borrowed from Japanese into Chinese in the late 19th and early 20th century,such as *jingji* 經濟 'economics',*kexue* 科學 'science' and *geming* 革命 'revolution' are <u>not</u> xenologues,because they are written in Chinese characters and normally pronounced according to the 'Chinese' sound-value,thus concealing their Japanese origin. Xenologues are extremely rare in pre-modern Chinese,but they do occur,for instance the swastika 卍 ,imported via Buddhism from India and given the pronunciation *wan*. See Liu Yueyun 劉嶽雲,'Fanwen youxing wuyin zi shuo ' 梵文有形無音字説 [On Sanskrit terms with a graph but no pronunciation] in *Shijiude Zhai jizhu* 食舊齋箸 [A collection of works from the Studio for Absorbing Ancient Virtue](1897),1.44a-45b

[281] A suggestion by Zhao Yuanren in 'Zai lun zhuyin zimu yiyinfa 再論注音字母譯音法 [The phonetic method of transliterating sounds reconsidered]' in *Kexue* 8,9(1923-24),888-902 was to use

It would have created serious practical difficulties for Chinese texts written in vertical columns to accommodate Western words usually written horizontally. The Western word could be written down the page,on its side(as is done today in books printed in Taiwan),but this inelegant solution was not appealing to printers nor,probably,would it have been accepted by most readers.

In Western languages,xenologues are a common phenomenon,particularly in religious writing,in which reverence for their antiquity and incantatory power meant that alien words and phrases - such as *Amen* - remained intact,untranslated,as well as in technical discourses on cookery,music,ballet,and so on. However,they are at least written in the same (or a slightly modified) Latin alphabet. The foreign-ness of a piece of Western script embedded within a matrix of Chinese is - even today - striking and disturbing,and in the nineteenth century was undoubtedly likely to increase readers' resistance to the foreign term.

An awareness of this prompted some translators to avoid even the conventional mathematical symbols used in the West,preferring to make up their own system derived from Chinese script which they thought would be better camouflaged.[282]

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a phonetic system to write foreign names rather than the *ad hoc* transliterations which existed at that time. A more radical proposal by Liu Zexian 劉澤先 in 'Cong kexue xin mingci de fanyi kan Hanzi de quedian' 從科學新名詞的翻譯看漢字的缺點[Seeing the shortcomings of Chinese characters from the translation of scientific terms] in *ZGYW* **14**(August 1953),9-13 was to write the foreign names in their original script.

[282] See Section 9.1 For a modern example of a personal mathematical notation which had eventually to be abandoned see Edward Hutchings(ed.)*Surely you're joking,Mr Feynmann?*(London:Vintage,1985),24

(ii)Transliteration[283] of the sounds into the phonemes and then the graphs employed in L2. This is the method employed most commonly in Chinese texts for foreign personal- and place-names,but relatively rarely for terms in scientific translation,with the exception of organic compounds.

(iii)The use of an existing term in L2. This was the method favoured by early Buddhist translators who generally preferred translation to transliteration[284],employing the method known as *geyi* 格義 'matching concepts',the matching usually being with neo-Daoist terms.[285] *Geyi* gradually fell out of favour as it was felt to corrupt Buddhist doctrine with Daoist ideas,and the transliteration of Sanskrit and other foreign terms predominated from the 6th century onwards.

A striking case of the difficulty of adopting an existing term was the controversy over the correct translation of 'God' in Chinese.The Roman Catholics eventually agreed the term *Tianzhu* 天主 [Lord of Heaven] for 'God'[286],but the 19th century Protestant missionaries found it impossible to agree on a satisfactory alternative,the main contenders being *shen* 神,which had the necessary spiritual connotations,but was regarded by some as <u>too</u> widely used for all manner of water-sprits,wood-spirits,etc.; and *Shangdi* 上帝,a Supreme Being who had been

283 Usually called 'transfer' in the nineteenth century.

284 See Tang Yongtong,*Han-Wei-Liangjin-Nanbeichao Fojiaoshi*,409-409

285 E.Zürcher,12; T'ang Yung-t'ung,'On "ko-yi",the earliest method by which Indian Buddhism and Chinese thought were synthesised.' in W.R.Inge(ed.)*Radhakrishnan:Comparative studies in philosophy* (London:Allen & Unwin,1951),276-286; and Arthur F.Wright,*Buddhism in Chinese history*,36-38

286 After a papal decree in 1715 had forbidden the use of *Tian* 天[Heaven] and *Shangdi* 上帝[Supreme Emperor].

mentioned in the Classics.[287] The dispute was never resolved,different missionary groups adopting one or other of the terms.[288]

The scientific translators did sometimes use existing terms. According to John Fryer,the procedure used was

a.To search in the principal native works on the arts and sciences,as well as those by the Jesuit missionaries and recent Protestant missionaries;

b.To inquire of such Chinese merchants,manufacturers,&c.,&c.,as would be likely to have the term in current use.[289]

In practice,though,at the Jiangnan Arsenal Translation Department existing terms were rarely used,because they were often thought to be too misleading(as in the case of *sanxiandan* above),or too vulgar(the term *woqian* 倭鉛[dwarf(=Japanese)] lead] already existed for 'zinc',but they preferred to make a new term such as *xin* 鋅 [290] or *xing* 鋥 [291].

(iv)The formation of a new term by combining two existing terms in L2. In Chinese this was by far the most

[287] See Douglas G.Spelman,'Christianity in Chinese: the Protestant term question' in *POC* **22A**(1969),25-52.

[288] S.Wells Williams,'The controversy among the Protestant missionaries on the proper translation of the words God and Spirit into Chinese' in *Bibliotheca Sacra* **35** (1878),732-778

[289] John Fryer,'Science in China',54. The term for 'acid' *qiangshui* 強水,for instance,was adopted from Jesuit writings.

[290] In *Huaxue jianyuan* 化學鑑原.See Table 1.

[291] In *Huaxue chujie* 化學初階.See Table 1.

important way in which scientific and technical terms were and are still translated. The term for electricity *dianqi*電氣 came from *dian* 電 'lightning' and *qi* 氣 'vapour';*huoche*火車 'train' derived from *huo* 火 'fire' and *che* 車 'vehicle'. It was this facility which allowed the majority of scientific terms to be translated without the formation of new characters.

The formation of technical terms was not an easy matter. As Calvin Mateer,the great missionary educator of Dengzhou College in Shandong,said

> Good terms are not often made off-hand. They are generally the result of experience,together with careful thought and large knowledge of the genius and resources of the language. A good term is supple in use,adapting itself readily to varying conditions and forms of expression. a poor term is like a crooked stick that will fit in only one place.[292]

(v)The formation of a new character such as *fan* 釩 for 'vanadium' or the resuscitation of an archaic one such as *xin* 鋅 for 'zinc'[293]. This process occurred mainly in the formation of the chemical nomenclature,in which in was felt that each element needed its own unique character,and certain sorts of compounds such as alcohols,aldehydes and phenols also needed to be named. This process will be discussed below.

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[292] George A.Stuart (ed.)*Technical terms English and Chinese prepared by the Committee of the Educational Association of China* 2nd ed.(Shanghai:Methodist Publishing House,1910),1

[293] Although this involved altering the original pronunciation,which was *zi* rather than *xin*.

5.33 The transliteration of foreign terms

The borrowing of foreign words is an important mode of the evolution of any language,but languages vary dramatically in the ease with which they absorb foreign words phonetically. As Edward Sapir said

> It seems very probable that the psychological attitude of the borrowing language itself has much to do with its receptivity to foreign words.[294]

This receptivity can be likened to the immune system in the human body,which also varies in its intolerance of alien tissue from person to person. Some languages(such as English and Japanese) are very tolerant towards the inoculation of external phonetic borrowings,others(such as German and Chinese) more intolerant,and the latter tend to prefer the creation of terms from within the resources of the native language.

Just as for the material for a tissue transplant,which has to be as near as possible in type to the host tissue,languages are most tolerant towards words which mimic the 'type' (phonetically,graphically and morphologically) of the host language. This may partially explain why Chinese,in which most words have one or two syllables,finds the absorption of polysyllabic transliterated terms from Western languages(let alone the use of the Latin alphabet) so uncomfortable,whereas the two character phrases of so many loan-words from Japanese presented a 'Chinese' appearance which prevented their rejection.[295]

5.331 The rebus technique

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[294] Sapir,194

[295] See n.280 for examples of loan-words from Japanese.

The method of using a symbol which originally represented a *thing* to stand for a *sound* is known as the 'rebus' technique.In English,the symbol  might stand for 'I' in a children's puzzle,but in non-alphabetic scripts the rebus technique is a serious and important method of transcribing words,such as grammatical particles and foreign names,which do not correspond to things. It has been used by the writers of scripts as diverse as Mayan glyphs[296] and Egyptian hieroglyphic[297].

This method is of great antiquity in Chinese. The 'false borrowing'(*jiajie* 假借) category of characters are no more than rebuses,as in all cases they were originally pictographs. The Chinese use of characters in this way has the following characteristics:

(i)the characters used still retain at least a residual *'halo'* of their original meaning[298].Sometimes the characters used manage cleverly both to imitate the sound of the foreign word <u>and</u> echo the meaning,as in *Kekoukele* 可口可樂 [Coca-Cola],which means,roughly translated,'tasty and enjoyable'. There are many technical terms in which the translation is <u>partially</u> a

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[296] The Mayan script was,like Chinese,originally probably pictographic,but it developed a sophisticated rebus system in which the same word could be expressed by several different graphs. See S.D.Houston,*Maya glyphs*(London:British Museum Publications,1989),37

[297] For instance,the hieroglyph for 'mouth'  *r'i* came to be used as the as the symbol for any syllable beginning with the letter 'r' with a following vowel,as in the famous cartouche for 'Cleopatra' on the obelisk from Philae,which Champollion used to begin his decipherment.See Sir E.A.Wallis Budge,*Egyptian language*(London:Routledge & Kegan Paul,1910)Chapters 1 and 2,and John F.Healey,*The early alphabet*(London:British Museum Publications,1990),16

[298] Chao Yuen Ren[Zhao Yuanren 趙元任],*A grammar of spoken Chinese*(Berkeley:University of California Press,1968),139

> In the technical terms derived from foreign borrowings,there is a strong tendency,whenever there is a chance,to read Chinese monosyllabic meanings into foreign polysyllables or even consonant clusters.

transliteration,as in *tuolaji* 拖拉機[tractor],in which the first two characters translate as 'drag' and 'pull',as well as roughly corresponding to the 't' and 'ra' sounds of the English word 'tractor'[299]

The 'root' meaning of most characters used in transliterating foreign proper names is usually submerged,as it were,but at times of crisis may return to the surface,as when foreigners object to the supposedly derogatory characters used in transliterating their names or the name of their place of origin[300]. Sometimes even the elements constituting the graphs may be regarded as imparting a meaning to what was intended merely as a phonetic emblem.[301]

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[299] This example is given in Chao Yuen Ren,*A grammar of spoken Chinese*,139.

[300] In early 1989 there was considerable friction between Chinese and African students at a number of Chinese universities. The Africans accused the Chinese of racism,citing(amongst other things) the negative connotations of the word *fei* 非 in *Feizhou*非洲 'Africa',contrasted with the *ying* 英 ('hero')in *Yingguo* 英國[England] and *mei* 美 ('beautiful') in *Meiguo* 美國(U.S.A.).See Jasper Becker,'China urged to act fast on African student row',*The Guardian* (5th January,1989),9 and Philip Snow,*The Star Raft: China's encounter with Africa*(London:Weidenfeld and Nicolson,1988) for a general account of China's relations with Africa.

Chiang Kai-shek during the Anti-Japanese War claimed that the Japanese name for America *Miguo* 米國 [rice country] indicated that the Japanese intended to swallow its rival on the Pacific rim. See Arthur F.Wright,'The Chinese language and foreign ideas' in A.F.Wright(ed.)*Studies in Chinese thought* (Chicago:University of Chicago Press,1953),299.

Occasionally there seems even to have been sardonic humour in the choice of characters,as in *laifu* 來福 'bringing happiness' for 'rifle'.

[301] A recent Governor of Hongkong,Sir David Wilson,changed his adopted Chinese name from Wei Dewei 魏德魏 to Wei Yixin 衛奕信 when he became Governor,because the residents of the territory felt that the two *gui* 鬼 [ghost] elements in the graphs

ei 李 徽 ,'Cong Xianggang xin wailai gainian yuci dao ciku

ei 李 徽 ,'Cong Xianggang xin wailai gainian yuci dao ciku

(ii)because there is no unique way of phoneticising,let alone transliterating,a foreign word[302],there has often been a profusion of different attempts to render the same words in Chinese[303].The immense possibilities for confusion have led to attempts at standardisation,especially at times in Chinese history when large numbers of loan-words were entering the language.

<u>*5.332 The use of transliteration by the translators of Western scientific and technical texts*</u>

The translators of Western texts were faced with a formidable task. By the mid-nineteenth century,Western science had developed an enormous specialist vocabulary,derived partially from Greek and Latin roots(*geology,Carboniferous*),but also including many proper names(names of minerals,elements,geological epochs,chemicals,botanical names,etc).

> For these there was little choice but to
>
> phoneticise the foreign term,using the sounds of the Mandarin dialect,and always endeavouring to employ the same character for the same sound as far as possible,giving preference to characters most used by previous translators or compilers.[304]

Transliteration was severely limited by the great distance in linguistic terms between Chinese and the

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jianshe 从香港新外来概念语词到词库建设 '[From new concept loan-words in Hongkong to the establishment of a word storehouse]in *YYJXYYJ* **4**(1992),35.

302 See Chao Yuen-ren[Zhao Yuanren],'The non-uniqueness of phonemic solutions to phonetic systems' in *BIHP* **4** (1933),363-397

303 Xiao Zhengfang,35.

304 Fryer,'Science in China',54-55

foreign languages:there were virtually no already existing shared lexical elements,and this made borrowing far more difficult than between say French and English or English and German [305].The translators were well aware of the difficulties[306],and the 'uncouthness' of transliteration was always keenly felt,and accounts for its general avoidance wherever possible. Even Daniel Jerome Macgowan,who had used transliteration widely in several of his books,felt that such polysyllabic clusters employed in the naming of plants 'which if the translation had no other defects [render] it almost valueless.'[307] We also have the account of his collaborator Hua Hengfang describing their work on the translation of J.D.Dana's *Manual of Mineralogy*

> The substances discussed in this book include those with a Chinese name and those with no Chinese name,and some whose Chinese name we did not know and which it was not easy on the spur of the moment to investigate. For every translation we discussed many times how to render the term. For those with Chinese names,we used the Chinese terms; for those without a Chinese name,or whose name was unknown to us,we used the Western term,translating its meaning. However,there were some whose names derived from the names of people or places,and had no meaning,so could not be translated,and others were somewhat vulgar,and likewise could not be translated:for these we

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[305] Jean Aitchison,*Language change: progress or decay?*(London:Fontana,1981),120-121

[306] Servus(E.C.Bridgman),'The Bible:its adaptation to the moral condition of man;remarks on the qualifications of translators and the style proper for a version of the scriptures in Chinese.' in *CRP* **4**(November 1835),297-305

[307] Daniel Jerome Macgowan in 'Methods of imparting Western knowledge to the Chinese',*JCBRAS* **21**(1886),11-12. The translation referred to is *Zhiwuxue* 植物學[Botany] which he carried out with Li Shanlan.

> used Chinese characters for the sounds of the Western name,with the result that the translated names are hard to pronounce,and cannot be connected together in prose. It is not uncommon to encounter as many as five,six,or even seven and eight characters in succession [in such transliterated terms]. Yet the original book arranges them in order and mentions then together in order to compare one substance with another,with the result that several names are connected together with several comments upon them:this makes it difficult to ascertain where sentences begin and end. The reader therefore needs particles or empty spaces to separate them so that the names do not merge into one another. All this is because we could not avoid it,not because we wanted to waste paper.[308]

The use of transliteration(*yinyi* 音譯) in scientific translation was always somewhat limited,the formation of new terms being much preferred[309]. Apart from early attempts in the naming of minerals and chemical elements[310],the largest group of words translated in this way were the names of organic compounds.

Nevertheless,as the Buddhists had discovered over a millennium earlier,the great advantage of transliteration

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[308] Hua Hengfang,Preface to *Jinshi shibie* 金石識别 dated 1872 in Zhang Yinhuan 張陰桓(ed.) *Xixue fuqiang congshu* 西學富强叢書[Collectanea on achieving wealth and power through Western studies](Hongwen shuju 鴻文書局,1896),5 *ce*.

[309] Liu Zexian 劉澤先,*Kexue mingci he wenzi gaige* 科学名词和文字改革[Scientific terms and language reform](Beijing:Wenzi gaige chubanshe 文字改革出版社,1958),29. Liu points out that the inconsistencies of transliteration,and its clumsiness,have led to 'translation by meaning' supplanting many transliterated terms.

[310] In *Jinshi shibie*.

is that it <u>is</u> alien,and does not therefore bring to the reader's mind all kinds of misleading comparisons.[311] It also avoids the proliferation of new characters,especially of homophones,which are bound on occasions to cause confusion in speech.

5.333 The transliteration used in the names of the chemical elements

A comparison of the characters used in transliterations of the chemical elements in *Jinshi shibie* with those used as transcriptors in Buddhist texts,in *Yuanchao bishi* 元朝秘史[The secret history of the Mongols],and in *Haiguo tuzhi* 海國圖志[Illustrated gazetteer of the maritime countries][312],reveals that the majority of the transcriptors had indeed already been used,yet there was little system in the nineteenth century transliterations. The same sound is transcribed by a number of different characters,and there seems to be no obvious pattern in the way they chosen,and this served to reinforce the prejudice against transliterations,as the same Western term existed in several different versions.

5.334 Transliteration and taboo names

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[311] Herbert J.Allen claimed,rather despairingly,that transliteration was the only choice,as

> there is such an absolute dearth of words in Chinese capable of translating the scientific names required in teaching geology,chemistry and the other sciences,that the only way sometimes is to give the sound of the English word in Chinese characters.

(In 'Methods of imparting Western knowledge to the Chinese' in *JCBRAS* **21**(1886),18)

[312] I have carried out this comparison but do not have space to include it here.

The taboos surrounding the Emperors' personal names(and those of their ancestors),both the characters themselves and their homophones,were an additional hazard which the translators had to negotiate,and may even have had a minor effect on usages. During the period in question the Emperors' personal names were taboo characters[313],and an examination of the characters used in transliteration shows that these characters and their homophones were indeed avoided. It is not easy to prove the effect of this on transliteration,as avoidance is by its nature unseen - and also not written about - ,but perhaps in the case of the element bromine,given in *Jinshi shibie* 金石識別[The identification of minerals][314] as *boluoming* 孛羅明,there seems to be no other obvious reason to prefer the syllable *ming* to *min* to transliterate the syllable '-mine' [315],the choice of character may perhaps reflect a taboo on the syllable *min*. The character *chun* 醇 for 'alcohol' was usually written 䣍 by the translators rather than 醇 ,presumably also to avoid a similar character in the Tongzhi Emperor's name.[316]

5.335 Transliteration:conclusions

[313] See Chen Yuan 陳垣,*Shihui juli* 史諱舉例[Examples of historical taboo words](Beijing:Kexue chubanshe科學出版社,1958),169.

[314] A translation of J.D.Dana *Manual of mineralogy*. *Jinshi* 金石 would traditionally have meant 'metals and stones',but in this period was used for 'minerals'.

[315] 'Fluorine' is given as *fuluolin* 弗羅林 in *Jinshi shibie*,with no nasalisation of the final syllable.

[316] There is some corroborative evidence for this speculation. Dong Xun 董恂changed his *ming* 名 from *chun*醇 to *xun* 恂 in 1861 in order to avoid the Emperor's name,even though it was not strictly a taboo. See Hummel,790. John Fryer mentions this issue in 'Scientific terminology: present discrepancies and means of securing uniformity' in *Records of the General Conference of Protestant Missionaries*(Shanghai:American Presbyterian Mission Press,1890),531-549.

Transliteration was always regarded by the scientific translators as a poor alternative to direct translation. The lack of a system(which was beginning to grow up around the Buddhist translations of the Han and Tang dynasties,and the Yuan transcriptions of Mongolian,but was never fully standardised) meant that any transliterated term was likely to exist in a number of different forms,thus greatly confusing an already confused situation of chemical nomenclature. An ideal system of transliteration would have denoted certain characters as *transcriptors*,chosen for their relative rarity,but transparent phonetic value(as happened for instance with certain characters such as *ma* 瑪[agate],etc);a more radical step would have been a syllabary on the lines of the Japanese *katakana*. For some reason this step was never taken,probably because of the status of the written characters,which would have been compromised if a syllabary had been adopted.

5.34 The formation of new terms

The principle of the formation of new scientific terms was set out by John Fryer in 1881

> Invent a descriptive term,using as few characters as possible.[317]

The majority of new scientific terms,outside chemistry,were made by combinations of existing characters,chosen for their meaning rather than their sound(*yiyi* 意譯 'translation by meaning'). For instance,in electricity, resistance:*dianzu* 電阻 'lightning + to obstruct'; voltage:*dianya* 電壓 'lightning + to press'

Chinese showed itself to be remarkably flexible in generating such terms,and,once accepted,they generally

[317] Fryer,'Science in China',54

displaced their transliterated counterparts[318]. (In contemporary Chinese, new terms such as 'laser', 'paradigm', and so on are nearly always rendered in this way, with transliteration only used when unavoidable, for instance where someone has given their name to a theorem, effect or process.)

The question of standardisation, was a difficulty which has even today not been fully solved, with different versions of Western politicians' names appearing in newspapers published in the People's Republic of China, Hongkong and Taiwan. There comes a point at which whatever is the most widely current version becomes the standard, whatever its shortcomings as a phonetic transcription, and even if it has resulted from a misunderstanding.[319]

Once standardisation was achieved, or as part of the process of standardisation, lists, glossaries and vocabularies were produced, so that the confusion could be minimised.

5.35 The creation of new characters

One of the striking features of the nineteenth century chemical translations was the number of "new" characters that were created. These *xinzi* 新字 were often not really "new": a significant number were actually obsolete characters taken from the *Kangxi Zidian* 康熙字典 or some

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[318] For instance, *hali* 蛤利 was used for 'alkali' in some early texts, but was displaced by *jian* 碱.

[319] See Liang, 'Lun yishu', 72. Liang pointed out that the standard term for 'Siberia' [*Xiboliya* 西伯利亞] ought really to be *Xibi'er* 悉畢爾, but that such changes would be too confusing. See also Yao Hanming 姚汉铭, 'Shilun xinciyu yu guifanhua' 试论新词语与规范化 [On neologisms and standardisation] in *YYJXYYJ* (1995,1), 82-95.

other source,chosen because they had a suitable radical and/or phonetic[320].

Nevertheless,a large number of new characters <u>were</u> created,particularly by the translators of chemistry texts. This was criticised by later writers as 'Everyone wanting to be his own Cang Jie 倉頡[the legendary creator of the Chinese script]'[321],but most missionary translators felt they had no choice,and set about their task with some relish. Much acrimony was generated as rival translators argued for the superiority of their own creations. There were no suitable existing characters for most of the newly discovered chemical elements,or for many classes of compounds such as aldehydes,ketones,ethers,esters,and so on. Transliteration was generally thought to be too clumsy[322],and compound term formation,though possible[323],created difficulties in rendering chemical formulae,where there really had to be a single symbol for each element if the formulae were not to be confusing.

The new characters were created either by attempting to form a *huiyizi*,using graphs which described the substance in question,such as: 金骨 calcium (metal radical and 'bone' 骨)[324] or by making a *xingshengzi* 形聲字 by simply choosing a suitable radical(usually metal or stone),and then taking a character with the proper sound as the

[320] Fryer,'Scientific terminology',542; and Liang Qichao,'Lun yishu',74

[321] Liu Zexian,'Cong kexue xin mingci de fanyi kan Hanzi de quedian',12 and Aylmer,3.

[322] John Fryer,'Scientific terminology',538

[323] As in chlorine:*lüqi* 綠氣 'green gas' and oxygen *yangqi* 養氣 'nourishing gas'.

[324] Proposed by Calvin Mateer in 'Revised list of the chemical elements' in *CR* **29**(February 1898),94ff.

phonetic. (The 'proper' sound usually being the initial syllable of the English word),the preferred method of John Fryer and Xu Shou in *Huaxue jianyuan* 化學鑑原 and its sequels.

Fryer described the creation of the new character thus:

> Make a new character,the sound of which can easily be known from the phonetic portion,or use an existing but uncommon character giving it a new meaning. [325]

For example,

molybdenum *mu* 鉬 (*mu* 目 'eye')[326]

In such cases the original meaning of the character chosen as a phonetic was irrelevant,but there were also attempts by some writers to create characters in which the sound of the phonetic <u>and</u> its primary meaning were chosen to match the element in question,such as

osmium *e* ⿰金惡,in which the phonetic *e* 惡 'evil' was chosen both as an approximate phonetic and to match the original meaning of the name osmium,from the Greek *osme* 'evil-smelling'[327].

One inevitable consequence was the formation of many homophones or near-homophones.although in practice the confusion caused was less serious than might have been expected,in everyday speech people preferred to use dissyllabic terms where these were less ambiguous e,g. *lüqi* 綠氣 for chlorine gas rather than *lü* 綠,and *baijin* 白金 rather

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[325] Fryer,'Science in China',54

[326] In *Huaxue jianyuan*

[327] This character was also proposed by He Liaoran and John Kerr in *Huaxue chujie*.

than 鉑 for platinum.[328]

5.4 The translation of scientific texts into Chinese

5.41 The aims of scientific translation

During the nineteenth century,the translation of science texts was taken seriously first by Protestant missionaries in the late 1840s and by the 1860s the Chinese government themselves decided to invest in the project,at the Jiangnan Arsenal and other institutions.

The missionaries saw the propagation of Western science as part of their mission in China,to open the minds of the Chinese to Western philosophy and the Western religion. Western science,though not in itself directly a means of evangelism,was thought by its nature to dispose the student to accepting the truths of Christianity. This was true even of the so-called 'secular missionary' John Fryer,who seemed to see his role almost as much as an evangelist as a science educator. The message was the superiority of Western culture over Chinese culture,and that nothing less than a wholesale rejection of the latter would suffice to bring China into the modern world.

The Chinese were firstly interested in Western military technology,but those who studied the building of ships and guns soon recognised that the science which lay behind them had to be mastered before the Chinese could hope to develop their own industry. The translation of textbooks was one means of propagating this knowledge relatively cheaply,but as the project got under way it became clear that the technology was not only a matter of 'skills' which could be picked up,but also a way of thinking about the material world which could only be acquired through a long period of study.

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[328] Liu Zexian,*Kexue mingci he wenzi gaige*,49

5.42 The possibility and necessity of scientific translation

There were foreigners in China who disputed that Chinese could ever be the vehicle for scientific instruction. Their arguments usually centred on the alleged 'imprecision' of the literary language. In a discussion in 1886 between missionaries on 'Methods of imparting Western knowledge to the Chinese', Ernst Faber regarded translations into Chinese of scientific works as 'either impossibilities or monstrosities'.

> The Chinese language being yet in a state of vagueness, makes it impossible to enter into scientific details with sufficient exactness to convey definite notions.[329].

Whilst G.M.H.Playfair claimed that Chinese was incapable of having 'grafted on to it any such new vocabulary as the terminology and nomenclature of Western sciences require.'[330]

Other objections raised were the existence of a number of conflicting terms for the same concept[331], and the stylistic problems associated with a translation including polysyllabic terms[332]. One speaker claimed that successful translations could only be conducted by chemists to translate chemistry, anatomists to translate anatomy, and so on: his implication being that such people did not yet

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[329] Ernst Faber in 'Methods of imparting....', 15

[330] *ibid.*, 16

[331] S. von Fries in *ibid.*, 17

[332] Herbert J. Allen in *ibid.*, 18

exist in China.[333]

This was very unfair to those who like Benjamin Hobson,Daniel Macgowan,John Fryer and W.A.P.Martin,had for many years been translating just such texts into Chinese and who had discovered that the alleged imprecision did not exist,or no more so than in the original tongue. Terms could be made or even new characters invented,and Chinese proved as capable of assimilating the jargon of Western science as it had once assimilated the equally technical language of Buddhism. W.A.P.Martin pointed out that

> Are [Chinese characters] like old bottles that cannot bear the infusion of new wine? Nothing is further from the truth; for no language,not even the German or the Greek,lends itself with more facility than the Chinese to the composition of technical terms.Its elements being devoid of inflection form compounds by mere juxtaposition - each component reflecting on the other a tinge of its own colour. It is not therefore an achromatic medium such as we require for the purposes of philosophy,but its residuary tints in most cases offer aid rather than hindrance to the apprehension and the memory.[334]

As to the necessity of translation,Calvin Mateer made an eloquent speech,pointing out that if only Western languages were used as the medium of propagating science,it would be imparted only to the tiny minority who could master a foreign tongue.

Knowledge is needed,not for the few,but for the

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[333] R.A.Jamieson in *ibid.*,20

[334] W.A.P.Martin in *ibid.*,3. The mnemonic aspect of Chinese characters was the basis of the system in *Huaxue zhinan*,itself developed from Martin's techniques in *Gewu rumen*. See Section 6.1.

> many.It finds its true mission not in filling the shelves of the bookworm but in serving the practical ends of life. We not only want men in China who know,but who can also use and teach what they know. So far as influence on the Chinese people is concerned,it is more important to have one man educated in the use of Chinese than ten men educated in the use of English.[335]

The argument was not settled. In an editorial in October 1889,the *North China Herald* said that

> Chinese is good enough as far as the textbooks go,for popular science;but it is impossible that any full knowledge of Western science can be gained in a language which is entirely destitute of a scientific terminology. [...] as a medium of thought English(and indeed any foreign language) is immeasurably superior to Chinese in precision and clearness. The English speaking student has a vast field of collateral thought open to him which does not exist,and never will exist,in Chinese. The English speaking student can keep up with the times,while the one who knows only Chinese must depend on translation.[...]It seems to us as easy for a man born blind to apprehend colours as for a Chinaman who knows none but his own language to reach any proficiency in modern science.[336]

Fryer and his fellow translators proved the main argument wrong,but there was some justice in the point that a monoglot Chinese research scientist would be at a serious disadvantage in a world of rapidly developing ideas.[337]

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[335] *ibid.*,5

[336] *NCH*(4th October,1889),405-406

[337] George Sarton,'The tower of Babel' in *ISIS* **39**(1948),3-15

However,this was beside the point,for in China in 1889 there were no research scientists,only a population which was just beginning to be interested in knowing some science.

For progressive Chinese intellectuals no debate was necessary: the need for translation was obvious,the only questions were *what* should be translated and *how* it should be done.[338]

5.43 The Translation Department at the Jiangnan Arsenal[339]

The Jiangnan Arsenal was the site of the most systematic attempt to translate Western scientific texts during this period. Founded in late 1867[340],the department was from 1870 housed above the Guang fangyanguan 廣方言館 college. The original intention was that the textbooks translated would be used in the Arsenal and college

> Textbooks translated into Chinese will be used for all these subjects as far as possible,and foreign languages only taught to a class of interpreters. The number of available textbooks already translated into Chinese is at present very limited. Works on Arithmetic,Algebra,Euclid's *Elements*,Differential and Integral Calculus,Astronomy and the steam engine have been translated at different times and published by Mr

338 Yang Yuhui 楊毓輝(1889/90) in *GZKYHB*,5.44b

339 The primary sources for the activities of the Translation Department are : John Fryer,'An account of the ....' in *NCH*(29th January,1880),77-81; the same article,reprinted with a full appendix of translations up to 1880 in *FP*; John Fryer,'Science in China' in *Nature* **24**(5th May,1881),9-11 and **24**(19th May,1881),54-57,also basically a reprint of the *NCH* article.

340 John Fryer,'An account of the Department(*NCH* version)',77

> Wylie; mechanics by Revd.J.Edkins; Physical and Political Geography by Revd.W.Muirhead,and natural philosophy by Dr Martin. Dr Macgowan has contributed a large treatise in eight Chinese volumes on Geology,Mineralogy & c. Mr Fryer has been translating at the Arsenal some time,where he has completed works on Practical Geometry,coal mining and chemistry,and has other books in the course of translation which are to be completed during the year. The Revd.Karl Kreyer has just been added to the staff of translators. The department has a small scientific library and a small collection of philosophical instruments; and will receive considerable additions during the present year.[341]

The Jiangnan team included a number of Westerners[342],none of whom seems to have been particularly well-qualified in science,yet they had lived in China long enough to have attained a proficiency in the language. The extent of this proficiency is not clear:the foreigner's role as *kouyi* 口譯 was to interpret the content into colloquial Chinese of sufficient intelligibility for the Chinese *bishu* 筆述 to render it in literary Chinese,and so clearly had to understand the text well enough to be able to advise on difficult points.

The Chinese members of the Jiangnan team included men

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[341] *NCH*(11th January,1870),22

[342] Their names and their periods of employment at the Translation Department were: John Fryer(1868-1896),Daniel Jerome Macgowan(1868),Alexander Wylie(1868),Carl.T.Kreyer(1869-1878), Young J.Allen(1871-1881),Henry Loch[Luohengli 羅亨利],F.H.James[Xiuyaochun 秀耀春](1897-1898) and E.T.Williams[Weili衛理](1898-1901). See Wang Yangzong 王扬宗,'Jiangnan Zhizaoju Fanyiguan shilue' 江南制造局翻译馆史略[An account of the history of the Translation Department of the Jiangnan Arsenal] in *ZGKJSL* **9**(1988),65-74,especially p.71.

of exceptional scientific talent: Li Shanlan,Xu Shou,Hua Hengfang and Xu Jianyin [343]. Although initially some of the subject matter might have been unfamiliar,they already had a formidable practical and theoretical understanding of science before they arrived at the Jiangnan Arsenal,a knowledge which John Fryer himself admitted left him far behind.[344]

The Jiangnan Arsenal also employed people to act as editors and checkers *jiaozi* 校字:these included Xu Jianyin himself,as well as lesser figures such as Zhong Tianwei 鐘天緯 and Zhao Yuanyi 趙元益(1840-1912) who became in effect trainee translators[345].

In addition to translation,glossaries and vocabularies were compiled,so that the terminology could be systematised,a goal which proved impossible to reach until the next century when the Chinese Government itself took a hand.

5.431 The Beijing Tongwenguan translators

At the Beijing Tongwenguan the situation was rather different. In W.A.P.Martin and Anatole Billequin there were two of the most highly qualified men in China with respect to Western science,especially Billequin,who was as far as I know the only chemistry graduate in China at the time,yet their Chinese assistants were obscure by comparison with Xu Shou and his colleagues.This may explain why so few translations were published by the Tongwenguan,compared to

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[343] See Chapter 9.

[344] Fryer to Susy(11th July,1868),2(*FP*:Box 1)

[345] See Wang Yangzong,'Jiangnan zhizaoju',72 for a list of the major Chinese translators.

the Jiangnan Arsenal where Xu Shou and his colleagues worked with such enthusiasm in the late 1860s and 1870s.

5.44 Intended readership

Almost all of the books written were intended for the educated elite,and this aim was reflected in the style of the translation,and hence colloquial Mandarin was avoided by the translators,with the notable exception of Calvin Mateer. Although there were attempts at 'popular science' in journals such as *Gezhi Huibian*,these too were in literary Chinese,and therefore accessible only to the few.

It is not clear whether those who were actually building the ships and guns in the Arsenal read these books at all. The Jiangnan Arsenal seems to have employed its own translator[346],and Fryer at one point complained bitterly that his books were not even used in the very Arsenal where he was working.[347] The direct,practical effect of the books therefore has to be in question. Nevertheless,the books did gradually reach a wider readership,especially those that were serialised in the journals,and by the 1890s were beginning to affect the thinking of reformist intellectuals.

5.45 The choice of source-texts

The early interest of the Chinese was in military techniques,and fundamental science was generally neglected in favour of technology.[348] The choice of texts was crucially important,as the numbers of texts translated was

[346] Wang Ronghe 王榮和,born in Singapore.

[347] Fryer,'An account(*FP* version)',16

[348] Liang Qichao,'Lun yishu',68

really quite small, and so the influence of a particular choice was significant. The choice of texts was initially - and probably until the end of the century - mainly due to the Western translator, as he alone had access to knowledge about what was available, although officials sometimes indicated their preferences. This resulted in some idiosyncratic choices of textbooks which were in some respects obsolescent, a problem which was heightened by the long time-lag of the translation process itself. As John Fryer wrote

> Various high officials asked to have works translated for them on special subjects[...] In most cases each translator and Chinese writer seems merely to have selected such subjects as suited him best without regard to the symmetry or harmony of the whole collection.[349]

Given that so few texts were available, the fact that the Western books often seemed to assume knowledge which a Chinese reader would be unlikely to possess posed a serious problem for the reader, as he would have little hope of finding another book to help him with his difficulties. The problem of the unsuitability of the content could in the end only be solved by authors compiling books themselves, with examples such as John Glasgow Kerr's modifications to the original text of *Huaxue chujie* 化學初階 and Calvin Mateer's arithmetic text *Bisuan shuxue* 筆算數學. Most translators stuck closely to the Western original.

5.46 Illustrations

The earliest translations(such as *Bowu tongshu, Bowu xinbian, Huaxue chujie*) were profusely illustrated. Sometimes the drawings were done by Chinese artists(*Bowu tongshu, Bowu xinbian, Huaxue zhinan*), in other cases the original

[349] John Fryer, 'An account...' (*FP* version), 11

illustrations of the Western book were employed(*Huaxue chujie* and many articles in *Gezhi Huibian*). The official Jiangnan Arsenal translations were often rather poorly illustrated,for reasons not entirely clear. Perhaps they took up too much space,were too expensive,or were simply not thought necessary. There often seems to have been an unwillingness to add extra diagrams even when these would have added greatly to the clarity of the text.

The propriety of explicit illustrations in medical textbooks posed particular problems. One anxious reviewer commented:

> The work is copiously illustrated with the ordinary drawings of medical works at home,many of which we should not certainly put into works in English for use in schools,or even among scientific or unprofessional persons.[350]

but for science textbooks the problems were probably more financial than moral.

5.47 The quality of the translations

The famous criteria proposed by Yan Fu 嚴復(1853-1921) for a good translation were: *xin* 信[faithfulness],*da* 達[transmission of the content],*ya* 雅[literary elegance][351],and these could be applied to natural science translations. Most were very - often too - faithful to the

[350] John Dudgeon,'Review of a new medical vocabulary' in *CR* **13**(1882),31

[351] See Yan Fu's introduction to *Tianyanlun* 天演論[The unfolding of Heaven:a translation of Huxley's *Evolution and Ethics*](1898; reprinted Beijing:Shangwu yinshuguan 商务印书馆,1981),xi

original texts; in most cases they did successfully transmit much of the content. To demand literary elegance was probably unreasonable given the subject matter and especially the cumbrous nature of many of the terms,although for the scholarly readers who first came across them their lack of elegance was probably the abiding impression.

Liang Qichao in his article *Lun yishu* 論譯書(On translation)attacked the poor quality of many of the translations:

> Those who are proficient in foreign tongues cannot express themselves in Chinese,and *vice versa*.[...]Over two-thirds of [the translations] are confused,distorted,garbled and vulgar[...] This gives ammunition to the conservatives,who say that Western books all come from the hands of vulgar scholars and are unworthy to be looked at,thus making matters even worse for Western studies. Thus today,in translating books we should establish three principles: (1)Choose appropriate books (2)Establish rules for translation (3)Nurture talented people who are able to carry out the translation.[352]

Liang recommended that translators should be well-versed in Chinese,in the relevant Western tongue,and in the subject-matter they were translating. Citing the great Buddhist translators of the past Kumārajīva and Xuanzang 玄奘 for their dedication,he praised Yan Fu for his translation of Huxley's *Evolution and Ethics* which,he claimed,used similar techniques. The transmission of learning was for

[352] Liang Qichao,'Lun yishu',68. See also *GZKYHB*,5.42b and 5.46b-47b(1889/90) on the difficulties of translation.

Liang the prime criterion,and literary elegance secondary.[353]

Liang judged the mathematics translations of Wylie and Li Shanlan to be the best of the nineteenth century attempts,and made no mention of any of the natural science texts,which suggests that he did not value them too highly,but we should not be overly influenced by his view. Liang had no great interest in or knowledge of science,and despite his claim to the contrary he would probably in practice have judged any book he had picked up mainly on its literary merits rather than its success in transmitting the subject matter. Nevertheless it is interesting to see how disdainfully at least one progressive intellectual viewed most translations despite all the efforts of the translators to make them acceptable to the elite.

Zeng Zhaolun had a kinder view of the Jiangnan translations:

> Looking back,the translations from the era of the Jiangnan Arsenal are better than those done in this country during the first half-century. It is very regrettable that this enterprise has not been continued. [354]

Judging by the number of copies sold,many of these translations were surprisingly successful. Benjamin Hobson's *Bowu xinbian* and W.A.P.Martin's *Gewu rumen* were both reprinted in Japan,and the science texts sold by John Fryer at his Scientific Book Depot ran into many thousands.

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[353] Liang Qichao,'Lun yishu',75

[354] Zeng Zhaolun 曾昭掄,'Zhongguo xueshu de jinzhan' 中國學術的進展 [The development of Chinese scholarship] in *DFZZ* **38**,1(1941),57. The translation is from Reardon-Anderson,52.

5.48 Printing and distribution

One of the earliest presses used for scientific texts was the Mohai Shuguan 墨海書館[Inkstone Press] in Shanghai,run by the London Missionary Society under the supervision of Alexander Wylie from 1847[355],later succeeded by the American Presbyterian Mission Press [Meihua shuguan 美華書館]. The Jiangnan Arsenal began publishing books from 1868. In 1887,using the residual capital of the Inkstone Press,Alexander Williamson set up the Society for the Diffusion of Christian and General Knowledge among the Chinese(*Tongwen Shuhui* 同文書會),which changed its Chinese name in 1894 to *Guangxuehui* 廣學會: it mainly published works of an historical and political nature,but one or two science texts were also translated. The Protestant missionaries set up the School and Text-book Committee(*Yizhi Shuhui* 益智書會)in 1877,succeeded by the Educational Association of China [also known in Chinese as *Yizhi Shuhui* 益智書會]in 1890,both of which encouraged the publication of many school science textbooks.[356]

The distribution network was partly through the missionary schools,John Fryer's own Chinese Scientific Book Depot(*Gezhi Shushi* 格致書室)founded in 1884[357] and later through the academies and bookshops which sprang up in

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[355] See Cyrus Peake,'Some aspects of the introduction of modern science into China' in *ISIS* **22**(1934),313

[356] See Wang Shuhuai 王樹槐,'Qingji de Guangxuehui' 清季的廣學會 [The Qing Dynasty Society for the Diffusion of Useful Knowledge] in *BIMH* **4**(1973),193-227.

[357] See John Fryer,'Report of the Chinese Scientific Book Depot' in *NCH* (28th December,1887),702-703.
The Depot had officially opened at Chinese New Year in 1885,and there were branches in Tianjin,Hangzhou and Shantou 汕頭 [Swatow]. Books were sold at full price,with no subsidy,as Fryer believed that this encouraged them to be valued more than volumes which were simply given away. By 1890 there were also branches in Hongkong,Beijing,Wuchang 武昌,Wenzhou 温州 and Xiamen[Amoy]. (*GZHB* **5**,1(Spring 1890),1b)

post-1895 China. Fryer boasted in 1880 that 31,111 copies of 98 titles had been sold[358]. Even if - which is doubtful - they were all read,this readership still represented only a tiny fraction of the educated population of China. Nevertheless an indication of some popular demand was the existence of a considerable market for pirated science textbooks.[359]

5.5 Conclusion

The translation of scientific texts and the terms they contained into Chinese,apparently much simpler than the translation of philosophy or literature,proved to involve formidable lexicographic problems. It also made a profound impact on the written language,generating or resuscitating scores of 'new' characters on a scale not seen for over two millennia.Thousands of new compound terms were also formed,creating the basis of a scientific lexicon which allowed China to enter mainstream science by the first two decades of the twentieth century,and forming a semantic space within the Chinese language with a relative ease which was to confound those critics of translation who thought Chinese too imprecise a vehicle to express scientific thought. As China's political situation changed,so too did the willingness to accept new meanings of old words,and to allow into the language newly-formed characters on a scale which was truly unprecedented.

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358 Fryer,'An account of the Department for the Translation of Foreign Books(*NCH* version)',81

359 See *CR* **28**(August 1897),388-389 and **28**(September 1897),444. The latter mentions by name Calvin Mateer's *Bisuan shuxue* 筆算數學 [Written problems in arithmetic] and *Daishu beizhi*代數備旨[Algebra]; W.A.P.Martin's *Gewu rumen* 格物入門[Natural philosophy]; and John Fryer's *Huaxue jianyuan xubian* 化學鑑原續編[Organic chemistry],*Huaxue jianyuan bubian* 化學鑑原補編[Inorganic chemistry],*Huaxue kaozhi* 化學考質[Qualitative analysis] and *Huaxue qiushu* 化學求數[Quantitative analysis].

Translation began to gain official support,at least from the more progressive provincial leaders who saw how badly China needed technical expertise. Access to Western learning through the new academies was hampered by the lack of books and teachers. The experience of having foreigners teach science with the assistance of native interpreters had not on the whole been a happy one. Zhang Zhidong,writing at the close of the century, commented:

> Interpreters are often superficial in their learning,only knowing the words and not being able to communicate the meaning[....]And even if the interpreters are good,the foreign teachers only work for 4 to six hours per day,so they cannot get across more than one or two matters. Westerners have a habit of teaching very slowly in order that their skills be not exhausted and in order to prolong their stay,some even taking a whole year just to teach addition and subtraction.[360]

This being the case,Zhang recommended that it was preferable that there should be large-scale translations,so that 'the book would be the teacher'.[361]

The translation of scientific texts also revived interest in the native tradition of science,especially the writings of Mo Zi,and resulted in claims that the West had preserved the ancient wisdom of China and was now reintroducing it,a claim in which there may well be some truth. The grand,unifying ideas of nineteenth century science - such as the ether,and the conservation of mass in chemical reactions - also appealed to intellectuals who were looking for ways of synthesising Western and Chinese

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[360] *Zhang Wenxianggong quanji* 張文襄公全集 [The collected works of Zhang Zhidong](Shanghai:Commercial Press,1937),203.14a

[361] *ibid.*,203.16a

thought: thinkers such as Kang Youwei and Tan Sitong drew heavily on Western science in creating their visions of a Chinese Utopia.

The translation of science texts directly affected only a small proportion of the educated elite,the books were hard to understand without a teacher,and few are likely to have gained more than a superficial understanding merely from reading. This is not to denigrate the importance of the translations: the very act of carrying them out,especially under government auspices,was an indication of a change of heart towards Western learning in general,and natural science in particular,which would in time have a profound effect on the whole Chinese Empire.

Chapter 6. The great desideratum[362]: Chinese chemical nomenclature and the transmission of Western chemical concepts[363]

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[362] See Benjamin Hobson's remarks below.

[363] Works consulted include: John Fryer,'An account of the Department for the Translation of Foreign Books at the Kiangnan Arsenal,Shanghai'; John Fryer,*Huaxue cailiao Zhong-Xi mingmubiao* 化學材料中西名目表 [Vocabulary of the Chinese and English names of chemical substances] (Shanghai:Jiangnan Arsenal,1885); Sun Weixin孫維新,'Taixi gezhi zhi xue yu jin ke fanyi zhu shu xiang lüe de-shi he zhe wei zui yao lun 泰西格致之學與近刻翻譯諸書詳略得失何者為最要論 '[A brief account of whether the successes or the failures of the recent translations of Western science books into Chinese are the more important] in Wang Tao 王韜(ed.)*Gezhi keyi huibian* 格致課藝彙編[A collection of the work of the winners of the Chinese Prize [Science] Essay Contests](1890),4.18b-17b; Yang Yuhui 楊毓輝,'Huaren jiang qiu Xixue yong Huawen yong Xiwen libi ruohe lun 華人講求西學用華文用西文利弊若何論 '[On the advantages and disadvantages of using Chinese and Western languages for Chinese people striving after Western studies] in *ibid.*,5.42a-42b(1890); Yang Yuhui 楊毓輝 's essay on chemistry in *ibid.*,6.1a-1b (1891); George A.Stuart,'Chemical nomenclature' in *CR* **25**(January 1894),88-90; G.Schlegel,'Scientific confectionery' in *T'oung Pao* **5**(1894),147-151; John Fryer,'The present outlook for Chinese scientific nomenclature' in *Records of the Second Triennial Meeting of the Educational Association of China held at Shanghai May 6-9,1896*(Shanghai:American Presbyterian Mission Press,1896),155-161; Hua Hengfang's preface to *Jinshi shibie* 金石識別[The identification of minerals] in Zhang Yinhuan 張蔭桓(ed.)*Xixue fuqiang congshu* 西學富強叢書[A collection of works on the acquisition of wealth and power through Western studies](Hongwen shuju 鴻文書局,1896); Calvin Mateer,'Revised list of chemical elements' in *CR* **29**(February 1898),87-94; Calvin Mateer,'Report of the Committee on Technical and Scientific terms' in *Records of the Third Triennial Meeting of the Educational Association of China held at Shanghai May 17-20,1899*(Shanghai:American Presbyterian Mission Press,1900),15-16; Calvin Mateer,*Technical terms,English and Chinese prepared for the Committee of the Educational Association of China*(Shanghai:Presbyterian Mission House,1904); Philip B.Cousland(ed.)*An English-Chinese lexicon of medical terms compiled for the Terminology Committee* (Shanghai:Medical Missionary Society of China,1908); *Huaxue yuhui* 化學語彙 [A chemical vocabulary](Shanghai:Shangwu yinshuguan 商務印書館,1908); George A.Stuart,*Technical terms,English and Chinese,prepared by the Committee of the Educational Association of China*(Shanghai:Methodist Publishing House,1910); William Henry Adolph,'Synthesizing a chemical terminology in China' in *JCE* **4**,10(October 1927),1233-1240; Georges Roudakoff,'La terminologie

6.0 Introduction

Classification and nomenclature were important concerns of nineteenth-century science,but to the layman the obscurity of the resulting jargon was one of its least endearing features,witness the distaste for the pedantry personified most memorably in Mr Gradgrind.[364]

chimique chinoise' in *Bulletin de l'université l'Aurore* 3e série 7(1946),619-627; Zeng Zhaolun 曾昭掄,'Kexue mingci zhong de zao zi wenti 科學名詞中的造字問題'[The problem of creating characters in scientific terms] in *ZGYW* **14**(August 1953),3-4; Liu Zexian 劉澤先,'Cong kexue xin mingci de fanyi kan Hanzi de quedian' in *ibid.*,9-11; Liu Zexian,*Kexue mingci he wenzi gaige*; Viviane and Jean-Claude Alleton,*Terminologie de la chimie en chinois moderne*(Paris:Mouton,1966); Wang Shuhuai 王樹槐, 'Qingmo fanyi mingci de tongyi wenti' 清末翻譯名詞的統一問題[The problem of the standardisation of translated terms in the late Qing] in *BIMH* **1**(1969),47-82; Joseph Needham,*SCC* Vol.5 Part 1(Cambridge:Cambridge University Press,1974),154ff on chemical nomenclature; Joseph Needham,*SCC* Vol.5,Part 3(Cambridge:Cambridge University Press,1976),220ff 'The coming of modern chemistry'; Zhang Zigao 张子高 and Yang Gen 杨根,'Cong *Huaxue chujie* he *Huaxue jianyuan* kan woguo zaoqi fanyi de huaxue shuji he huaxue mingci从"化学初阶" 和 "化学鉴原" 看我国早期翻译的化学书籍和化学名词[Seeing the earliest translated Chinese chemistry textbooks and Chinese chemical terms *via Huaxue chujie* and *Huaxue jianyuan*] in Yang Gen杨根 (ed.),*Xu Shou he Zhongguo jindai huaxueshi* 徐寿和中国近代化学史[Xu Shou and the history of modern Chinese chemistry](Beijing:Kexue jishu wenxian chubanshe 科学技术文献出版社,1986),105-118; and Zeng Zhaolun 曾昭掄,'Jiangnan zhizaoju shidai bianji zhi huaxue shuji ji qi suo yong zhi huaxue mingci 江南制造局时代编辑之化学书籍及其所用之化学名词[The chemical texts compiled in the period of the Jiangnan Arsenal and the chemical terms they employed] in *ibid.*,252-279.

364 As Gradgrind put it,'Facts alone are wanted in life. Plant nothing else,and root out everything else.'(Charles Dickens,*Hard times*(1854; reprinted London: Everyman's Library,1987),1. See also Susan Faye Cannon,*Science in culture: the early Victorian period*(New York:Dawson and Science History Publications,1978),18-22. The most negative of all Dickens' portrayals of men of science is perhaps the chemist in *The haunted man*(1843; reprinted London:Dent,1909)an earlier,bleaker version of *A Christmas Carol,* in which the central figure is empty of compassion and humanity,representing the 'growth of man's presumption'(*ibid.*,140).

Yet as William Whewell proposed, reflecting upon the diverse materials exhibited in the Great Exhibition of 1851, a sound - a transparent - classification could also be a liberating, even a democratic, force, allowing access to knowledge which would otherwise be reserved for the initiates.

> What the value and advantage would be of a permanent and generally accepted classification of all the materials, instruments and productions of human art and industry you will none of you require that I explain at length. One consequence would be that the manufacturer, the man of science, the artisan, the merchant, would have a settled common language, in which they could speak of the objects about which they are concerned.[365]

Yet a chemical nomenclature had to be more than simply a common language. As Antoine Lavoisier had recognised, the language of chemistry was also an expression of a *theory* of chemistry, and the use of the language thus became a rehearsal of - and an implicit acceptance of - the theory. Lavoisier, in his introduction to *Elements of chemistry in a new systematic order*, explained:

> "We think only through the medium of words - languages are true analytical methods - Algebra, which is adapted to its purpose in every species of expression in the most simple, most exact and best manner possible, is at the same time a language and an analytical method. - The art of reasoning is nothing more than language well arranged." Thus, while I thought myself employed only in forming a

[365] William Whewell, 'The general bearing of the Great Exhibition on the Progress of Art and Science', 25.

> nomenclature,and while I proposed myself nothing more than to improve the chemical language,my work transformed itself by degrees,without my being able to prevent it,into a treatise upon the Elements of Chemistry.
>
> The impossibility of separating the nomenclature of the science from the science itself,is owing to this,that every branch of physical science must consist of three things: The series of facts which are the objects of science; the ideas which represent these facts; and the words by which these ideas are expressed. Like three expressions of the same seal,the word ought to produce the idea and the idea to be a picture of the fact[...][366]

In translating the ideas of chemistry into Chinese,this ideal was,as we shall see,very hard,some thought impossible,to attain.

6.1 The need for a new Chinese chemical nomenclature

Speaking in 1896,John Fryer reflected on the question of scientific nomenclature in China:

> Before foreigners undertook to find new terms for them the Chinese experienced no trouble themselves in finding terms for foreign things or ideas. Many of the Chinese names of plants,animals and products of other countries that have been in use for centuries might be instanced to show how easily the process of engrafting

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366 Antoine Lavoisier,*Elements of chemistry in a new systematic order*,xiii-viv

foreign terms into Chinese is effected.[367]

The term *huaxue* 化學[the study of change] for 'chemistry' itself first appears in the late 1850s,in the writings of missionaries associated with the Mohai shuguan,making a significant stress on the *flux* of matter rather than its stability.[368]

In physics,astronomy and mathematics,it was almost always possible to coin new terms by employing existing characters; in any case,the number of terms needed in these fields was (relatively speaking) not large,whereas the rapid growth of chemical knowledge in the nineteenth century made it necessary to name an enormous number of substances,of three types:

(i)the chemical elements

(ii)inorganic compounds

(iii)organic compounds

In addition,the growth of chemical theory required terms for concepts such as 'atom','molecule', 'equivalent','affinity',and so on. There were those who said that it could not be done,and that science could only be communicated through an Indo-European language,but for

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367 Fryer,'The present outlook for Chinese scientific nomenclature',159

368 The earliest known sighting of *huaxue* 化學 is in an article by Alexander Williamson in *LHCT* **1**,1(January/February 1857),1b.3. See also Pan Jixing 潘吉星,'Tan huaxue yi ci zai Zhongguo he Riben de youlai' 谈化学一词在中国和日本的由来[A discussion of the origin of the term *huaxue* in China and Japan] in Zhao Kuanghua 赵匡华(ed.)*Zhongguo gudai huaxueshi yanjiu* 中国古代化学史研究[Research into the history of ancient chemistry in China](Beijing:Beijing Daxue chubanshe 北京大学出版社,1985),654-661 p.. At the turn of the century the term *zhixue* 質學[the study of matter] was briefly preferred,but in the end *huaxue* prevailed.

the missionaries who saw it as their duty to provide translated books there was no choice:

> The opinion prevails that the Chinese cannot be instructed in the sciences except through alphabetic languages,their own being deficient in the terms that are needed. The difficulty of communicating this knowledge is unquestionably great,and seems to increase as if a new language had to be formed. For example,the Chinese have terms for less than one-fourth of the elementary bodies of chemistry. For the numerous and increasing combinations of these substances,we derive terms from Greek and Latin so expressive that the nature of the body is at once recognised in its name. But how shall nomenclatures be formed for China? If a student might venture an opinion it would be,that it is possible to devise the requisite terms which would be intelligible to educated natives.[369]

The writer's optimism proved well-founded: in this chapter I will consider in detail the way in which the changing terminology of Western chemistry was presented in China,and how eventually a standard system developed out of the efforts of the early translators.

6.2 The translation of the names of the chemical elements

In translating the names of the chemical elements,the early translators attempted to produce terms that would be both the *names* and the *symbols* for the elements,whereas in Western languages by contrast the name and the symbol are distinct entities(as in sodium - Na,iron - Fe,etc). The Chinese terms for the elements were therefore at least

[369] Daniel Jerome Macgowan in *CRP* **18**,10(1849),511

divalent(*name* and *symbol*),and usually trivalent(*name,symbol* and *pronunciation*)[370].

A number of elementary substances were already known to the Chinese by 1850[371]:these included carbon(*tan* 炭),copper(*tong* 銅),gold(*huangjin* 黄金),iron(*tie* 鐵),lead (*heiqian* 黑鉛),mercury(*gong* 汞),phosphorus(*lin* 燐) ,silver(*yin* 銀),sulphur(*liuhuang* 硫黄),tin(*xi* 錫),and zinc(*woqian* 倭鉛). Most translators were content to allow these terms to remain,except for the expression for zinc[*wo*倭 'dwarf' was a derogatory term for the Japanese].

The very earliest writers were extremely cautious about new terms in general: *Bowu tongshu* 博物通書(1851) contained no transliterations,few new terms and no new characters.[372] In *Bowu xinbian*(1855) oxygen was given as *yangqi* 養氣 'nourishing gas',hydrogen as *qingqi* 輕氣 'light gas',but zinc was transliterated as *jingqi* 精錡 [373]. Benjamin Hobson explained his approach thus:

> The great desideratum for a translator is a good and fixed nomenclature on every branch of science. The

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[370] I say 'usually' because Billequin's characters(see Table 2)do not all carry a pronunciation.

[371] Although they had not of course been recognised as elements in the modern sense.

[372] Some of the pioneer writers on physical science in China have avoided as far as possible all new technical terms. The result has been a vague disquisition about the science in question,rather than the accurate setting forth of the science itself.
(Calvin Mateer,*Technical terms*(1904),1)

[373] This seems to have been originally a Japanese term. See Wang Yangzong 王扬宗,'Qingmo Yizhishuhui tongyi keji shuyu gongzuo shuping 清末益智书会统一科技术语工作述评'[An account and evaluation of the work of the late Qing Educational Association of China in the standardisation of scientific and technical terms] in *ZGKJSL* **12**,2 (1991),11.

> language admits of a satisfactory and distinct explanation of most new terms; where it does not,these must be transferred [i.e.transliterated].[374]

The transliteration of the names of all the known chemical elements was attempted for the first time at the Jiangnan Arsenal by Hua Hengfang 華衡芳 and Daniel Jerome Macgowan in *Jinshi shibie* 金石識別[The identification of minerals[375]],the 1868 translation of J.D.Dana's *Manual of Mineralogy*. The characters chosen for their phonetic value in this list were to play an important role in the system eventually adopted by Xu Shou and John Fryer for use in all the Jiangnan Arsenal translations.

Meanwhile at the Beijing Tongwenguan W.A.P.Martin's book *Gewu rumen* 格物入門[An introduction to science(Martin himself translated the title as *Natural Philosophy*)](1868) included a list of the Chinese translations of the names of certain of the elements,with others given only as Western symbols with the Chinese pronunciation of the letters of the symbols. Martin,who believed that the strong alchemical background of Chinese science should be emphasised,revived the alchemical term *jing* 精 'principle'[376] for a number of the elements[377]. He also initiated a long series of disputes over the standardisation of chemical nomenclature by adopting the term *danqi* 淡氣(which Hobson had already used for 'nitrogen') for 'hydrogen',thus replacing Hobson's term *qingqi* 輕氣 'light gas' which had stood for many years. It

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[374] See K.Chimin Wong and Wu Lien-teh,*History of Chinese medicine* 2nd ed.(Shanghai,1936; reprinted Taibei:Southern Materials Center,Inc.,1985),365.

[375] *Jinshi* 金石 traditionally meant 'metals and stones',but in late nineteenth-century usage came to mean 'minerals'.

[376] See Ho Peng Yoke,*Tuku T'ao's* <u>Tan-fang chien-yüan</u>,86

[377] W.A.P.Martin,*A cycle of Cathay*,314.

was this kind of arbitrary change which Fryer referred to in his 1880 article on translation,when he said

> [...]we find the identical term employed by Dr. Hobson for nitrogen is used many years afterward by another equally eminent missionary scientist as the name for hydrogen. The difficulties thus caused to Chinese readers may be easily imagined. Yet while so much dissension exists as to the proper term for the Divine Being,it is not much to be wondered at that such terms as those for nitrogen and hydrogen should be altered or interchanged by any one[sic] just to suit his own particular fancy and regardless of consequences.[378]

Shortly afterwards,He Liaoran 何瞭然 and John Glasgow Kerr in Guangzhou translated David Wells' *Principles and applications of chemistry* as *Huaxue chujie* 化學初階 [First steps in chemistry](1871)[379],including the most complete list of translated terms so far,relying on Martin's *Gewu rumen* and on a list provided by John Fryer of the terms he and Xu Shou were using in their translation of the same book.[380] A most important feature of the *Huaxue chujie* terms was that they were without exception <u>single characters</u>,which made it possible to use them within chemical formulae. This had not been possible using the two-character terms in use previously. He Liaoran and Kerr also invented a number of entirely new characters,sometimes

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[378] *NCH*(29th January,1880),79. The confusion of terms for the Deity and and also those for nitrogen is commented upon in *GZKYHB*,5.49b(1889/90).

[379] See Section 7.7.

[380] In the English introduction to *Huaxue chujie* Kerr wrote

> A few of the names of the elements were taken from a list sent by Mr Fryer,and where no suitable term existed,new ones proposed.[...]The Chemical Catechism[*Gewu rumen* 格物入門] by the Rev.W.A.P.Martin DD has been made use of and has been a valuable guide,on many subjects,to my teacher.

based on Martin's two-character terms, such as *lü* 鑥 for 'sodium' [= metal radical + 鹵 *salt* (sodium chloride)] and *hui* ⿰金灰 for 'potassium' [= metal radical + 灰 *ash*, potassium being found in plant ash]; and 鉐 for 'calcium' [= metal + *shi* 石 'stone', as calcium is an important component of many rocks]. Their mnemonic value meant that these received widespread currency, even amongst authors who usually adopted the Jiangnan Arsenal terms[381].

With *Huaxue jianyuan* 化學鑑原 [The mirror of chemistry: a source-book] (1872) the translation by Xu Shou and John Fryer, we reach the first system almost completely based on radical-phonetic principles.[382] Thus all the metallic elements were given the metal radical 金, and the phonetic parts were chosen to imitate the sound of the English name; whilst solid non-metal elements were given the stone radical 石 [383]. An examination of the *Jinshi shibie*

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[381] For example, *Huaxue jiezhi* 化學解質 (1900) compiled by a Presbyterian missionary Linbaoluo 林保羅, uses 鍟 (zinc), 鉐 (calcium) and ⿰金灰 (potassium) as in *Huaxue chujie* 化學初階; and 鋁 (aluminium), 鈉 (sodium), and 錳 (manganese) as in *Huaxue jianyuan* 化學鑑原.

[382] See Section 5.311. The only exceptions to the phonetic principle, other than long-standing terms for gold, copper, etc, were the gases such as hydrogen, oxygen, and chlorine; and bromine, which as *xiu* 溴 [foul-smelling] seemed to have such a perfect combination of the correct radical and meaning.

There is one choice of phonetic which may possibly have had some significance, namely *fan* 凡 for vanadium *fan* 钒. Song Yingxing 宋應星 in *Tiangong kaiwu* 天工開物, states that alum (*fan* 矾) has five coloured forms, just as vanadium is remarkable for the range of colours of its salts (See Pan Jixing 潘吉星, *Tiangong kaiwu jiaozhu ji yanjiu* 天工開物校注及研究 [Annotations and research on *The exploitation of nature*] (Chengdu: Bashu shushe 巴蜀書社, 1986), 436). It is also interesting to note that an early English name for vanadium was 'panchromium', whose *pan-* prefix also echoes the meaning of the Chinese word *fan* 凡 'all'.

[383] This involved some changes in the normal phonetic values of characters: the character for cerium *xi* 错 was normally pronounced *cuo*, but the element 昔 as a separate character does have the pronunciation *xi*. Similarly, the obsolete character *xin*

transliterations shows that the majority of the *Huaxue jianyuan* terms used the first character of the former transliterations as the phonetic element of the characters. The only significant exceptions were the gaseous elements,for which two-character terms were retained,and the small number of elements known in China from antiquity. It was this system which became used in all the Jiangnan Arsenal translations,and which eventually overcame all its rivals to be the basis of the modern system.

The novelty of these characters should not be exaggerated: the majority of the 'new' characters were not new but archaic. The translators looked for characters with the metal or stone radicals[the latter for the solid nonmetallic elements] in the *Kangxi Zidian* 康熙字典 ,and quite often suitable ones were discovered. Such resuscitated characters are marked **!** in Table 1[384]. Xu Shou and John Fryer described their method thus:

> There are many elements,some of which were known in China in antiquity,and their names are retained,including:gold,copper,lead,tin,mercury,sulphur,phosphorus and carbon. The substance white lead *baiqian* 白鉛 [zinc] is also known as dwarf [Japanese] lead,and was unknown in antiquity. Such a dissyllabic term is unsuited to [the naming of] compounds,so we translate it as *xin* 鋅,transliterating the sound of its

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鋅 'zinc' was pronounced *zi*,but for chemical purposes its phonetic component 辛 *xin* was taken to be the pronunciation of the 'new' character.

384 I have marked **!** resuscitated characters and terms which were already in existence by 1850,but not terms which are simply transliterations.

John Fryer actually mentions using *Kangxi Zidian* as an authority in *CR* **26**(June 1895),289 and in his article 'Scientific terminology: present discrepancies and means of securing uniformity' in *Records of the General Conference of Protestant Missionaries*(1890),542.

Western name.

> Names already translated by Westerners [and] which are appropriate we also retain: oxygen *yangqi* 養氣,nitrogen *danqi* 淡氣,and hydrogen *qingqi* 輕氣 fall into this category. [...] Apart from the foregoing,there are several tens [of elements] which were unknown to the ancients or which they had but the name they used was deficient in some respect. [...]Transliterating the whole name would be excessively complicated. We therefore take the first sound of the Western word and transliterate it with one Chinese character. If the first sound is unsuitable,we take the second sound. We then add a radical to distinguish it from its homophones. [385]

The fact that *Huaxue chujie* and *Huaxue jianyuan* were both translations of the same text,and that they appeared so close in time,meant that they were destined to be rivals for the following two decades. The *Huaxue chujie* terms tended to be used in medical texts(a series of which had been translated by Kerr); whereas chemical texts tended to use those in *Huaxue jianyuan*[386].

There was some correspondence between John Fryer and John Kerr on the terms for the elements. One letter survives written by Fryer to Kerr on 10th November,1869:

> My dear Sir,
>
> I much regret that your letter has remained unanswered so long. My object in delaying was to be able to give you the Chinese characters from a very elementary work on Chemistry I have been attempting to

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[385] *Huaxue jianyuan,*1.20b

[386] See J.Neal,'Treatises on chemistry' in *CR* **26**(April 1895),187 and the editorial comment on p.189.

> translate. The Superintendent of the Arsenal together with some scholars who are supposed to know something of scientific subjects revise such translations as are made and throw out anything they consider savours too much of the Foreigner. Hence I am not responsible for any errors they choose to make.
>
> Herewith I send you the 29th paragraph from the book[*Huaxue jianyuan*] as it now stands. If you can send me the characters you have employed in your work I should be much obliged.
>
> It is a pity that some arrangement has not yet been made for establishing a scientific vocabulary. If someone would make a collection of all scientific works that have hitherto been translated into Chinese,as well as works written by natives without foreign assistance and divide them among such sinologues as are willing to undertake the task of sorting out a vocabulary the result of their endeavours would supply the need which all translators experience.
>
> Yours sincerely,
>
> John Fryer [387]

Some twenty-five years later,the editor of the Educational Department of *Chinese Recorder* [probably John Fryer himself] commented on the rivalry which still existed

> It is a great pity that there should exist these rival sets of chemical terms,in which the names of 14 of the elements differ. If Dr.Kerr had only delayed the

[387] *FP*:Box 1 Folder 4

> publication of his work on chemistry for a month,the negotiations that were being carried out respecting terms would have been brought to a successful issue ,and a compromise would easily have been effected,securing entire harmony. Had he communicated a list of the terms he had finally determined to use,several of them would have been adopted by Dr.Fryer in his first work,published almost simultaneously with Dr.Kerr's,because they were equally good; and thus the number of differences would have been greatly reduced.[388]

This attack elicited an indignant reply in the following issue from John Kerr:

> Before publishing my work on Chemistry(1870-1871) I wrote to Mr. Fryer proposing that an agreement should be come to in regard to terms. He replied sending me a copy of his terms and stating that the Chinese who superintended the publication of scientific works objected to many of mine,but he had no power except to advise.This of course placed me in a position where it was impossible to do anything further.[389]

Fryer's letter of 1869 does not appear to say what Kerr took it to mean,but perhaps this is irrelevant,as it seems most unlikely that 'entire harmony' would have broken out between the two authors. Fryer in his 1895 editorial went on to criticise Kerr bitterly for using the term *huang*磺 for 'sulphur',saying it was 'gratuitously invented'; and for using the same character *ge* 鎘 for 'nickel' which Fryer had 'already' used for 'cadmium'[390]. These were not only matters of science nor even of linguistics,but of

[388] *CR* **26**(April 1895),189

[389] *CR* **26**(June 1895),288

[390] *CR* **26**(April 1895),189

personal pride and taste,and could not,as the standardisers of the Educational Association of China were to find,be resolved harmoniously.

The chemistry professor at the Beijing Tongwenguan,Anatole Billequin,developed a system in *Huaxue zhinan* which was far more akin to those of Martin and He/Kerr than that of Xu/Fryer. He seemed to be intending that almost every character used for the elements(and even for certain classes of organic compounds(See below Section 6.3) would be a *huiyizi* 會意字 built of components which would remind students of the properties of the element in question. Though this technique sometimes resulted in complex characters,the accusation that has sometimes been levelled,that his characters were 'bizarre',does not seem fair: although there were one or two extreme cases - such as the character for manganese - many of the characters in the Xu/Fryer system had just as many if not more strokes,and Billequin's characters had the merit of teaching the student a little about the element they referred to[391]. Moreover,the Billequin system avoided the problems of relating a system to pronunciation: essentially,his characters were visual mnemonics,and were deliberately not assigned pronunciations,although some could be pronounced according to the apparent phonetic. (Billequin himself seems to have intended the French pronunciation for the element to be used.) Table 2 gives Billequin's own explanations for the characters he created. The text of *Huaxue zhinan* explains:

> Among the elements,there are some which have no familiar Chinese name. If the Western name were used,we fear that the sound would become

[391] For a contemporary comment on the *Huaxue zhinan* system see Sun Weixin,24b.

> confused,resulting in much uncertainty,due to the multiplicity of dialects in the various provinces of China.We therefore create our terms on the basis of the form and nature [of the element] in order to make them impartial[i.e.independent of any pronunciation]and [this system] is better than the arbitrary nomenclature formerly employed,which merely regarded the external appearance of the substances.[...]We either refer to the meaning of the name of the element,or investigate its origin,or its nature,or its colour,combining several characters together to form the term. Although the characters seem to be new-fangled,if the scholar sincerely investigates their use and meaning he will avoid confusing one [name] with another.[392]

By the 1890s confusion reigned: the *Huaxue chujie* system,the *Huaxue jianyuan* system,and the *Huaxue zhinan* systems for the chemical elements were all in use,whilst other authors were busy inventing yet more variations in their own textbooks,picking and choosing from the other systems as they saw fit.[393] The Terminology Committee of the Educational Association of China(E.A.C.) was set up in May 1890 [394] to standardise the terminology once and for

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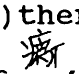
[392] *Huaxue zhinan* 1.1b-2a. Billequin was by no means the only translator who freely created characters. In Philip Cousland (ed.)*An English-Chinese lexicon of medical terms*(Shanghai:Medical Missionary Society of China,1908)there are many examples of hybrid characters such as(p.395)  [a combination of the sickness radical 疒 and 新 'new'] for 'acute disease' and(p.396)  [禾 'grain',少 'young' and 生 'living'] for 'bacterium'.

[393] See Li Guoying 李國英 in *GZKYHB*(1890/91),6.32b on the different characters for sodium and potassium in *Huaxue jianyuan* and *Huaxue chujie*,and Sun Weixin 孫維新's remarks in *ibid.*,4.24b(1889).

[394] The Educational Association of China,founded in 1890,was the successor to the School and Textbooks Series Committee set up in 1877 at the General Conference of Protestant Missionaries in Shanghai.See Wang Yangzong,'Qingmo Yizhi Shuhui tongyi keji

all. It proved immensely difficult: none of the translators was willing to admit his own system was inferior to the others. As John Fryer wrote to Mateer:

> Your committee ought not to change my terms unless they are radically wrong and impossible to be used. Should any terms of mine be shown to be erroneous,absurd,or otherwise unserviceable,and another be [...]without defects,I will gladly yield to it and not otherwise.[395]

Mateer found other missionary translators just as obstinate,saying on one occasion

> If I had the power I would send an officer to arrest Dr Kerr,Dr Fryer,Dr Martin and Dr Hunter,and I would lock them in a room on bread and water until they agreed on a chemical nomenclature.[396]

Progress was painfully slow,but by 1898 Mateer was able to publish his *Revised list of the chemical elements*,which proposed some dramatic changes. The principles on which the *Revised list* was drawn up were:

> 1.Let each element be represented by a character distinct from all the others,not only in form but also in sound,ignoring tones which are too uncertain and

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shuyu gongzuo shuping,9-19.

[395] A.A.Bennett,*John Fryer,*32

[396] *Records of the Second Triennial Meeting of the Educational Association of China held at Shanghai May 6-9,1896*,163

> variable to form the sole basis of the distinction between the names of two elements.[397]

Mateer attacked the *Huaxue chujie* and *Huaxue jianyuan* systems for having far too many homophones(*Huaxue chujie* had five elements called *lu* and four called *shi*; *Huaxue jianyuan* had three elements called *di* and six called *shi*); stopping when teaching to define which *'di'* was meant was 'an unmitigated nuisance'[398]. Having dealt with the phonetics of the system,he then went on to define the types of graphs he would permit:

> 2.Let the names of all the gases(including the four halogens which are either gaseous or strongly inclined to pass into a gaseous state),together with the names of all the more important metals and earths,be significant.[399]

By *significant* Mateer meant that the character should be a *huiyizi*,with the components giving some information about the element in question,as Billequin had tried to do in *Huaxue zhinan*. He recognised that this technique was limited in its practical application and so

> 3.Let the names of the less common substances be phonetic,seeing as it is impossible in most cases to form a term which will convey any distinctive idea of their nature.[400]

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397 Calvin Mateer,'Revised list of the chemical elements',87.

398 *ibid.*,88

399 *ibid.*,88

400 *ibid.*,88

Thus he allowed the principles followed in *Huaxue jianyuan* to be followed for the less important elements. This included the choice of radicals for the solid elements:

> 4.Whether significant or phonetic prefix a 金 to all metals and a 石 to all such as are neither gases nor metals(commonly classified as earths).[401]

Thus far there was no violent disagreement with the Xu Shou/Fryer system,but the next principle meant that no compromise was possible:

> 5.In giving phonetic names avoid as far as possible all such characters as already have a well defined signification,and let all if possible be pronounced according to the sound of the phonetic part.[402]

Xu Shou and Fryer had built their system on the opposite presumption,that wherever possible an obsolete character was to be <u>preferred</u> to the creation of a new one. It was this principle above all that made the E.A.C. list look so different from that in the Jiangnan Arsenal textbooks,as even well-established characters like 鉑 for platinum were rejected because they could be found in *Kangxi zidian*[Kangxi Dictionary]. However,this principle was not applied consistently,as the terms allowed for sodium and potassium were both pre-existing graphs.

Finally,one further restriction was placed on the characters to be used:

> 6.The characters formed or chosen to represent the

[401] *ibid.*,88

[402] *ibid.*,89

> elements should in all cases consist of as few strokes as possible.[403]

This was aimed at Billequin's system with the infamous [illegible] character with 37 strokes for 'manganese'. The Committee did put forward a number of quite reasonable suggestions such as [illegible] for 'calcium' [the *gu* 骨 component indicating that calcium is found in bones],but there were several which verged on the eccentric,such as creating an entirely novel character *man* 鏋 for 'gold'[404],and also rejecting the long-standing term for nitrogen because the character *dan* 淡 was also needed for its meaning of 'dilute',and choosing instead *yu* 育 because nitrogen 'nourishes'. Generally the Committee seem to have preferred Kerr and Martin's approach to Xu and Fryer's: even Billequin's ideas,though regarded as impractical,clearly influenced the choice of the characters for phosphorus,fluorine and iodine.

The E.A.C. list was finally published in book form in 1904 with a revised version in 1910. [405] The most important change introduced in the 1910 system was the contraction of the names of the gases to a single character formed by using the gas radical 氣 with a phonetic component,so that oxygen became *yang* 氧,an improvement retained by the standardisers of the twentieth century . By the first decade of the century the phase of foreign control of chemical nomenclature was over: in 1908 the new Board of Education(*Xue Bu* 學部)published its own chemical vocabulary

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403 *ibid.*,89

404 *ibid.*,92-93. This was on the grounds that *jin* 金 meant 'metals in general' rather than 'gold' in particular.

405 See Mateer,*Technical terms*(1904) and Stuart,*Technical terms*(1910).

Huaxue yuhui 化學語彙,which turned out to be almost entirely the same as the Xu/Fryer system[406]. The late victory was not due mainly to the inherently overwhelming superiority of the *Huaxue jianyuan* system,which had,and still has,many critics,but simply to the fact that so many translations already used it,and familiarity was a powerful argument when chemical terminology was generally in such flux and disarray. The glib way in which the E.A.C. committee had admitted that their reforms would

> [require] the revision and reprinting of all existing works on chemistry.[407]

showed a cavalier disregard for the practical problems of book publication - let alone the difficulties for students who had mastered the older system - which was somehow typical of the arrogant attitude of the Western missionaries to their task,typified by their failure to include any Chinese members on their Terminology Committee: it was a presumption of the whole enterprise of the E.A.C. Terminology Committee that the Chinese themselves were incapable of deciding what form their technical language should take.

Thus in the end the sheer industry of the Jiangnan Arsenal translators - and the skill and knowledge of first-rank Chinese scientists such as Xu Shou - ensured that

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[406] In *Huaxue yuhui* 化學語彙,for the 64 elements introduced in *Huaxue jianyuan*,the only changes made were: a stone radical introduced for the characters for arsenic and boron; *bo* 鋍 rather than *gu* 鋊 used for 'beryllium'; *si* 鉰 instead of *xi*錯 for 'silicon'; *shuiyin* 水銀 rather than *gong* 汞 for mercury; *e* 鑩 rather than *mi* 𨥙 for osmium(the sole concession to Billequin); *baijin* 白金 rather than 鉑 for platinum; *liuhuang*硫黃 replaced *liu* 硫 for sulphur.

[407] Mateer,'Revised List',94

their system for the chemical elements triumphed completely over its rivals, as the first truly official work on chemical terminology in China, the trilingual (Chinese, Japanese, English) *Huaxue yuhui* 化學語彙 [A glossary of chemical terms], published by the Board of Study (*Xue Bu* 學部) in 1908 completely ignored the E.A.C. list, using almost entirely the Jiangnan Arsenal terms for the elements.

```
          [Pre-1850 Chinese terms]
                    *
                    *
                    *
                    *
           Bowu xinbian(1855)
                    .     .
                    .        .
                    .            .
          Gewu rumen(1868)     Jinshi shibie(1868)
                    *                   *
                    *                   *
                    *                   *
                    *                   *
   Huaxue chujie(1870) ...... Huaxue jianyuan(1871)
                    *                   *
                    *                  .*
                    *                 . *
                    *                .  *
         Huaxue zhinan(1873)        .   *
                    *              .    *
                    *             . Huaxue yuhui(1908)
                    *            .      *
                    *           .       *
        Revised list(1898)              *
                       .                *
                          .             *
                               .        *
                              Modern system
```

Key: . . . . weak influence

* * * * strong influence

Figure 14. A genealogy of the modern Chinese nomenclature of the elements

Table 1. The Chinese translations used for the chemical elements from 1850 to 1900

No.	element	Modern name	*Bowu xinbian* (1855)	*Jinshi shibie* (1868)	*Gewu rumen* (1868)	*Huaxue chujie* (1870)	*Huaxue jianyuan* (1871)	*Huaxue zhinan* (1873)	*E.A.C. list* (1898)
1	aluminium	*!lü* 鋁	x	**aluminien* 阿盧彌尼恩	*fanjing* 礬精	*fan* 釩	*!lü* 鋁	? ⿰金礬	? 釷
2	antimony	*!ti* 銻	x	**andimoni* 安的摩尼	x*[*sibi* 思避]	*!ti* 銻	*!ti* 銻	? ⿰金吐	*an* 銨
3	arsenic	*shen* 砷	x	*pi* 砒	*xinshi* 信石	? ⿱信金	*shen* 鉮	? ⿰石信	*pi* 砒
4	barium	*!bei* 鋇	x	**beieryien* 貝而以恩	x*[*bi'a* 避阿]	*!bei* 鋇	*!bei* 鋇	? 鍾	*!bei* 鋇
5	beryllium (glucinum)	*pi* 鈹	x	**guluoxien* 谷羅西恩	x	?! 銑	*!gu* 鋊	?! 鉗	*bo* 鋍
6	bismuth	*!bi* 鉍	x	**biesimosi* 別斯末斯	x*[*bi'ai* 避愛]	*!bi* 鉍	*!bi* 鉍	? ⿰金粉	*!bi* 鉍
7	boron	*!peng* 硼	x	**buerlun* 布而倫	*!peng-jing* 硼精	*!peng* 硼	*!bu* 鈽	*!pengjing* 硼精	*!peng* 硼
8	bromine	*!xiu* 溴	x	**boluoming* 孛羅名	x*[*bi'er* 避而]	*!xiu* 溴	*!xiu* 溴	? 溴	*!xiu* 溴
9	cadmium	*!ge* 鎘	x	**kaitemien* 開特彌恩	x	*!qie* 鍥	*!ge* 鎘	? [illegible]	*ka?* 鉲

10	caesium	*se* 銫	x	x	x	*si* 鉰	*xi* 鏭	?# 鑑	*kai* 鎧
11	calcium	*gai* 鈣	x	**gaierxien* 丐而西恩	*shijing* 石精	!*shi* 鉐	*gai* 鈣	? [illegible]	*gu* 鋦
12	carbon	!*tan* 碳	!*tan* 炭	!*tan* 炭	!*tan-jing* 炭精	!*tan* 炭	!*tan* 炭	!*tan-jing* 炭精	!*tan* 碳
13	cerium	*shi* 鈰	x	**xieryien* 昔而以恩	x	*li* 鑗	!*xi* 錯	x	*shi* 鈰
14	chlorine	!*lü* 氯	x	!*lüqi* 綠氣	!*yanqi* 鹽氣	!*lü* 綠	!*lüqi* 綠氣	!*lüqi* 綠氣	!*lü* 綠
15	chromium	!*ge* 鉻	x	**keluomien* 客羅彌恩	x	!*lu* 鏴	!*ge* 鉻	? [illegible]	*mo?* 鏌
16	cobalt	!*gu* 鈷	x	**kubaoer* 苦抱爾	x*[*xi'e* 悉俄]	!*gao* 鎬	!*gu* 鈷	? 錆	*kou* 釦
17	copper	!*tong* 銅	!*tong* 銅	!*tong* 銅	!*tong* 銅	!*tong* 銅	!*tong* 銅	!*tong* 銅	!*tong* 銅
18	didymium[408] [dysprosium]	!*di* 鏑	x	x	x	!*di* [illegible]	!*di* 鏑	x	x

[408] The element didymium was discovered later to be a mixture of two elements, *dysprosium* and *neodymium*, but the symbol formerly used for didymium was used for dysprosium.

19	erbium	*!er* 鉺	x	**erpien* 耳皮恩	x	*!er* 鉺	*!er* 鉺	x	*!er* 鉺
20	fluorine	*fu* 氟	x	**fuluo'erli-n* 夫羅而林	x*[*fei* 肥]	*!fu* 弗	*!fuqi* 弗氣	? [illegible]	*!ke* [illegible]
21	gold	*!jin* 金	*!jin* 金	*!huangjin* 黄金	*!huang-jin* 黄金	*!jin* 金	*!jin* 金	*!jin* 金	*man* 鏋
22	hydrogen	*!qing* 氫	*!qingqi* 輕氣	*!qingqi* 輕氣	*!danqi* 淡氣	*!qing* 輕	*!qingqi* 輕氣	*!qingqi* 輕氣	*!qing* 輕
23	indium	*yin* 銦	x	x	x	*yan* [illegible]	*yin* 銦	x	*yin* 銦
24	iodine	*dian* 碘	x	**aiading* 愛阿靛	*!hailan* 海藍	*dian* 碘	*dian* 碘	? [illegible]	*zi* 紫
25	iridium	*yi* 銥	x	**yiridien* 衣日的恩	x*[*ai'er* 愛而]	*yi* 銥	*yi* 銥	? [illegible]	*ai* 鎄
26	iron	*!tie* 鐵	*!tie* 鐵	*!tie* 鐵	*!tie* 鐵	*!tie* 鐵	*!tie* 鐵	*!tie* 鐵	*!tie* 鐵
27	lanthanum	*lan* 鑭	x	**langtinien* 浪替尼恩	x	*lan* 鑭	*!lang* 鋃	x	*!lang* 鋃
28	lead	*!qian* 鉛	*!qian* 鉛	*!qian* 鉛	*!heiqia-n* 黑鉛	*!qian* 鉛	*!qian* 鉛	*!heiqia-n* 黑鉛	*!qian* 鉛

29	lithium	*li* 鋰	x	**liefeidien* 劣非地恩	x*[*li* 梨]	*li* 鋰	*li* 鋰	!*shi* 鉐	*li* 鋰
30	magnesium	*mei* 鎂	x	**meihenixi-en* 美合尼西恩	x*[*mi-zhi* 米治]	*mei* 鎂	*mei* 鎂	? ⿰金鹵	*mei* 鎂
31	manganese	*meng* 錳	x	**menggenisi* 孟葛尼斯	!*meng-shi* 蒙石	*meng* 錳	*meng* 錳	? ⿰金蒙	*mo* ⿰金墨
32	mercury	!*gong* 汞	!*shui-yin* 水銀	!*shuiyin* 水銀	!*shui-yin* 水銀	!*gong* 汞	!*gong* 汞	!*gong* 汞	!*gong* 汞
33	molybdenum	*mu* 鉬	x	**mulibiedie-neng* 目力別迭能	x	*mao* ⿰金冒	*mu* 鉬	#*mo* ⿰金墨	*mu* 鉾
34	nickel	*nie* 鎳	x	**niekeer* 臬客爾	x*[*ni'ai* 尼愛]	!*ge* 鎘	*nie* 鎳	*cui* ⿰金翠	*nie* 鎳
35	niobium (columbium)	!*ni* 鈮	x	**kelunpien* 可倫皮恩	x	!*ke* 鈳	!*ni* 鈮	x	!*ni* 鈮
36	nitrogen	!*dan* 氮	!*danqi* 淡氣	!*xiaoqi* 硝氣	!*xiaoqi* 硝氣	!*dan* 淡	!*danqi* 淡氣	!*xiaoqi* 硝气	!*yu* 育
37	osmium	!*e* ⿰金惡	x	x	x	!*e* ⿰金惡	*mi* ⿰金米	!*e* ⿰金惡	*ou* 鏂

38	oxygen	*!yang* 氧	*!yangqi* 養氣	*!yangqi* 養氣	*!yangqi* 養氣	*!yang* 養	*!yangqi* 養氣	*!yangqi* 養氣	*!yang* 養
39	palladium	*!ba* 鈀	x	**baliudien* 鈀 留底恩	x*[*bi'a* 彼阿]	*!ba* 鈀	*!ba* 鈀	x	*!ba* 鈀
40	phosphorus	*!lin* 磷	x	*!lin* 燐	*!guang-yao* 光藥	*!lin* 燐	*!lin* 燐	*!guang* 硄	*!lin* 燐
41	platinum	*!bai* 鉑	x	*!baijin* 白金	*!baijin* 白金	*!bai* 鉑	*!bai* 鉑	*!bai* 鉑	*shen* 鈂
42	potassium	*!jia* 鉀	x	**buduisien* 卜對斯恩	*!hui-jing* 灰精	*hui* ⿰金灰	*!jia* 鉀	*hui* ⿰金灰	*hui* ⿰金灰
43	rhodium	*lao* 銠	x	**rihuodien* 日和地恩	x*[*er* 而]	*lu* ⿰金坴	*lu* ⿰金坴	*dan* ⿰金丹	*lou* ⿰金西
44	rubidium	*!ru* 銣	x	x	x	*lu* 鑪	*!ru* 銣	x	*!ru* 銣
45	ruthenium	*!liao* 釕	x	x	x	*!lao* 銠	*!liao* 釕	x	*!lao* 銠
46	selenium	*xi* 硒	x	**xilinien* 昔里尼恩	x*[*siyi* 思意]	*xi* 硒	*xi* 硒	? 硼	*lun* 碖
47	silicon	*gui* 硅	x	**xilixien* 夕里西恩	*!bojing* 玻精	*!bo* 玻	*xi* 矽	*!sha-jing* 砂精	*jing* ⿰石晶

48	silver	*!yin* 銀	x	*!yin* 銀	*!baiyin* 白銀	*!yin* 銀	*!yin* 銀	*!yin* 銀	*!yin* 銀
49	sodium	*!na* 鈉	x	**sudien* 素地恩	*!jian-jing* 鹻 精	*!lü* 鑥	*!na* 鈉	? 鍼	*!lü* 鑥
50	strontium	*xi* 鎴	x	**xituolang-xien* 息脱浪西恩	*x*[si-'er* 思而]	*xi* 鎴	*xi* 鎴	? 鐂	*chi* [illegible]
51	sulphur	*!liu* 硫	*!liu-huang* 硫 黃	*!liuhuang* 硫 磺	*!liu-huang* 硫 磺	*!huang* 磺	*!liu* 硫	*!liu-huang* 硫 磺	*!liu* 硫
52	tantalum	*dan* 鉭	x	**tantailien* 談台里恩	x	*dan* 鉭	*dan* 鉭	x	*dan* 鉭
53	tellurium	*di* 碲	x	**tuoluolien* 脱羅里恩	x	*di* 碲	*!di* 鍗	? [illegible]	*ti* [illegible]
54	terbium	*te* 鉽	x	**teerbien* 忒而比恩	x	*die* [illegible]	*te* 鉽	x	*te* 鉽
55	thallium	*ta* 鉈	x	x	x	*ta* [illegible]	*!tai* 鈶	x	*ta* [illegible]
56	thorium	*tu* 釷	x	**tulien* 土里恩	x	*!dao* 釖	*tu* 釷	x	*dou* 鋀
57	tin	*!xi* 锡	*!xi* 锡	*!xi* 锡	*!xi* 锡	*!xi* 锡	*!xi* 锡	*!xi* 锡	*!xi* 锡

58	titanium	*tai* 鈦	x	**tituonien* 替脱尼恩	x	*?tai* 鈦	*ti* [illegible]	*chi* [illegible]	*tai* 鈦
59	tungsten	*!wu* 鎢	x	**dongsitian* 東斯天	x*[*wei* 微]	*!wu* 鎢	*!wu* 鎢	x	*teng* [illegible]
60	uranium	*!you* 鈾	x	**yourinien* 由日尼恩	x	*!you* [illegible]	*!you* 鈾	*huang* 鐄	*!you* 鈾
61	vanadium	*fan* 釩	x	**fannaidien* 凡奈地恩	x	*!fan* 鐇 鐇	*fan* 釩	x	*fan* 釩
62	yttrium	*yi* 鐿	x	**yitelien* 以特里恩	x	*yi* 鐿	*tai* 鈦	x	*ye* 釶
63	zinc	*!xin* 鋅	*!jingqi* 精錡	*!baiqian* 白鉛	*!bai-qian* 白鉛	*!xing* 鍟	*!xin* 鋅	? 鏤	*zheng* 鉦
64	zirconium	*gao* 鋯	x	**erguonien* 爾果尼恩	x	*xie* [illegible]	*gao* 鋯	x	*xie* [illegible]

Notes: (1) x means that the element is not mentioned at all

(2) * means that what follows is a transliteration of the Western name,not a symbol. In *Gewu rumen* the characters simply indicate the letters of the Western symbol e.g. Br,rather than the whole word.

(3) # means that this term was used in *Huaxue shanyuan*,also translated by Billequin,and published in 1882,rather than *Huaxue zhinan*.

(4)Phonetic readings for the *Huaxue zhinan* characters are based on the phonetic component where this is evident. Billequin himself did not intend the characters to be pronounced.

(5)! means that the character/s used already existed.(This symbol is not used where the name is simply transliterated).

(6) ? means that the pronunciation is indeterminate

Table 2. The explanation of the characters used by Anatole Billequin in *Huaxue zhinan* [409]

Element	character used	Billequin's explanation	Comments
aluminium	⿰金礬	A metal extracted from white alum *baifan* 白	Alum is a salt containing aluminium.
antimony	⿰金吐	The ingestion of salts of this metal causes vomiting *tu* 吐	Antimony was a well-known emetic.
arsenic	⿰石信	It is extracted from *xinshi* 信石	*Xinshi* was an ore of arsenic from Guangxin 廣信 near Shangrao 上饒 in modern Jiangxi Province.[410]
barium	鍾	A metal which is smelted from a heavy [*zhong* 重] earth [*tu* 土] .	Barium is noted for the density of its salts.

[409] *Huaxue zhinan*, 1.5b and 3.1b–2a

[410] See Frederick Porter Smith, *Contributions towards the Materia Medica of China*, 24. According to Song Yongxing, it was also found at Xinyangzhou 信陽州 in Henan Province. See Pan Jixing (ed.) *Tiangong kaiwu jiaozhu ji yanjiu*, 451

beryllium	鉗	The salts of this metal have a sweet[*gan* 甘]taste.	Glucinium is a former name for the metal beryllium,whose highly toxic salts have a sweet taste.
bismuth	⿰金粉	The salts of this metal are used for face-powder[*mianfen* 面粉]	Bismuth compounds were formerly used as cosmetics.[411]
boron	硼 精	The principle[*jing* 精] of borax[*pengsha* 硼 砂].	
bromine	溴	It has a foul[*chou* 臭]smell and it is a liquid.	Billequin included the *death* radical 歹 to show how toxic bromine was.
cadmium	⿰金⿱霜黃	This metal is similar to zinc: when burned it produces a yellow[*huang* 黄] solid 'frost'[*shuang* 霜].	Cadmium is noted for its yellow salts. The term *shuang* was used by the alchemists for solid precipitates.
calcium	⿰金石灰	This metal is extracted from lime[*shihui* 石灰].	Slaked lime is calcium hydroxide.

[411] J.R.Partington,*History of chemistry* Vol.3(London:Macmillan,1962),

carbon	炭精	That is,diamond[*jin'gangshi* 金剛石]	Diamond is only one allotrope of carbon.
chlorine	綠氣	That is,salt gas[*yanqi* 鹽氣]:it is extracted from salt [鹽]and is green [綠] in colour.	The green colour would seem to have been a more memorable property of the element.
chromium	銫	The salts of this metal can produce[*sheng* 生] all kinds of colour[*se* 色].	Chromium forms several series of brilliantly coloured salts,some of which are used as pigments.
cobalt	錆	The salts of this metal are sky-blue[*qing* 青] in colour.	Cobalt salts are usually deeply coloured,and may be pink or blue.
fluorine	[illegible]	This substance can corrode [*xiaoke* 消剋]other substances.	Fluorine is intensely corrosive of most materials,and attacks even glass containers.
hydrogen	輕	This is the lightest [*zuiqing* 最輕] gas.	
iodine	[illegible]	Its vapour is purple[*zi* 紫]	Billequin added *yan* 炎 'hot',presumably to show that it needed to be heated to make the purple vapour.

iridium	⿰釒虹	The colours of the salts of this metal are like the rainbow[*hong* 虹].	
lithium	鉐	According to the meaning of the Greek name.	That is, *lithos* = stone[石]
magnesium	⿰釒滷	A metal extracted from brine	This is one of the weaker names, as many other metals are also present in brine.
manganese	⿰釒⿱無⿰名異	A metal extracted from pyrolusite[*wumingyi* 無名異]	Pyrolusite is manganese dioxide, the principal ore of manganese.
nickel	⿰釒翠	The salts of this metal are jade-green [*cui* 翠] in colour.	
nitrogen	硝 氣	This gas is extracted from saltpetre[*xiao* 硝]	
osmium	⿰釒惡	This metal when vaporised is evil[e 惡] - smelling and poisonous.	The Greek root *osme* = evil-smelling.
phosphorus	硄	It gives out light[*guang* 光].	White phosphorus glows in the dark.

platinum	鉑	This substance is like gold[*jin* 金]and is white[*bai* 白]in colour.	
potassium	[illegible]	A metal extracted from wood ash[*muhui* 木灰].	Potassium salts are found in plant ash.
rhodium	[illegible]	The salts of this metal are vermilion[*dan* 丹] in colour.	
selenium	[illegible]	When this substance was first obtained its colour seemed like that of the Moon.	From the Greek *selene* = moon.
silicon	砂 精	The principle[*jing* 精] of sand [*shatu* 砂 土].	Sand is mainly silicon dioxide.
sodium	鍼	A metal extracted from alkali[*jian* 碱]	Sodium hydroxide is the strong alkali caustic soda.
strontium	[illegible]	This metal produces a compound[*yao* 藥] which when burned produces a red[*hong* 紅] flame [*miao* 苗].	Strontium salts impart a deep red colour to the flame.
sulphur	硫 磺		Billequin adds a stone radical to both components of this term

tellurium	⿰石地	Its colour is like that of the earth[*di* 地]	The name derives from Latin *telluris* 'earth'.
titanium	⿰金赤	This metal,when compounded with other substances,produces a red[*chi* 赤]colour.	Titanium compounds are often red or orange in aqueous solution.
uranium	⿰金黄	This metal produces many yellow[*huang* 黄] salts.	At this time uranium was known chiefly for its pigmentation properties:radio-activity not yet having been discovered.
zinc	⿰金倭	That is 'dwarf lead'.	'Dwarf' [*wo* 倭]was the derogatory term for the Japanese at this time[412].

[412] Song Yingxing stated that it was called 'dwarf lead' because it is more 'fierce' than normal lead. See Pan Jixing(ed.)*Tiangong kaiwu jiaozhu ji yanjiu*,358

6.3 The naming of inorganic compounds

The naming of inorganic compounds in Chinese in this period reflects the confusion in Western chemistry over chemical nomenclature. During this period there was still debate over the use of atomic and equivalent weights,and the use of dualistic or unitary formulae. The confusion was not soon resolved,and some commentators complained that the foreigners were simply importing into China the confusions of the 'alchemical' Western system.[413]

In Chinese,most translators agreed,the *symbol* for the element should also be its *name*: this opened the possibility,at least for the simpler substances,for the *formula* of a compound also being its *name*,just as,in English chemists,may refer colloquially to 'HCl' rather than 'hydrochloric acid'.

The Jiangnan Arsenal translators and also the Beijing Tongwenguan chemistry professor Billequin,adopted: (1) the *dualistic system* of Berzelius,that is treating compounds of metals as compounds of the metal oxide with a nonmetal oxide

[413] G.Schlegel,'Scientific confectionery',151

e.g. copper sulphate $CuO.SO_3$

and (2) the system of using *equivalents* rather than atomic weights for the formulae. Thus, in this system, water was given as HO (one equivalent of hydrogen - 1 gram - combining with one equivalent - 8 grams - of oxygen).

These two systems are logically quite independent, and since both differ from modern usage this has caused much confusion in previous writing on the subject.[414]

[414] Zeng Zhaolun, 'Jiangnan zhizaoju shidai bianji zhi shuji ji qi suo yong zhi huaxue mingci', 273 explains the formulae used in terms of the atomic weights not being settled until the Karlsruhe Conference (1860), but this is only part of the story: dualistic formulae continued to be used even after the atomic weight issue was settled.

In the case of the Jiangnan Arsenal the reason was not that the translators held to one or other system, but simply that they were using textbooks - such David Wells' *Principles and applications of chemistry*(1862) and Charles Loudon Bloxam's *Chemistry inorganic and organic with experiments and a comparison of equivalent and molecular formulae*(1867) - which followed systems which even by the late 1860s were becoming outdated. As Bloxam himself admitted in the introduction to his book

> In explaining chemical changes by equations, I have, as a general rule, employed symbols representing combining weights(or equivalents), and not the atoms [= atomic weights], of the elements. Had the work been intended for advanced students, I should have hesitated to incur the reproach of obstinate conservatism or of being behind the chemical spirit of the time, though even then, which of the more advanced systems was to be adopted would have been a very formidable question, for at present the different modes of representing chemical changes are almost as numerous as chemical writers.[415]

Xu Shou and John Fryer followed this system in *Huaxue jianyuan* 化學鑑原 and in its successors such as for example *Huaxue jianyuan xubian* 化學鑑原續

[415] Charles Loudon Bloxam, *Chemistry inorganic and organic*, iv. In the second(1872) edition he used atomic formulae. See D.I.Davies, D.C.Lyon and R.J.Spring, 'Charles Loudon Bloxam - a Victorian university and military academy chemistry teacher' in *Ambix* **33**,1(March 1986),26

編,*Huaxue kaozhi* 化學考質,as well as many works on collateral subjects. The dualistic/equivalent system was also used by Billequin in *Huaxue zhinan* 化學指南 .

They described their method as follows:

> The Western names of substances have many letters and are phonetically complex.When translating into Chinese,we cannot take up[so much space,so [we] now take just one character to stand for the name of each element,whilst the names of the compounds are given by writing the names of the elements [in the compounds]in succession. It is [thus] not only desirable that the names of all the elements should be clear and simple,but also that the names of compounds should not exceed more than a few characters. Usually an [equivalent] number is added to the character [of an element] to show [its] proportion [in the compound]. The name may also be given in symbols.[416]

They went on to give examples first of binary compounds such as water 輕養 [HO] and sulphuric acid 硫養三 [SO_3].(At this time the term 'acid' was used for the oxides of nonmetals which dissolved in water to make acids.) For salts

> [The system] may be extended by putting the primary substance first and then the secondary substance for example [iron(II)sulphate] 鐵養硫養三 [FeO.SO_3 in dualistic or $FeSO_4$ in modern notation]. [417]

[416] *Huaxue jianyuan*,1.20b

[417] *Huaxue jianyuan*,1.21a

In compounds in which the proportions of the oxides were not 1:1,they put a large number before one of the oxides,and stated that

> its effect ceases when it reaches the [next] equivalent number,for example 二鉛養鉛養二 [$2PbO.PbO_2$,red lead oxide,now written Pb_3O_4]means that two parts of PbO are combined with one part of PbO_2[418]

For chemical equations they put the symbol 丄 (used for + in mathematics texts of this period) between the compounds,and a long equality sign ════ to signify chemical reaction,for instance the reaction between calcium carbonate and sulphuric acid

鈣養炭養二 丄 硫養三 ════

鈣養硫養三 丄 炭養二

[$CaO.CO_2$ + SO_3 = $CaO.SO_3$ + CO_2

or,in modern notation

$CaCO_3$ + H_2SO_4 = $CaSO_4$ + CO_2][419]

Alone of the early translators,John Glasgow Kerr used atomic weights and unitary formulae in *Huaxue chujie*,and it is curious that this book seems much more modern in its

418 *ibid.*,1.21b

419 *ibid.*,1.21b

approach than the later Jiangnan Arsenal and Tongwenguan textbooks.

6.31 The use of Western symbols for compounds

The general opinion of the translators was that Western symbols should be avoided and the Jiangnan Arsenal texts used Western symbols rather sparingly,preferring to translate everything into Chinese. In *Huaxue zhinan,* Billequin generally gave all the formulae in Western symbols using the dualistic system for inorganic substances,with *superscripts* indicating the proportions of the elements as was the custom of the time in France.

6.32 Equivalents and equivalent formulae

The formulae used in the Jiangnan Arsenal texts look strange to our eyes partly because they used the system of equivalent formulae rather than atomic formulae.

Section 13 of *Huaxue jianyuan* has been criticised by both Chinese and Western writers,but in fact the criticism it has attracted rests upon a misunderstanding of the history of mid-nineteenth century chemical notation. The relevant passage reads:

> Equivalents of chemical combination
>
> *This discusses weight.*
>
> The numbers in which the chemical elements combine are called equivalent numbers [*fenjishu* 分劑數]. Oxygen takes 8 parts as its equivalent,so if we refer to one equivalent of oxygen,we mean 8 parts.[...] If you combine one equivalent of hydrogen(1 part) with one

equivalent of oxygen(8 parts) then you get one equivalent of water(9 parts).[420]

This has been said by some writers to be confusing atomic weights and equivalents[421],but in fact the critics are mistaken: *Huaxue jianyuan* does state that weight is the consideration,and is in fact a perfectly accurate translation of Wells' text,which employs equivalent formulae throughout. *Huaxue zhinan* also used equivalent formulae,whereas He Liaoran and Kerr's *Huaxue chujie* usually used 'atomic' formulae which gives their work a more familiar look.

This is an example of the same problem which faced the Jesuits in their transmission of astronomy when Western astronomy was undergoing a paradigm shift from the Ptolemaic to the Copernican system: should it be admitted that 'science' was not a doctrine to be revealed,but a system of ideas which were constantly being revised and modified in the light of more experience? The loss of face which wholesale revision would have demanded placed Fryer in particular,as the selector of the texts,in a difficult position. As the leading advocate of standardisation and consistency,his instinct was to press on with the system that he had used in *Huaxue jianyuan*,even though he must have realised how outdated it was,and despite the fact that Kerr and He Liaoran had already published their text with so-called 'modern' notation in 1871.

Fortunately for Fryer there were few people in China

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420 *ibid*.1.8a

421 Zhang Zigao and Yang Gen,'Cong *Huaxue chujie* he *Huaxue jianyuan* kan woguo zaoqi fanyi de huaxue shuji he huaxue mingci',110. This is also cited in James Reardon-Anderson,*The study of change*,37-38,who says that they omitted to mention that these parts are measured by weight. See also Sun Weixin 孫維新,writing in *GZKYHB*,4.24a.

who had the knowledge to question his translations openly,although as late as 1895 Dr Neal was led to complain

> on looking into the subject some years ago,when hunting for a suitable chemistry to teach my own students I found there was not a single book in which the new notation was used; and so far as I am informed this defect has not yet been remedied although it is now over twenty years since the new system was introduced into foreign text books on chemistry.[422]

Generally though the level of instruction in science in the few institutions which taught it was of such a low standard that the discrepancies between the systems attracted little attention at the time,but must have made the task of the students much harder. It may also have been a factor in the great interest in translations from Japanese textbooks after 1895,and especially after 1900.

6.33 The naming of oxides

In these simple compounds,the naming was often giving by simply placing the characters for the metal and for 'oxygen' in juxtaposition,as in *Huaxue chujie* 1.10b.1

lead oxide *yangqian* 養鉛

or in *Huaxue jianyuan* 2.2b.1

mercury oxide *gongyang* 汞養

The heuristic weakness of this method is that,unlike in European languages,in which the name of the compound is never just a string of the names of the elements it contains(thus we say 'lead oxide ' and not 'lead

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[422] Neal,'Treatises on chemistry',188

oxygen'),the latter usages would tend to suggest a mere mixture of the two elements rather than a chemical combination.

In the *Huaxue chujie* and the Jiangnan Arsenal systems,the more complex oxides were named by simply giving their formulae,so that sulphur trioxide for instance was simply *huangyang$_{san}$* 磺養$_{三}$ (*Huaxue chujie)* and *liuyang$_{san}$* 硫養$_{三}$ (Jiangnan Arsenal).

Huaxue zhinan used Berzelius' system of putting dots or circles above the name of the element to indicate the amount of oxygen,

as in $\dot{鐵}$ [FeO] and $\dddot{鐵}_{三}$ [Fe_2O_3] [423]

Billequin simply called metal oxides *xiu* 鏽 'rusts' of the metals in question.

6.34 The naming of salts

In the Jiangnan Arsenal texts,salts were indicated by the dualistic formula,with equivalent numbers

e.g. iron(II) sulphate *tieyang liuyang$_{san}$* 鐵養硫養$_{三}$ [$FeO.SO_3$]

whereas *Huaxue chujie* gave the unitary formulae using atomic formulae:

iron(II) sulphate *tieliuyang$_{si}$* 鐵硫養$_{四}$ ($FeSO_4$)

In *Huaxue zhinan* salts were named from the metal and the acid formed from the nonmetal

[423] *Huaxue zhinan,*1.3b

iron(II) sulphate *tiehuangqiangyan* 鐵磺強鹽

or 'iron salt of sulphuric acid'

6.35 The naming of acids

During this period the term 'acid' was sometimes used not only for the liquid or aqueous acids but also for the gases from which the acid came,so that carbon dioxide,nitrogen pentoxide and sulphur dioxide were all termed 'acids'.

Huaxue zhinan used both *suan* 酸 and *qiang* 強 for 'acid',[424] with prefixes *ji* 極[extreme],*ci* 次[inferior] to indicate the suffixes '-ic','- ous' etc used in naming the acids of phosphorus,chlorine and nitrogen.[425]

[424] *Huaxue zhinan*,1.3b

[425] *Huaxue zhinan*,1.2b

Table 3. A comparison of chemical terms used in early modern chemistry texts

English term	Modern Chinese term	*Gewu rumen* (1868)	*Huaxue chujie* (1870)	*Huaxue jianyuan* (1871)	*Huaxue zhinan* (1873)	Mateer, *Technical terms* (1904)	*Huaxue yuhui* (1908)
absorb	*xishou* 吸收		*shi (re)* 食熱 1.7b.4		*shi* 食 1.12a.2	*shoushi* 收食 2	*xishou* 吸收 1
acid	*suan* 酸	*qiangshui* 强水 6.11a.	*suanlei* 酸類 1.7b.10	*peizhi* 配質 1.14a.8 or *suanlei* 酸類 1.14b.5 or *qiang-shui* 強水[426]	*suan* 酸 1.2a.8	*suanlei* 酸類 3	*suan* 酸 1

[426] The term *qiangshui* was not new. It had been used by Xu Guangqi 徐光啓(1562-1633) in *Zao qiangshui fa* 造強水法[Methods for making acids](1625-1628). See Pan Jixing 潘吉星, 'Woguo Ming-Qing shiqi guanyu wujisuan de jizai' 我国明清时期关于无机酸的记载[Records of inorganic acids in the Ming and Qing periods] in Zhao Kuanghua 赵匡华 (ed.)*Zhongguo gudai huaxueshi yanjiu* 中国古代化学史研究[Research on the history of chemistry in ancient China](Beijing:Beijing Daxue chubanshe 北京大学出版社,1985),638-639.

air	*kongqi* 空氣	*tianqi* 天氣 2.20a.4	*tianqi* 天氣 1.1b.3	*kongqi* 空氣 1.2a.3	*tianqi* 天氣 1.7b.6	*kongqi* 空氣 7	*kongqi* 空氣 1
alkali	*jian* 碱	*hali* 哈利 6.61a <u>or</u> *hali* 蛤利 6.61a <u>or</u> *jianlei* 鹻 類 6.61a	*hali* 蛤利 1.8a.1 <u>or</u> *jianlei* 鹻 類 1.8a.10	*jianlei* 鹻 類 1.14a.8	x	<u>or</u> *ahali* 阿蛤利 9	*jian* 鹻 <u>or</u> *aerjiali* 阿爾加里 1
alloy	*hejin* 合金				*ronghe-jin* 鎔 合 金 3.2a.1	*chanjin* 攙 金 <u>or</u> *hejin* 合金 9	*hejin* 合金 2
anode	*yangji* 陽極			*yangji* 陽極 1.14b.9	*yangji* 陽極 1.18a.3	*shangji-duan* 上極端 17	x

atom	*yuanzi* 原子		*[ji]wei-dian* 極微點 1.2a.4	*zhidian* 質點 1.2a.7		*yuandian* 元點 <u>or</u> *weidian* 微點 28	*yuanzi* 原子 3
attract (-ion) (chemical)		*xili* 吸力 6.5a.6	*huali* 化力 1.2a.1	*ainieli* 愛攝力 1.2a.8 <u>or</u> *aili* 愛力 1.2b.1	*qiannie* 牵摄 1.45b.6	*xili* 吸力 28	x
base	*jian* 碱		*dilei* 底類 1.7b.10	*benzhi* 本質 1.14a.7 <u>or</u> *yanlei zhi ben* 鹽類之本	*fansuan* 反酸 1.2a.8	*di* 底 *dilei* 底類 *genzhi* 根質 35	*yanji* 鹽基 4
cathode	*yinji* 陰極			*yinji* 陰極 1.14b.9	*yinji* 陰極 1.18a.3	x	*yinji* 陰極 6

chemical combin-ation	*huahe* 化合		*peihe* 配合 1.1b.7 or *huahe* 化合 1.4b.6	*huahe* 化合 1.2a.2	*qinhe* 親合 1.6b.8	*huahe* 化合 96	*huaxue jiehe* 化學結合 6
compound	*huahewu* 化合物		*zazhi* 雜質 1.1b.7	*zazhi* 雜質 1.1a.7	*hecheng zhi lei* 合成之類 1.1b.9	*hezhi* 合質 *zazhi* 雜質 99	*huahewu* 化合物 8
decompose	*fenjie* 分解			*huafen* 化分 1.14b.8		x	*fenjie* 分解 9
dissolve	*rongjie* 溶解	*xiaorong* 销融 2.32a.2	*shi* 食 1.2b.6	*xiaohua* 消化 1.2b.4 or *ronghe* 融合 2.4b.6	*xiaohua* 消化 1.22a.2 or *shi* 食 1.22a.2	x	*rongjie* 溶解 9

element	*yuansu* 元素	*yuanxing* 原行 6.2a.4 <u>or</u> *yuanzhi* 原質 6.3a.6	*yuanzhi* 原質 1.1a.4	*yuanzhi* 原質 1.1a.7	*yuan-xing* 原行 1.1b.9	*yuanzhi* 原質 147	*yuanzhi* 原質 10
equivalent [part]	*dangliang* 當量			*huahe fenji* 化合分劑 1.8a.1	*dingshu* 定數 1.7a.1	x	*dangliang* 當量 10
gas	*qiti* 氣體		*qilei* 氣類 1.1b.1	*qizhi* 氣質 1.1b.6		*qi* 氣 <u>or</u> *xuzhi* 虛質 188	*qiti* 氣體 12

to heat	*jiare* 加熱	*jiuhuo* 灸火 2.35a.8	*xialian* 煆 煉 1.10a.3 <u>or</u> *jiu* 灸 1.10b.1	*jiu* 灸 3.2a.8 <u>or</u> *fu* 煏 2.2b.2 <u>or</u> *jiare* 加熱 2.2a.10	*xia* 煆 1.10a.10 <u>or</u> *jiu* 灸 1.32a.7	x	x
liquid	*yeti* 液體		*liuzhi* 流質 1.1b.1	*liuzhi* 流質 1.1b.6	*liuzhi* 流質 1.1a.4	*liuzhi* 流質 <u>or</u> *yezhi* 液質 <u>or</u> *liuti* 流體 255	*yeti* 液體 15

litmus	*shirui* 石 蕊		*caolan* 草藍 1.8a.2	*caomu zhi lanse* 草木之藍色 1.14a.10 or *lidimuse* 里低母司 1.5a.8	*caolan* 草藍 1.2b.2	x	*lidimosi* 立低莫司 15 or *shirui* 石 蕊
to make	*zao* 造		*lian* 煉 1.2b.8		*lian* 煉 1.10a.8	x	x
metal	*jinshu* 金屬		*jin zhi lei* 金之類 1.1a.10	*jinlei* 金類 1.1b.4	*jinlei* 金類 1.2a.4	*jin* 金 276	**jinshu* 金屬 16
metal oxide	*yanghua jinshu* 氧化金屬		*yangqiji-n* 養氣金 1.8a.1		*xiu* 銹 1.3b.5	x	*yanghuawu* 養化物 19
molecule	*fenzi* 分子			*zadian* 雜點 1.10a.9		*hedian* 合點 282	*fenzi* 分子 17
neutral	*zhonghe* 中合				*danbao* 淡薄 1.3a.2	*zhongli* 中立 296	*zhongxing* 中性 17

nonmetal	*feijinshu* 非金屬		*feijin zhi lei* 非金之類 1.1a.10	*feijinlei* 非金類 1.1b.4	*feijinlei* 非金類 1.2a.4	x	*feijinshu* 非金屬 18
particle	*lizi* 粒子	*weizhi* 微質 6.2b.3 <u>or</u> *weidian* 微點 6.4b.7	*weidian* 微點 1.1b.10 <u>or</u> *jiweidian* 極微點 1.2a.3		*weidian* 微點 1.1b.5	x	x
precipitate	*chendianwu* 沈人物 澱				*shuang* 霜 1.6a.2	*dian* 澱 345	*shendian* 沈澱 21
to react/ reaction	*fanying* 反應	*jiaogan* 交感 6.2b.1	*jiaogan* 交感 1.3a.3	*huahe* 化合 1.15a.4	*xianggan* 相感 1.1a.9 <u>or</u> *xiaoyan* 效驗 1.3a.1	x	*fanying* 反應 21
salt/s	*yanlei* 鹽類		*yanlei* 鹽類 1.8a.3	*yanlei* 鹽類 1.14b.7	*yanlei* 鹽類 1.2b.10	*yanlei* 鹽類 384	*yan* 鹽 22

solid	*guti* 固體	*jianying* 堅硬 6.2b.10	*wai er chou ti* 外而綢體 1.1b.2 <u>or</u> *jianshi zhi ti* 堅實之體 1.3a.2	*dingzhi* 定質 1.1b.7	*jianshi zhi wu* 堅實之物 1.1a.4	x	*guti* 固體 23

Table 4. The naming of inorganic compounds in early modern chemistry texts

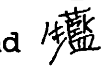
substance	*Huaxue chujie* (1871)	*Huaxue jianyuan* (1872)	*Huaxue zhinan* (1873)	Modern name or formula
ammonia	-	*danqing*$_{san}$ 淡輕三	*amonia* 阿摩尼阿 1.13a.9 <u>or</u> 硝輕三 1.30a.1 <u>or</u> 硝 輕三 9.11a	*an* 氨
hydrochloric acid	*qinglǜsuan* 輕綠酸 1.31a.6	*yanqiang-shui* 鹽強水 2.50b.2	*qinglǜ-qiang* 輕綠強	*qinglǜsuan* 氫 氯 酸
iron(II) sulphate	*tiehuang-yang*$_{si}$ 鐵磺養四 2.27a.10	$FeO.SO_3$ 1.19a.10 <u>or</u> *tieyang. liuyang*$_{san}$ 鐵養硫養三 5.5a.2	*tiehuang-qiangyan* 鐵磺強鹽 $FeOSO^3$ 7HO 4.51a.4	*liusuan-yatie* 硫酸亞鐵

manganese (IV) oxide	*mengyang*$_{er}$ 錳養二 1.10a.7		[illegible] 1.11a.3	*eryang-huameng* 二氧化錳
mercury (II) oxide	*yanggong* 養汞 1.10a.3	*gongyang* 汞養 2.2b.1 <u>or</u> *sanxiandan* 三仙丹 2.2b.1	*gongxiu* 汞锈 1.10a.9	*yanghua-gong* 氧化汞
nitric acid	*xiaoqiang-suan* 硝強酸 1.27a.8	*xiaoqiang-shui* 硝強水 2.33b.2	*xiaoqiang-shui* 硝強水 1.26a.1	*xiaosuan* 硝酸
ozone	*achun* 阿純 1.12b.8	*chouyangqi* 臭養氣 2.9a.10	*dianyangqi* 電養氣 1.13a.3	*chouyang* 臭氧
sulphur trioxide	*huangyang*$_{san}$ 磺養三 1.47a.1	*liuyang*$_{san}$ 硫養三 3.11b.9	*huangqiang-shuang* 磺強霜 1.40b.5	*sanyanghua liu* 三氧化硫
sulphuric acid	*huangqiang shui* 磺強水 1.47a.4	*liuqiang-shui* 硫強水 3.11b.9	*huangqiang* 磺強 2.2b.2	*liusuan* 硫酸

sulphurous acid	*huangsuan* 磺酸 1.48a.1	*liuyang*er 硫養 3.9b.10	*huangsuan-shui* 磺酸水 1.36a.10	*yaliusuan* 亞硫酸

6.4 The naming of organic compounds

The naming of organic compounds presented an even greater conundrum than that for inorganic ones. The Western names were unsystematic,and bore no direct relation to the actual constituents,but the solution which presented itself for inorganic compounds,of naming them on the basis of their formulae(whether equivalent or atomic),was impossible because of the large number of isomers. Translators therefore either transliterated(as in the Jiangnan Arsenal texts) or attempted to translate the meaning of the Western name(Billequin) or even to invent new characters(Billequin).

The *Huaxue zhinan* terms were often remarkably vivid: acetic acid *cuqiang* 醋強 'vinegar acid',hippuric acid *maniaosuan* 馬尿酸 'horse urine acid',and morphine *shuijing*睡精 'sleep essence'. Billequin again experimented with new *huiyizi* such as  酒精 for 'aldehyde',showing that it was alcohol *jiujing* 酒精 which lacked 少 hydrogen 輕 ;and  for the cyanide radical,showing that it produces 生 a blue藍 colour with certain compounds.

The Jiangnan Arsenal translators tended to transliterate such compounds,although sometimes they gave the translated version as an alternative. The enormous number of organic compounds made transliteration unmemorable and increasingly impractical,whilst the direct translation of names,easy enough in some cases such as when named after the plant or the animal from which they were extracted,could not be extended indefinitely to substances synthesised in the laboratory.

The situation was only resolved in the twentieth century when a systematic organic nomenclature became possible. The modern system had created a number of new characters for homologous series such as ketones,aldehydes,ethers,etc.

Table 5. The naming of organic compounds in early modern chemistry texts(with exact page references)

name of compound	*Huaxue cailiao Zhong-Xi mingmu biao*(1885)	*Huaxue zhinan* (1873)	*Huaxue yuhui*(1908)	modern Chinese
acetic acid	*cusuan* 醋酸 1	*cuqiang* 醋強 10.27a	*cusuan* 醋酸 1	*cusuan* 醋酸
acetone	*axiduoni* 阿西多尼 1	*jiucujing* 灸醋精 10.23a	x	*bingtong* 丙 酮
alcohol	*chun* 醇 1	*jiujing* 酒精 10.23a	*aerkeer* 阿爾科爾 1 or *jiujing* 酒精 1 or *chun* 醇 1	*jiujing* 酒精
aldehyde	*aledihaite* 阿勒弟海特 2	*qingjiu jing* 輕酒精 10.23a	*aledihaite* 阿勒弟海特 1	*quan* 醛
aniline	*anilini* 阿尼里尼 3	*shengse jing* 生色精 10.30a	*anilin* 阿尼林 2	*ben'an* 苯胺

benzene	*bianxini* 偏西尼 5	*meijing you* 煤精油 10.23a	*biansuen* 偏蘇恩 4	*ben* 苯
chloroform	*geluolufuermi* 格羅路福耳密 10	*mijing* 迷精 10.23a	*gelufangmu* 哥路仿姆 7	*sanlüjiawan* 三氯甲烷
chlorophyll	*geluolufeile* 格羅路非勒 10 or *yelü* 葉綠 10	*caolü jing* 草綠精 10.25a	*yelü* 葉綠 7	*yelüsu* 葉綠素
citric acid	*ningmengsuan* 檸檬酸 10	*yuan-suan* 櫞酸 10.25a	*ningmengsuan* 檸檬酸 7	*ningmengsuan* 檸檬酸
ether	*yituo* 以脫 14	*qing-jing* 輕精 10.23a	*yituo* 以脫 10	*yimi* 乙醚
ethene	*yituolini* 以脫里尼 14	*taner-qingsi* 炭二輕四 9.8a	*yituolien* 以脫里恩 10	*yixi* 乙烯

formic acid	*yisuan* 蟻酸 15 <u>or</u> *fuermike suan* 福耳密克酸 15	*yi* *qiang* 蟻強 10.27a	*yisuan* 蟻酸 11	*jiasuan* 甲酸
glucose	*gelugesi* 哥路哥司 16	*guotang* 果糖 10.22a		*putaotang* 葡萄糖
glycerine	*gelisilini* 各里司里尼 16	*youtian* 油甜 10.24a	*putaotang* 葡萄糖 13	*bingsanchun* 丙三醇 <u>or</u> *ganyou* 甘油
hippuric acid	*xibuyoulike suan* 希布由里克酸 17	*maniao* *qiang* 馬尿強 10.28a	*maniaosuan* 馬尿酸 13	*maniaosuan* 馬尿酸

indigo	*dian* 靛 18	*landian* 藍靛 10.32a	*qinglan* 青藍 14 <u>or</u> *dianqing* 靛青 14	*landian* 藍靛
ketone	*jiduoni* 幾朵尼 19			*tong* 酮
lactic acid	*rusuan* 乳酸 <u>or</u> *lagedike suan* 拉格的克酸 19	*ru-qiang* 乳強 10.27a	*rusuan* 乳酸 15	*rusuan* 乳酸
malic acid	*pingguo suan* 蘋果酸 or *malike suan* 瑪里克酸 21	*pingguo qiang* 蘋果強 10.27a	*pingguo suan* 蘋果酸 16	*pingguo suan* 蘋果酸
methanol	*miyituolike chun* 迷以脱里克醇 23	*mujiu-jing* 木酒精 10.23a	*mituoer aerkeer* 迷脱爾阿爾科爾 16	*jiachun* 甲醇
morphine	*moerfeini* 莫爾非尼 23	*shui-jing* 睡精 10.30a	*mafeihen* 嗎啡痕 17	*mafei* 嗎非

naphthalene	*naputalini* 那普塔里尼 24	*shiyou-jing* 石油精 10.23a	*nafutalin* 那夫塔林 17	*nai* 萘
oxalic acid	*cao suan* 草酸 or *akesalike suan* 阿克撒里克酸 25	*zha-jiang-qiang* 酢漿強 10.27a	*caosuan* 草酸 19	*caosuan* 草酸
paraffin	*balafeini* 巴辣非尼 25	*dujing* 獨精 10.24a	*balafeien* 巴拉非恩 19	*wanting* 烷烴
quinine	*jinayini* 雞那以尼 29	*linüe-jing* 理瘧精 10.31a	*jinien* 雞尼恩 21 or *jina* 雞那 21	*kuining* 奎寧
tartaric acid	*guo suan* 果酸 or *dadalike suan* 打打里克酸 34	*putao qiang* 葡萄強 10.27a	*jiushisuan* 酒石酸 25 or *guosuan* 果酸 25	*jiushisuan* 酒石酸

6.6 The concept of a chemical element

The term 'element' was taken by the Jesuits to be translatable by the Chinese term *xing* 行 ,which is now normally rendered as 'phase'. We have already seen in Chapter 2 that *xing* 行 and the modern '[chemical] element' are two completely different concepts,yet some translators persisted in retaining the false connection. Some of the earliest chemistry texts retained the Jesuit term *xing* 行 as an attempt at *geyi* 格義 or 'matching concepts',but later this was felt by the mainstream Jiangnan Arsenal translators to be unsatisfactory,and the term *yuanzhi* 原質 'original substance',with its more material emphasis,came to replace it.[427]

The explanation of the concept of the chemical elements as irreducible building-blocks of material substances varied,from none at all in *Bowu xinbian*,to an account based upon an analogy with the strokes in Chinese characters in *Gewu rumen* and another using the letters of the alphabet in *Gewu tanyuan*. Yet despite the rather sketchy accounts given in these textbooks the idea of an element seemed not to pose any serious problems for the Chinese readers.

[427] See Section 5.32.

Table 6. The term for 'chemical element' used in various translated Chinese sources,1608-1908.

Source	Translated term for 'chemical element' (page reference)
'Qiankun tiyi'(1608) in *Siku quanshu*	*yuanxing* 元行 (727.621b)
Bowu tongshu(1851)	*yuanzhi* 元質 (11a)
Bowu xinbian(1855)	-
Liuhe congtan(1857)	*yuanzhi* 元質(1.3a)
Gewu rumen(1868)	*yuanxing* 原行 6.2a *yuanzhi* 原質 6.3a
Huaxue chujie(1870)	*yuanzhi* 原質 1.1a
Huaxue jianyuan(1871)	*yuanzhi* 原質 1.1a
Huaxue zhinan(1873)	*yuanxing* 原行 1.1b
E.A.C. list(1904)	*yuanzhi* 原質 147
Huaxue yuhui(1908)	*yuanzhi* 原質 10

The translators(Martin,Billequin)who wished to emphasise continuity with alchemical tradition used *xing* 行[phase](*Gewu rumen* and *Huaxue zhinan*),whereas the Jiangnan Arsenal translators chose to emphasise the *material* nature of the elements by using terms containing *zhi* 質[substance]. The modern term for 'element' *yuansu* 元素 derives from Japanese,and was first used in 1825 by Udagawa Yōan 宇田川庵 (1797-1846).[428]

6.7 The concept of particles

The concept of atoms had no place in the traditional Chinese paradigm,and so(unlike elements,which could - albeit erroneously - be identified with the *wuxing* 五行)new terms had to be created. Yet once again,there is a Buddhist

[428] Tsukahara,123

connection, as the early terms derived from expressions in Buddhist texts such as *jiwei* 極微(Skt.*anu*).

Table 7 The terms for 'particle' and 'atom' in early modern chemistry texts

Translated text	Terms used for particles(P) or atoms(A)(page number)
Gewu rumen(1868)	*weizhi* 微質 6.2b.3(P) <u>or</u> *weidian* 微點 6.4b.7(P)
Huaxue chujie (1870)	*jiweidian* 極微點 1.2a.4(P)
Huaxue jianyuan(1871)	*zhidian* 質點 1.2a.7(A) *weidian* 微點 6.4b.7(P) *weizhi* 微質 6.2b.3 (P)
Huaxue zhinan(1873)	*weidian* 微點 1.1b.5(P)
Mateer, *Technical terms*(1904)	*yuandian* 元點 28(A) <u>or</u> *weidian* 微點 28(A)
Huaxue yuhui(1908)	*yuanzi* 原子 3(A)

The term *zhidian* 質點 had wide currency by the 1890s, and was used by Tan Sitong and Kang Youwei, but in the first decade of the twentieth century the influence of Japanese translations increased, and *yuanzi* 原子, first used in Japan in 1875, became the standard term for 'atom'.

<u>*6.8 The persistence of the Chinese paradigm*</u>

There was no significant struggle (outside the field of medicine) between the Chinese science paradigms and the Western system. Most students of Western science seem to have ignored the ancient concepts, but we do find some writers attempting to relate the old to the new.

6.81 Chemistry the child of alchemy[429]

Although critics of the science translators facetiously called their nomenclature systems 'alchemical'[430] there was in fact a conscious attempt by the Beijing Tongwenguan translators - W.A.P.Martin and Anatole Billequin,as well as,to a lesser extent,John Kerr in Guangzhou,under Martin's influence - to revive certain alchemical terms in order to emphasise the continuity of modern chemistry with its Chinese alchemical past.[431]

These were not matters to excite the interest of most Chinese scholars,but we can find these issues discussed in the pages of *Gezhi keyi huibian* 格致課藝彙編,a collection of prize-winning essays in a competition run by the Shanghai Polytechnic in the 1880s and 1890s,edited by Wang Tao 王韜.[432]

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[429] See Douglas Allchin,'Phlogiston after oxygen' in *Ambix* **39**,(November 1992),110-116 .

[430] Schlegel,'Scientific Confectionery',147-151

[431] See W.A.P.Martin,'Alchemy in China,the source of chemistry' in *The lore of Cathay*(Edinburgh:Oliphant,Anderson and Ferrier,1901),44-71 and *Gewu rumen* 格物入門 6.77a-79b.
In the latter work,Martin says that alchemy and chemistry are *tong ben er yi ming,zi mu xiang shu* 同本而異名,子母相屬 [Of different names but the same origin,mutually related as mother is to child.](*ibid.*,6.77a).

[432] The scheme was set up in 1885(*NCH*(10th July,1885),45).See also *NCH*(25th January,1888),100-101 and *NCH*(20th July,1889),85-86 for John Fryer's reports on the essays; and *NCH*(1st November,1889),536-537 and *NCH*(14th April 1893),513-514 for reviews of the essays. Some of the winners were associated with the Translation Department of the Jiangnan Arsenal(such as Zhong Tianwei 鐘天緯,Zhao Yuanyi 趙元益),and most came from the coastal cities where Western influence had existed for several decades. (This has sometimes been confused with the Prize Story Competition,a completely different venture. See *CR* **27**(1896),142)) See Section 10.2 for the history of the Shanghai Polytechnic.

Zhao Yuanyi 趙元益,writing in 1887,stated that the alchemical techniques,being secret,had been lost in transmission,and the Westerners had obtained their essence,calling it 'chemistry'.[433] Cheng Yanluo 程瞻洛 specifically quoted the work of the late Tang alchemist Dugu Tao 獨孤滔 as using chemical equipment.[434]

Huaxue jianyuan introduced sixty-four elements,precisely the same number as the hexagrams in the *Zhouyi* 周易 [Book of changes],and this seemed to some writers
to suggest that the 'elements ' of the Westerners were simply the hexagrams in a new guise.[435] This was part of a generally held view that Western science was Chinese in origin and was being returned to China after a long exile. Evidence for this was the alchemists' chemical skills

6.82 The alchemical influence on nomenclature[436]

These terms [437]included

dian 點(*HXZN* 1.12b.1): to add a small amount of material,causing a large chemical effect. [The European

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[433] *GZKYHB*,2.8b and 4.9a

[434] *GZKYHB*,6.38a(1890)

[435] For instance,Cheng Yanluo in *GZKYHB*,6.37b(1890).

[436] See the references in n.21; Yuan Hanqing 袁翰青,'Cong *Daozang* li de jizhong shu kan woguo de liandanshu 从道藏里的几种书看我国的炼丹术'[Viewing Chinese alchemy from several books in the *Daoist Patrology*] in Yuan Hanqing (ed.)*Zhongguo huaxueshi lunwenji* 中国化学史论文集[A collection of essays on the history of Chinese chemistry](Beijing:Sanlian shudian 三联书店,1956),207-208; Joseph Needham and Lu Gwei-djen,*SCC* Vol.5 Part 1,154ff. on chemical nomenclature; and Ho Peng Yoke,*Tuku T'ao's Tan-fang chien-yüan*.

[437] The references are to *Huaxue zhinan(HXZN)*:

alchemists termed this 'projection.']

fan 反:indicates that one substance cannot be used with another[438]

fansuan 反酸 (*HXZN* 1.2a.8): base [anti-acid]

huolu 火爐(*HXZN* 1.10b.3): oven[439]

jiu 炙(*HXZN* 1.32a.7):partial heating; heating over a long period

lian 煉(*HXZN* 1.10a.8): to make(a chemical substance). The term *liandan* 煉丹 'making an elixir' was a central term in Chinese alchemy.

lin 淋 (*HXZN* 2.11b.9): to wash with water

shi 食 (*HXZN* 1.22a.2): to absorb,dissolve

shizu 食足 (*HXZN* 3.19b.5): saturated(solution)

shiqiping 食汽瓶 (*HXZN* 1.18b.3): drying tube

shuang 霜(*HXZN* 1.22a.8): precipitate

teng 騰(*HXZN* 2.5a.1): to sublime

[438] Ho Peng Yoke,*Tu-ku T'ao*,51

[439] See below on the illustrations used in *Huaxue zhinan*.

xia 煆 (*HXZN* 1.10a.10): to heat to a fairly high temperature

xianggan 相感(*HXZN* 1.1a.9): mutual reaction[440]

xiu 鏽(*HXZN* 1.3b.5):rust; an oxide[441]

yan 研(*HXCJ* 2.32a):to pulverise

Some of these terms of course existed in everyday language,but taken together they do constitute a clear attempt to revive alchemical terms.

The idea of alchemy as what Nathan Sivin has called 'an acceleration of cosmic forces' [442] was not fundamentally at variance with modern chemistry,and some of the concepts of the Chinese alchemists such as the resonance and interaction of like substances were actually hints of the solutions to problems which puzzled the nineteenth century chemists who tried to apply the Berzelian dualistic theory to compounds containing only nonmetals.

6.83 Qi and vital forces

In John Fryer's journal *Gezhi Huibian* 格致彙編 we find in January 1878 an article under a Buddhist pseudonym Pishengweishicao 毘生未是艸 entitled *Shengqi* 生氣. This

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[440] Ho Ping-yu and Joseph Needham,'Theories of categories in early medieval Chinese alchemy',21.

[441] Song Yingxing uses the term *yinxiu* 銀鏽 for silver oxide (Pan Jixing,*Tiangong kaiwu jiaozhu ji yanjiu*,357 and 510.)

[442] See Nathan Sivin's chapter of the theoretical background to alchemy in Joseph Needham,*SCC* Vol.5 Part 4(Cambridge: Cambridge University Press,1980),229

could be taken as simply 'oxygen'[443],but the article itself makes it clear that the author seeks to make a connection between life,oxygen and *qi* 氣.

> When we examine that which causes[living things] to live or die,there has to be one [thing] ruling within them,whose possession gives life and whose loss brings death,and this thing has to be a gas,without sound,colour,smell or taste,similar to electricity.[444]

The existence of positive and negative electricity led to their identification with *qi* 氣 in the forms of *yin* 陰 and *yang* 陽.

> All things in the beginning are based on the mutual interaction of *yin* and *yang*,and electricity is also divided into *yin* and *yang*. Moreover,the spirits[*ling* 靈] of living things differ,and it is not possible for them [to be made of]normal gases. Thus[I] suspect that vital *qi* has to be akin to [*lin yu* 鄰於] electrical *qi*.[445]

By now,it is clear that he is writing of *shengqi* 生氣 as 'vital substance'[446],the cohesion of which determines the longevity of living creatures:

> The force of cohesion between other materials and vital *qi* may be strong or brittle. If strong,it is

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[443] One of the Japanese terms for oxygen was *shengqi* 生氣 (Tsukahara,102).

[444] *GZHB* 2,12(January 1878),11b

[445] *ibid.*,11b

[446] Section 2.22

> hard to separate the vital *qi* from it; if brittle,it is easily separated and life is short. [...] All materials in chemical experiments have 'loving'[*ai* 愛] and 'hating'[*wu* 惡] natures. Poisons have a great hatred for vital *qi*,this if they encounter it,the vital *qi* departs and you die. [...] Westerners say that chemists are able to make all other substances and to get to know them - only vital *qi* they can not. I say that if you want to investigate vital *qi* you cannot use chemical methods. How is this? Because if the vital *qi* has departed from a body,it is already non-living,so that there is no way it can be analysed.[447]

John Fryer added a postscript to this article,saying

> Though we have printed this article,in places it does not accord with Western science. Thus we do not necessarily have full confidence in the ability of the reader to understand it.[448]

6.9 Conclusion

The creation of a Chinese chemical nomenclature was a complex struggle involving linguistic,aesthetic,scientific and cultural and political factors. In creating the semantic spaces for the new terms,the translators were either giving new meanings to old terms or hewing out entirely new spaces,giving them what they hoped to be shapes appropriate to the meanings they were supposed to hold.

Linguistically,the argument centred on whether,for the elements,the characters should be *huiyizi*,attempting to encapsulate the essence of the element with meaningful

[447] *GZHB* 2,12(January 1878),12a-12b

[448] *ibid.*,12b

components; or *xingshengzi,* essentially phonetic emblems, with only the radicals signifying their nature. The experiments of Martin, Kerr and Billequin with *huiyizi* were generally regarded as having failed, and the *xingshengzi* of Xu Shou and Fryer accepted as, if not the ideal solution, at least the most practical available. The use of false borrowing(*jiajie* 假借) of existing characters was I suggest a key element in the success of the Xu/Fryer system. It avoided creating too many totally new characters, was in keeping with the spirit of the language(which preferred always to draw on its existing stock), and set an aesthetic standard for the forms of the graphs which had to be met if the scholarly elite were not to regard them as ludicrously ugly. The *jiajie* characters filled an existing semantic space, and could therefore be secreted into the language, camouflaging their foreign origin, rather as hermit crabs disguise themselves by occupying discarded molluscan shells to blend in with their surroundings. They were not, in short, too obviously foreign.

Aesthetic considerations should never be undervalued when considering alterations to such a distinctive cultural artifact as the Chinese script: as recently as 1977, an attempt at further simplification of Chinese characters failed largely because of the ugliness of many of the new graphs.[449]

In translating the names of compounds the problems were scientific rather than linguistic, in that there were several parallel systems in operation in Western chemistry at the time: the *dualistic* system of Berzelius and the *unitary* system for inorganic compounds; the systems of *equivalent formulae* and of *atomic* formulae; and the use of *proportional numbers* as either subscripts or superscripts. It is not surprising that the translated books also show considerable variation in the manner of representing

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[449] *Renmin Ribao* 人民日报[People's Daily](20th December, 1977), 4

compound substances.

The cultural and political questions arise when we consider who controlled the translation system. Until 1900,most translations were carried out by foreigners or under foreign supervision,even when nominally under Chinese government control(as at the Jiangnan Arsenal). The impetus for standardisation came largely from foreigners,mainly missionary educators,imposing their ideas of what chemical nomenclature ought to be in Chinese,with little consideration given to what the Chinese themselves thought was best. The assumption of all the foreign translators seems to have been that they knew best,and consultation as equals with the Chinese seems not to have occurred to them. It is true that relatively few Chinese had the necessary scientific knowledge,but some did,and it reflects the Western attitudes of the time that the Chinese nomenclature was 'standardised' by foreigners.

The confusion in the late nineteenth century nomenclature in Chinese was perhaps inevitable as it reflected the state of the subject in the West. The translators were doing their best to convey the meaning of the texts they translated in the way they hoped would prove palatable to the scholars and also interesting to a wider readership. They were well aware of the problems their readers encountered,but the nature of the Chinese language made it difficult for them to avoid either creating polysyllabic monstrosities or making completely new characters for the terms they needed. In either case they risked alienating their public.

Perhaps they tried too hard,and it would have been better simply to have left all these terms in the Western language,with the appropriate formulae,and thus have avoided burdening the Chinese with yet more characters:

this was always impractical as it would have ignored the deep intolerance of the Chinese language to alien graftings.

It also ignores the fact that not all communication is written. Chinese scientists would have to talk about these substances somehow,and it was hardly practical that they would use French(as Billequin seems to have intended) or English to communicate the names of chemicals. The tendency of most translators to emphasise the literary language rather than the colloquial meant that oral communication was sometimes almost forgotten: in fact it was the relationship between the written and the spoken languages which eventually decided the balance in favour of the Xu/Fryer system,with its emphasis in the phonetic nature of the graph.

On the whole,the transition from the Chinese paradigms to the Western system of chemistry was smooth and uncontroversial. The students of Western studies found that the new ideas were of immediate practical application(in the analysis of ores,for example),and the Western theoretical concepts were soon accepted as a matter of fact. The few who resisted Western science were replaced by a new generation,educated in the new paradigms,for whom Western science was no longer foreign.[450]

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[450] Max Planck,*Scientific autobiography and other papers*(London:Williams and Norgate,1950),33-34:

> A new scientific truth does not triumph by convincing its opponents and making them see the light,but rather because its opponents eventually die,and a new generation grows up that is familiar with it.

Chapter 7. Science textbooks in China 1850-1900[451]

7.0 Introduction

Ludwik Fleck divided the written manifestations of modern science into four realms: (1)journal science for the specialist practitioner; (2)vademecum science for the generalist practitioner; (3)popular science for the uninitiated general public; and (4)textbook science for initiation into the esoteric circle[452]. In China,the first two categories barely existed before the twentieth century,yet popular science journals were surprisingly well-developed and influential,and will be considered in Chapter 11. In this chapter I shall look at some of the science textbooks translated or compiled between 1850 and 1900. Written both to popularise and to initiate,their effectiveness was severely constrained by the environment in which they were written and used. My emphasis will be on the chemical texts,because they show a rich variety of content,demonstrate the struggle with intractable problems of translating terms and concepts,and also some interaction with the native alchemical tradition.

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[451] Works relating to the general issues of translating science and science textbooks in Chinese are,in addition to those listed in Chapter 5,Victor Purcell,*Problems of Chinese education*(London:Kegan Paul Trench,Trubner & Co,1936),156-160; Li Kunhou 酈堃厚,'Jiangnan zhizaoju yu Zhongguo xiandai huaxue' 江南製造局與中國現代化學[The Jiangnan Arsenal and modern Chinese chemistry] in Lin Zhiping 林致平(ed.)*Zhongguo kexueshi lunji* 中國科學史論集[A collection of essays on the history of Chinese chemistry] (Taibei:Zhonghua wenhua chubanshe 中華文化出版社,1958),43-66; and Pan Jixing 潘吉星,'Ming-Qing shiqi(1640-1910)huaxue yizuo shumu kao 明清时期化学译作书目考'[An investigation of the translated chemistry works of the Ming-Qing period(1640-1910)] in *ZGKJSL* **5**,1(1984),23-38.

[452] Ludwik Fleck,*Genesis and development of a scientific fact*(Chicago:University of Chicago Press,1979),161

7.1 'Auxiliary of virtue': the missionary uses of science[453]

The spread of Western imperial power into China was followed by the invasion of the bringers of what was - for most Chinese —a new religion. Although Christianity had been introduced to China centuries earlier by Nestorian and then Jesuit missionaries,the scale of their activities was far smaller numerically and geographically,and had much less effect on the majority of the population than the evangelism of China in the nineteenth century.

The most dramatic evidence of the power of the new faith was the Taiping Revolution(1851-1864),a rebellion on an immense scale,which came close to destroying the Qing dynasty,and whose effects were still being felt many decades later. Although the religion was only one factor in the uprising,Hong Xiuquan 洪秀全 (1813-1864)[454],the leader of the Taipings,was strongly influenced by *Quanshi liangyan*勸世良言[Good words to admonish the age],a tract by the Chinese convert Liang Fa 梁發[Leang Afa](1789-1855). The Taiping ideology which he forged was an amalgam of traditional Chinese beliefs,Christian theology and progressive social ideas such as the stopping of footbinding[455] .Although the Taipings seem to have shown little interest in Western science as such they were well aware of the military superiority of the Westerners,and were to use steamships to

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[453] William Milne,writing in 1820 of his monthly missionary magazine *Chashisu meiyue tongjikao*:

> To promote Christianity was to be its *primary* object; other things,though they were to be treated in subordination to this,were not to be overlooked. Knowledge and science are the hand-maids of religion,and may become the auxiliaries of virtue.(Britton,18)

[454] Hummel,361-367

[455] See Ssu-yü Teng,*New light on the history of the Taiping Rebellion*(Cambridge,Mass.:Harvard University Press,1950),51-52,55-56,74-80 and 82-88.

great effect in the early stages of the rebellion.

In 1857 *Liuhe Congtan* 六合叢談['Discussions on all matters',subtitled *The Shanghae serial*] was started in Shanghai,and published a series of articles on natural theology by Alexander Williamson(1829-1890). Williamson became the doyen of the Paleyite tendency in missionary scientific writing,and his articles were published in again in two missionary journals edited by Young J.Allen *Jiaohui Xinbao* 教會新報[Church News] and *Wanguo Gongbao* 萬國公報[The Chinese Globe Magazine],before finally appearing in book form as *Gewu tanyuan* 格物探原 [Tracing the origin through the investigation of things]in 1875.

The thinking of many of those engaged in the diffusion of scientific knowledge for evangelical purposes was well expressed by the medical missionary Daniel Jerome Macgowan(1814-1893):

> The mere practice of medicine and surgery should not be considered the most important part of the professional labours of the medical missionary. It behoves him to instruct native practitioners in anatomy and physiology,to give them works on medicine and the collateral sciences in their own language,to excite an interest in useful knowledge amongst the people and *in fine* to arouse the dormant intellect of China to action,that it may approach in some degree the age we live in.[456]

> When the thinkers of this land become students of the *Novum Organum Scientiarum*,an accession will be made to philosophy which will not be barren in its results.

[456] D.J.Macgowan in *CRP* **18**,10(October 1849),511

> How important is it to the cause of truth that the knowledge they may receive from the West should be deeply imbued with sentiments derived from the sacred source of all truth! Besides separate treatises of the sciences,in which proofs of the existence and attributes of God should be interwoven,they should receive with some slight alteration for general readers the admirable work of Archdeacon Paley on natural theology as edited by the anatomist Paxton. It is the prosecution of such labours that will effect the most good in China.[457]

7.2 Natural theology and the Diffusion of Useful Knowledge in China

The core of Paley's *Natural theology* was the argument that only an intelligent creator could have made the extraordinary world we find ourselves living in. In particular,the evidence of biology in organs such as the eye and ear showed such an intricate design that blind chance could not possibly have made them.

The ability of the natural world to act as a mirror of Christian teaching was taken as an important adjunct to the work of propagating the gospel. The use of science for this purpose in China has a distinguished history,dating back to the time of Matteo Ricci. The Protestant missionaries of the nineteenth century,whilst not,on the whole,as distinguished intellectually as Ricci,still believed that science could convince the Chinese of their case in a way that preaching and religious tracts could not.

The nineteenth century missionary efforts in China

[457] *CRP* **18**,10(October 1849),511

coincided with the rise of a relatively new phenomenon: a technological revolution to which an understanding of scientific principles was an essential component. The sciences and the technologies they fostered were,the Westerners believed,a demonstration of the revealed truths of their religion,and their religion could be spread more rapidly into a population which appreciated the wonders of science.

> Facts in nature are the expression of the Divine will in the government of the physical world. The universe of matter is made up of facts which,observed,traced out,and arranged,lead us to the knowledge of certain laws and forces which proceed directly from the mind of God. These are the "law of nature": science is but the exposition of them and of such science based upon such grounds,the ancient philosophy was completely ignorant.[458]

Karl Gützlaff,one of the earliest Protestant missionaries to reach mainland China,was of the opinion that the introduction of the *knowledge* of the West would benefit China,and he wrote optimistically in 1834

> .....their language is adapted to convey the knowledge which a Chinese is capable of receiving,so that there are few sciences which might not be dressed in a Chinese garb.[...]to extend useful knowledge ought in the widest sense of the word be the only object. We do not wish to form scholars,nor publish works for

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[458] Benjamin Silliman,*First principles of chemistry*(Philadelphia:H.C.Peck & Theo. Bliss,1853),14. Silliman was instrumental in finding a teacher for the Morrison Education Society. See *CRP* 7,6(October 1838),303

academicians,but to benefit the whole nation.[459]

Later the same year Gützlaff helped to found the Society for the Diffusion of Useful Knowledge in China along with E.C.Bridgman,J.Robert Morrison and others in Guangzhou.[460] Their view of China's as yet unfelt need for science was expressed in the following terms:

> In our days,many nations have begun the race of improvement; and are now moving ahead in swift career,their cause constantly made more luminous by the light of science,and more rapid by the force of truth. This has resulted from the *diffusion of Useful Knowledge* among them. But no influence of this kind has yet reach the 'central nation' and China still stands stationary,shielding itself against the contaminating influence of the barbarians.[461]

The "prime object" of the new Society was to

> publish such books as may enlighten the minds of the Chinese,and communicate to them the arts and sciences of the West.[462]

The duty they felt of "contaminating" China with the seeds of their faith was almost matched by the urgency with

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459 Karl Gützlaff ['Philosinensis'],'The diffusion of knowledge in China' in *CRP* 2,11(1834),508-509

460 See 'Proceedings relative to the foundation of a Society for the Diffusion of Useful Knowledge in China' in *CRP* 3,8(December 1834),378-384

461 *ibid.*,379

462 *ibid.*,382

which they propagated Useful Knowledge.

In the next section we see how Christian natural theology was included in science textbooks,and in Chapter 12 I shall consider the influence it may have had on Chinese intellectuals during the late Qing dynasty.

7.3 God the Creator and Designer

Several of the leading Protestant missionaries in China of the period devoted a great deal of their time to translating or compiling works on natural science,and some of the most widely-read Christian textbooks openly used science as a demonstration of the power and might of the Creator.[463]

Even the very earliest examples of Protestant Christian literature in China include the Arguments from Design,one of the most powerful weapons in the armoury of natural theology. One of the most influential Christian tracts *Quanshi liangyan* 勸世良言,published in 1832 said

> If on flat ground there is a great house,extremely beautiful,them everyone knows there has to have been a builder for the house to exist,it has not appeared by accident.Now,if the trivial art of [building] a house cannot happen by accident,how much less can the great labour of [making] Heaven and Earth,the Myriad Things happen naturally?[464]

The very earliest texts did treat science in an overtly evangelistic manner,but by the 1870s most science authors,with the major exception of Alexander

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[463] Such as *Bowu tongshu* 博物通書 by Daniel Jerome Macgowan,*Gewu tanyuan* 格物探原 by Alexander Williamson,and *Tiandao suyuan* 天道溯原 by W.A.P.Martin.

[464] *Quanshi liangyan*(Canton:London Missionary Society,1832; reprinted Taibei:Zhongguo shixue congshu 中國史學叢書,1965),147

Williamson,preferred to keep religion out of their textbooks. The prefaces of the early textbooks - mostly written by missionaries - indicate that they were written to exhibit the wonders of Creation and thus to incline the reader's mind towards the Christian view of the universe. Translators working for the Chinese government such as John Fryer and W.A.P.Martin were of course unable to give any hint of a religious message in their texts,even though we know from their correspondence that both men saw their role as in part evangelistic.

In looking at these texts I have attempted to discover how their authors and sponsors viewed their task,and where possible to find out what reviewers and users made of them. The texts themselves have in some cases been compared with the Western original,revealing some interesting differences in approach where two groups of translators tackled the same text.

7.4 *Bowu tongshu* 博物通書*(1851)*[465]

Bowu tongshu was published in 1851 by the American Baptist medical missionary Daniel Jerome Macgowan(Magaowen

[465] *Bowu tongshu* was reviewed in *CRP* **20**,5 (May 1851),284-285,where it was called 'Dr Macgowan's *Philosophical Almanac*',and the main emphasis was on the telegraphic sections; and again in *CR* **5**(1874),53-54. The telegraphic proposal was also mentioned briefly in the 'Notes and Queries' section of *GZHB*(December 1877),14b. *Bowu tongshu* itself was rarely mentioned by other missionaries,and one can only assume it was probably limited in distribution to Ningbo and Shanghai,and not widely used. It may have been seen by Xu Shou and his colleagues at Anqing in the 1850s,but there is no direct evidence of this. It seems to have been adapted or plagiarised by Benjamin Hobson in *Bowu xinbian*,and may well have influenced the science writings of W.A.P.Martin who was himself a missionary in Ningbo for a time. See also Wang Yangzong 王扬宗,'Wan Qing kexue yizhu zakao' 晚清科学译著杂考[Sundry investigations into late Qing translated science works] in *ZGKJSL* **15**,4(1994),32-40.

瑪高温)(1814-1893)[466],then stationed in Ningbo 寧波,and who later worked as a private physician in Shanghai and at the Jiangnan Arsenal in the Translation Department under John Fryer. The title of the book seems to suggest that it might have been intended to be one of a series,but if so,this is the only volume which is known to have survived.

Macgowan's approach to his task was overtly evangelical: he was concerned that science should not be presented as a variety of religion,but that the two should be intertwined. Scientifically,its content is very thin: it presents a series of electrical devices,and describes the phenomena they display,with little attempt to explain what is going on. Even elementary theoretical concepts such as electric charge and electric current are not mentioned. It is therefore an account of electrical phenomena and electromagnetic technology rather than electrical science.

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[466] Daniel Jerome Macgowan is sometimes confused by writers on this period with his near-contemporary John Macgowan,an English Presbyterian of the London Missionary Society who worked at Amoy,and who as far as I can discover had no interest in science. See Donald Matheson,*Narrative of the mission to China of the English Presbyterian Church*(London: James Nisbet & Co.,1866) which includes 'Social life and religious life of the Chinese' by John Macgowan. The confusion between the two Macgowans is present in J.K.Fairbank and S.Y.Teng,*China's response to the West*(p.65),A.A.Bennett,*John Fryer,*107,and repeated in other articles,both in English and Chinese.

Daniel Jerome Macgowan arrived in Hongkong in 1843,and in November of the same year opened the American Baptist Mission Hospital in Ningbo. He left again in 1843,returning with Mrs Macgowan in 1845. He visited Japan in 1859,and returned to the U.S.A. in 1862. (See *CR* **8**(1877),129) In 1865 he returned to medical practice in China,working for a time at the Translation Department of the Jiangnan Arsenal with Hua Hengfang and John Fryer. His most important translations were perhaps *Jinshi shibie* 金石識別[a translation of J.D.Dana *Manual of mineralogy*] and *Dixue qianshi* 地學淺釋[a translation of C.Lyell, *Elements of geology*],both with Hua Hengfang. From 1879 he worked for the Imperial Customs in Shanghai and Wenzhou 温州. He died in 1893,and was at that time Shanghai's oldest foreign resident. (See *NCH*(2nd July,1893),110.)

On the front cover[Figure 15] there are the addresses of two Baptist churches,the Yesu Huitang 耶穌會堂 [Jesus Hall] and Zhenshen Tang 真神堂 [True God Hall]; the date of publication,using both the Western and Chinese calendars; and Macgowan's name,stating that he was a 'Western doctor' and the translator of this text,whose source-text I have not been able to discover.

7.41 The introduction of Bowu tongshu

The introduction of *Bowu tongshu* is polemical in tone. Macgowan explained that the subject of the book was not religion,even though its contents exemplified the wonders of creation. He then launched an attack on traditional Chinese cosmologies:

> The matters pertaining to natural philosophy[*bowu*博物]do not concern the holy religion of Jesus. [It is because] I profess the Way of Our Saviour Jesus that I have crossed over 50 thousand *li* 里[16,600 miles] of ocean to come here,to preach to the people in order to [make Christ] manifest to the world and save souls.
>
> [Yet] observing that Chinese scholars have widely investigated the Classics and freshly probed the principles of things (*wu li* 物理),I therefore append the discussion here,merely so that the reader can see the wonders of Creation. He who thinks that the Way of Jesus lies here is gravely mistaken.[467]
>
> In *Book of Changes* (*Yijing* 易經) there is the Supreme Ultimate(*taiji* 太極). This generates the Two

[467] *Bowu tongshu*,1a-1b. For Macgowan's cautious attitude to the issue of science in evangelism,see Ralph R.Covell, *W.A.P.Martin - pioneer of progress*(Washington D.C.:Christian University Press,1978),61

Exemplars(*liang yi* 兩儀). The Two Exemplars generate the Four Images(*si xiang* 四象). The Four Images generate the Eight Trigrams (*ba gua* 八卦) [468][....]Nowadays people do not carefully investigate [this view] and falsely believe that the Myriad Things of Heaven and Earth all originated in the Supreme Ultimate. The vulgar view is that Heaven(*qian* 乾)and Earth(*kun* 坤)both originated in chaos:then,may I ask,whence did Chaos itself originate? This theory has no basis.It is also said that Pangu 盤古 [469] divided Heaven from Earth. Those who speak [of] Pangu only speak [of] 'Extreme Antiquity' or 'High Antiquity': whose account is it? We must seek the person [whose account it is] in order to establish its veracity. To sum up,this is a spiritual matter,which mortal men do not have the capacity to fathom or comprehend,and which God shows us by revelation.[470][...]

7.42 The contents of Bowu tongshu

The contents of *Bowu tongshu* are:

General introduction

Preface

Illustrations

Chapter 1 Introduction

Chapter 2 Glass devices for storing electricity

Chapter 3 Metallic devices for transmitting electricity

Chapter 4 Magnetism

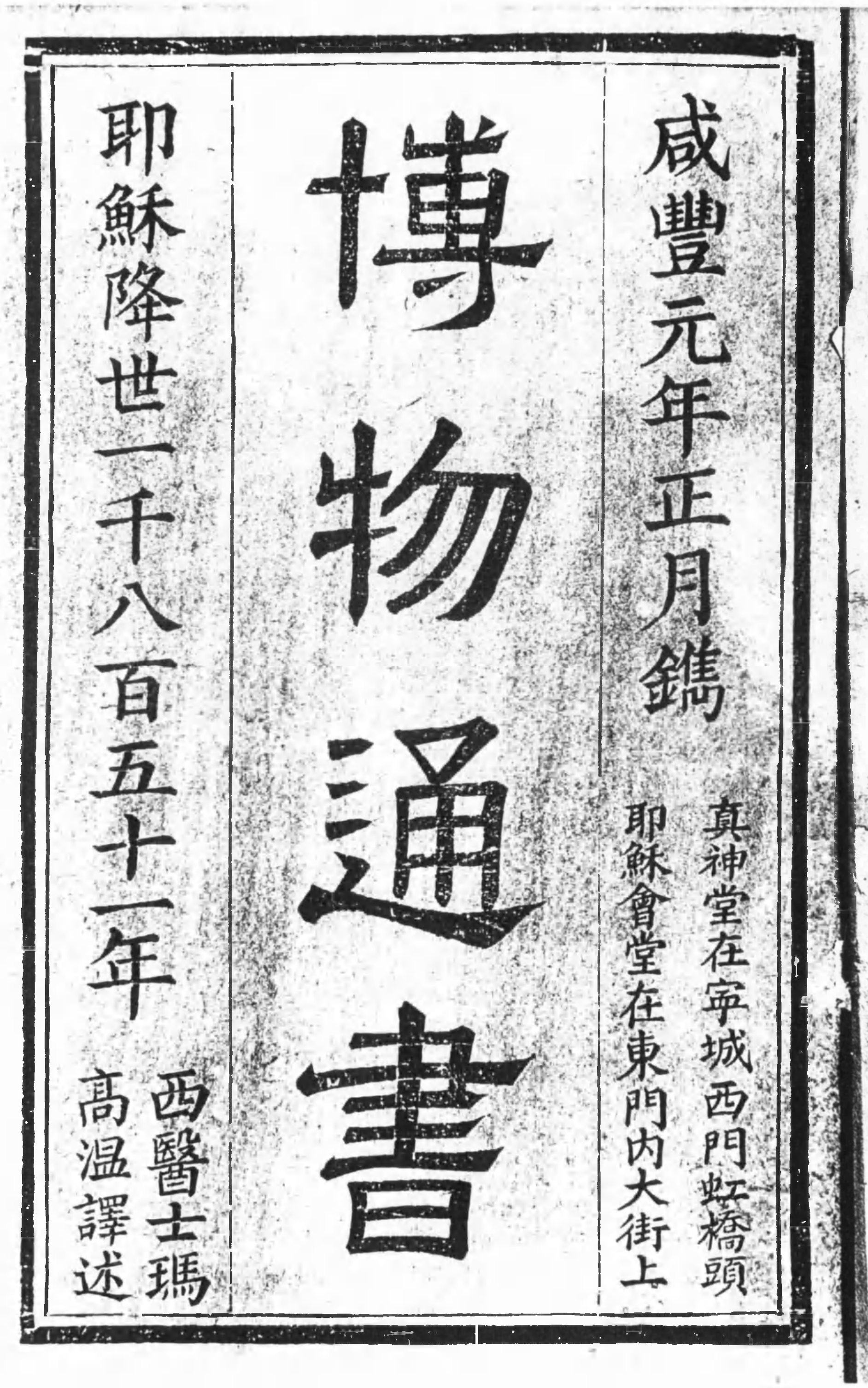
Chapter 5 Electromagnetism

---

[468] This translation of a passage from the *Great Appendix* of the *Book of Changes* is taken from A.C.Graham,*Yin-yang and the nature of correlative thinking*,68

[469] Pangu was supposed to have been created by the congealing of the primal *qi*(*yuanqi* 元氣),and was also known as *huntun* 混屯[Chaos].

[470] *Bowu tongshu*,1b


咸豐元年正月鐫

真神堂在寍城西門虹橋頭
耶穌會堂在東門内大街上

博物通書

耶穌降世一千八百五十一年

西醫士瑪
高温譯述

Figure 15 The front cover of *Bowu tongshu*

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Chapter 6 Electrical telegraphy

There are also appendices on the Christian calendar,sabbath observance,and the number of foreign ships trading in China during the 29th year of the Daoguang 道光 period(1849-1850).

It deals in a qualitative way with a number of electromagnetic phenomena,avoiding theoretical principles. Very few new terms are introduced,the most notable being *dianqi* 電氣 [lightning *qi*] for 'electricity' and *xitieqi* 吸鐵氣 [iron-attracting *qi*] for 'magnetism'.

The dancing figures

One of the experiments described [See Figure 16] involves mannikins being caused to move by electricity passing through them:

> [...]two copper plates,the upper one having a large lead [*yin* 引],the lower one being on the table. In between are placed three or four figures made of wood or paper. The electrical charge on the upper plate desires to pass through the figures to the lower plate,and [....] this causes the figures to move up and fall down,as if they are dancing. When the charges on the upper and lower plates are equalised [the movement] ceases.[471]

The analogy between 'breath' *qi* 氣 and 'electrical' *qi*氣 is clear,and the hint that there is some connection between electricity and life.

[471] *Bowu tongshu*,5a

Electricity excited much interest amongst the early modern Chinese scientists. Xu Shou is known to have bought electrical apparatus in Shanghai[472],and Hua Hengfang's younger brother records Xu Shou carrying out a similar experiment using glass:

> [Xu Shou] folded paper into the form of a man that hung by his hands from a glass rod[charged with static electricity]. The paper man danced,and I howled with delight,for I could not understand the cause [of this strange behaviour].[473]

7.43 The medical uses of electricity[474]

It was natural that Macgowan,as a medical missionary,would want to demonstrate the curative powers of the phenomenon he was introducing. In one diagram [See Figure 17] he shows electricity being used to help a paralysed patient [*bingfengzhe* 病瘋者]who has had electrodes attached to her knee and toe,the arrows indicating the points of entry and exit of the electrical *qi* 氣 .[475]

The machine which produced this high voltage was shown

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[472] Min Erchang 閔爾昌(ed.)*Beizhuanji bu* 碑傳集補[A supplement to the *Collection of Epitaphs*](Beiping:Yanjing University,1932),43.15b

[473] *ibid.*,43.15b. The translation is that in Reardon-Anderson,22. There is an almost identical account in *Bowu xinbian*,1.52.

[474] See Iwan Rhys Morus,'Marketing the machine: the construction of electrotherapeutics as viable medicine in early Victorian England' in *Medical History* **36** (1992),34-52. For devices similar to the ones in *Bowu tongshu* see Henry M.Noad,*The improved induction coil*(London: William Ladd,1861); and Henry M.Noad,*The student's text-book of electricity* (London:Lockwood &.co,1867),321.

Gezhi Huibian includes one query from a reader in Guangdong on electrotherapy(Query #221 *GZHB* **3**,1(February 1880),15a).

[475] Morus,39.

in Illustration 43 [Figure 18]:

> [...]a cylindrical copper flask[labelled *jia* 甲]has within it a roll of lead[labelled *yi* 乙]with some acid [this making an electric cell],the lead [being held in place by] three wooden hooks hanging on the side of the copper bottle. Over 10 *zhang* 丈[33 metres] of copper thread[labelled *ding* 丁] is tightly twisted to make copper wire,which is then made into a small tube [a solenoid]. [Forming the armature] are over one hundred pieces of iron wire [labelled *xu* 戊]. There is a vertical curved magnet [*xitie* 吸鐵] with copper wire coiled around both prongs of it[*si* 巳].The spindle [labelled *geng* 庚] piercing the governor [*yueshu zhi tie* 約束之鐵]is above the magnet,allowing it to move. The wires [labelled *xin* 辛 and *ren* 壬] allow the metallic electricity[*jindianqi* 金電氣] and the magnetism [*xitieqi* 吸鐵氣]to reach the governor and cause rotation [of the magnet]. The wires[labelled *gui* 癸] are positive[*zeng* 増] and negative[*jian* 減],and are used on the bodies of patients to allow the electricity to enter and leave.[476]

7.44 The transmission of Chinese by telegraphy

In the sixth chapter of *Bowu tongshu*,Macgowan gives a detailed account of how Western languages could be transmitted electromagnetically by the movements of a needle,the various positions of the needle corresponding to the 26 letters of the alphabet.

He the proposed how this technique could be applied to the Chinese script:

---

476 *Bowu tongshu,*19a-19b

> In standard Chinese calligraphy there are eight strokes, namely *ce* 側, *le* 勒, *nu* 努, *you* 趯, *ce* 策, *liao* 掠, *zhuo* 啄, *jie* 磔. These eight strokes [may be placed in] seven positions: in the centre, above or below, to the left and right, inside or outside. Together with the circle 。 acting as a full stop, there are a total of sixteen positions [of the needle]. [See Table 10]
> [...] Alternatively, a circular disc could be divided into sixteen sectors, with a rotating needle in the centre. The place to which the needle points could be observed. There are twenty-five letters in the Manchu alphabet. If some modifications are made [transmission with Manchu characters] is also possible. [See Figure 19] I have drafted Illustration 45 and await your exalted deliberations.
>
> As for the method of setting up copper wires along roads, in Western countries there are many railway lines from the capital to various large cities, and every twenty *zhang* [66 metres] short posts are set up beside the railway.[477]

This was a remarkable prefiguring of the techniques now used to input Chinese characters into word processors, that is, via either a stroke-by-stroke build-up by the of the character or a romanisation system. In the nineteenth century, neither of Macgowan's suggestions proved practical, as the first method would have been far too slow and uncertain[478], whilst Manchu was far from being a *lingua franca* in the Chinese Empire. Eventually the less elegant but more practical solution of giving each character a numerical code was adopted, and until recent times sufficed

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[477] *ibid.*, 21a-21b

[478] The character *yong* 永, not particularly complex, would have required twelve operations.

for the telegraphic transmission of Chinese characters.

7.45 The chemical elements

Although mainly about electricity, *Bowu tongshu* does mention the concept of chemical element.

> Platinum(*baijin* 白金 [white gold]): this is not silver, for beyond the 'Five Metals'(*wujin* 五金)[479] there are other kinds [of metal] which are very valuable. In fact altogether there are over forty metals, and not just five. And as regards the so-called Five Phases(*wuxing* 五行) of which Chinese people speak, saying that all the Myriad Things are born of their transformations: this is also a false theory. Westerners have investigated the material elements(*yuanzhi* 元質) fifty-six altogether: the Five Phases are not sufficient to exhaust them. Moreover, amongst the Five Phases there are substances which are not elements, and since I am writing about electricity I will give one or two examples to show this. There are many types of Earth, and if we investigate them, we find they must be compounds of a metal and a gas, such as lime(*shihui* 石灰, alum(*fanshi* 礬石), iron(II) sulphate(*qingyan* 青鹽), or natron(*jianni* 鹼泥) [sodium carbonate], and if put between two electric wires, positive and negative, then they split, with the metal going to the positive side, and the gas to the negative side. [Thus we] may know that Water is made of two gases combined.[480]

After a description of the electrolysis of water, proving it not to be a chemical element, he went on

[479] The collective term 'Five Metals' by 1850 included gold, silver, copper, iron, tin, lead and zinc.

[480] *Bowu tongshu*, 11a-11b.

If it is the case that, as Chinese people say, Water and Earth both contain spirits, how could [the gods] allow

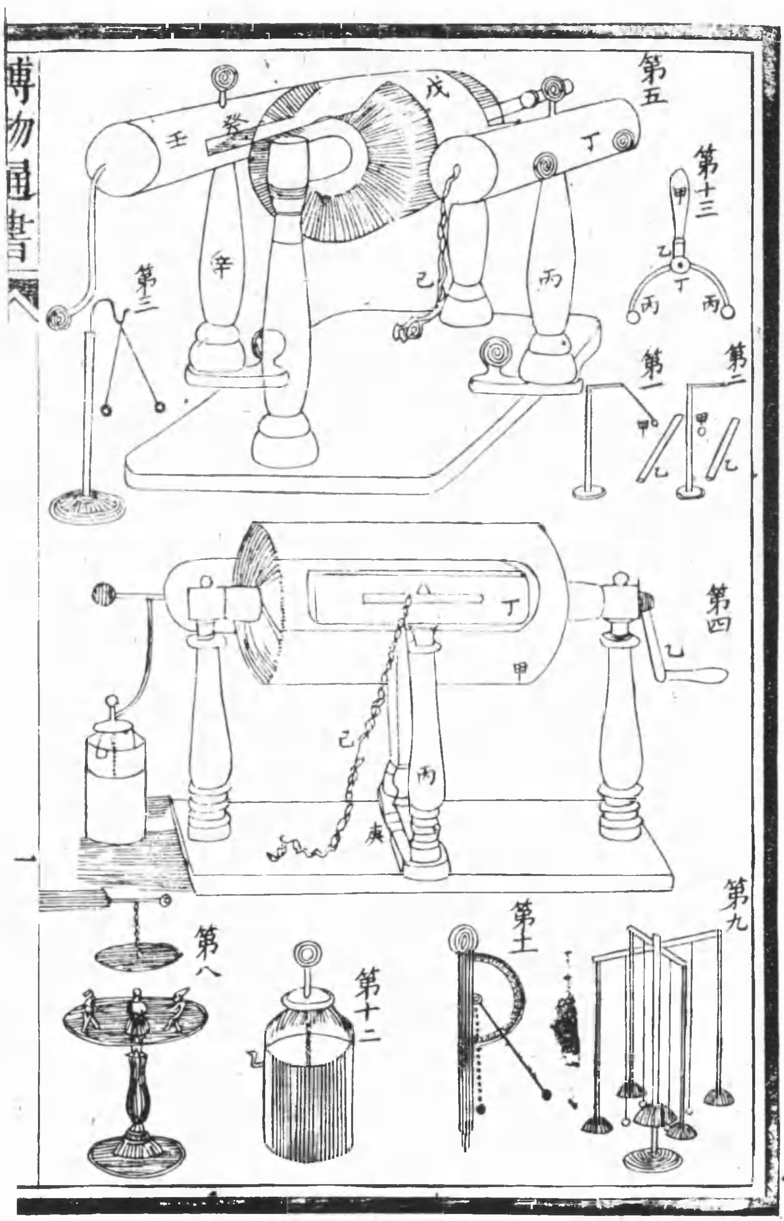

Figure 16. The bottom left-hand diagram shows the dancing figures (from *Bowu tongshu*, 1a)

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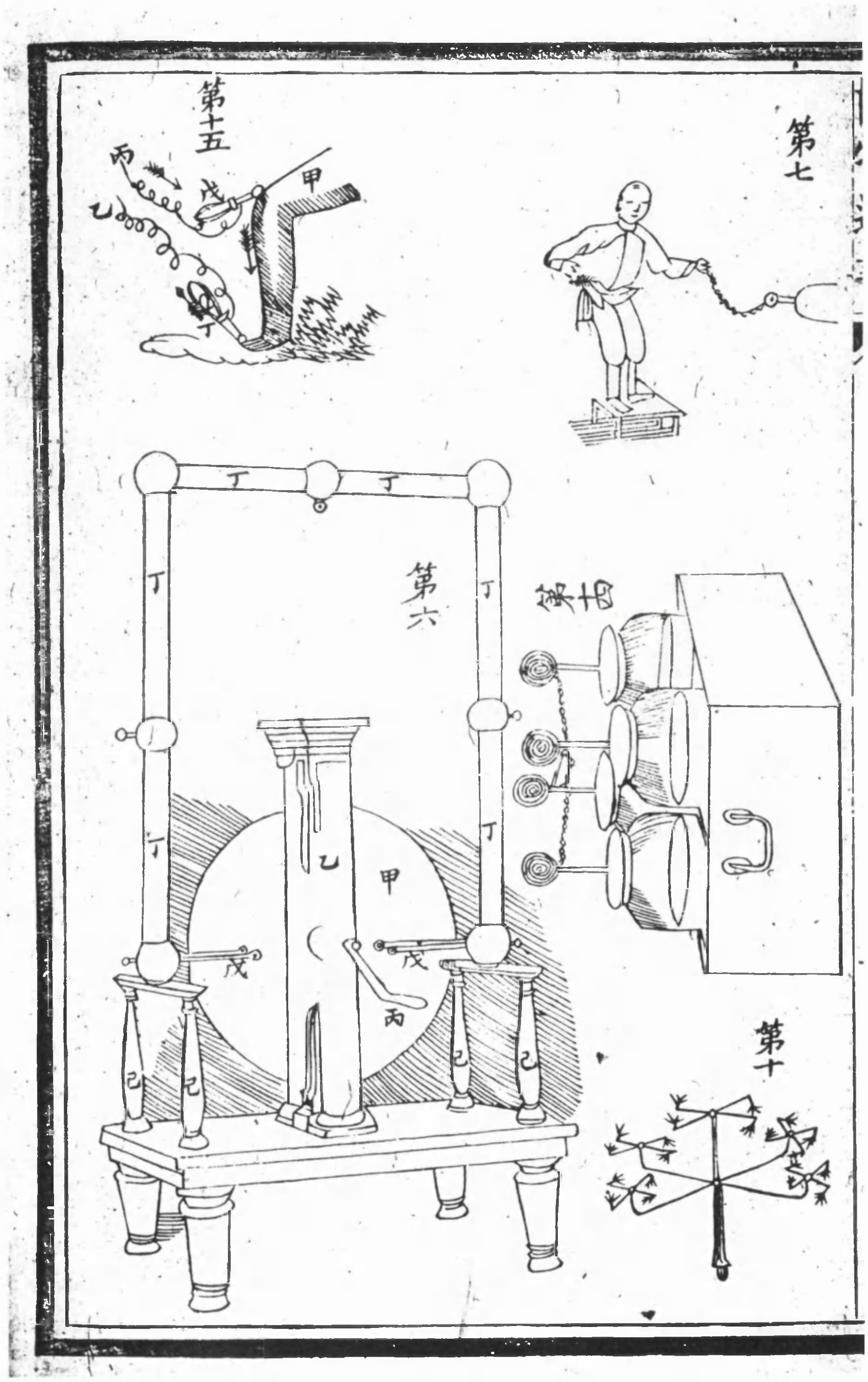

Figure 17. The top left-hand figure shows a patient having electricity passed into a paralysed leg(from *Bowu tongshu*,1b)

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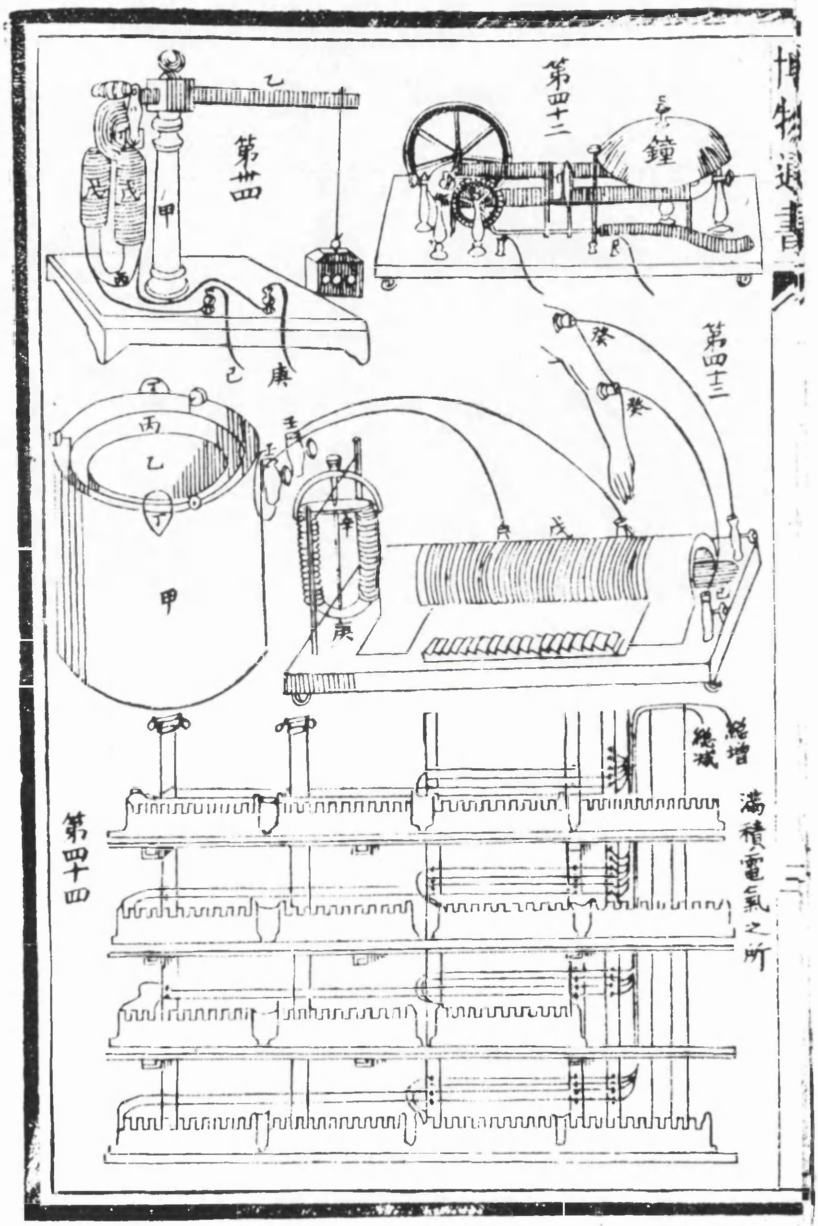

Figure 18. The central diagram shows an induction coil used to send a high-voltage shock into the patient's arm(*Bowu tongshu*,3b)

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Table 8. Needle positions for indicating the component strokes of Chinese characters, as proposed in *Bowu tongshu*

Position of needle	Instruction
North	above
West	below
East, West	inside
West, East	outside
East, East	left-hand side
West, West	right-hand side
East, East, West	*ce* 側
West, West, East	*le* 勒
East, East, West, West	*nu* 努
West, West, East, East	*you* 趯
East, East, East, West	*ce* 策
East, East, East, West, West	*liao* 掠
West, West, West, East	*zhuo* 啄
West, West, West, East, East	*jie* 磔
East, East, East, West, West, West	centre
West, West, West, East, East, East	full stop

people to split and combine them like this? Water and Earth are [Chinese] gods but the True God is One.[481]

Bowu tongshu was thus one of the most openly propagandistic of the early textbooks, but its attempt to combine Christian teaching with science was avoided by most, though not all, subsequent writers.

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481 *ibid.*, 12a

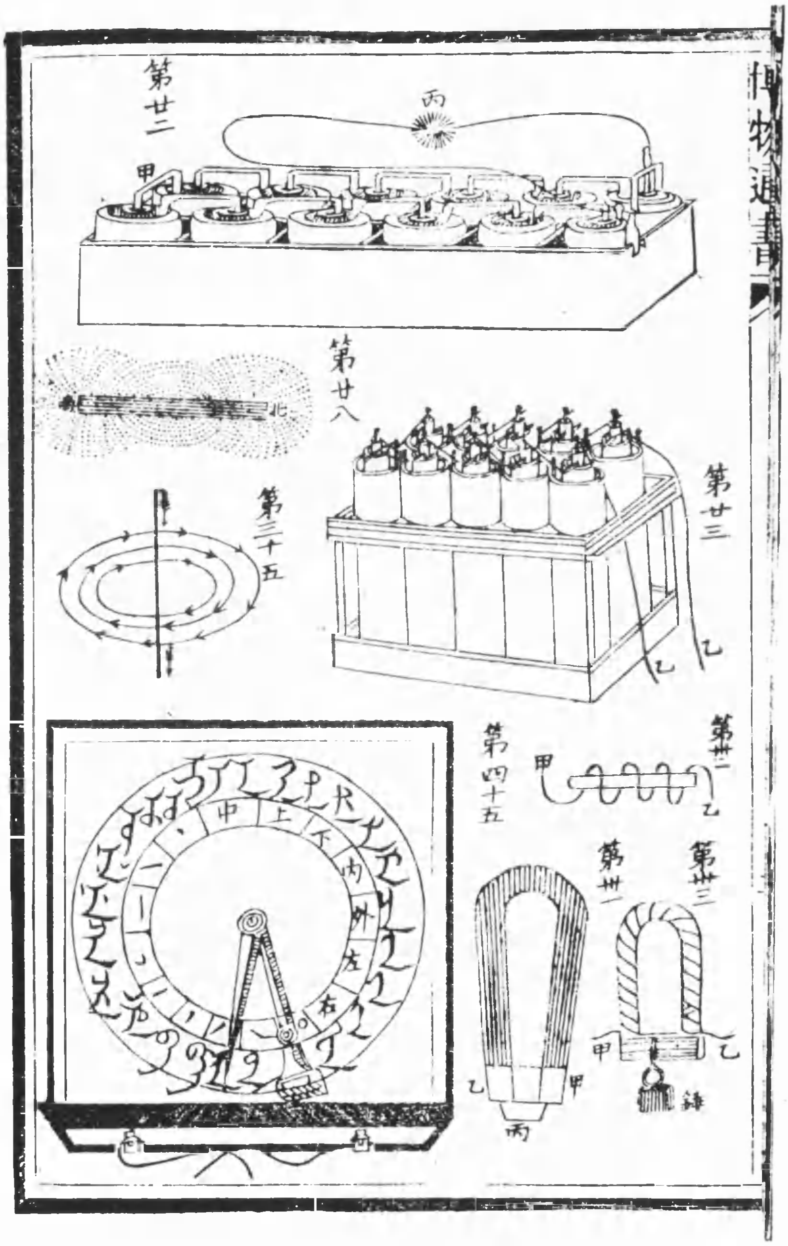

Figure 19. The diagram in the bottom left-hand corner shows the disc engraved with Manchu characters, from *Bowu tongshu*, 2b.

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7.5 *Bowu xinbian* 博物新編(1855) [482]

Bowu xinbian was published in Shanghai in 1855,written by Benjamin Hobson(1816-1873),another medical missionary,as a compilation of information on modern science,probably for the Chinese medical students he was training. As he wrote in 1844,expressing the interest he felt in

> the establishment of a medical class of from 6 to 10 boys,and I embrace the opportunity of soliciting the countenance and support of the gentlemen of the committee to the proposed measure. As preliminary to the study of subjects more strictly medical,I would endeavour to convey some instruction in the elementary branches of physics,chemistry and animal and vegetable physiology,considered with special reference to natural theology [...]'[483].

Hobson later wrote:

> It seemed very desirable to attempt to introduce the well-established principles and facts of Western medical science,to prepare the way for changes in the present system of China. Under this conviction a work was prepared eight years ago in Canton on the subject of anatomy and physiology,avoiding all theoretical opinions[484]. This has been extensively read and very

[482] The most important reference to the use of *Bowu xinbian* is that of John Fryer in *NCH*(29th January,1880),77.

[483] *CRP* **13**,7(June 1844),381-382. See also Wong and Wu,*History of Chinese medicine*,359

[484] This was *Quanti xinlun* 全體新論[A new account of anatomy](1851),which was issued with a reprint of the Chinese medical work *Yilin gaicuo* 醫林改錯 [Correcting the errors in the forest of medicine] by Wang Qingren 王清任(1768-1831). See Bridie Andrews,'Wang Qingren and the history of Chinese anatomy' in *Journal of Chinese Medicine* **36**(May 1991),30-36.

> favourably received,and has proved a good foundation for what was to follow.
>
> The next treatise [*Bowu xinbian*] was on the properties of air,light,heat and electricity,and the elements of astronomy and natural history,designed as an introduction to these various branches of the natural phenomena.[485]

Bowu xinbian was the first comprehensive attempt to explain post-1800 Western science to the Chinese. Although very elementary it nevertheless excited considerable interest amongst Chinese scholars such as Xu Shou who were already engaged in their own researches[486].

7.51 Contents of Bowu xinbian

The chapter headings of *Bowu xinbian* are:

Volume 1: The Atmosphere;Heat;Water;Light
Volume 2: Astronomy;Geography
Volume 3: Natural History

These volumes were profusely illustrated,as Hobson commented:

> The illustrations show at once the subjects treated of,and I have spared no pains,by the aid of an intelligent assistant,to make these works accurate,perspicuous and useful.
>
> Although attended with difficulties,it is still quite predictable to make every subject with which we are ourselves acquainted as clear and expressive in Chinese as in English. Both religious and scientific

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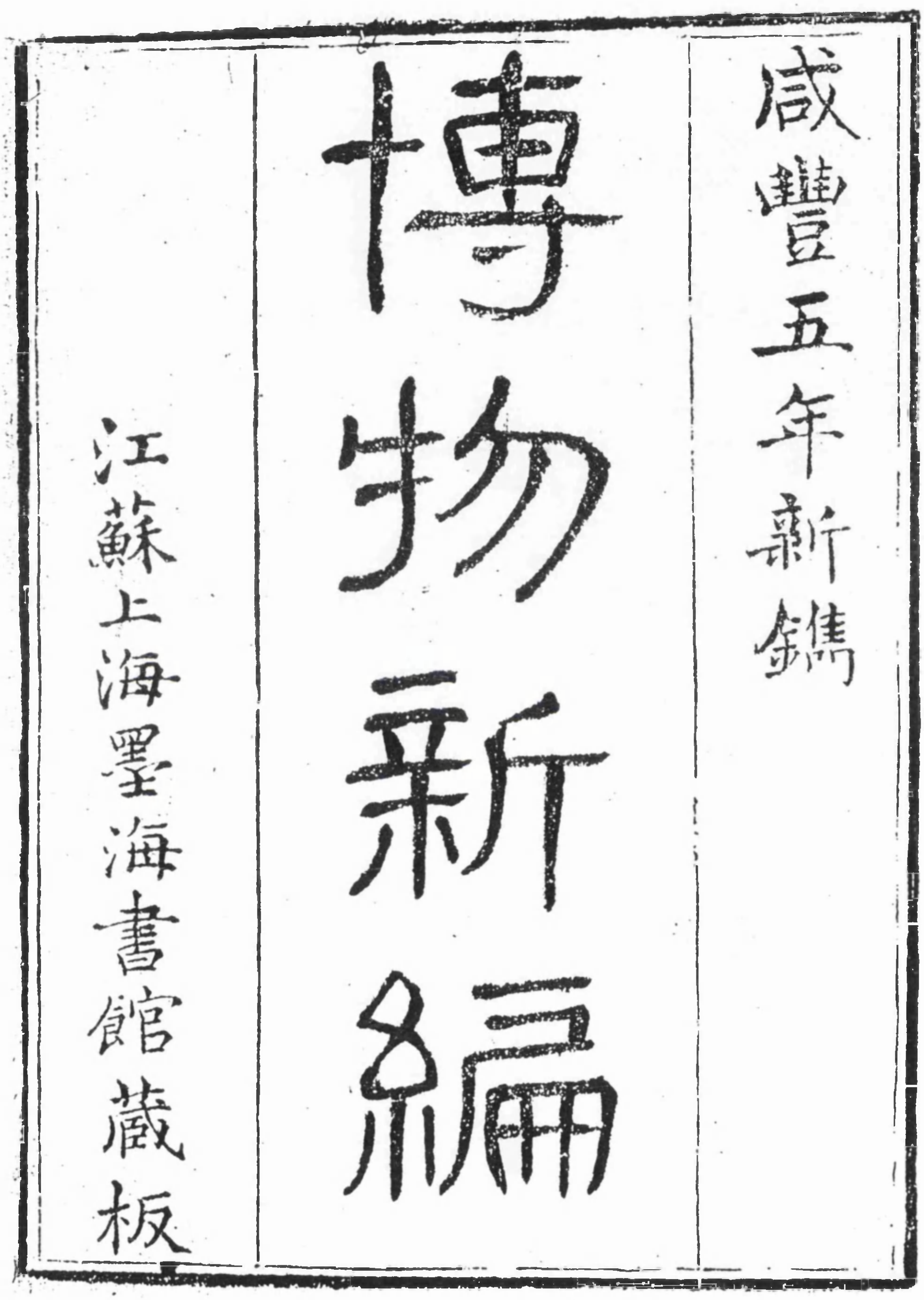
[485] Benjamin Hobson,quoted in Wong and Wu,364-365

[486] See Section 9.2.



咸豐五年新鐫

博物新編

江蘇上海墨海書館藏板

Figure 20. The front cover of *Bowu xinbian* (1855 edition)

[Reproduced by kind permission of The British Library, India Office and Oriental Collections] works should,however,only be made by persons who have been some time in the country,and conversant with Chinese authors. The great desideratum for a translator is a good and fixed nomenclature on every branch of science. The language admits of a satisfactory and distinct explanation,where it does not,these must be transferred.[487]

Hobson's opinion that there was no difficulty in principle in the translation of the notions of Western science into Chinese was by no means universally held,but the nomenclature question to which he alluded was,as we have seen in Chapter 6,to bedevil the transmitters of Western science until well into the next century.

7.6 Gewu rumen 格物入門*(1868)* [488]

Gewu rumen [Science(or 'Physics') Primer: Martin himself translated the title as *Natural philosophy*],was a seven-*juan* 卷 compendium written by William Alexander Parsons Martin (1827-1916),the President of the Beijing Tongwenguan. One of the earliest and most successful of the general science primers,it was reprinted many times,and still in use in the early twentieth century.[489] It was

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[487] That is,transliterated. Wong and Wu,364-365.

[488] *Gewu rumen* was one of the most successful of all the early science texts. Partly because of its clarity and style,and also because it seemed to be pitched at the right level for intelligent laymen,it was serialised by Young J.Allen in his journal *Jiaohui Xinbao* 教會新報 [Church News].

[489] See *CR* **33**(August 1902),419:

> A lady writes: - We have Dr.Martin's Physics -Elementary - "Keh Wu Ruh Men". It has seven books to the volume. May I ask your advice about using it in the girls' school here? It contains more than the <u>ideal</u> science primer for our girls' school should contain. We have not time in the course to give them <u>all</u> of this,nor does it seem to me quite advisable.

No reply to the lady's query is recorded. See Table 12 for its widespread use amongst missionary schools by the turn of the century.

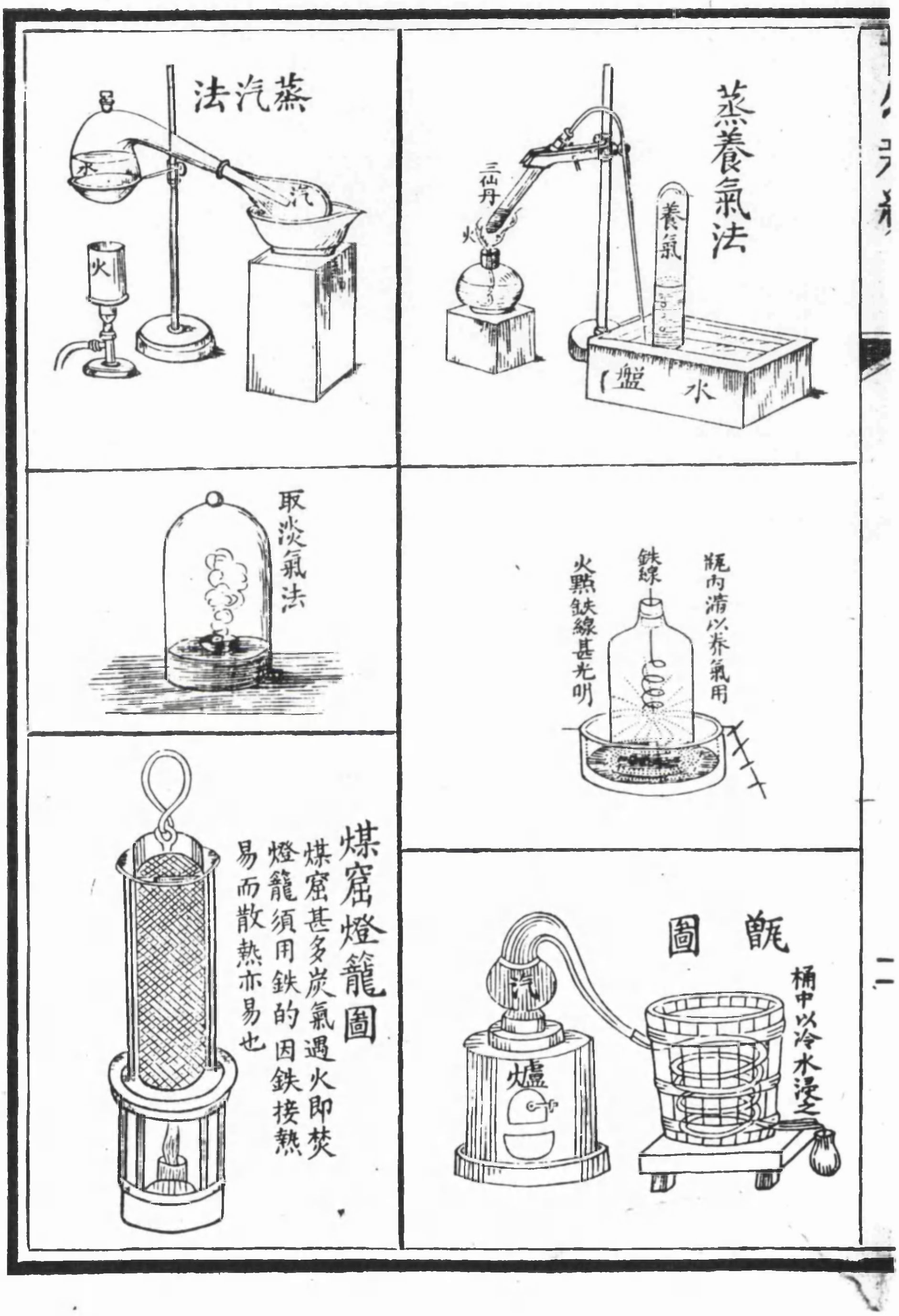

Figure 21. Chemical experiments illustrated in *Bowu xinbian*. Clockwise, starting top left, they are: A way of making steam; making oxygen gas; burning iron wire in

oxygen; a water-cooled still; a coal-miner's safety lamp; making gaseous nitrogen by removing the oxygen from air. [Reproduced by kind permission of the Wellcome Institute for the History of Medicine, London]

considerably more detailed than *Bowu xinbian*, but like its predecessors avoids theoretical principles. It was, much more than *Bowu tongshu* or *Bowu xinbian*, a serious attempt to explain the broad range of Western science to the lay Chinese reader.

Gewu rumen has two prefaces, one by the statesman Dong Xun 董恂 (1807-1892)[490] and another by Xu Jiyu, compiler of the famous geography text *Yinghuan zhilüe* which proved such a strong influence on the Self-Strengtheners, and who later played a part in the Beijing Tongwenguan[491].

The chemical section of *Gewu rumen* was later serialised by Young J.Allen in his journal *Jiaohui Xinbao* 教會新報[Church News], which must have greatly increased its influence amongst the coastal intellectuals. It was also a strong influence on all later science translations, especially those carried out at the Beijing Tongwenguan.

7.61 Contents of Gewu rumen

The *juan* headings were :

1. Hydraulics (*shuixue* 水學), including water pressure and

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[490] Dong Xun was a junior vice-president of the Board of Revenue, with appointment to the Zongli Yamen and had close contacts with the Beijing Tongwenguan. In 1868 he had written a preface to Martin's translation of Wheaton's *International law*. (Hummel, 789-791)

[491] Xu Jiyu mentions his meeting with the American missionary David Abeel [Yabeili 雅裨理] (1804-1846) in Fujian Province, from whom he gleaned his first ideas about Western science. See Hummel, 310 and *Gewu rumen*, 1.1b.

marine navigation

2.Pneumatics(*qixue* 氣學),including weather,steamships and sound

3.Heat and light(*huoxue* 火學)

4.Electricity(*dianxue* 電學)

5.Mechanics(*lixue* 力學)

6.Chemistry(*huaxue* 化學)

7.Mathematical physics(*gewu cesuan* 格物測算)

The chemical section begins with an account of the chemical elements,and of what constitutes a chemical reaction,moving on to an explanation of the attraction between particles.

Martin explains chemical combination as resembling the way in which strokes combine to make Chinese characters. This rather misleading analogy was an extension of an ancient parallel drawn by the ancient Greek originators of the atomic theory between atoms and the letters of the alphabet. Atoms were said to combine just as letters combine to form words. Since from a couple of dozen letters all known and unknown words could be generated,it was possible to explain the immense diversity of natural substances formed from a relatively small number of elementary substances. Unfortunately the strokes in Chinese characters have,mostly,no independent existence,and so do not correspond to the free elements,and in any case the building of Chinese characters is <u>not</u> really describable in terms of a small number of separate 'elementary' strokes. Nevertheless,Martin was the first person in modern times to attempt to make the idea of atoms comprehensible to Chinese readers,and as a first approximation his analogy was probably successful[492].

Unlike later authors,who tended to ignore the Chinese

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[492] *Gewu rumen*,6.7a-7b

paradigms altogether,Martin went to some trouble to acknowledge the existence of the *wuxing* 五行 theory,and then to explain - as tactfully as he could - why it was no longer accepted:

> Neither Metal,Water,Wood,Fire and Earth,which in China are regarded as the Five Phases(*wuxing* 五行),nor Water,Fire,Air(*feng* 風) and Earth,which are regarded as the Four Elements(*sixing* 四行)in the West,are [actually] chemical elements(*yuanzhi* 原質),for if we go further into the matter they each have their own antecedents(*benyuan* 本原). Water may be decomposed into two gases; Fire is the result of the combination of two gases which generates heat; Wood is a combination of Water,Air and Earth,and Earth [itself] can be decomposed into two materials; whilst only Metals,of which there are several types which cannot be decomposed,can be regarded as elements(*yuanxing*原行)[493].

Martin developed a relatively detailed chemical terminology,going well beyond *Bowu xinbian* in this respect,and was the pioneer in naming the majority of the chemical elements,adopting a pragmatic approach to nomenclature,using as far as possible existing Chinese terms from the alchemical tradition. For compounds he used the equivalent notation,with superscripts for the equivalent numbers. In his terms for chemical concepts and operations he also drew on the alchemists' nomenclature,an approach which was not favoured by his successors in Shanghai,who preferred to emphasise the break with past ideas,but his methods were followed and extended by his colleague Anatole Billequin in his text *Huaxue zhinan*. The

493 *ibid.*,6.6b

final section of the chemistry chapter is a remarkable honouring of the Chinese alchemical tradition in the light of modern chemistry.[494]

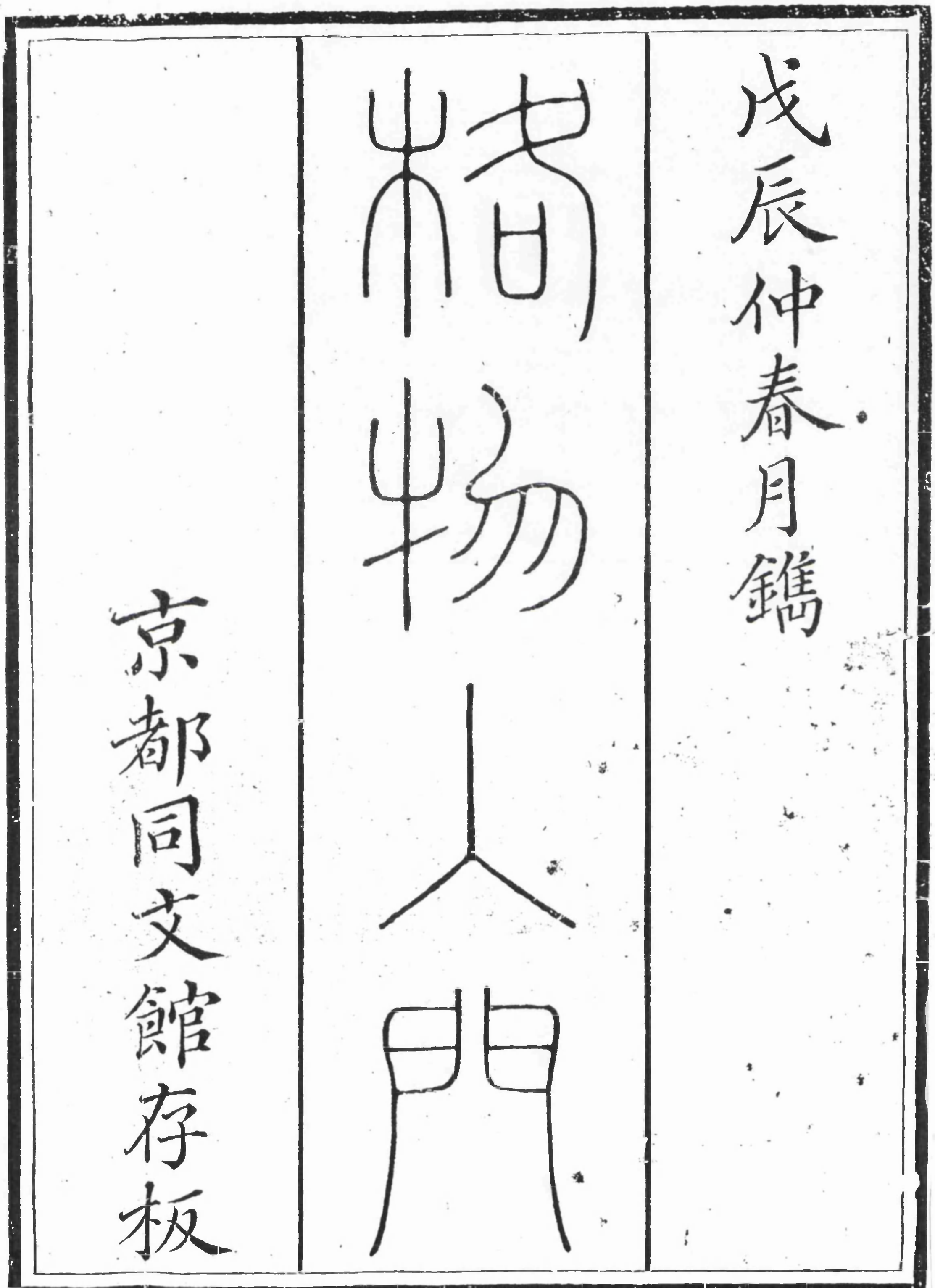

Figure 22. The front cover of *Gewu rumen* [Reproduced by kind permission of the British Library,Oriental and India Office Collections]

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494 See Section 6.5.

Figure 23. Illustrations of chemical equipment and processes from *Gewu rumen*. Top row, left to right: a safety lamp; diffusion of light and heavy gases; lime-light

Middle row: use of the blowpipe; a blowpipe; showing the gases within the candle-flame are not burning; an iron gauze(for safety lamps).Bottom row: a back-draught flame used for smelting iron; phosphine (*guangdan* 光淡) gas bubbles igniting as they leave the water.

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7.7 *Huaxue chujie* 化學初階*(1870)* and *Huaxue jianyuan* 化學鑑原*(1871)* [495]

These two books are,remarkably,both translations of the same original text,the 1858 edition of David Wells' *Principles and applications of chemistry*. *Huaxue chujie* was published in 1870[496] in Guangzhou,the result of collaboration between the American Presbyterian medical missionary John Glasgow Kerr [Jiayuehan 嘉約翰](1824-1901)[497]

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[495] *Huaxue chujie* was published by Boji yiyuan 博濟醫院[Medical Missionary Society Hospital] in Canton; *Huaxue jianyuan* by the Jiangnan Arsenal in Shanghai.

There are several articles in the secondary literature on these two works and their impact,for example: a review of *Huaxue chujie* in *CR* **4** (June 1871),26-27; Pan Jixing,'Ming-Qing shiqi (1640-1910) huaxue yizuo shumu kao,23-38; Zhang Qinglian 张青莲,'Xu Shou yu *Huaxue jianyuan*' 徐寿与化学鉴原[Xu Shou and *Huaxue jianyuan*] in *ZGKJSL* **6**,4 (1985),54-56; Zhang Zigao and Yang Gen,'Cong *Huaxue chujie* he *Huaxue jianyuan* kan woguo zaoqi fanyi de huaxue shuji he huaxue mingci,105-118; Wang Yangzong 王扬宗,'Guanyu *Huaxue jianyuan* he *Huaxue chujie* 关于"化学鉴原"和"化学初阶"'[On *Huaxue jianyuan* and *Huaxue chujie*] in *ZGKJSL* **11**,1(1990),84-88.

[496] Wang Yangzong ('Guanyu *Huaxue jianyuan*',85) considers it possible that it was not actually published until 1871,although the preface is dated 1870.

[497] Kerr arrived in Canton in May 1854,and worked as a medical missionary there for many years. (See 'Sketch of the Canton Protestant Missions' in *CR* **7**(1876),187-194 and the tributes to Kerr in *CR* **32**(September 1901),462 and *CR* **33**(July 1902),350-353).

See also Peter Buck,*American science and modern China 1876-1936* (Cambridge:Cambridge University Press,1980),14-16 for an account of Kerr's life.

and He Liaoran 何瞭然,who had been one of Benjamin Hobson's students[498]. It is the shorter of the two translations,giving less detail about the rarer elements,but providing the reader a much stronger theoretical foundation in the early sections.

The introductions to *Huaxue chujie* (one in English by John Kerr; separate Chinese introductions by both Kerr and He) furnish much interesting information. Kerr's English introduction tells us that he adapted the 'modern' notation from 'Fownes,10th Ed.,Rolfe & Gillet,and other recent works'. The illustrations,which appear as a separate section,were from 'electrotype plates obtained from Messrs Ivison,Phinney,Blakeman & Co.,New York'[499]. Kerr also mentioned that he used the 'Chemical Catechism [i.e.the sixth *juan* of *Gewu rumen*] by the Rev. W.A.P.Martin',and also remarked

> A few of the names of elements were taken from a list sent by Mr J.Fryer,and where no suitable term existed,new ones are proposed.A few foreign names have been transferred[transliterated],where there was evident necessity for it. This effort to introduce a chemical nomenclature into the Chinese language is an

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[498] He Liaoran gives this information about himself,and that he came from Panyu 番禺 in Guangdong Province,in the introduction to *Huaxue chujie* 1.1a. In giving the reasons for carrying out the translation,He Liaoran says that

> Firstly,it serves to reveal the great wonders(*hongqi* 宏奇) of the Creator;secondly it serves to benefit the people and the nation; thirdly it serves to [allow us to] profit from the vast [reserves] of metals and coal.[Using] analysis and synthesis(*fen he* 分合),and [making] deductions: all [these] methods are fully illustrated and set out [*tufa biju* 圖法畢具]. The scholar will certainly able to use [scientific] equipment [to experiment for] himself,and [if he does so] he will be able to ascend step by step. These are not mere empty words. (*ibid.,*1.1a)

[499] The publisher of Wells's work.

> experiment,and whether it is a success,or only a preparatory step,to be decided by Chinese scholars,after they have become familiar with the science. The hundreds of new substances introduced to the Chinese cannot fail to find suitable names in a language so rich as that of this Empire. [500]

The Chinese prefaces of Kerr and of He Liaoran are notably Christian in flavour. Kerr wrote

> The great subject of chemistry is particularly suited to make men know of the mysteries of the Creator(*zaowuzhu* 造物主). Although between Heaven and Earth there are a myriads of different fluid and solid substances,in the end there are just sixty-five elements(*yuanzhi* 原質),and these elements all possess a force of attraction(*qianxi zhi li* 牽吸之力). They are separated over and over again,transformed and combined,and distributed in accordance with Our Lord's plan,and did not require any [other raw] materials in order to make matter. It is very clear that all things were made by the combination of these elements,their combination being[according to] definite proportions,crystals forming according to definite shapes: thus we can know the divine wisdom of the Creator. By combining the elements in the Myriad Substances,of which not one is without its precise use for human beings,we can know the way in which the things the Creator made are especially for our use. For,seeing that we could use materials which had mutual attraction,and which having attraction for each other,combine to make substances,but that we could not make this attraction come from nothing,in the Beginning He gave material things this attraction.Is

[500] *ibid.*

His omnipotence not great?[501]

Xu Shou and John Fryer translated *Huaxue jianyuan* independently at about the same time as Kerr and He Liaoran were working in Canton,but their work was published slightly later,probably in 1871[502].

Just as serious a problem as differences in the choice of terms was in the content of the texts themselves,namely that the Western science being transmitted was in considerable flux and confusion over such matters as atomic weights,the correct way to write chemical formulae,and the importance (or even the existence) of atoms.

The missionaries were of course unwilling to admit that the supposed certainties they were transmitting were in fact a matter of heated debate: they tended in their early works to ignore the problem by translating the empirical,descriptive sections which ,on the whole,could not be held in controversy. Whilst this might have been acceptable for the most elementary of texts,it proved impossible once any depth was attempted. Choices between systems had to be made,and Fryer kept to the system of equivalents which was preferred by many British and some continental chemists,yet which had become,even when he was translating *Huaxue jianyuan*,somewhat old-fashioned.

Fryer himself explained his decision thus:

It is unfortunate that the work of translation had to be commenced during the period of the transition from

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[501] *Huaxue chujie* Preface,2b.

[502] The preface of the book itself is dated March,1871. Pan Jixing,following John Fryer in 'An account of the Department for the Translation of Foreign Books at the Kiangnan Arsenal,Shanghai' in *FP* gives the date of publication as 1871,whereas Zhang Qinglian and Wang Yangzong give 1872. I am following Fryer.

> the old to the new notation,when only textbooks in the old notation were obtainable. When the new system[i.e. using atomic weights rather than equivalent weights to obtain the formulae of compounds] had become fully established in Western countries several books had been published in Chinese according to the old notation. It was feared that a change in the system in succeeding works would only lead to confusion and hence the old notation has been retained throughout the whole series of works relating to chemical subjects. A little trouble however is all that is needed to enable the student to change from the old to the new and *vice versa*.[503]

This would be more convincing if his rival translator John Kerr had not used the 'new' system as early as 1870,when according to Fryer only texts using the 'old' system were obtainable. Changing from one system to another was in fact far from being a 'little trouble': it was actually quite impossible without expert guidance. If Fryer had really been concerned for his readers,why were the old and new systems not given in a glossary or the new system given as an annotation to the old? I suspect that by 1885 Fryer,whose co-translator Xu Shou had died a year earlier,had by then lost interest in chemistry,and was unwilling to go to the considerable trouble (and loss of face) of revising the previous translations,even though by the 1890s they were scandalously outdated.

Both textbooks proved to be influential. *Huaxue chujie*化學初階 was used by Kerr as the basis of the chemical content of a series of medical texts,whilst the system in *Huaxue jianyuan* 化學鑑原 was extended to all the Jiangnan Arsenal

503. John Fryer in his preface to *Huaxue cailiao Zhong-Xi mingmubiao*.

translations on related subjects.

> For medical students it stands to reason that Dr Kerr's terms are the more advantageous,as they run through the whole of his excellent series of medical works. For students of ordinary scientific subjects,and the Chinese public generally,who need to read and study the higher branches of chemistry,metallurgy,mineralogy,the arts,the manufactures,etc.,etc.,Dr Fryer's nomenclature,running through all his works on these subjects,widely circulated all over the empire,would perhaps be preferable.[504]

A small part of *Huaxue jianyuan* was also serialised in *Jiaohui Xinbao*[Church news] which was edited by Fryer's fellow-translator Young J.Allen.[505]

7.71 A comparison of the contents of *Principles and applications of chemistry*,*Huaxue chujie* and *Huaxue jianyuan*[506]

A modern reader of a mid-century chemistry textbook is struck by the breadth of material included as 'chemistry': gravity,heat,light and electricity all came within its purview. The relative lack of chemical theory is also remarkable. Atoms are hardly mentioned,and there are none of the structural diagrams one is used to see even in the most elementary texts in use today. This also reflects the caution of many in employing the atomic theory,for,as we have seen in Chapter 6,chemists often preferred to use the equivalent formulae rather than the 'speculative' atomic

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[504] Neal,'Treatises on chemistry',189

[505] *Jiaohui Xinbao* **5**,214(30th November,1872),98b; **5**,215 (7th December,1872),104b-105b; **5**,216(14th December,1872),111b-112b

[506] The numbers in brackets refer to page numbers in the respective books.

formulae.[507]

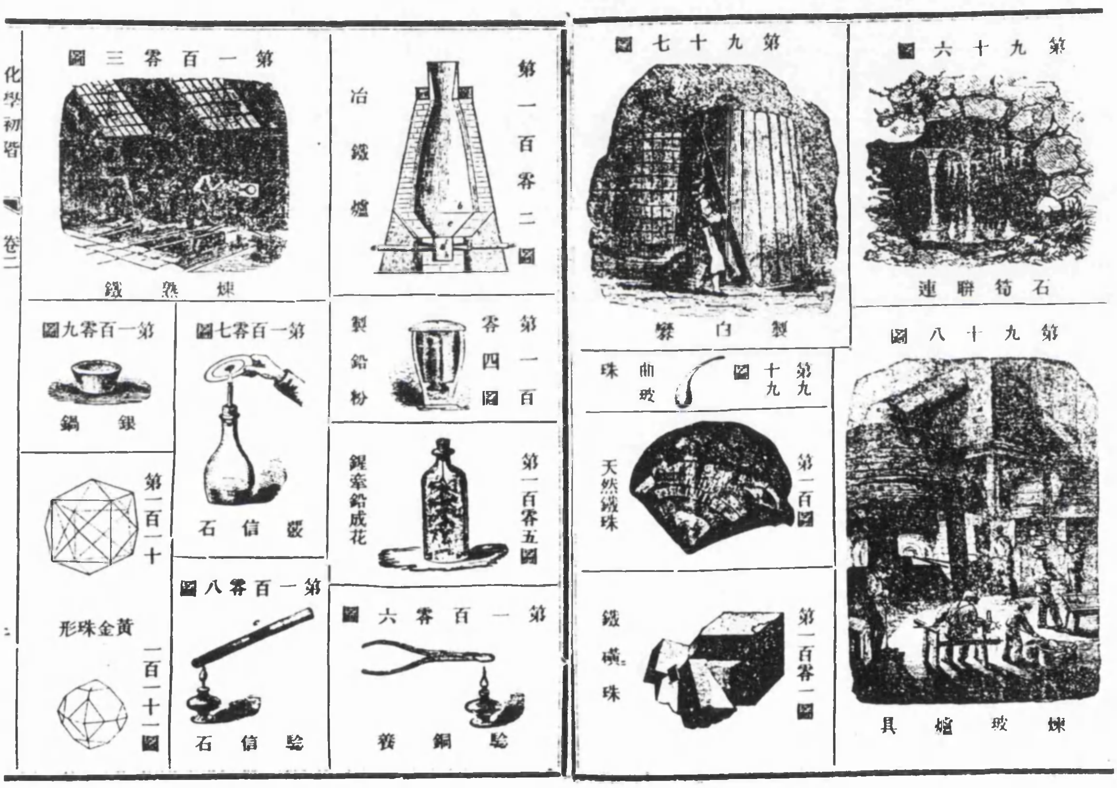

Figure 24. Illustrations from *Huaxue chujie*.

The right-hand page shows, starting from the top left-hand

[507] See Carl Fresenius, quoted by his translator A.Vacher in the preface to the 9th (1876) English edition of *Qualitative chemical analysis*, v-vi

I do not retain the old notation out of prejudice, but from a most firm conviction that for Inorganic Chemistry it is the simplest and the best. This view is not peculiar to myself but is shared with the highest authorities in Germany (Wohler, Bunsen, & c.)

corner and going clockwise: making alum; stalactites and stalagmites; a glass-making furnace; crystals of iron sulphide[iron pyrites]; crystals of marcasite(*tianrantie* 天然鐵); a curved glass crystal.The left-hand page shows: making cast iron; a blast furnace; making powdered lead; zinc displacing lead from solution; testing copper oxide; testing for arsenic [by the decomposition of arsine gas]; investigating arsenic [sublimation]; a silver bowl; the shapes of gold crystals.

[Reproduced by kind permission of the Wellcome Institute for the History of Medicine,London]

Table 9. A comparison of the *Huaxue chujie* 化學初階 and *Huaxue jianyuan* 化學鑑原 translations of David Wells' *Principles and applications of chemistry*

Principles and applications of chemistry(1862)	*Huaxue chujie*(1870)	*Huaxue jianyuan*(1871)
Introduction(9) 1.Matter(9) 2.Simple substances(9) 3.Compound bodies(10) 4.Atoms and molecules(10) 5.Porosity(11) 6.Inertia(11) 7.Forces(12) 8.Gravitation(12) 9.Varieties of force(13) 10.Molecular forces(13) 11.Cohesion(14) 12.Adhesion(14) 13.Capillary attraction(14) 14.Affinity(16) 15.Repulsion(16) 16.Elasticity(17) 17.Three forms of matter(17) 18.Solids(17) 19.Liquids(18)		

20.Gaseous bodies(18) 21.Change of condition(18) 22.Ethereal condition(19) 23.Matter indestructible(19) 24.Force indestructible(20) 25.Classification of forces(20) 26.Natural philosophy[physics](20) 27.Physiology(20) 28.Chemistry(20) 29.Chemical action (21) 30.Properties of matter(21)		
<u>Chapter 1</u> *Section 1 Gravity* 31.Connection of gravity with chemical phenomena [...] 3.Light(112) I.Nature and sources of light(112) II.Properties of light(115) 4.Electricity(130)		

5.General principles of chemical philosophy(156) 38.Finding the specific gravity of solids(27) 39....of liquids(27) 40.Hydrometer(28) 41.Specific gravity of gases(29) 42.Use of specific gravity to distinguish gold from iron pyrites(29) *Section II* 43.Cohesion and chemical action(29) 44.Limpid and viscous liquids(30) 45.Variations of cohesion in solids(31) 46.Hardness(31)		

Section III 47.Adhesion and chemical action (32) 48.Surface action(33) 49.Capillary attraction(34) 50.Filtration(35) 51.Endosmosis(37) 52.Diffusion of gases(37) *Section 4* *Crystallisation*(44)		
<u>Chapter 2 Heat</u>(56) <u>Chapter 3 Light</u>(112) <u>Chapter 4 Electricity</u>(130)		

<u>Chapter 5 General principles of chemical philosophy</u>(156) 250.Elements(156) 251.Number of the elements(156) 252.The classification of the elements(157) 253.Compound bodies(158) 254.Cause of chemical combination(158) 255.Characters of chemical affinity(159) 256.Laws of chemical combination(162) 257.Law of definite proportions(163) 258.Law of multiple proportions(163) 259.Law of equivalent proportions(163) 260.Law of substitution(260) 261.Chemical equivalents(165) 262.Equivalent volumes(168) 263.Atomic theory(169) 264.Specific heat of atoms(172) 265.Chemical nomenclature and symbols.Acids. Bases.Alkalies. Salts(174) 266.Neutral bodies 267.Origin of chemical nomenclature(176)	<u>Introduction</u> (1.1a) 1.Measuring chemical affinity(*huali* 化力) (1.2a) 2.No chemical affinity between the same substances(1.2b) 3.Chemical affinity(1.2b) 4.Chemical combination producing two substances(1.2b) 5.Differences in chemical affinity(1.3b) 6.Elements are indestructible(1.3b) 7.Two substances combined(1.4a) 8.Two methods for combining compounds(1.4a) 9.The limits of combination of the elements(1.4b) 10.Three examples of chemical combination(1.4b) 11.Table of elements(1.5a) 12.Two methods of combination 13.Two classes of compounds(1.7b) 14.Methods of combining compounds(1.8b) 15.Different substances with the same elements(1.9a)	<u>Introduction</u> 1.The types of substances(1.1a) 2.The meaning of 'elements'(1.1a) 3.The number of elements(1.1a) 4.The types of elements(1.1b) 5.The meaning of 'compounds'(1.2a) 6.The theory of chemical combination(1.2a) 7.The theory of chemical affinity (*ainieli* 愛攝力) (1.2b) 8.The strength of chemical combination(1.5a) 9.Definite proportions(1.5b) 10.Multiple proportions (*jia bili* 加比例)(1.6a) 11.Equivalent proportions(*deng bili* 等比例)(1.6a) 12.Displacement (*huahe xiang dai* 化合相代)(1.7b) 13.Equivalents[by weight](*fenji* 分劑)of chemical combination(1.8a) 14.Equivalents[by volume](*tiji fenji* 體積分劑)(1.9b)

269.Nomenclature of compounds(176) 270.Classification of acids(178) 271.Classification of salts(178) 272.Symbols(179) 273.Symbols of elements(180) 274.Symbols of compounds(180) 275.Reactions and reagents(181) 276.Isomerism(182) 277.Allotropism (183)		15.The theory of atoms(1.9b) 16.The specific heat of atoms(1.12a) 17.The use of equivalents by volume and by weight(*qingzhong fenji* 輕重分劑)(1.14a) 18.Bases(本質)(1.14a) 19.Acids(*peizhi* 配質)(1.14b) 20.Salts(*yanlei* 鹽類)(1.14b) 21.Neutrality(1.15b) 22.Allotropes(1.6b) 23.Isomerism(1.16b) 24.The beginnings of Western nomenclature(1.17a) 25.The nomenclature of the chemical elements(1.17a) 26.The nomenclature of compounds(1.17b) 27.The symbols for the elements(1.18b) 28.The symbols of compounds(1.18b) 29.Chinese nomenclature(1.20b) Table of the elements

Inorganic chemistry Chapter 6 Non-metals(184) I.Oxygen(184) II.Management of gases(196) III.Hydrogen(199) IV.Nitrogen,or azote(219) V.Chlorine(235) VI.Iodine(253) VII.Bromine(255) VIII.Fluorine(256) IX.Sulphur(258) X.Selenium and tellurium(268) XI.Phosphorus(269) XII.Boron(276) XIII.Silicon,or silicium(279) XIV.Carbon(282)	1.Oxygen(1.9b) 2.Handling of gases 3.Hydrogen(1.15a) 4.Nitrogen(1.23b) 5.Chlorine(1.30b) 6.Iodine(1.39a) 7.Bromine(1.40b) 8.Fluorine(1.41b) 9.Sulphur(1.42b) 10.Selenium(1.49b) Tellurium(1.50a) 11.Phosphorus(1.50b) 12.Boron(1.54a) 13.Silicon(1.55b) 14.Carbon(1.58a)	30.Non-metallic substances(2.1a) 31.The difference between metals and non-metals(2.1a) 32-42.Oxygen(2.1b) 43-56.Hydrogen(2.13b) 57-70.Water(2.23a) 71-72.Hydrogen peroxide(2.29b) 73-93.Nitrogen(2.30a) 94-105.Chlorine(2.49b) 110-120.Iodine(3.1a) 121-123.Bromine(3.4a) 124-126.Fluorine(3.5a) 127-142.Sulphur(3.7a) 143-144.Selenium(3.19a) 145-154.Phosphorus(3.20a) 155-158.Boron(3.27b) 159-168.Silicon(3.29b) 169-210.Carbon(3.39a)
Chapter 7 Combustion(307)	15.Combustion(1.74a)	
Chapter 8 The metallic elements(324)	16.Metals(2.1a)	211-224.Metals(4.1a)

<u>Chapter 9</u> The metals of the alkalies(327) I.Potassium(327) II.Sodium(333) III.Lithium(339) IV.Ammonium(339)	17.Potassium(2.3a) 18.Sodium(2.8b) 19.Ammonium(2.11b)	225-235.Potassium(4.4a) 236-244.Sodium(4.10b) 245.Lithium(4.15b) 246.Caesium(4.16a) 247.Rubidium(4.16a) 248-257.Ammonium(4.16b)
<u>Chapter 10</u> The metals of the alkaline earths(343) I.Barium and strontium(343) II.Calcium(344) III.Magnesium(349)	20.Barium(2.15a) 21.Calcium(2.16a) 22.Magnesium(2.19a)	258.Barium(4.21a) 259.Strontium(4.21b) 260-269.Calcium(4.22a) 270-275.Magnesium(4.27a)
<u>Chapter 11</u> The metals of the earths(350) I.aluminium(351)	23.Aluminium(2.20a)	276-285.Aluminium(4.28b)
<u>Chapter 12</u> Glass and pottery(355)	24.Ceramics(2.23a)	

<u>Chapter 13</u> The common or heavy metals(360) I.iron(360) II.Manganese and cobalt(367) III.Cobalt and nickel (370) IV.Zinc and cadmium(371) V.Lead and tin(372)	25.Iron(2.25b) 26.Manganese(2.31a) Chromium(2.33a) 27.Cobalt(2.33a) 28.Zinc(2.34a) 29.Lead(2.35b) 31.Antimony(2.40b)	286.Thorium(4.33b) 287.Yttrium(4.33b) 288.Erbium(4.34a) 289.Terbium(4.34a) 290.Cerium(4.34a) 291.Lanthanum(4.34a)292- 294.Didymium(4.34b)295- 312.Iron(5.1.1a)[508] 310-312.Steel(5.1.23a) 313-314. Manganese(5.2.1a) 315-317.Chromium(5.2.3b) 318-319.Cobalt(5.2.4b) 320-321.Nickel(5.2.5b) 322-326.Zinc(5.2.6a) 327.Cadmium(5.2.8a) 328.Indium(5.2.8b) 329-335.Lead(5.2.9a) 336-349.Tin(5.2.15b)

[508] The fifth *juan* is divided into two parts,*shang* 上 and *xia* 下 ,which I have labelled 5.1 and 5.2.

VI.Copper and bismuth(377) VII.Uranium,vanadium,tungsten,columbium,titanium,molybdenum,niobium,pelopium,ilmenium[509],etc.(380) VIII.Antimony and arsenic(380)	30.Copper(2.38b)	340-359.Copper(5.2.19a) 360-362.Bismuth(5.2.32b) 363.Vanadium(5.2.34b) 364-365.Tungsten(5.2.35a) 366.Titanium(5.2.35b) 367.Molybdenum(5.2.36b) 368.Nickel(5.2.37a) 369-370.Antimony(5.2.37b) 371-376.Arsenic(5.2.40b)
<u>Chapter 14</u> The noble metals(385) I.Mercury(385) II.Silver(388) III.Gold(392) IV.Platinum,palladium,rhodium,ruthenium,osmium,iridium(395)	32.Precious metals(2.42a) 33.Silver(2.45b) 34.Gold(2.49a) 35.Platinum(2.51b)	377-385.Mercury(6.1a) 386-397.Silver(6.5b) 398-402.Gold(6.11a) 403-405.Platinum(6.14a) 406.Palladium(6.16b) 407.Rhodium(6.17a) 408.Osmium(6.17a)
<u>Chapter 15</u> Photography(397)	[not included]	[not included]

509 Pelopium and ilmenium were later found not to be elements. See V.Karpenko,'The discovery of supposed new elements: two centuries of errors' in *Ambix* **27**,2(July 1980),77-102,especially pages 93-95.

Chapters 16-25 Organic chemistry(401)	[not included]	[not included]

Both translations were faithful to the original in their sequencing of the descriptive sections,yet each attempted to give its own edited version of the long introductory section. Kerr's can be accounted the more successful of the two,perhaps because as a medical doctor he had a deeper and more confident grasp of the principles he was expounding. In particular,Kerr had the insight to change the old-fashioned equivalent,dualistic formulae into unitary formulae based upon atomic weights. *Huaxue jianyuan* also includes many of the rarer elements,which Kerr decided to omit.

Both translations gave only a very sketchy accounts of the more technical aspects of chemistry,in particular of the laws of proportionality which led to modern ideas of chemical combination,and little or no idea how they came to be discovered. The impression given is a vast array of facts,with few guiding principles. Nowhere is there a hint that previous theories had been found to be erroneous.

The illustrations in *Huaxue chujie* are far superior to those in *Huaxue jianyuan*(in fact the standard of the illustrations in all the Jiangnan Arsenal chemistry texts is poor by comparison with *Gewu rumen* or *Bowu xinbian*.)

We have some direct evidence of the students' view of *Huaxue jianyuan* in an account by Luan Xueqian 欒學謙,a student and teacher at the Shanghai Polytechnic in the 1890s,which shows that most students found it very difficult and indigestible - like "chewing wax" as he put it.[510]

7.72 The nomenclature of compounds

A major difference in the two texts is in the system of

[510] See Section 10.22 for a full translation and reference.

chemical formulae: Xu Shou/Fryer followed Wells in using the dualistic or Berzelian system, in which compounds were regarded as compounds of positive[metallic] oxides and negative[non-metallic] oxides, such as for instance potassium chlorate: $KO.ClO_2$, and the formulae of the oxides themselves were given as *equivalent formulae*, not the atomic formulae with which we are nowadays familiar.

Kerr adopted the 'new' system of atomic formulae, based upon atomic weights, which until the 1860s had been regarded as uncertain. Many chemists such as Charles Bloxam still regarded equivalents as more reliable and understandable than atomic weights, and continued to use them in their textbooks. Kerr/He Liaoran were not entirely consistent, for example, potassium dichromate was given in *Huaxue chujie* as *hui* $_{er}$ *yang (luyang* $_{san}$*)* $_{er}$ [illegible]二養(鏴養三)二 [511], or in Western notation $K_2O.(CrO_3)_2$, thus using the Berzelian system, but they sometimes also used the *atomic system*, for instance in the same section writing potassium chromate as *hui* $_{er}$ *lu yang* $_{si}$ [illegible]二鏴養四 [512]

7.8 *Huaxue zhinan* 化學指南(1873) and *Huaxue shanyuan* 化學闡原(1882)

Both these texts were translated by Anatole Billequin of the Beijing Tongwenguan. The first, *Huaxue zhinan* [A guide to chemistry] was published in 1873, a translation of Faustino Malaguti's *Lecons elementaires de chimie*[513]. It

[511] *Huaxue chujie*, 2.32a

[512] *Huaxue chujie*, 2.32a

[513] The second edition was published in Paris by Dezobry, E.Magdeline and Co in 1858-1860. Faustino (also called François or Francesco) Jovina Mariano Malaguti(1802-1878) was born in Bologna, and fled as a refugee to France in 1831, where he worked as an assistant to Pelouze in Gay-Lussac's laboratory. In 1850 he became first Professor, then Rector, at Rennes. (See *Nouvelle Biographie Générale* (Paris: Firmin Didot, 1860), J.R.Partington, *A history of chemistry* Vol 4. (London: Macmillan & Co, 1964), 362-363 and Maurice Crosland, 'The

followed Martin's catechetical style of presentation, and attempted to present both inorganic and organic chemistry in a single volume.

Huaxue shanyuan [514] was published in 1882, translated by Billequin with the help of his students Cheng Lin 承霖 and Wang Chongxiang 王重祥. It began with an account of the importance of chemistry:

> Chemistry is one of the great divisions (*duan* 端) of Western studies. Its methods include the transformation of one substance into another; the conversion of two [separate] substances into a single substance[515]; the conversion of one substance in to two, three, four or even more substances[516]. Coarse (*cu* 粗) substances may be converted into refined (*jing* 精) ones; cheap substances may be converted into costly ones; hard substances may be converted into soft substances[517], and *vice versa*[518]. [Chemistry] involves collecting all the essences of the Five Phases (*wuxing* 五行) and taking to the extreme the miraculous transformations of the two beginnings [*yin* 陰 and *yang* 陽][519]. It is not easy to become familiar with it or

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development of a professional career in science in France' in M.Crosland (ed.) *The emergence of science in Western Europe*, 146.

[514] The character 闡 is more usually read *chan* nowadays.

[515] Such as: mercury + oxygen ---> mercury(II)oxide

[516] Such as by the fractional distillation of crude oil.

[517] Metal ores are generally harder than the metals they contain.

[518] Perhaps the manufacture of glass from sand is in mind.

[519] This sort of reference to traditional Chinese concepts is typical of the Tongwenguan writers. It seldom went beyond such passing mentions, but reflects W.A.P.Martin's belief that the Chinese were particularly well-disposed towards chemistry because of their long alchemical tradition.

> to explain in words. It is particularly important for anyone concerned with tax revenue(*huzheng* 户政),military matters,and manufactures: it is used by [such] people every day. Those in need of healing and at risk of their lives are often provided for by [chemistry]. The [Beijing] Tongwenguan as well as teaching many other major subjects such as languages,scripts,astronomy,mathematics and medicine,also has a chemistry department. The Western scholar Billequin specialises in this subject,and has been at the Tongwenguan for a long time,discussing with and teaching many students,with great effectiveness. He has translated the text *Huaxue zhinan* 化學指南 in 10 *juan* 卷 [chapters]and it has been distributed both within China and overseas for many years. Now,after discussion with the President [W.A.P.] Martin,[Billequin] has also made a translation of *Huaxue shanyuan*,and [......] the book has been written in six *zhang* 章[chapters].[Although] as far as these [chemical] changes are concerned,this book is like tracing the source of a pool or lifting the collar when removing a garment[520],it is being printed and distributed in order to benefit those who are eager to learn of this subject and who inquire exhaustively about the laws of chemistry.[521]

The reference to the antiquity of Chinese chemistry is made more explicitly in the other preface,which states:

> It is said [...] that,originating with the ancients,Fire was produced by the drilling of Wood; that Metal and [ceramic] vessels are made by the

[520] That is,only superficial.

[521] *Huaxue shanyuan*,Preface.

> combination of Fire with Earth[522]; this was passed to later generations, with the professions of the makers of alcoholic wine, sweet wine and pickled meat. These matters were [also] known in the flavouring of meat soup[*geng* 羹], where the goodness of teeth, bones and horns was used.[523]
>
> Recently, it has been learned how, by the exercise of ingenuity, the [number of] substances can be increased indefinitely, and this is what is termed 'chemistry'.[524]

Huaxue shanyuan was, according to the preface, for 'deeper study' than *Huaxue zhinan*[525]

These books are most remarkable for Billequin's attempt to create a new system of characters for the chemical elements, a system which has been considered in Chapter 6, but which proved in practice to be too unwieldy despite certain advantages. Another interesting feature is that, like Martin before him, Billequin attempted to smooth the introduction of Western chemistry by emphasising the connections with Chinese alchemy wherever possible. This extended to terminology, using terms such as *shuang* 霜 [frost] for 'precipitate' and *lian* 煉[to refine] for various chemical processes, echoing the alchemical term *lian dan* 煉丹 [refining elixir]. Even the diagrams he used were not taken from Western texts but drawn in a traditional Chinese way, in order to make the reader feel that the science was

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[522] That is, by smelting metal ores.

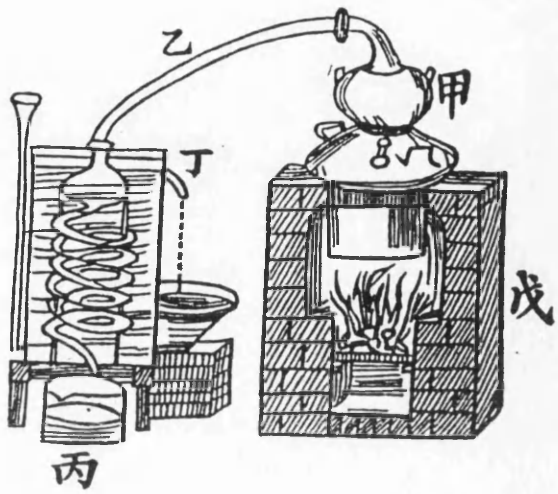
[523] The writer is deliberately using the productive sequence of the Five Phases - Wood, Fire, Earth, Metal, Water - to make his point. See Section 2.22.

[524] Preface by Fen Chixiang 棻 池祥

[525] *Huaxue shanyuan: Fanli*, 1a

not truly alien.

問煉淨水具其式若何、



答圖式、甲爲蒸釜、乙爲曲管、丙爲接水瓶、丁爲冷水箱、戊爲火爐、法以火爐煮甲釜內之水、使蒸氣由乙管達於丙瓶即成爲水、蒸氣甚熱被丁箱內冷水所激、故成爲水也、

問蒸氣水其氣臭若何、

答無氣臭、草藍遇之不變色、但其滋味不佳、若遇天氣中之養氣相攙、其味便佳、

Figure 25. Diagram of a still closely resembling a traditional Chinese still, from *Huaxue zhinan*, 1.19b,

[Reproduced by kind permission of the British Library, Oriental and India Office Collections]

7.9 *Gewu tanyuan* 格物探原 [526]

Gewu tanyuan ['Seeking the origin of the investigation of things' known in English as 'Scientific and Religious Essays' or 'Natural Theology'] was published in 1875-1880 in Shanghai,and marks the culmination of many essays written by the Scottish missionary Alexander Williamson[527] on the theme of natural theology. It is unusual in that by the 1870s most missionary science writers avoided mixing religious and scientific writing for fear of offending Chinese readers who might otherwise be disposed to read of Western science. Alexander Williamson would have none of this,and he spared no effort in deploying all aspects of natural history to show that science supported,indeed corroborated,the Christian view of the world. His book was one of the most widely used science texts in missionary schools by the turn of the century.[528]

7.91 *The contents of Gewu tanyuan*

The first section(*shou juan* 首卷) includes essays on Heaven and Earth,matter,geology,human anatomy.

The second section(*ci juan* 次卷)describes aspects of the Deity: His uniqueness,omnipotence,omniscience,omnipresence

The third section (*san juan* 三卷)returns to the theme of science.

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[526] See Liu Guangding 劉廣定,'*Gewu tanyuan* yu Weilianchen de Zhongwen zhuzuo' 格物探原與韋廉臣的中文著作 [*Gewu tan yuan* and Williamson's Chinese works] in Yang Cuihua 楊翠華 and Huang Yinong黃一農(eds.)*Jindai Zhongguo kejishi lunji* 近代中國科技史論集 [A collection of articles on the history of science and technology in modern China](Taibei:Zhongyang yanjiuyuan jindaishi yanjiusuo中央研究院近代史研究所,1991),195-214.

[527] See his obituary in *NCH*(5th September,1890),288-289

[528] See Table 13.

The omnipresence of God was emphasised in his discussion of chemical combination,which he saw as an instance of His intervention in what would otherwise be a stagnant,unchanging world. [529]

Having established the complexity of creation and the need for a creator-God to sustain it,Williamson went on to discuss the Creator's supreme intelligence as manifested in the language of the natural world.

7.92 Letters as metaphors for atoms

As language was thought by the Westerners to be the prerogative of only the most intelligent of God's creatures,so that the 'language' of the natural world meant that there was indeed a Supreme Intelligence speaking to us.[530] Williamson,aware of the deep reverence the Chinese had for literary learning,employed these ideas to impress

[529] *Gewu tanyuan,*3.1.2b

[530] This is an ancient idea,relating to the concept of God as the Word,and to words being more than simply conventional expressions for things. See G.N.Cantor 'Revelation and the cyclical cosmos of John Hutchinson' in L.J.Jordanova and Roy S.Porter(eds.)*Images of the Earth: essays on the history of the environmental sciences*(Chalfont St.Giles:British Society for the History of Science,1979),3-22. Hutchinson believed that in the original Hebrew language words "represented reality". See also Martin J.S.Rudwick,'Transposed concepts from the human sciences in the early work of Charles Lyell' in *ibid.*,67-83,for Lyell's analogy of 'reading' the fossil records.

upon the Chinese the respect and awe due to the author of creation,comparing letters with the atoms of which compounds are made,actually a very ancient analogy,first used by the Greek philosophers who first proposed the atomic theory. It is of course a natural metaphor for writers using an alphabetic script,but as we have seen in Chapter 5 the Chinese script is constructed on a completely different set of principles,and the analogy therefore required some explanation[531].

> These sixty-two elements combine to make the Myriad Things,just as in Western countries they have twenty-six letters which combine to make words.[532] For example,[from the letters 'a','b','l','e',you can make] 'able','bale' and 'lable'[sic]. There are about 60,000 commonly used words,and a further 60 million words[are possible]. Thus these twenty-six letters suffice for 60 million words,thus the sixty-two elements are able to make numberless substances. Can the twenty-six letters themselves combine to make language,or make a book? I know they cannot. Thus the sixty-two elements: if it were not for an extremely intelligent being combining them,how could the Myriad

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[531] See Michel Foucault,writing of the sixteenth-century view of written language,says that

> Words group syllables together,and syllables letters,because there are virtues placed in individual letters that draw them towards each other or keep them apart,exactly as the marks found in nature also repel or attract one another.(Michel Foucault,*The order of things: an archaeology of the human sciences*(London:Routledge,1992),35)

[532] Note that sixty-two and twenty-six are neat mirror images of one another: such a numerological coincidence would have been an implicit argument for the analogy. Conversely,when the number of known elements rose to sixty-four,some Chinese writers took this as evidence of a connection with the sixty-four hexagrams of the *Zhouyi* 周易 [Book of changes],and argued that chemical theory was therefore anticipated in ancient China.

Things of the world be made? Master Zhu[Zhu Xi 朱熹] said that *li* 理 and *qi* 氣 combine to make knowledge and perception,but this cannot be understood,as *li* 理 is a dead thing,and belongs to emptiness. How can it do anything? Without human beings you cannot make a book,and without God there cannot be a single thing in the world.[533]

[...]If you read any chemistry[534] book you can get to know these matters. For these particles(*weimiao* 微渺) are similar to bricks: in order to build a house,their size and shape all have to be fixed. Particles are thus not there spontaneously,it is only because the Creator dwelt there beforehand,and in accordance with His will that they were there,and long before [they existed] there was God,who has no beginning and no end. The particles each have their natures,and [some] have the properties of attraction,like lacquer,and properties of repulsion,like oil and water,properties of mutual interaction and transformation,properties of rarefaction and concentration. Light,heat and electricity can all change the particles,making them more or less dense,making them [into] solids,dense liquids or light liquids.[535]

[533] *Gewu tanyuan*,1.3a

[534] The original form of this article in *Liuhe Congtan* 六合叢談 is one of the earliest uses of the term *huaxue* 化學 for 'chemistry'.

[535] *Gewu tanyuan*,3.1.1b

Figure 26. A kangaroo and a porcupine. From the section on 'Skin' in *Gewu tanyuan*, 1.8.13b.

[Reproduced by kind permission of the British Library, Oriental and India Office Collections]

> All the elements(*yuanzhi* 元質)are like this and the changes in position and combination of the sixty-two elements to form the Myriad Things of the world,if there were no God amongst them moving them to combine,how could they become [compound] substances? There is not a single substance which could move spontaneously(*zi ran er ran yundong* 自然而然運動),for if there were only one thing in the world, it would stagnate and not live,but if there are two things,they can react(*jiaoshe* 交涉),and as more and more things are made,so do their reactions increase in magnitude.[536]

Williamson applied similar arguments to the wonderful,'designoid' structures of the living world,such as the structures of the skins of kangaroos and porcupines.[See Figure 26] His book was used in a number of missionary schools[537],and also seems to have been widely read by Chinese officials,for instance by Zeng Guofan's son Marquis Zeng(Zeng Jize 曾紀澤(1839-1890)[538]. Its appeal was helped by its excellent illustrations,which are the most vivid of any of the science textbooks of this period.

7.10 Conclusion

The growth of the modern science textbook in China had been a curious process,a translation not only of chemical terminology but also of a distinctive form of writing about the natural world,a form which gave the impression of science as a fixed and certain body of knowledge,lacking controversy,and with no historical or social context.

The time-lag between the original publication and its

[536] *ibid.*,3.1.2b

[537] See Chapter 10,Tables 12 and 13.

[538] See Zeng Jize,*Chushi Ying-Fa-E guo riji* 出使英法俄国日记[A diary of an embassy to Britain,France and Russia](Changsha:Yuelu shushe 岳麓书社,1985),685-686.

Chinese translation [See Table 10] meant that the Chinese were inevitably reading the science of at least a decade earlier. Although in part this delay was due to the time a translation took to prepare,it also reflected the science with which the foreign translator felt comfortable. With the exception of Billequin,none of the foreigners engaged in translation were professional scientists,and they all were naturally happier in transmitting the science they had learned in their youth than the latest ideas in the West,some of which greatly modified or even contradicted those revealed in earlier works.

The Christian agenda of certain textbooks(*Bowu tongshu* and above all *Gewu tanyuan*) only reinforced the Chinese scholars' view of the foreignness and uncouthness of science texts. In general,their subject matter seemed arcane and their style often boorish to the *literati* who first read them seriously in the 1880s and 1890s. Conscious that there was more to Western culture than steam trains and guns,reformers such as Kang Youwei determined to set up their own translation bureaux which would open up the more interesting,but more dangerous and less certain realms of philosophy,economics and politics.

The certainty which these books manifest also reflect the contemporary view of the steady march of progress. An admission that the previous ideas were now proved incomplete or wrong would have been humiliating and dangerous in the eyes of the foreign educators,and was,as we have seen,resisted until the end of the century,when returned students from the West and Japan began updating the mid-century texts.[539]

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[539] See N.Sivin,*Copernicus in China* and M.D'Elia *Galileo in China*,for the ways in which the Jesuits had dealt with these awkward revisions of conventional scientific wisdom.

Table 10. The time lag between certain Western science source-texts and their Chinese translations

Source-text	Chinese text	Time-lag(years)
D.Wells, *Principles and applications of chemistry*(1862)	*Huaxue chujie*(1870) *Huaxue jianyuan*(1871)	8 9
F.Malaguti *Leçons élémentaires de chimie*(1858-1860)	*Huaxue zhinan*(1873)	13
J.W.Johnston, *The chemistry of common life*(1859)	*Gezhi huibian*(1876-1881)	17
C.L.Bloxam, *Chemistry inorganic and organic*(1867)	*Huaxue jianyuan bubian*(1879)	12
C.L.Bloxam, *Chemistry inorganic and organic*(1867)	*Huaxue jianyuan xubian*(1875)	8
J.D.Dana, *Manual of mineralogy*(1858)	*Jinshi shibie*(1870)	12
Thomas Huxley, *Evolution and ethics*(1893)	*Tianyanlun*(1898)	5
Carl Fresenius, *Quantitative chemical analysis*(1876)	*Huaxue qiushu*(1888)	12

Carl Fresenius, *Anleitung zur qualitativen chemischen Analyse*(1841)	*Huaxue shanyuan*(1882)	41

The closed nature of these texts,together with the intrinsic difficulty of the concepts,made learning science in China forbidding to all but the most determined students,and even those fortunate enough to have instruction(as at the Shanghai Polytechnic)found little to ease their path.

By the 1890s there were Chinese students of science who had sufficient knowledge to write their own textbooks,for instance *Huaxue xinbian* 化學新編 on the chemistry of the metals and their ores by Y.T.Woo,who had studied abroad and worked on chemical analysis at the Kaiping Mines.[540] The role of the foreign missionaries in transmitting science was no longer dominant,whilst Japan was becoming a major influence,with many Chinese students travelling to Japan to study after 1895,and it was Japanese science textbooks which were to be the major influence on the next generation of Chinese science students.

The texts produced by the government translation bureaux,and especially the Jiangnan Arsenal,were certainly

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[540] *CR* **36**(October 1905),517. Mr Y[ang].T[seng].Woo might have been Wu Yangzeng 吴仰曾,who was in the first group of Chinese students to go to the USA with Yung Wing in 1872. See Qu Lihe, 瞿立鶴 *Qingmo liuxue jiaoyu* 清末留學教育[The education of students studying abroad in the late Qing](Taibei:Sanmin shuju 三民書局,1973),77. A mineralogy and practical chemistry class,taught by E.K.Buttles,had been running at Kaiping for returned students from the United States since the 1880s. See Knight Biggerstaff, *The earliest modern government schools in China*,70 and 234.

the most numerous,and perhaps the most influential,although the question of influence is extremely problematic. Some writers have assumed that,because the texts existed,they must therefore have contributed to the transmission of science into China,but it is far from clear to what extent and in what ways they played a role in the transmission. The number of people in China with any serious interest in Western science was extremely small until the last decade of the nineteenth century. The Tongwenguan and other arsenal-based academies did teach science but,with the probable exception of the Beijing Tongwenguan,seem to have done the job rather badly. Beyond these government institutions were the missionary schools,which tended to ignore natural science in favour of English and religious instruction. Only in Dengzhou College does Calvin Mateer seem to have provided a sound science curriculum. There is little evidence about the student's view of the textbooks used in these schools: we have Luan Xueqian's account[541] of the use of *Huaxue jianyuan* in the Shanghai Polytechnic of the 1890s,and it confirms the impression one gains by looking at it with modern eyes that it was - even to students like Luan,who were very knowledgeable - forbidding and incomprehensible: in short,very far from being what we now call 'user-friendly'.

The existence of these textbooks <u>did</u> probably play some kind of role,although the very slow progress made by science education in the 70s and 80s despite the apparent increase in the number of texts available,shows that in spite of all the optimistic statements by the few enthusiasts for science in China,the reality was official and public indifference to the efforts of the propagators,and often disappointment for the foreign agents of transmission who dedicated their lives to the advancement of science in the Celestial Empire.

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[541] See Section 10.22.

Chapter 8. The 'Divine commission'[542]: two foreign agents of transmission

8.0 Introduction

In this chapter I shall consider the role of two foreigners in the transmission of Western science to China,John Fryer and Calvin Mateer,the former the doyen of the 'secular missionaries',who worked for almost thirty years as translator of scientific books at the Jiangnan Arsenal,the latter a Presbyterian missionary and pioneer science educator.

The rivalry of these two men was at times intense: they had both given their lives,in different degrees,to the task of bringing Western science to China,an enterprise which initially elicited interest neither amongst most high officials nor the ordinary Chinese people. Yet by the end of the century both their works were beginning to bear fruit.

8.1 John Fryer

In the diary of his first voyage to China in 1861,John Fryer wrote

> It is with a combination of curious feelings that this journal is commenced. There is a mingled hope and fear,gloom and light;anticipations of a bright future ,and occasional forebodings of ill. Yet whatever may

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[542] According to John Fryer:

> It is impossible to shut one's eyes to the fact that the Teutonic element seems to be acting under a Divine commission to spread Western civilisation and the English language all over the world,and that China in spite of herself must join in this march of progress sooner or later.

(See 'Methods of imparting Western knowledge to the Chinese',9)

> befall,whether pleasure or pain,prosperity or adversity,it is a joyful fact that nothing can happen unless directed by a Father's hand. Jesus knows all,and safe under his guidance all will be well.[543]

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His time in China was indeed a mixture of light and gloom,success and bitter disappointment. At the height of his ambition he expected to achieve high office

> I want to be named among those who are foremost in enlightening and administering the Empire.[544]

and when he left China on 5th June,1896 to become a professor at the University of California at Berkeley,he had translated a small library of works on science and technology,and helped to create a scientific - and particularly a chemical - nomenclature and terminology which is the basis of the modern system[545]. Yet he never fully achieved the recognition he craved from the Chinese Imperial bureaucracy or from his Western missionary colleagues,and there is in his last years a sense of disappointment,his hopes of greatness unfulfilled.

8.11 An outline of his life

John Fryer was born in St Leonard,Hythe,Kent on 6th

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[543] John Fryer,*Diary of a voyage to China*(*FP*: Carton 3),1

[544] John Fryer to George Fryer(15th March,1870) (*FP*:Box 1 Folder 1)

[545] Nearly all of our school books have been printed under his editorship,and they are but a part of the work he has done to provide a basis for the acquisition of a new knowledge by the Chinese. His translations and compilations form a library by themselves,and are sufficient to give a student a thorough knowledge of science. (*CR* **27**(1896),348-349)

August,1839,into a family of modest means[546]. His grandfather John Rogers Fryer(born about 1780) had been a carpenter and joiner in the Canterbury area[547],and his father,John Fryer Senior(1812-1895),a grocer[548] living in New Romney,later became an itinerant lay preacher[549] and scripture reader to the coastguard[550]. His father's insecure existence meant that the family lived in near-poverty,sometimes eased by Fryer's mother's work as a teacher[551], and as a boy Fryer worked at the local brewery,cleaning boots and knives and running errands[552],a fact he tried to conceal in later life when living amongst

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[546] See Birth Certificate of John Fryer,held at St Catherine's House,London (BXBZ 469820). He was registered at Eltham,Kent on 16th September,1839,by his father John Fryer Senior.

[547] Fryer,*Genealogy of the Fryer Family* (*FP*:Carton 3),8

[548] See the Birth Certificate of John Fryer.

[549] His father was originally a Wesleyan,but the Wesleyans themselves split and 'Mr Fryer left the Wesleyan body entirely and determined to start a new church of his own.'(Fryer,*The Life of John Fryer,Senior of Hythe,Kent,England*(*FP*: Carton 3),9. The church was called the 'Congregational Arminian Church' and soon closed,whereupon he turned to itinerant preaching and scripture reading.(*ibid.*,10) His long-suffering wife,Mary Ann Fryer(nee Wiles),was not a member of his congregation,and she 'regularly attended the Wesleyan church alone'(*ibid.*,10).John Fryer Senior was said to have preached over 6,000 sermons.(Fryer,*Genealogy of the Fryer Family*(*FP*: Carton 3),10)

[550] Fryer,*Genealogy of the Fryer Family,*14

[551] The poverty of his family continued into his adult life. In the diary of his voyage to China he wrote

> I am afraid however for mother; that she will work herself to death. Let her take things easy as I do,and she will do far better. She need not fear coming to the workhouse,as she anticipates,now I can get bread and cheese enough for two. Only let her keep her "pecker" up and she will get on all the better.(Fryer,*Diary of voyage to China*,58)

[552] Fryer,*Diary of a voyage to China*,55. The phrases 'clean boots and knives' and 'at a brewhouse' were deleted by Fryer in the typescript version in *FP*.

the strict teetotallers of the Baptist church[553].

An unusual feature of his family was the interest they took in China. His father subscribed to a proposed Wesleyan mission in Canton[Guangzhou][554],his mother,Mary Ann Fryer[555] 'for a time adopted rice as a considerable part of her diet'[556],and during a visit by a missionary and a Chinese tea merchant from Canton to his home,the merchant pressed a silver dollar into the infant John's hand[557]. Fryer was teased at school because he always chose to write about China whenever he could,and earned the nickname 'Ching-chong Fy-ung'[558].

The family moved from Kent to Bristol in about 1852[559],where his father set up a city missionary centre[560] and his mother taught in the village of Horfield[561]. John received his secondary education at St James' School,Bristol,an experience on which he was he was later to reflect bitterly:

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553 See also Fryer,*Genealogy of the Fryer Family*,14: 'At twelve years he went to work at Mrs Mackeson's house,attending school in the afternoon.'

554 Fryer,*The Life of John Fryer Senior*(*FP*:Carton 3),15

555 See Birth Certificate of John Fryer.

556 Fryer,*Reminiscences of life in China*(*FP*: Carton 3),2

557 *ibid.*,3

558 *ibid.*,3

559 This date is based on Fryer's remark in *Genealogy of the Fryer Family*,14 'At 13 he went with others of his family to the St James School[..].'

560 Fryer,*The Life of John Fryer Senior*,11

561 *ibid.*,11

> My education was of a most imperfect description and the people among whom I associated when I associated with any were generally of the poorer classes. I was apprenticed to a National School at Bristol which was attended only by the lowest of the low,the master himself was not an educated man.[562]

His parents left Bristol and moved to Chudleigh in Devon around 1854,where they ran a day school attached to a Congregational church[563]. In 1857 Fryer left St James',having been a pupil teacher for several years[564],and on a First Class government scholarship entered Highbury Training College,London,where in 1861 he graduated as a teacher[565].

In the same year he was offered a post by the Lord Bishop of Victoria as Head of St Paul's College,a Church school in Hongkong[566],and he travelled out to China,arriving in August 1861. In 1863 he was invited by

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[562] John Fryer to Susy(4th January,1865) (*FP*:Box 1 Folder 5)

[563] *ibid.*,12

[564] *ibid.*,14. Fryer said that he had taught in England for seven years.

[565] In 1860 his family moved to Canterbury,where they settled,Fryer's father returning to his mysterious 'small business transactions'. Mrs Fryer died in 1866,and her husband in 1895. Fryer's relations with his family seem to have been less than cordial. He seems to have been embarrassed by their low social status and perhaps by his father's rather eccentric religious convictions. However,as we shall see,Fryer himself was also inclined to idiosyncrasy in spiritual matters.

[566] Fryer claims he was headmaster(See *Reminiscences of life in China,*3) yet in one of earliest pieces of writing from China he refers to 'My head master',a certain 'Hah-shoe',who lived 'in the rooms under the Bishop's Drawing and Dining Room',but this may simply mean that Hah-shoe was the most senior of his assistant teachers.(Fryer,*First Impressions of Hong Kong and the Chinese people*,9 in *FP*:Carton 3 'Travels' folder)

the Rev.J.S.Burdon of the Church Missionary Society[567] to join the Tongwenguan(Interpreters' College)in Beijing which had only opened a year earlier,where he perfected his command of Mandarin Chinese,and in 1864 he became an agent of the Church Missionary Society,who agreed to help him arrange for his fiancee to come to China.[568]

The following year he married Anna Roleston(1838-1879) of Chudleigh,Devon[569]. He had met her in 1858 at her Baptist church in Chudleigh,where she ran a Sunday school,whilst Fryer was on holiday visiting his parents with his brother George[570]. Anna and John were married in the Chapel of the British Legation in Beijing[571],whilst Fryer was still employed at the Tongwenguan.

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[567] He was a missionary for the Church Missionary Society 1863-1865,according to the C.M.S. records,becoming an official C.M.S. agent in 1864.(See John Fryer to Revd.Benn (8th March,1864)(C.M.S.Archives CCH/038/2). It may have been that,having been accepted as a missionary,the Missionary Society felt he was more useful to them in Beijing than Hong Kong,but I also suspect that,if he was Headmaster of St Paul's College,he was not a great success in the post. His youth(he was only just 22 when he arrived),rather scornful manner,and his apparent dislike for many of the characteristics of the Chinese people he met in Hong Kong(See Fryer,*First Impressions*,6-9),would have made it hard for him to have gained the cooperation he required.

[568] Little is known about Fryer's time at the Tongwenguan,other than his short article *Recollections of life in Peking*(1863)(*FP*: Carton 3). Perhaps he saw the post as an opportunity to see the capital city,and to learn Mandarin Chinese. See Bennett,*John Fryer*,5-6. He must have impressed his colleagues,as his successor as Professor of English,and later President of the College,W.A.P.Martin,evidently thought well enough of him to invite him to rejoin the Tongwenguan in 1870. (See n.583.) His obituary said that it was here he 'laid the foundation for his wonderful knowledge of the Chinese language'.(See *JNCBRAS* **60**(1929),ii)

[569] Fryer,*Sketch of the Life of Mrs Anna Roleston Fryer*(*FP*:Carton 3),1

[570] *ibid.*,3

[571] *ibid.*,4

He claimed later that he left the Beijing Tongwenguan due to his 'dislike of teaching English' and the 'interference of petty officials'[572],but it is more likely that it was because he was dismissed from the C.M.S.[573],as a result of his wife's seduction during her voyage to China and the subsequent scandal[574] His restless journey across China resumed in 1865,when he went,with considerable reluctance[575],to Shanghai to set up a small Anglo-Chinese School in a rather out-of-the way part of the city.[576] Anna meanwhile returned to England. This was a time of considerable frustration,alleviated only by his work as editor of the *Shanghai Xinbao* 上海新報 [Shanghai Gazette] from 1866-1868[577]. Around this time his mother died (in 1866 or 1867[578]),and his father,for reasons not entirely

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[572] John Fryer to the Head of the Unitarian Association,n.d. probably about 1885.(FP:Box 1 Folder 6)

[573] Fryer to Rev.H.Benn(4th July,1865)(C.M.S. Archives C CH/038/4),1

[574] *ibid.*,2. Fryer said that she had been 'kept by the captain under the influence of a drug of strong aphrodisiacal properties and thus became an easy prey to him,when he had insinuated her into his confidence'. It would appear from the same letter that Anna was pregnant by the time she returned to England,but there is no subsequent mention of this child.(*ibid.*,3)

[575] Fryer had by this time formed the opinion that evangelisation through mission schools was a hopeless task,and wished instead to become a conventional missionary.(Fryer to Rev.H.Benn(28th February,1865) (C.M.S.Archives CCH/038/3)

[576] One of Fryer's most famous students was Zheng Guanying 鄭觀應 (1842-1923),comprador and reformist writer. See *'Shengshi weiyian* houbian' <盛世危言> 後編[Postscript to *Warning to a seemingly prosperous age*] in *Yangwu yundong* Vol.8,83.

[577] *Shanghai xinbao* (1864-1871) was edited successively by A.Alexander Jameson,Marquis L.Wood,John Fryer and Young J.Allen.See Adrian A.Bennett,*Research guide to the 'Chiao-hui hsin-pao'*(San Francisco:Chinese Materials Center Inc,1975),xvii.

[578] Fryer,*Genealogy of the Fryer family,*10 states that his mother died in 1866,but one letter from Fryer to both his parents survives dated 9th March 1867.(*FP*:Box 1 Folder 1). Certainly she

clear,cut Fryer out of his will[579].

He joined the Jiangnan Arsenal in mid-1868,occupying a position sufficiently well-paid that on 14th October,1868 Anna was at last able to join him. The 'trouble' which had come upon him in Beijing must have increased Fryer's isolation from the small foreign community,in which his position as a secular missionary in itself made him an

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must have died by 1868 as by then he is writing only to his father and sister.

[579] Fryer to his sister(15th July,1867)(*FP*: Box 1 Folder 1)

> Father has made his will and has left all he has to you and Charley,and I fully acquiesce in the wisdom and correctness of the arrangement.

Although Fryer was by this time reasonably well off,it seems unlikely that this in itself would account for his father's action. I suggest that Fryer's relations with his father had long been difficult,and the remarks that Fryer makes about teetotalism in one of his letters to his parents suggest that he was breaking free of his Wesleyan upbringing

> I have got through the winter all right and am now going to take a regular system of diet and exercise to prepare me for the trial of another summer,if it please God to spare me. I shall get in a firkin of beer and shall take my glass twice a day. China has cured me of homeopathy and teatotallism[sic]. I believe in good exercise,good food,a glass of wine and two glasses of beer a day with plenty of beefsteak and eggs.(Fryer to his parents(9th March,1867) (*FP*:Box 1 Folder 1))

He was also beginning to be more independent in his views on religion. In a letter to his brother George later the same year he wrote

> Half the people who talk so much about religion seem to me to say one thing and mean another.(John Fryer to George Fryer (23rd November,1867)(*FP*:Box 1 Folder 2))

He gradually turned away from the religious ideas his father had taught,towards Unitarianism,and it is likely that the beginning of this process was a major cause of the breach between them. He also undoubtedly resented the poverty of the family's early years,the poor standard of his own education,and the strain on his mother,which must have contributed to her early death.

oddity. John and Anna lived at first near the Arsenal,'in a foreign house near St Catherine's Bridge,outside the western gate of the native city,and subsequently moved to a better house outside the south gate of the native city'[580]. Later still they moved to the British settlement [581]. His first son,born after Anna had suffered a bout of 'Shanghai fever',died only eight days old,in August 1869[582],but she was eventually to bear him another four healthy children[583]. Anna's own health was so poor that in 1872 she returned to England with her two children,and she then went back with him to China,leaving the children with Fryer's relative Miss Colegate at Bridge near Canterbury[584].

In 1878 John and Anna again returned to England,Anna living in Canterbury whilst Fryer worked in Berlin for three months,helping the Chinese to set up a legation there and then travelled back to China with the disgraced Guo Songtao 'as his guest on board the steamer'[585]. During Fryer's long absence,Anna became so ill that she left the

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[580] Fryer,*Sketch of the life of Mrs Anna Roleston Fryer*,5

[581] *ibid.*,5

[582] John Fryer *ibid.*,6. In a letter to his brother George he commented '....she is not strong enough for China.'(John Fryer to George Fryer(26th August,1869)(*FP*:Box 1 Folder 4)).

[583] Annie Rogers Fryer on 21st December,1870; John Rogers Fryer on 3rd February,1872; Charles Edmund Fryer on 14th February,1878; George Bladben Fryer on 22nd October 1877.

[584] *ibid.*,7. Bridge was where his favourite Cousin Susy lived.

[585] Guo Songtao refers several times to Fryer in his journal. See Guo Songtao 郭嵩燾,*Guo Songtao riji* 郭嵩燾日記 (Changsha:Hunan Renmin Chubanshe 湖南人民出版社,1982). Fryer arrived from Berlin on January 28th,1879 [Guangxu 5.1.7](*ibid.*,751),and had many conversations with Guo on topics as diverse as phrenology(*ibid.*,779 dated 24th February,1879 [Guangxu 5.2.4]) and mesmerism(*ibid.*,790-791) dated 6th March 1879 [Guangxu 5.2.14]).

four children in Canterbury and went to Chudleigh where she died on 2nd October 1879[586],whilst Fryer was still on his travels. It was around this time,perhaps guilty about his wife's death,that Fryer first became convinced of his Unitarian views and planned a Unitarian campaign of evangelism in China,an idea he was still contemplating six years later.

Three years after Anna's death he married Eliza Nelson(1847-1910) Eliza went to Alfred University in New York in 1869[587],and in 1879 to Shanghai with Reverend and Mrs Davis of the Seventh Day Baptist Mission[588]. There she was the bridesmaid to 'a young English lady who was to marry Reverend Mr [Carl T.] K[reyer]'[589],one of Fryer's translator colleagues at the Arsenal. By now Fryer must have been desperately lonely,and he invited the Davis's and Eliza to live with him[590]. On 8th June,1882 John and Eliza were married[591]. The following year they went on a 'world trip' to Japan,the United States and Britain. Three of their children were educated at Alfred University,from which Fryer himself later received an honorary doctorate.

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586 *ibid.*,8. gives the date of her death as 27th October,1879,but Anna Fryer's death certificate in St Catherine's House(DXZ 147253) states that she died of 'Chronic Dysentery and Exhaustion' on 2nd October,1879. I can find no explanation for the discrepancy.

587 Fryer,*A beautiful life: memoir of Mrs Eliza Nelson Fryer 1847-1910*(Berkeley:John Fryer,1912),12

588 *ibid.*,4

589 *ibid.*,15

590 *ibid.*,21

591 *ibid.*,24 According to Fryer,Eliza was a quiet and compliant wife,and

> Her conversation was never wearisome since she only spoke when she had something to say and having said it in the most concise and appropriate manner that suggested itself at the time,she was silent.(John Fryer,*ibid.*,63)

The two eldest(Anne and John) went to Berkeley[592],and in 1892 Eliza moved to Oakland to be near them[593]. In 1896 Fryer went to Oakland to become the first Louis Agassiz Professor of Oriental Languages in the University of California at Berkeley 'chiefly as a means to be with his wife and family and to attend to the education of his children'[594],but by 1901 he had decided to settle there for good,having become gloomy about the future in China[595].

By the last years of his time in China,Fryer's books were at last beginning to be noticed by the intellectuals in the way he had hoped. Kang Youwei,Liang Qichao and Tan Sitong all bought and read the translations of the Jiangnan Arsenal,and the ideas about the world started to seep into their philosophies,in particular that of the young scholar Tan Sitong,who created a brilliant synthesis of Western science,Buddhism and traditional Chinese thought in his book *Renxue* 仁學 [An Exposition of Benevolence]. Fryer was able to write

> The walls of obstruction are gradually being broken down by the spread of Western learning. A strong demand has set in among the thinking part of the nation for all the useful knowledge foreigners have to

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592 John Fryer Junior died in California on 16th December,1896 of typhus.(John Fryer to George Fryer (17th December,1896) (*FP*:Box 1 Folder 5))

593 John Fryer,*A beautiful life*,60

594 *ibid.*,61

595 We are beginning to build our home soon out at Berkeley, I have now pretty well made up my mind to give up China for the time being. I am afraid things are going from bad to worse and that my old place will soon fall into the hands of the philistines.(John Fryer to unknown (28th April,1901) (*FP*:Box 1 Folder 5))

Fryer's gloom probably derived from the recent events of the Boxer Rebellion.

impart.[596]

In California,having attained a social status which had always eluded him before,an ocean away from the country to which he had given his life,he still retained his interest in and affection for China,continuing to translate for the Arsenal,and setting up schools for the blind in Hankou 漢口 and for the deaf and dumb in Shanghai. In his will of 1928,according to A.A.Bennett,he

> established a school for blind Chinese girls and provided buildings,land and an initial endowment for the General Institute for Chinese Blind,which his son,George B.Fryer,managed until 1950.[597]

In what he called 'the "quiet evening" of an eventful life'[598] John Fryer saw his work grow to a kind of fruition,but the days of the foreigner as the sole source of knowledge about Western science had passed,and the role he had filled so vigorously in his thirty years there,became redundant as more and more Chinese students who had studied science in China,Japan and the West,became qualified to write their own translations and make their own textbooks,and to decide what was and was not suitable for 'enlightening' China.[599]

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596 John Fryer,*The commerce of China*(22nd October,1898),29 (*FP*:Carton 1)

597 See Bennett,*John Fryer*,68

598 John Fryer,*Reminiscences of life in China*,9-12

599 He died on 2nd July,1928,and was buried next to Eliza in a quiet corner of Mountain View Cemetery,Oakland,a site which I am grateful to the Fryer scholar Dr Fred Dagenais for showing me.(This area of the cemetery was,according to Dr Dagenais,used by the Freemasons.) The legend on his grave reads *Fulanya mu* 傅蘭雅墓 [The grave of John Fryer],a somewhat ironic inscription,as it should correctly have read *Fulanya zhi mu* 傅蘭雅之墓 Even in death Fryer did not escape the perils of translation.

Figure 27. Portrait of John Fryer from *Gezhi Huibian*,**4**,5(June 1881),10a

[Reproduced by kind permission of the British Library,Oriental and India Office Collections]

8.12 Independence and its cost:the character of John Fryer

Fryer is one of the most interesting of the expatriates in China in the second half of the nineteenth century. Although apparently a devout Christian,he was something of an outcast amongst the missionary fraternity,and he remained to the end a lonely figure,with few if any close friends amongst the foreign community.

He comments on his own character in one of his early letters to his cousin Susy Johnson in Bridge,near Canterbury:

> I heard from many people before leaving England that I was very proud,and seemed to keep myself very reserved.To the latter charge I plead guilty but not to the former in the sense people intended it. From the circumstances of my boyhood I acquired a feeling of shyness which even now forms a prominent part of my character. [...] The result was that when I went to London[600] I was quite unaccustomed to society and generally kept myself quiet to avoid exposing my awkwardness and ignorance. What smattering of learning I had when I went to College I had picked up my self in great part. A knowledge of my defective education made me shy and reserved and has thus been attributed by some to pride,and by other more charitable persons like yourself to "scorn".[601]

The 'shyness','pride' or 'scorn' were to remain with him all his life,and to shape both the type of his work and the manner of its commission. For he remained a single-

[600] That is,Highbury Training College.

[601] John Fryer to Susy(4th January,1865)(*FP*: Box 1 Folder 5)

minded worker,the initiator of one-man projects,jealous of ownership,and rarely willing to work with others,except where necessity demanded some cooperation with his Chinese or missionary co-workers.

Equally important is his shame about his own education. Although he did achieve a remarkable grasp of a wide range of sciences,his lack of mathematics meant that he often avoided subjects such as aspects of physics or astronomy where the contemporary mathematical treatments had become very sophisticated,and preferred to deal with subjects such as chemistry which were still to a large extent descriptive.

His fear of showing his ignorance many also have had another effect on his translation work: his unwillingness to adapt his material to his Chinese readers' needs by paraphrasing. His translations are generally accurate and faithful to the original texts,but were often very difficult for beginners to understand. Had he had more confidence in his own grasp of the topics he might have found better ways of introducing them to the uninitiated.

He was given to tactlessness: even on his outward voyage to China,he managed to upset a fellow-passenger by discoursing against popery before discovering that she was a Roman Catholic[602],and the ship's captain commented to him that

> [you] can never touch lightly but always do it with a "regular maul"[603].

Once in China he made no attempt to conceal his rather

602 Fryer,*Diary of voyage to China*,28

603 *ibid.*,16-17

unorthodox religious views from his fellow missionaries[604]. His rather arrogant approach made it difficult at times to achieve the ends he sought,especially when there had to be some compromise,either with his foreign colleagues or with the 'Chinese way' of doing things. In the matter of chemical terminology,for example,he was quite unwilling to agree to any changes in his system.[605]

He keenly felt his social inferiority,and this fuelled what was for a time at least,an intense ambition. He saw in China an opportunity to overcome the handicaps his poverty and poor education had given him. Few other foreigners were willing or able to undertake the grinding monotony of translating long scientific treatises into Chinese. By sheer hard work and dedication he would achieve what university men could not.

Social inferiority might not have mattered had he become a missionary,but his rather unusual role,as an employee of the Chinese government,must itself have made him an object of some suspicion amongst the foreign community in Shanghai.

In one of his first letters after his appointment to the Jiangnan Arsenal he wrote of his early life in Hythe

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[604] Fryer to the Head of the Unitarian Association,n.d. probably 1885. 'But my religious views which I make no secret of stand in the way of anything like cordiality in my intercourse with any of them in the way of Christian work.' During the 1890s he seems to have become interested in mental healing,judging from his translation of Henry Wood's *Ideal suggestion through mental photography*.(See Section 12.1)

[605] Calvin Mateer and W.M.Hayes,*To the Committee of the Educational Association on Terminology,and the Committee of the China Medical Association on Terminology* (n.d.,perhaps about 1896: it mentions the illness of Fryer's son,who died later that year) (*FP*:Carton 3),1

> This however is only the beginning of the second era of my life. Excelsior is my motto. When I was sent as an errand boy in the Brewery at Hythe to clean boots and shoes my spirit was so galled that I resolved to work my way up in the world if it was within the range of possibility and as I washed down the door steps every morning I resolved to make every position a stepping stone to something higher. Every move I have made since has been in the upward direction and with God's help I mean to go higher still.[606]

To his father and sister he wrote of his feeling of triumph at achieving a respectable position entirely through his own efforts

> My ambition knows scarcely any bounds. I have got my position independently of any one - consuls,customs and all I set at naught.[607]

His independence was very precious to him:it was the centre of his achievement,but the cost was an isolation and self-pity which was only made bearable by the prospect of future advancement. Whilst still at the Anglo-Chinese School in Shanghai he wrote

> I have quite got out of the foreign world altogether and move in a little Chinese microcosm of my own. "I am monarch of all I survey and my right there is no-one to dispute" except the dear old [Church]

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[606] Fryer to Susy(11th July,1868) (*FP*:Box 1 Folder 2)

[607] Fryer to his father and sister (9th May,1868) (*FP*:Box 1 Folder 2)

> Missionary Society[608]. Oh how I love and respect it. I shall be sent adrift soon I suppose to goodness knows where.[609]

He thoroughly enjoyed the excitement of new discoveries and inventions. He is said to have

> imported the first phonograph into China,made the first telephone in China in 1877,and took up photography and taught many Chinese how to take and develop photographs.[610]

and his enthusiasm was attractive enough to draw large audiences to the Saturday evening magic-lantern lectures he gave at the Shanghai Polytechnic in the 1890s.

His concern for the ordinary Chinese people seems to have been genuine,despite his irritation with individuals who obstructed his purposes. He made efforts to help the deaf,dumb and blind,who previously had little chance of any education,and was interested in developing a Chinese version of Braille. After leaving China,he continued to work for the interests of the Chinese immigrants and Chinese students in the United States,when there could have been little personal advantage for him in doing so.

He was outwardly a man of great self-assurance,a pioneer spirit who was never happier than when initiating some grand new project,preferably under his own personal control and supervision. Yet his letters reveal that he was

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[608] By this time the running of the Anglo-Chinese School had been taken over by the Church Missionary Society.

[609] Fryer to Brown(13th March,1867)(*FP*:Box 1 Folder 1)

[610] *JNCBRAS* **60**(1929),iii

much less sure of the rightness of his calling,with a sceptical attitude towards established religion. He had gone to China with the intention of making his mark,and to achieve a distinction which was not possible in his native land.

His real life's work was not in pedagogy,but in the translation of a body of 'useful knowledge' for the scholar-elite,the mandarins who he hoped would read and be 'enlightened' by his translations at the Jiangnan Arsenal.

8.13 Fryer as translator

Fryer's delight in leaving teaching was matched by his high hopes for his future. Before he obtained his post at the Arsenal,he had already decided to stay in China

> I think that my lot is fixed in China. Having studied six years at Chinese and having acquired some facility in three dialects and the general written language,it would be like throwing away so much time if I gave it all up. And besides what could I find to do in England? And again China is just now opening up to European civilization. Every year a rapid advance is made. A year or two more and my knowledge will be invaluable and people say I shall be worth my weight in gold. Very flattering is it not?[611]

It is not clear to whom his knowledge would be 'invaluable',but his optimism about China opening itself to 'European civilization' was shared by many of his contemporaries. For energetic and gifted young foreigners it must have seemed,in its way,as much a land of opportunity as the western United States. As Fryer wrote to his brother George in 1867

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[611] Fryer to Susy(4th March,1867)(*FP*:Box 1 Folder 1)

> There are plenty of good positions in China if people have only got the talent. Only first rate men can now get on in China. Every year the Consulate has to pay the expenses of dozens of fellows who cannot get their living and have to be sent home.[612]

Fryer was approached,probably early in 1868,whilst still Head of the Anglo-Chinese School in Shanghai,to begin translating scientific books for the Arsenal,the first being a book on practical geometry with Xu Jianyin[613],which Fryer translated at his home [614],but by June 1868 he was working in a building set apart for the purpose of translation.

> It is a great relief to feel settled and able to get on quietly with one's work. Indeed I may say I was never more happy in my life than I am in my new situation of Translator of Scientific Books for the Chinese Government. It is an honourable and useful position as well as being respectable,and with a salary of £800 a year or thereabouts I can afford to live well.[615](The 1871 contract gave him 250 taels per month,including his board,lodging,heating lighting and food.)

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[612] John Fryer to George Fryer(23rd November,1867)(*FP*:Box 1 Folder 2)

[613] The book was *Yungui yuezhi* 運規約指,a translation of William Burchett,*Practical geometry*(1855).

[614] Fryer to Broadhurst Tootal(28th April,1868) (*FP*:Box 1 Folder 2). It would seem from this letter that Xu Jianyin was actually staying in Fryer's house at thus time.

[615] Fryer to Susy (11th July,1868) (*FP*:Box 1 Folder 3). An annual salary of £800 in 1868 was a comfortable,but by no means a princely,sum to live on,that of a Senior Clerk in the Civil Service,or a young lawyer. For Fryer,whose mother apparently had feared ending her days in the workhouse,it must have seemed great prosperity. See Geoffrey Best,*Mid-Victorian Britain*(London: Fontana Press,1979),107 and 110.

Yet in the same letter he shows the depression his social isolation has brought

> It is very little praise or commendation which is ever bestowed upon me,for nobody ever seems to understand me,and therefore it is necessary for me to "fish for praise". This is a bad habit which is growing upon me of late and which is very difficult to get rid of.[616]

He was still extremely lonely,and his wife Anna did not reach him until 14th October,1868[617]. Unfortunately her arrival and the concomitant scandal only served to drive him further apart from the small foreign community.

He was keenly aware of his lack of knowledge of science,but he set to work to teach himself what he would need for his work as translator.

> I have always loved science but have never had the time or opportunity to cultivate it. Now it is my duty and a very pleasant duty it is too. I go at it in real earnest and although I shall never be a scientific man I yet aspire to becoming familiar with several of its branches. I have begun by studying and translating three subjects at once. In the morning I take coal and coal-mining in all its details,in the afternoon I dig into chemistry and in the evening acoustics.[618]

It would seem that his interest in science had not begun

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616 Fryer to Susy(11th July,1868)(*FP*:Box 1 Folder 2)

617 Fryer to Carrman(23rd November,1868)(*FP*:Box 1 Folder 3)

618 Fryer to Susy(11th July,1868)(*FP*:Box 1 Folder 3)

at the Arsenal,as in a letter to his brother George in March 1867,over a year before he became a scientific translator,he wrote

> By next mail will you please send me about as much magnesium wire as you can conveniently do in a letter,just for showing experiments to the Chinese. If you can get me a catalogue of scientific instruments and prices I should be glad to have it by next mail also. Such instruments as microscopes,telescopes,magic lantern slides,electric machines and galvanic batteries,air pump and such philosophical apparatus. Also a small packet of those cards for children which by application of a damped paper produce a photograph(if not very clear).[619]

There is no clue as to the occasion of such an apparently sudden and specific interest. It sounds unlikely that Fryer wanted the equipment for his school,and suggests perhaps that he was already beginning to realise the potential interest some of the Chinese mandarins had in science,and was arranging a display for them. This would also perhaps explain why he was chosen over other possible candidates for the post of chief translator,his linguistic skills having been already proven as editor of *Shanghai Xinbao* 上海新報. His initial impression of his Chinese colleagues was very favourable:

> The Chinese who are working with me are some of them really clever . There are none lower in rank than district magistrates. We get on capitally together so far. One[Xu Jianyin] is younger than the rest has made quite a strong friendship with me and tells me all his affairs as though I were his brother. He is the

[619] John Fryer to George Fryer(25th March,1867)(*FP*:Box 1 Folder 1)

> cleverest Chinaman I ever met and I am but a child compared to him in many respects. We sometimes argue different points of view up till midnight. I have taught him to sit at table and behave properly,and he really is a very good fellow for a companion. I hope some day he will become a Christian. [620]

Some time later he was to compare his treatment by the Chinese favourably with that he had received from his fellow-Europeans:

> The Chinese mandarins are very good people and have treated me with far more kindness and fairness than the Europeans I have been connected with in China. They are slow in making friends and in making promises,but when once a promise is made ,they always seem to adhere to it.[621]

But later he was to distance himself from them,especially from Xu Shou,whom he came to see as the most obstructive of his Chinese colleagues,and his isolation from the Chinese and foreign communities became deeper.

He was occasionally required to conduct experiments,as he recorded:

> Today they came and asked me to make some chlorate of potash for some caps and tubes for firing cannon. It

[620] Fryer to Susy(11th July,1868)(*FP*:Box 1 Folder 3)

[621]John Fryer to Uncle and Aunt (1st November,1869) (FP:Box 1 Folder 4). This was after the trouble he had suffered after Anna's arrival,the problems with the Anglo-Chinese School and his general isolation from the British community.

> was just a day's work and they watched the process very narrowly. When it was complete they were in ecstasies.[622]

but the core of his work was the translation of scientific and technical texts.[623]

He was characteristically scornful of his European colleagues at the Arsenal,who at various times included Alexander Wylie,Daniel Jerome Macgowan and his successor as editor of *Shanghai Xinbao*,Young J.Allen.

> I have no competitors for a very simple reason that none can be found up to the mark. I wish I had two or three that I might be stirred up and cured of my laziness.Sometimes I only do an hour's work in a day[624].

In one of his later letters he makes clear his irritation that his versions were often tampered with by his Chinese colleagues,and by now his scornful tone has returned.

> The superintendent of the Arsenal with which I am connected together with some scholars who are supposed to know something of scientific subjects revise such translations as are made and throw out anything they consider savours too much of the foreigner. Hence I am

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[622] John Fryer to George Fryer (15th July,1869) (*FP*: Box 1 Folder 4)

[623] By 1870 he was sufficiently settled to refuse a request by W.A.P.Martin to return to work at the Beijing Tongwenguan. See John Fryer to W.A.P.Martin (25th May,1870) (*FP*: Box 1 Folder 4)

[624] John Fryer to George Fryer (23rd September,1869) (*FP*: Box 1 Folder 4)

not responsible for any errors they choose to make.[625]

There was a rather high turnover of foreign and Chinese personnel,partly no doubt because Fryer could not have been an easy man to work for,but also because the nature of the work meant that few were willing to do it for very long if easier ways of earning a living presented themselves. This certainly affected the output of the Translation Department:

His childhood years of near penury meant that money was a constant theme in his letters,his initial salary of £800 being a considerable sum for the time. He was pleased to tell his cousin Susy that Daniel Jerome Macgowan,the medical missionary,earned only two-thirds of his salary[626],and when Carl Kreyer arrived in 1869 as another subordinate,he exulted to his brother

So you see I am almost "cock of the walk".[627]

He was,despite his alleged 'laziness',remarkably productive,and for scientific textbooks no other translation bureau approached the Jiangnan Arsenal in quantity or consistent quality of output. As the longest-serving foreign member of the translation team,Fryer must take a large part of the credit for this. Although his Chinese associates Xu Shou,Xu Jianyin,Hua Hengfang,Zhao Yuanyi 趙元益,Jia Buwei 賈步緯,and the foreigners mentioned

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[625] John Fryer to John Kerr,10th November,1869(*FP*: Box 1 Folder 4). The uneasy relationship between the foreign translator and his or her Chinese colleagues continues to the present time. See Rashid Butt 'My days in China',describing his work as a translator,in Dainisi 戴妮斯 (ed.),*Living in China*(Beijing:New World Press,1982),144.

[626] John Fryer to Susy Johnson (11th July,1868) (*FP*: Box 1 Folder 3)p.2

[627] John Fryer to George Fryer (7th December,1869) (*FP*: Box 1 Folder 4)

above also played important roles,the energy and determination to see matters to a conclusion came above all from Fryer.

As time went on he became disenchanted with his work as a translator,writing in 1881 that

> The work of translating and compiling scientific books is for the time being perhaps about as dull and unthankful a task as any foreigner could engage in especially in such a secluded place as the Kiangnan[Jiangnan] Arsenal,and under the depressing influences of the climate of this part of China. Nothing but a strong sense of duty and a firm belief that this kind of labour is one of the most effective means,under the Divine Guidance,for bringing about the intellectual and moral regeneration of this great country,has sufficed to render endurable the long and weary years of close and continuous application which it has involved.[628]

His earlier enthusiasm for and expectation of official advancement,had by now faded,and he sought new outlets for his boundless energy: as the former editor of *Shanghai Xinbao*,the return to journalism was an obvious move.

*8.14 Fryer as a science journalist:**Gezhi Huibian*** 格致彙編

Fryer's work as editor of *Shanghai Xinbao* had allowed him to keep his sanity whilst performing the drudgery of teaching English to the sons of Chinese merchants[629]. The mandarins who employed him at the Arsenal

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[628] John Fryer 'Science in China' *Nature* **24** (May 19,1881),56

[629] In March 1867 he wrote

A few months ago(November) I had the editorship of the Shanghai Chinese newspaper put in my hands. Really it was had undoubtedly been impressed by his work,but they did not encourage him to continue his journalism. In fact,his 1871 contract specifically forbade his involvement with 'newspapers and other activities'[630],and they had insisted that he resign as editor of *Shanghai Xinbao* when he took up his post at the Arsenal[631]. Yet by the mid-1870s they apparently changed their minds,allowing him to edit a new journal,perhaps because it eschewed all political and religious comment to preach the secular gospel of science.

His new journal *Gezhi Huibian* 格致彙編,subtitled *The Chinese Scientific Magazine* (later *The Chinese Scientific and Industrial Magazine*) was published,with several interruptions,from 1876 to 1892. Its contents and their influence will be examined in Chapter 11. Here it is enough to say that it allowed Fryer the freedom to express ideas in his own way,to introduce topics of a more popular nature than was possible through his work for the Chinese government. And,most interestingly,it allowed readers to ask questions of him,and to indicate what their interests were.

It was widely read at least in the coastal cities,and is known to have influenced many of the reform-minded intellectuals of the late Qing period such as Li Hongzhang,Xue Fucheng,Liang Qichao,Kang Youwei and Tan Sitong.

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quite a godsend not so much on account of the Taels 50 per month added to my salary as for the pleasure and relaxation it gives me. After four hours in the school it is with no little feeling of relief that I go to my office and translate my articles.(John Fryer to Stewart (4th March,1867) (*FP*: Box 1 Folder 1))

[630] See Fryer's contract of 1871 (*FP*: Carton 3)

[631] Fryer to Broadhurst Tootal(28th April,1868)(*FP*:Box 1 Folder 2). In his letter to Tootal of 1st May,1868,he mentions Young J.Allen taking over the editorship.(*FP*:Box 1 Folder 2).

8.15 Fryer as a lay Christian missionary.

Some writers seems to have assumed that Fryer was not a missionary at all,yet for the first six years of his time in China he was connected with Christian mission ventures: St Paul's School,Hongkong,was a Church school; the Beijing Tongwenguan,whilst a Chinese government school,had a strong missionary involvement[632]; and the Anglo-Chinese School in Shanghai was also a Church School,initially run by a committee and later by the Church Missionary Society. The latter's archives show him to have been a C.M.S. lay missionary from 1863 to 1865.

The pious remarks in some of his diaries and letters,and particularly in his eulogistic accounts of his two wives,would have suggested a conventional view of religion,and he was certainly a regular churchgoer,rowing down in a sampan from the Jiangnan Arsenal to the Bund,where he was Honorary Organist at the Church of Our Saviour on Broadway.[633]

However,there survives a letter he wrote in 1885 which shows him by then to have become a follower of Unitarianism since 1878,a sect which many missionaries would have regarded as unorthodox or even heretical. Fryer himself was not at all unwilling to share his views with the other missionaries,and his naturally rather argumentative and tactless nature was another reason for his feelings of isolation in Shanghai.

In his 1885 letter to the Head of the Unitarian Association,he wrote

> But I must confess that a feeling of dissatisfaction

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[632] W.A.P.Martin,J.S.Burdon and John Dudgeon were all missionaries and taught science at the Tongwenguan.

[633] See *JNCBRAS* **20**(1929),iii

> has crept over me,together with a craving for some kind of help and sympathy from my fellow Christians that will give me a greater zest and value to my labours.[...]In fact,I have to stand alone,bearing the stigma of being a man with very unsound and dangerous views. Yet I experience a certain amount of toleration which perhaps arises out of pity for my erroneous notions.
>
> [...]Under such circumstances I feel constrained to lay before you a plan which I have had in mind for several years past and which with God's blessing may serve as a noble beginning for the spread of Unitarian views among the Chinese. [...]So confident am I of the ultimate success of this undertaking which embodies the experience and result of almost a quarter of a century's work and observation that I intend to resign my present excellent position under the Chinese Government with commodious salary above £900 per annum at the end of the present month of September giving full six months intimation before leaving to throw myself entirely into the scheme so that I am prepared to sacrifice everything for it,and to enter upon it with all the ardour that my whole nature is capable of.[634]

This extraordinary and reckless scheme was never realised,but that he should even contemplate it indicates how frustrating his position must have been. Presumably his wife Eliza (of just three years' standing) would not have approved of his abandoning his position at the Arsenal,nor does he even mention his responsibilities to his four children. There is no record of a reply from the Unitarians - perhaps the letter was never sent -,but they were hardly

[634] Fryer to the Head of the Unitarian Association,London (1885)(*FP*:Box 1 Folder 6)

in a position to launch a crusade in China even with so formidable a campaigner as Fryer at the helm. The letter shows his spiritual isolation,even from his own family,and the desire for 'greatness',which his mundane work as a translator and editor could never fulfil. It also perhaps shows echoes of his father's restlessness and inability to fit comfortably within the existing churches,but,unlike his father,Fryer did not have the courage to give it all up - perhaps he had more to lose - and the moment passed. Yet there is evidence that around this time he was giving talks on religious topics - appropriately enough on purgatory.[635]

8.16 John Fryer: Conclusion

Fryer saw science as a means of enlightenment,and himself as the torch-bearer. He failed as a missionary in the orthodox way,and once he became an employee of the Chinese Government he was unable to advocate the most daring reforms that he knew were needed. He had to be content with practical measures which would disseminate useful knowledge,albeit only to a tiny fraction of the population. It was the sustaining of the transmission,by training the Chinese themselves to be scientists,to which his greatest contemporary,working under conditions still more adverse than Shanghai,devoted his life.

8.2 Calvin Mateer

Calvin Mateer and John Fryer had much in common: a ferocious energy and fierce self-dedication. But Mateer was primarily an evangelist,and only when his itinerant ministry failed did he turn to education,and particularly to scientific education. His approach to everything he did was exacting,pragmatic,selfless and a little grim. Where

[635] *NCH*(12th December,1880),860

Fryer dressed in the robes of a mandarin,and dreamt of unspecified 'greatness',Mateer dealt with sober practical problems and their solutions.

8.21 Outline of his life[636]

Calvin Wilson Mateer was born on a farm in Cumberland County,Pennsylvania in 1836. He came to Dengzhou[637] in Shandong Province on 15th January,1864,three years after Fryer arrived in China. From 1864-1873 he travelled all over Shandong as an itinerant preacher,but encountered much hostility and won few converts. After 1873 he threw all his energies into another,more circuitous route to the conversion of the Chinese,that of education.

In September 1864 his wife Julia had opened the Dengzhou Boys' High School in an old Buddhist temple,the Guanyintang 觀音堂 with just six students,yet it was this school which proved to be the source of Mateer's greatest achievements in China.[638] At first,they had an open enrolment policy,but this was not successful,and from 1873 they enrolled only Chinese Christians[639]. The school curriculum included Chinese studies,religious instruction

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[636] The best account of Mateer's life is by Irwin T.Hyatt,Jr., *Our Ordered Lives Confess*(Cambridge,Mass.:Harvard University Press,1976).

[637] Present-day Penglai 蓬來.

[638] Mateer's sister Lilian arrived to help in 1881,and in 1882 Rev. and Mrs Watson M.Hayes came to work in the school. W.M.Hayes eventually became its president in 1895.(See *Cheeloo*,Chapter 3 p.5 (of unknown authorship: held by Yale Divinity Library).

[639] Hyatt,166

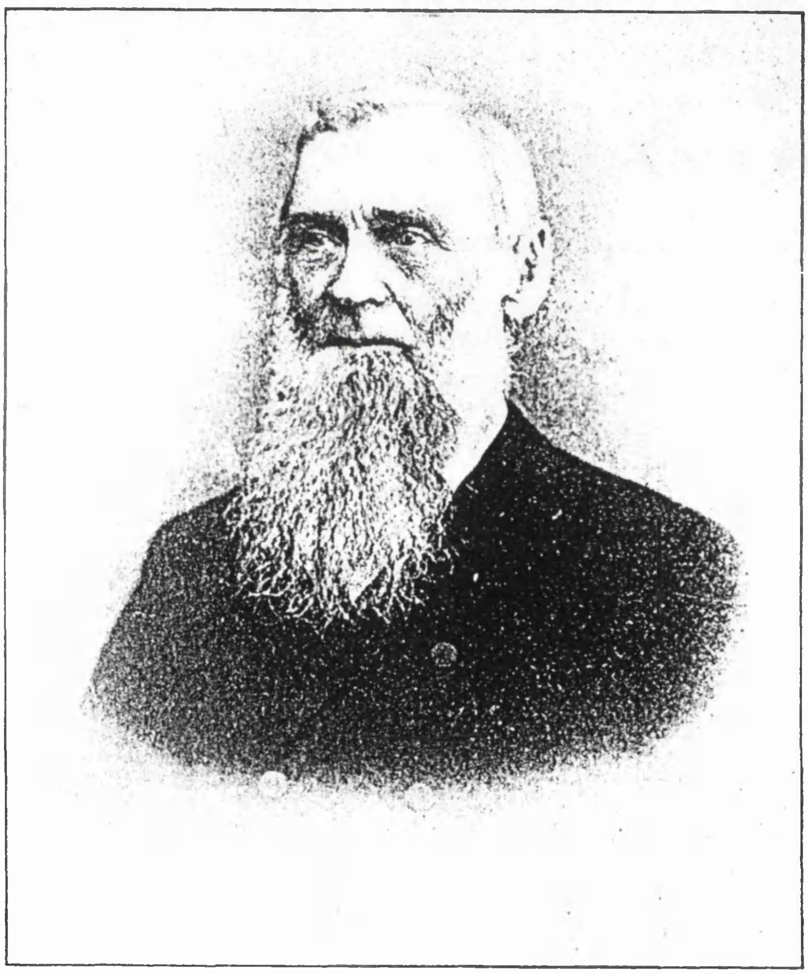

Figure 28. A portrait of Calvin Wilson Mateer from *Shantung College: its history,outlook and endowment 1864-1902*,4
[Reproduced by kind permission of the Presbyterian Church(U.S.A.), Department of History and Records Management Services]

and Western science. From 1868 he began putting together written arithmetic lessons,in 1873 began teaching algebra,and by 1876 geometry,trigonometry and chemistry.[640] The number of students gradually rose,from 22 in 1874 to 45 in 1880. In 1877 the school held its first graduation ceremony,and in 1883 changed its name to Dengzhou College.

In 1877,as a result of the General Conference of Protestant missionaries in China, he set up the School and Textbook Series Committee which from 1871-1890 published over 100 books,maps and charts,and Mateer was also the driving force behind the standardisation committees of the Educational Association of China during the last decade of the century.

8.22 Mateer as a science educator and author

Mateer lived in a much smaller city than Fryer,and his scope was narrower: essentially he aimed to provide for the needs of his own school students above all. The methods he developed came from his experience of teaching in Dengzhou,and although he believed that they were applicable elsewhere he never made any attempt to propagate them directly. According to Mateer:

> Special attention has been paid to mathematics and Natural Sciences. Much stress has been laid on the thorough mastery of Natural Philosophy[physics] and chemistry. An extensive collection of apparatus has been provided,and we have spared no pains in giving each class a full course of experiments. The apparatus embraces all branches,but is especially full in electricity. The last additions to our apparatus consist of a new five-inch transit theodolite,a one-horse power steam engine and boiler,and a first class ten-inch reflecting telescope,with driving clock

[640] Hyatt,168

> complete. The telescope will be mounted on a suitable observatory in the spring.[641]

His science courses included 'geology field trips, astronomical observations, physics experiments, and lessons in watch repair'[642]. He and his students made laboratory equipment such as an air pump, and later 'devices to demonstrate gases and electricity'[643], altogether what he called "the largest and best assorted collection in China of laboratory apparatus".[644]

In 1874, he noted in his journal

> I heard them a lesson every day,---one day in philosophy[physics]and the next in chemistry. I went thus over optics and mechanics and reviewed electricity, and went through the volume on chemistry. I practically gave all my time to the business of teaching and experimenting ,and getting apparatus. I had carpenters and tinners at work a good part of the time. I got up most of the things needed for illustrating mechanics, and a number in optics; also completed my set of fixtures for frictional electricity, and added a good number of articles to my set of galvanic apparatus. With my new battery I showed the electric light and the deflagration of metals very well. The Ruhmkorff coil performed very well indeed, and made a fine display. I had an exhibition of two nights with the magic lantern, using the oxyhydrogen light. In chemistry I made all the gases and more than are described in the book, and

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[641] *CR* **13**(March-April, 1882), 151

[642] Hyatt, 186

[643] *ibid.*, 191.

[644] *ibid.*, 186

> experimented on them fully. They gave me no small amount of trouble,but I succeeded with them all very well. I made both light and heavy carburetted hydrogen,and experimented with them. Then I made coal gas enough to light up the room through the whole evening. Altogether I have made for the students a fuller course of experiments in philosophy and chemistry than I saw myself. They studied well and appreciate what they saw. I trust that the issue will prove that my time has not been misspent.I have learnt a great deal myself,especially in the practical apart of experiment-making. It may be that I may yet have occasion to turn this knowledge to good account. I have also gathered in all a very good set of apparatus,which I shall try to make further use of.[645]

John Fryer,on a visit to Dengzhou in 1882 with his second wife Eliza,noted

> Dr Mateer's High School for Boys,conducted entirely in the Chinese language,has long ranked first among mission schools in China and it was a desire to see

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[645] Daniel W.Fisher,*Calvin Wilson Mateer: a biography*(Philadelphia:The Westminster Press,1911),212-213. Mateer had a strong practical bent,which he put to early use at Dengzhou,constructing a stove and repairing a chimney. He later also designed the two-storey house in which he and Julia lived.

He wrote to his brother

> In order to repair apparatus,and in order to make many simpler articles,I have fitted up quite a complete entirely at my own expense. I have invested in the shop in tools and materials quite one thousand dollars. I keep a workman at my own cost,whom I have trained so that he can do most ordinary kinds of work.(*Cheeloo*,Chapter 3,p.6)

By 1902,he had become so confident of his mechanical expertise that,whilst travelling across Siberia by train,he was able to advise a Russian engineer of the reason why the locomotive had stalled.(*ibid.*,6-7)

> something of its workings that partly influenced us to make the journey there. The courses of study extend over twelve years,embracing the complete course of mathematics and sciences as taught in the colleges at home,besides giving a thorough knowledge of Chinese classics. He has a complete laboratory of chemical and philosophical apparatus,the greater part of which is kept in order and the experiments are made by the students under his own careful tuition.[646]

An important and somewhat surprising aspect of his school curriculum was the emphasis on literary Chinese.

> The Classics have been thoroughly taught by a first-class Chinese teacher,and in the High School one day each week is devoted exclusively to the writing of essays in classic Chinese.[647]

Yet Mateer had nothing good to say about the traditional school system,which he castigated as 'defective and unsound'[648],filling its students with 'the mere shell and shadow of learning'[649],but he recognised that his students would need to pass the literary examinations if they were to achieve success,and so one-third of their time was devoted to Chinese studies,including written and spoken Mandarin.

He himself was a great believer in colloquial Mandarin as a medium for writing science textbooks,a practice then almost unknown amongst the missionary educators. Virtually

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[646] Fryer,*A beautiful life*,39

[647] *CR* **13**(March-April,1882),151-152

[648] Calvin W.Mateer,'Chinese education' in *CR* **14**,6(November-December,1883),464

[649] *ibid.*,466

all the foreign translators and compilers had up until then written their texts in an accessible version of the literary language ('easy *wenli* 文理'),believing that the vulgar tongue would be unacceptable to the *literati*. Mateer felt that,for school students,it was imperative that the study of science and mathematics be started as early as possible,and that waiting until they were proficient in *wenli* was far too late. In the preface to the second edition of his *Bisuan shuxue* 筆算數學 [Written calculations in arithmetic] he wrote

> This book is written purely in Mandarin. It is not because I am unable to write in literary Chinese(*wenli* 文理),but that I believe that arithmetic(*shuxue* 數學 [650])is the first step in mathematics,and best studied when people are young; if one has to wait until they are proficient in the literary language before studying [arithmetic],I fear it is too late. Although works written in *wenli* are valued more highly,they often breed doubt because their literary style is too elliptical,causing their meaning to be misunderstood. Moreover in Mandarin [the meaning] may be rendered much more clearly,so that scholars may be certain [of it]. [651]

Most of his educationist colleagues disagreed. W.A.P.Martin,in his review of *Bisuan shuxue*,wrote

> The style is a low kind of Mandarin,which has little in common with the elegant conciseness of the literary. It strikes one oddly as out of place when he meets it in the first line of the preface,and it does

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[650] *Shuxue* is nowadays used for 'mathematics'.

[651] Calvin Mateer and Zou Liwen 鄒立文,*Bisuan shuxue* 筆算數學[Written calculations in arithmetic](Tianjin:Wubei xuetang 武備學堂,1897),preface dated 1892,p.2b.

> not grow in favour as the reader finds himself at every step cumbered by needless redundancies. The author,of course,intended by presenting the subject in the every day colloquial to alleviate the toil of the teacher:but he gains so little in this regard that it is not worth while to offend in the taste of the educated classes.[652]

His great experience of the language and people in Dengzhou allowed him to adapt the text so that the examples he used all had a Chinese flavour,where many of the Arsenal publications retained all the original references to French and English units of measurement,with little or no concession to their Chinese readers.For example, one of the early questions in *Bisuan shuxue* read

A child earned nine cash and spent seven. How many were left? [653]

A much later problem ran:

> There was an imposing monastery in the mountains,[but we] don't know how many monks there are. There were exactly 364 bowls used,just enough for there to be no disputes. [...]Three monks would eat rice from a single bowl,whereas four would share a [different] bowl for soup.[...] May I ask you,Sir,to calculate how many monks were there altogether?[654]

Mateer also wrote texts entitled *Xingxue beizhi* 形學備旨[Elementary geometry],*Xinsuan shuxue* 心算數學 [Mental

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[652] W.A.P.Martin in *CR* **16**,5(Sept-Oct,1879),379-398.

[653] *Bisuan shuxue*,3.20a

[654] *ibid.*,22.89b

arithmetic], *Daishu beizhi* 代數備旨 [Elementary algebra], *Sanjiao cesuan* 三角測算 [Trigonometrical surveying], and *Gezhi shengtang* 格致升堂 [Ascending [to] the hall of science][655].

8.23 Mateer as an organiser and standardiser

An important aspect of his works in the 1880s and 1890s was the School and Text Book Committee set up at the 1877 General Conference of Protestant Missionaries in Shanghai[656], which published a number of important scientific works, and in which Mateer was a leading light. A list of volumes the Committee had published by 1881 already included sixty-three works on scripture, mathematics, geography, geology, astronomy, botany, zoology, physiology, political economy, jurisprudence and chemistry[657], a wider range of topics than the Arsenal produced, probably because the Chinese Government was rather cautious about allowing political and social themes to be discussed.

In 1890 the Educational Association of China was formed, a missionary organisation which aimed to introduce a more systematic approach to the development of education in China. One of its ventures was a systematisation of the chaos in nomenclature, particularly for chemical substances. Mateer was temperamentally not ideally suited to the work. Although naturally rigorous and logical, abhorring confusion of any kind, he was ill-prepared for the arduous work and the arguments which he must have known would result from forcing the leading scientific translators to admit change

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655 *Gezhi shengtang* was never completed, according to *Cheeloo* Chapter 3 p.4, yet it appears in a list of translated books in *GZHB* **3**, 8 (September 1880), 9a.

656 *CR* **8** (1877), 247-248

657 *CR* **12** (1881), 94-95.

in their systems. For each writer clung stubbornly to his own creations,and there was no agreement nor any prospect of one(any more than,earlier,it had been possible to agree over the proper translation of 'God'). Mateer made no serious effort at tactful reconciliation,but went ahead and created his own system,using what he judged to be the best of the existing terms,and the Committee finally published its report in 1898.

Mateer was a man of strong opinions,and had always found it difficult to compromise. His long battle over the correct terms for 'God' and 'Holy Spirit' continued for over forty years,and in 1906,as stubborn as ever,he wrote:

> My views are based on firmer ground than a popular stampede for union. I have studied this question long and carefully,having read practically everything that has been written on it. It has been said that the later generation of missionaries are free from prejudice. It is equally true that they are largely uninformed on the subject.[658]

His convictions on chemical nomenclature were almost as deeply felt,and he was just as obdurate. Far from clarifying the confusion as we have seen in Chapter 6 he created a whole wave of *new* terms,which he regarded as the new paradigm which all future textbook-writers should follow.

8.3 Conclusion

John Fryer and Calvin Mateer both showed qualities of pioneers:tenacity,discipline and self-confidence,an both made lasting contributions to the development of Western science in China.

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[658] *CR* **37**(July 1906),409

Fryer's greatest achievement was to show that,no matter how complex,the ideas of Western science could be translated into intelligible Chinese,and that the creation of a modern chemical nomenclature,though difficult,was quite possible within the resources of the Chinese language,even though some 'new' characters had to be employed. This may seem self-evident now,but at the time there were those who believed that the supposed 'defects' of the Chinese language would prevent it ever being a vehicle for scientific thought.

Fryer also demonstrated the power of science in changing the way some Chinese intellectuals viewed the word,and his books certainly influenced Kang Youwei,Liang Qichao and Tan Sitong in their search for a modern remaking of China.

For Calvin Mateer the essence of his work was practical,sound scholarship. He created an environment in his school which was able to transmit Western Science through the medium of spoken and written Chinese. By the end of the century Dengzhou College was turning out young Chinese Christians who were able to go on to teach and research into the natural sciences.

Both men struggled with immense difficulties - personal,linguistic,psychological and cultural,in fulfilling what they regarded as their Divine commission to bring Western science to the Chinese. It was not enough,as it turned out,merely to 'bring it to their attention': only an exceptionally gifted scholar,like Tan Sitong,could make sense of it simply by reading. In the end,only students who had been educated in a course of practical science could be expected to understand the real significance of the forbidding volumes full of uncouth transliterations. Only when students such as those whom Mateer taught had completed their studies were they able to read Fryer's books with any real understanding,and so successful transmission was found to depend more on education than translation: it is to those institutions within China which attempted to transmit Western science to which we now turn our attention.

Chapter 9. 'Seeking truth from facts'[659]: four nineteenth-century Chinese scientists

9.0 Introduction

The introduction of Western science in mid-nineteenth century China came as a *stimulus* to the native Chinese tradition rather as a collection of totally new ideas. The new science and technology was also to lead to limited but significant opportunities for employment in institutions such as the arsenals,translation bureaux and government academies which sprang up in the wake of the Self-Strengthening movement of the 1860s.

The most important figure in mathematics was Li Shanlan 李善蘭,a gifted scholar who later became a professor at the Beijing Tongwenguan,and who translated some important Western mathematical and scientific works; whilst the group based in Wuxi included the polymath Xu Shou 徐壽,his second son Xu Jianyin 徐建寅,and Xu Shou's friend the mathematician Hua Hengfang 華衡芳,who were firstly involved in private scientific researches at Wuxi,then in shipbuilding at the Arsenals at Anqing and Nanjing,and as translators at the Jiangnan Arsenal.

9.1 Li Shanlan 李善蘭(1810-1882) [660]

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[659] *Shishi qiushi* 實事求是[Seek truth from facts] was one of the central ideas of the *kaozheng* movement,and has been resurrected as a slogan by the Chinese Communist Party since Mao's death,encouraging a pragmatic and critical attitude towards theory and dogma.

[660] Primary sources on Li Shanlan which I have consulted include: the prefaces to *Dai-wei-ji shiji* 代微積拾級,*Zhongxue*重學[Mechanics] and *Zhiwuxue* 植物學[Botany]; John Fryer 'An account of the Department for the translation of foreign books at the Kiangnan Arsenal,Shanghai' in *North China Herald*(29th January,1880),79-81; John Fryer 'Science in China' in *Nature* (May

Li Shanlan(Li Renshu 壬叔) came from Haining 海寧 in Zhejiang Province. His biography in *Qingshigao* claims he was a prodigy,being able to understand the *Jiuzhang suanshu*九章算術[Nine chapters on the art of mathematics] by the age of ten *sui*. From 1845 he was tutor to the Lufei 陸費 family [661],but in 1852 he went to Shanghai,where he was befriended by Wang Tao 王韜(1823-1897),and they together with Jiang Dunfu 蔣敦復(1808-1867)became known as the "Three Friends of Shanghai" (*Haitian sanyou* 海天三友)[662]. It was here that he met Dr Medhurst at a chapel where the latter was preaching,and Li showed him one of his mathematical works.[663] Medhurst introduced him to Alexander Wylie,Joseph Edkins and Alexander Williamson who were working at the Mohai shuguan 墨海書館[Inkstone Press],and Li went to work with them in translating a number of mathematical and scientific works into Chinese in the mid-to-late 1850s,coming close to being converted to Christianity.[664]

1881),9-11 and 54-57; W.A.P.Martin *A cycle of Cathay*,368-370; Alexander Wylie *Chinese researches*,193-194; Zhao Erxuan 趙爾巽(ed.) *Qingshigao* 清史稿[Draft history of the Qing dynasty](Beijing: Zhonghua shuju 中華書局,1977)43.14011-14013; Min Erchang 閔爾昌(ed.)*Beizhuanji bu* 碑傳集補[A supplement to the *Collection of epitaphs*](Beiping: Yanjing University,1932),43.3b-12a.

Secondary sources include: Hummel,479-480; Horng Wann-sheng (Ph.D.thesis)*Tongwenguan jiaoxi Li Shanlan* 同文館教習李善蘭[The Tongwenguan professor Li Shanlan]; Wang Yusheng 王渝生 'Li Shanlan de jianzhui shu' 李善蘭的尖佳术[The wedge technique of Li Shanlan] in *Ziran kexueshi yanjiu* **2**,3(1983),266-288; Wang Yusheng 王渝生 'Li Shanlan yanjiu' 李善兰研究 [Researches on Li Shanlan] in *Ming-Qing shuxueshi lunwenji* 明清数学史论文集(Nanjing: Jiangsu jiaoyu chubanshe 江苏教育出版社,1990),334-408; Jean-Claude Martzloff *Histoire des mathématiques chinoises*(Paris: Masson,1988),318-325.

661 Hummel,479 and 542-543.

662 Hummel,836.

663 John Fryer,'Science in China',11.

664 W.A.P.Martin,*A cycle of Cathay*,370.

In 1859-60 he moved to Suzhou 蘇州,working for the governor of Jiangsu and fellow-mathematician Xu Youren 徐有壬(1800-1860)[665] until the latter was killed at Suzhou doing battle with the Taipings. Li returned to Shanghai,and from here he joined the *mufu* 幕府 [private secretariat] of Zeng Guofan in 1863, working first at Anqing at later at Nanjing[666]. He and another mathematician Zou Boqi 鄒伯奇(1819-1869) were recommended by Guo Songtao to be lecturers at the Beijing Tongwenguan[667],but both declined on health grounds,first in 1864 and again in 1866. Li worked briefly under John Fryer at the Translation Bureau of the Jiangnan Arsenal[668],but in 1868 he finally agreed to go to the Tongwenguan,and in the following year was appointed Professor of Mathematics and Astronomy[669],in which post he remained until his death.

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[665] Hummel,479

[666] Li seems to have been on friendly terms with Zeng Guofan,as on at least one occasion they played chess(*weiqi*圍棋[Japanese *go*]). See Zeng Guofan,*Zeng wenzhenggong shoushu riji* 15.69b,dated 30th January,1863 [Tongzhi 1.12.12]

[667] Hummel,480

[668]
> He was the author of several elaborate treatises and regarded "Newton's *Principia*" as well as the most abstruse mathematical problems I could give him from our Western authors as so much child's play.

(John Fryer,*The China of today*(21st January,1904),22 in *FP*:Carton 1.)

[669] His interest in astronomy was so intense that it is reported that on his wedding night he suddenly disappeared and was discovered in an upstairs room looking at the stars.(There may of course have been other,more personal,reasons for his behaviour.) See Mei Rongzhao,'Li Shanlan yanjiu',336. His lectures were evidently rather popular,as a foreign newspaper complained

> The halls of the foreign teachers were deserted for the lectures of Li,the expounder of the true celestial science.(*NCH*(25th January,1870),59)

9.11 His work as a mathematician

Li Shanlan was the foremost Chinese mathematician of his day, writing several works of great originality, as well as translating a number of seminal Western books on mathematics and science. I do not propose here to go into any detail on his mathematical work, save to say that his most original contributions were in the fields of logarithms[670] and infinite series.

9.12 His work as a scientific translator

As far as natural science is concerned, Li Shanlan's importance lies in his roles as the earliest of the modern Chinese translators of Western mathematical and scientific texts; as the creator of many new terms; and in the failure of his attempt a complete sinicising of Western mathematical notation.

His mathematical translations included: with Alexander Wylie *Xu jihe yuanben* 續幾何原本(1852-56)['A continuation of Euclid's *Elements*', which had been partially translated by Xu Guangqi and Matteo Ricci between 1606 and 1608 and published in 1611]; *Huoqi zhenjue* 火器真訣 [A true explanation of firearms](1858); *Daishuxue* 代數學 [Algebra](1859)[671]; *Dai-wei-ji shiji* 代微積拾級 [First steps in algebra, differential and integral

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[670] For example his book *Duishu tanyuan* 對數探源 [Investigations of logarithms](1846). According to Alexander Wylie

> he details an entirely new method for their [i.e. logarithms'] computation, based upon geometrical formulae, which he says in his introduction is "ten thousand times easier than the methods used by the Europeans" and that "although they can just calculate the numbers, yet they are ignorant of the principle."
>
> (Wylie, *Chinese researches*, 193)

[671] A translation of Augustus de Morgan, *Elements of algebra*(1835)

Figure 29. A portrait of Li Shanlan, from *Gezhi Huibian* **2**,5(July 1877)

calculus](1859)[672]; *Tantian* 談天[On the heavens](1859)[673];and *Naiduan shuli* 奈端數理[Newton's principles of mathematics],an uncompleted translation of Newton's *Principia mathematica*. He also translated *Zhongxue* 重學[Mechanics](1858)[674] and *Yuanzhui quxian* 圓錐曲線[Conic sections](1858)[675] with Joseph Edkins[676],and *Zhiwuxue* 植物學[Botany](1859) with Alexander Williamson and Joseph Edkins[677].

During the 1850s we find in the Mohai shuguan texts the first occurrences of the modern names for many of the sciences.[678] It would seem probable that in creating terms such as *zhiwuxue* 植物學 for 'botany',that Li Shanlan also first proposed *huaxue* 化學 for 'chemistry',but I can find no proof of this.

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[672] A translation of Elias Loomis 羅密士 (1811-1889), *Elements of analytical geometry and of differential and integral calculus*(New York: Harper and Brothers,1850). See Zhang Dianzhou, 张奠宙,'*Dai-wei-ji shiji* de yuan shu he yuan zuozhe' 代微積积拾级的原书和原作者 [The source-text and original author of *Dai-wei-ji shiji*] in *ZGKJSL* **13**,2(1992),86-90.

[673] A translation of John Herschel(1792-1871),*Outlines of astronomy*(1851).

[674] A translation of William Whewell,*An elementary treatise of mechanics*

[675] A translation of William Whewell,*Conic sections*

[676] Only a few copies of these works were printed in 1858 as the woodblocks were destroyed by fire,but they were reprinted in 1866. See Hummel,479.

[677] A translation of John Lindley,*Elements of botany* 6th edition(London:Bradbury and Evans,1849)

[678] Zeng Guofan later listed a number of these terms in his diary. See *Zeng Wenzhenggong shoushu riji* 15.66b,dated 24th January,1863 [Tongzhi 1.12.6],which includes the following terms: *guangxue* 光學[optics],*zhongxue* 重學[mechanics],*liuxue*流學[hydraulics],*huaxue* 化學[chemistry],*dianqixue* 電氣學[electricity],*cishixue*磁石學[magnetism],*dongwuxue* 動物學[zoology] and *zhiwuxue* 植物學[botany].

9.121 The sinicising of mathematical notation

Li Shanlan and Alexander Wylie seem to have decided that only an almost complete sinicising of Western mathematical notation would suffice to make it acceptable to the Chinese *literati*. Thus,not only were new terms created,such as *daishuxue*[the study of the substitution of numbers] for 'algebra',*weifen* 微分[subtle division] for 'differential calculus',*jifen* 積分[accumulating divisions] for 'integral calculus',*changshu* 常數[constant],*hanshu*函數[function],*bianshu* 變數[variable],*jishu* 系數[coefficient],*zhishu* 指數[index],*jishu* 級數[series],*qiexian*切線[tangent],*faxian* 法線 [normal],*gen* 根[root],and *fangcheng* 方程[equation],but even conventional Western signs such as those for integration and differentiation were abandoned in favour of new ones derived from Chinese characters. The sign for integration 禾 for instance came from *ji* 積[accumulate],part of the term for 'integration'; whilst the symbol for the infinitesimal d in dy/dx was taken from the radical of the character *wei* 微[subtle].

Not all the Western notation was rejected: x (multiplication); ÷ (division),the line separating the numerator and denominator of a fraction,( )(brackets),√ (square root),> (greater than),< (less than),and the exponent system to indicate powers were all retained.[679] Yet the Western notation for fractions was inverted,so that if a = 甲 and b = 乙 , a/b was written 乙/甲.[680]

[679] *Dai-weiji shiji. Fanli* 1a.

[680] This was in order to make it closer to the Chinese way of expressing the fraction 甲/ 乙 as *yi fen zhi jia* 乙分之甲.

Table 8. A comparison of the Li Shanlan/Alexander Wylie sinicised notation and the standard mathematical notation

standard notation	Li/Wylie notation	Reference to *Dai-wei-ji shiji*
+ (plus)	⊥	*Fanli* 1a
- (minus)	⊤	*Fanli* 1a
y	地[earth]	10.1a 地 = 甲天 乙 [y = ax + b]
x	天[heaven]	*Fanli* 1b-2a 彳天 [dx]
(constants) a,b,c,....u,v,w A,B,C,.....U,V,W	甲,乙,丙 for lower case letters 口甲,口乙,口丙 for upper case letters	*Fanli* 2b
D (differentiation)	彳	*Fanli* 1b-2a 彳天 [dx]

$\int$ integration	禾	禾三天^{二}彳天＝天^{三} [$\int 3x^2.dx = x^3$]

The notation was used in the Jiangnan Arsenal science texts,but was eventually found to be unsuited to school use. John Fryer defended the system as being more likely to excite approval amongst the conservative *literati*

> Is there any magic charm in the Arabic figures that we must drag them into our Chinese books to suit our hobbies,and to the perplexity or annoyance of the conservative Celestial mind?[681]

And Fryer even justified the inversion the Western convention for the notation of fractions

> [...]or,still worse,what shall be said of those who would turn the mathematical world upside-down,as far as it is within their power,by changing the time-honoured and rational practice of writing vulgar fractions with the denominator above and the numerator below?[682]

His protagonist Calvin Mateer was of the view that

> the effort to propagate in China a system of mathematical notation different from that which prevails in the whole civilised world outside of China,is to put a block in the way or progress,and greatly to retard the advancement of modern science in China.[...]I have yet to hear that this [i.e. Li Shanlan's] system is used in a single school in China.[683]

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681 John Fryer,'Scientific terminology: present discrepancies and means of securing uniformity',543.

682 *ibid.*,543.

683 Calvin Mateer in *Records of the General Conference of the Protestant Missionaries of China*(1890),550.

In this instance,unlike in chemical notation,Mateer was to prove the wiser judge of which would prevail. As Chinese students went to study mathematics abroad they soon abandoned Li Shanlan's system in favour of that used in Berlin,Paris and New York.

9.13 Li Shanlan as a leading influence on the development of modern Chinese science

Li Shanlan was not only a scholar of mathematics and astronomy. He wrote poetry and journal articles,and was almost as anatgonistic as Xu Shou towards aspects of the traditional Chinese view of nature,attacking the 'magicians'[*shushi* 術士] who used the planets to predict longevity,premature death,success and failure. He also objected to the *wuxing* 五行[Five Phases],which he claimed were in the canonical *Hongfan* 洪範 account simply useful materials,and the various correlations with seasons,colours,etc and the mutual production and destruction cycles were all later accretions.[684]

Although he may have never openly professed Christianity,there were occasions when his writings betray a profound Christian influence,and an unusual sympathy with Christian ideas,as in his preface to *Zhiwuxue* 植物學 [Botany],in which he wrote

> Williamson and Edkins are both Christian missionaries,serving God diligently,and in their spare time they have translated this book. Plants and animals are all made by God. [Just as] by examining the skill used in making a machine [you] can know the skill of the artisan,or by seeing the manner in which the fields are cultivated

[684] See *ZXWJL* **12**(July 1873),3a-3b,and Section 2.2.

Figure 30. The front cover of *Zhiwuxue*[Botany],translated by Li Shanlan,Alexander Williamson and Joseph Edkins,with calligraphy by Li Shanlan.

> [you] can know the hard work of the farmer,so by seeing the intricate beauty and subtle wonders of plants you can see the intelligence and wisdom of God. These two men have therefore assiduously translated this book,so that it is certain that scholars reading [it],if they have doubts,[will become] aware of the necessity of the existence of God,and because of this [they will] fear [Him],inwardly cultivating the control of their body and mind,and outwardly cultivating [their] filial piety,brotherliness,sincerity and loyalty[685],fearing to transgress God's will: [this being so],how can their translation of this book fail to be of great benefit to others?[686]

Li Shanlan seems to be suggesting that not only will the study of botany lead the scholar to God,but that through his fear of the Deity he will become a better Confucian!

9.14 Li Shanlan: Conclusion

Li Shanlan was the most senior and perhaps the most gifted of the early modern Chinese scientists. The respect in which he was held by leading figures such as Zeng Guofan and Li Hongzhang helped to give Western studies a certain respectability at a time when the ultra-conservative factions regarded all foreign ideas as worthless. Li played a direct personal role at the Anqing Arsenal,the Jiangnan Arsenal and particularly at the Beijing Tongwenguan,where he held the chair in mathematics and astronomy for 15 years. Yet his latter years seem to have been less energetic in the transmission of science: perhaps the more

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685 The four cardinal virtues in Confucianism.

686 *Zhiwuxue* Preface,1a-1b. Li Shanlan also wrote several more evidently Confucian pieces on filial piety in *ZXWJL*,such as 'Xiao gai shi' 孝丐詩 [Poem about a filial beggar] *ZXWJL* **16**(November 1873),1a-1b; 'Gai fu zhuan' 丐婦傳 [The story of the beggar-woman] **16**(November 1873),1b

conservative atmosphere of the capital had its effect on him. During these years,he seems not to have written any texts of his own,even though these were sorely needed,and to have taken no vigorous steps to make Western science more accessible to a wider public. In this he contrasts markedly with his younger colleagues at the Anqing Arsenal,Xu Shou,Xu Jianyin and Hua Hengfang.

9.2 Xu Shou 徐壽(1818-1884) and Xu Jianyin 徐建寅(1845-1901)[687]

Xu Shou and Xu Jianyin were father and son,and together spanned the transition between the arrival of the first modern science textbooks in China and the beginnings of a sustained modern Chinese science community. They worked with Li Shanlan at the Anqing Arsenal,building a small steamship to the delight of their patron Zeng Guofan,and then went to the Jiangnan Arsenal,where they were principally engaged in the translation of Western science texts.

Xu Shou was a scholar who,although unsuccessful in the literary examinations,devoted himself to Western studies,and together with Hua Hengfang carried out a number of interesting experiments using the limited number of Western textbooks then available such as *Guanglun* 光論 [On light](Shanghai,1853)[688] and *Bowu xinbian* 博物新

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[687] I am giving here only a brief summary of my research on these two men,detailed in my article 'Careers in Western science in nineteenth-century China: Xu Shou and Xu Jianyin' in *JRAS* 5,1(April 1995),49-90. Please see this article for a list of sources used.

[688] A translation by Joseph Edkins and Zhang Fuxi 張福僖(?-1862)of an unknown optical text. Zhang Fuxi was a mathematician-astronomer,author of *Huixing kaolue* 慧[彗] 星考略[A investigation of comets],and a friend of Li Shanlan. See *Qingshigao*,46.13981 and Wright,'Careers',55-58

Figure 31. A portrait of Xu Shou from *Gezhi Huibian*(October 1877)

[Reproduced by kind permission of the British Library,Oriental and India Office Collections]

編[A new account of natural philosophy](Shanghai,1855) [689] on optics,thermometry[690] and mathematical acoustics.

Xu Shou is particularly noted for his work on sound,especially his correction of a statement about the vibrations produced by an open pipe by John Tyndall in the latter's book *Sound*. This led to the publication of a letter in *Nature* from John Fryer to Tyndall,including a translation of Xu Shou's observations,the first known example of a Chinese scientist's work appearing in a Western scientific journal.[691]

In 1861 he went to work in the *mufu* of Zeng Guofan to build a prototype steamship[692],together with Xu Jianyin,and Hua Hengfang. Although not the very earliest Chinese-built steamship [693],it was more significant than the experiments of the 1840s,as it led directly to the first serious efforts to set up a modern shipbuilding industry.

In 1867 they moved to the newly-built Jiangnan Arsenal,particularly to engage in the translation of foreign books on science and technology,and embarked upon a series of translation with John Fryer,Daniel Jerome Macgowan and other foreigners which resulted in the first systematic attempt to translate a corpus of modern Western

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[689] A translation by Benjamin Hobson,apparently incorporating earlier work by Daniel Jerome Macgowan *Bowu tongshu*. See Chapter 6,Section 6.2. Correspondence between Xu Shou and Hua Hengfang on the experiments they performed is given in Jiang Shuyuan 蒋树源,'Xu Shou de liang feng qinbi xin' 徐寿的两封亲笔信 [Two letters of Xu Shou in his own hand] in *ZGKJSL* **5**,4(1984),52-54.

[690] Wright,'Careers',58-59

[691] *ibid.*,69-71 and *Nature*(March 10,1881),448-449

[692] Wright,'Careers',62-66

[693] See Section 4.22.

scientific knowledge.[694]

Xu Shou is nowadays best known for his translations of chemistry texts such as *Huaxue jianyuan* 化學鑑原[The mirror of chemistry: a source-book][695],and his latter years preferred to stay in his study in Shanghai,whilst sending Xu Jianyin to help in the setting up of new powder works and arsenals.

Xu Shou and Xu Jianyin both played significant roles in the early days of the founding of the Shanghai Polytechnic, but their view of its purpose differed sharply from that of John Fryer,leading to a complete reorganisation of the Polytechnic after Xu Shou's death.[696]

Xu Jianyin travelled to Europe in the late 1870s on a technological reconnaissance mission[697],and on his return seems to have become involved in the movement to reform China's political structures. In 1898 he was one of the leading figures in the Hundred Days' Reform,as Director of the short-lived Central Bureau for Agriculture,Industry and Commerce[698]. He returned to work for Zhang Zhidong at the Hanyang Smokeless Powder Works in the aftermath of the Boxer Rebellion,and died tragically in an enormous explosion whilst trying to making smokeless gunpowder.[699]

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694 Wright,'Careers',67ff

695 See Section 7.7.

696 *ibid.*,71-75

697 *ibid.*,79-81

698 *ibid.*,83

699 *ibid.*,83-86 and Ji Hongkun 季鸿昆,'Xu Jianyin yu wuyan huoyao de yanzhi' 徐建寅与无烟火药的研制[Xu Jianyin and the manufacture of smokeless gunpowder] in Yang Gen(ed.)*Xu Shou*,317-334.

Figure 32. A portrait of Xu Jianyin, from Zhong Shuhe (ed.) *Zou xiang shijie*

9.21 Xu Shou and Xu Jianyin: conclusion

Xu Shou and Xu Jianyin were remarkable for their complete commitment to Western studies. Xu Shou expressed his contempt for the traditional Chinese concepts of *li* 理,*qi* 氣 and *wuxing* 五行 several times[700],and once said of some books on Chinese science that they were 'sooner burnt the better'.[701] In Xu Shou we see the continuity of the *kaozheng* tradition of evidential research with the new paradigms of Western science; for his son Xu Jianyin the technological imperatives of Self-Strengthening eventually kindled a demand for political change,which,though far from revolutionary,rejected at least part of the traditional emphasis on literary studies.

9.3 Hua Hengfang 華衡芳(1833-1902)[702]

9.31 An outline of his life

Although Hua Hengfang(Hua Ruoding 若汀) was less creative a mathematician than Li Shanlan,less prolific a translator than Xu Shou,and less energetic a technologist than Xu Jianyin,he deserves nevertheless to be considered alongside them as one of the four great pioneers of modern Chinese science.

Born in Jinkui 金匱 near Wuxi[703],he showed a precocious

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[700] Wright,'Careers',60

[701] *NCH*(6th April,1874),321-322,referring to the books of Johannes von Gumpach.

[702] The sources on Hua Hengfang are substantially similar to those on Xu Shou: Zhao Erxuan(ed.)*Qingshigao* 46.14013-14016; the epitaphs collected in Min Erchang,*Beizhuan jibu* 43.18b-21a; John Fryer 'An account of the Department for the Translation of Foreign Books at the Kiangnan Arsenal,Shanghai' in *NCH* 29th January,1880),77-81; the preface to *Jinshi shibie* in Zhang Yinhuan ed. *Xixue fuqiang congshu*,12.1a; and the preface to *Dixue qianshi* 地學淺釋.

[703] His younger brother Hua Shifang 華世芳 was also a talented scholar,becoming the director of the Changzhou Longcheng Academy(Changzhou Longcheng Shuyuan 常州龍城書院),chief lecturer at the Shanghai Nanyang Academy (Nanyang Gongxue 南洋公學) and a

ability in mathematics. His father Hua Yilun 華翼崙 bought him some of the great Chinese mathematics texts such as *Shuli jingyun* 數理經縕 [Collected basic principles of mathematics] and *Jiuzhang suanshu* 九章算術[Nine chapters on the mathematical art][704],and he is said to have mastered the *tianyuan* 天元 and *siyuan* 四元 methods of solving equations [705].

In the 1850s he got to know Xu Shou,who was fifteen years his senior,just as the latter was beginning his study of natural science,and together they formed a scientific partnership which was to continue for the rest of their lives. They performed a number of experiments,including the study of the behaviour of light passing through a prism[706].It was at this time that he worked with Xu Shou studying the trajectories of projectiles[707]. Xu Shou apparently distrusted the ballistic theory,and so they set up targets at different distances to check the mathematical formulae[708].

In 1861 he and Xu Shou went to Anqing to work in Zeng Guofan's *mufu*,where he worked on the building of steamships,mainly involved in making drawings and calculations[709] and was also involved with more experiments

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mathematics lecturer in the Advanced Industrial Academy of the Ministry of Agriculture,Industry and Commerce(Nong-gong-shang Bu Gaodeng Xuetang 農工商部高等實業學堂). See Yang Mo,28.

[704] *Beizhuan jibu,*43.19a

[705] *ibid.*,43.19a

[706] *ibid.*,43.19b

[707] *ibid.*,43.19b

[708] *ibid.*,43.19b

[709] *ibid.*,43.19b

with guns[710].

From 1867 he went with Xu Shou to the Jiangnan Arsenal,where he worked in the Translation Department with Fryer and Daniel Jerome Macgowan. His collaboration with Macgowan on Dana's *Manual of mineralogy* and Charles Lyell's *Elements of geology* seems to have been frustrating,as Macgowan was also a doctor,and was often called away to attend patients whilst they were in the middle of their work,but,Hua said,'I just sat and carried on correcting the drafts whilst awaiting his return'.[711] The translation of the latter book almost cost him his life: after the first seventeen *juan* 卷 of the *Elements* had been translated,Hua fell so seriously ill with dysentery that he had to ask a Chinese friend to be his amanuensis,but his health soon deteriorated so badly that even dictation became impossible. His illness also affected his mental state,as he wrote

> The more anxious I became[about the translation] the worse the illness became. The house where I lived faced the main road,and I could not sleep for the sound of people's voices. Sometimes the sound of horse-carts rumbling by seemed to be touching my heart and crushing my lungs. When I had just closed my eyes,it seemed as all kinds of creepy-crawlies were moulting their scales and fins,weird and terrifying beasts were more and more frequently falling in a chaotic way and gathering in front of me,whilst I felt water and land shifting,in great mountains and immense gorges. The commonplace things which had [previously] entered my ears and dwelt in my eyes,now blended

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[710] Zeng Guofan recorded in his diary 'I saw Hua Hengfang firing over ten shells outside the North Gate' See Zeng Guofan,*Zeng wenzhenggong shoushu riji*,13.62a,dated 12th August,1862 [Tongzhi 1.7.17].

[711] Hua Hengfang,Preface to *Dixue qianshi*,1a

> together in my mind,and became manifest one by one[...][712]

He did not fully recover for over six months,and the book took a further two years before it was ready for publication.[713]

In the 1870s he worked at the Longhua 龍華 Gunpowder factory in Shanghai[714],Tianjin Gunpowder Factory(Tianjin Dongju 天津東局) and at the Tianjin Military Academy (Tianjin Wubei Xuetang 天津武備學堂). At the Tianjin Gunpowder Factory, Chinese ambassador to Germany bought a device for measuring the speed of bullets,but no-one knew how to use it until Hua used the differential calculus to figure it out.[715] At the Tianjin Military Academy,a German lecturer had a hydrogen reconnaissance balloon which had been used in the war with the French in Vietnam: the lecturer had wanted to make a new one to teach his students,and so Hua supervised the making of a balloon 5 *chi* 尺 in diameter,making hydrogen by putting zinc in sulphuric acid,and the onlookers 'gasped in admiration' as it rose aloft[716].

During the early 1880s he was also the resident Curator

[712] Preface to *Dixue qianshi*,1b-2a. The 'strange beasts' and cataclysmic movements of sea and land were probably the prehistoric animals and geological processes described by Lyell in his book. See Charlotte Furth,*Ting Wen-chiang*,37

[713] *Dixie qianshi*,2a

[714] He narrowly escaped death in an explosion at Longhua. See Yang Mo,18-19.

[715] Yang Mo,19

[716] *Beizhuan jibu*,43.20a and Yang Mo,19.

at the Shanghai Polytechnic[717], and according to John Fryer's *Third Report*(1883)

> Mr Hwa [Hua] performs his duties without expense to the Institution and occupies his leisure time in preparing treatises on Mathematics and other subjects in which he is well versed. [...] The Committee have much to feel thankful for in the voluntary services which he renders in taking charge of the premises for them and attending to visitors.[718]

Despite this apparently warm praise, in his *Fourth Report*(1885) Fryer was much less complimentary about Hua's work at the Polytechnic, and implied that Hua had been employed at the Institution only because of his connection with the Xu family.[719]

Unlike Xu Shou, Hua Hengfang seems to have been a much-loved teacher, working at the Ziqiang xuetang 自強學堂 [Self-strengthening College] in Hubei, the Liang Hu shuyuan 兩湖書院 [Hubei and Hunan Academy] and the Wuxi 無錫 Sishi xuetang 竢實學堂 [Attending-reality Academy]. He was noted for his clear explanations and diagrams and the simple language he employed in teaching[720]. One anecdote about him is that he was working on a calculation at the blackboard, and made a mistake, and one of his students said, "Sir, you are wrong!". He asked where the mistake was, and smiled, saying, "I am old, and am not as good as you at mathematics!" His students were said to have been delighted by his humility, and encouraged to study even

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[717] According to Yang Mo, Hua worked at the Shanghai Polytechnic for ten years. See Yang Mo, 16.

[718] John Fryer, 'Third Report of the Chinese Polytechnic Institution and Reading Rooms, Shanghai', 433

[719] See Section 10.2

[720] *Beizhuan jibu*, 43.20a

harder.[721]

However,his efforts in teaching were not as great as in writing books,for as he once said,in teaching you just influence one class at a time,whereas with books you can influence immense numbers of people [722]. After 1867,at the Jiangnan Arsenal he took on the translation of texts on mathematics and geology[723],works that were highly praised for their accuracy and literary quality[724].

His translations and original works[725]

His most important translations were,with John Fryer *Fanghai xinlun* 防海新論 [A new discussion of maritime defences](1871)[726]; *Daishushu* 代數術 [Techniques of algebra](1872)[727]; *Weiji suyuan* 微積溯源 [Tracing the origin of the differential and integral (calculi)](1875)[728]; *Sanjiao shuli* 三角數理 [Mathematical principles of tri-angles](1878)[729]; *Daishu nanti jiefa* 代數難題解法 [Difficult problems in algebra](1879)[730]; *Jueyi shushu* 決疑數術 [The

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[721] *ibid.*,43.20a

[722] Yang Mo,19

[723] *ibid.*,43.19b

[724] *ibid.*,43.19b

[725] The information on the works given here is taken from John Fryer 'An account of the Department...'(*FP* version),22-31 and Bennett,*John Fryer*,82ff.

[726] A translation of Von Scheila,*Coast defence*

[727] A translation of William Wallace 'Algebra' in *Encyclopaedia Britannica* 8th edition

[728] William Wallace,'Fluxions' in *Encyclopaedia Britannica* 8th edition

[729] A translation of John Hymers,*Treatise on Plane and Spherical Trigonometry* 4th edition(London,1858)

[730] A translation of Thomas Lund,*A Companion to Wood's Algebra*(London and Cambridge,1878)

mathematical techniques of certainty and uncertainty](1880)[731]; *Heshushu* 合數術 [Techniques for combining numbers](1888)[732]; *Daishu zongfa* 代數總法 [A combination of algebraic methods][733]; *Fengyubiao shuo* 風雨表說[On barometers][734]; *Haiyong shuilei fa* 海用水雷法[Methods for the use of sea torpedoes][735].

With Carl Kreyer[*Jinkaili* 金楷理] he translated *Yufeng yaoshu*御風要術[Important techniques for withstanding the wind](1871)[736] and *Cehou congtan* 測候叢談[Discussions on measuring the weather](1877)[737].

With Daniel Jerome Macgowan he translated *Jinshi shibie* 金石識別[The identification of minerals](translated in 1868,but not published until 1885)[738] and *Dixue qianshi* 地學淺釋[A superficial account of geology](1873)[739]

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731 A translation of Thomas Galloway,'Probability' in *Encyclopaedia Britannica* 8th edition and R.E.Anderson,'Probabilities,Chances or the Theory of Averages' from *Chambers Encyclopaedia*.

732 A translation of Ball,*Combinatories*

733 A translation of Byrne,*Dual arithmetic*

734 'Barometers' in *Encyclopaedia Britannica*

735 A translation of Harvey,*Sea torpedoes*

736 A translation of Birt,*Law of Storms*

737 The original was an article in *Encyclopaedia Britannica*.

738 J.D.Dana,*Manual of Mineralogy* 4th edition(New Haven: Durrie and Peck,1851)

739 Charles Lyell,*Elements of geology*. A number of sources(e.g. Sophia Chen Zen,*Symposium on Chinese culture*(Shanghai: China Institute of Pacific Relations,1931),169 and W.H.Wong in *ibid*.,192)erroneously identify this translation as that of Lyell's more famous work *Principles of geology*,but I have compared *Dixue qianshi* with the British Library copy of the 6th edition of *Elements of geology*,and agree with James Pusey in *China and Charles Darwin*(Cambridge,Mass.: Harvard University Press,1983),4 that *Dixue qianshi* is a translation of the *Elements* and not the *Principles*.

Hua himself wrote *Shugen kaifangshu* 数根开方術 [Techniques for extracting roots using prime numbers](1872),and is said to have been so proud of his calculation of *pi* to 36 places of decimals that he asked his family to have the number engraved on his tomb.[740]

9.4 Kaozheng 考證 *scholarship and Western science*[741]

The achievements and influence of this small group of active workers in the field of natural science are out of all proportion to their numbers. With only very limited help from Westerners in China(many of whom,like John Fryer,themselves had only a sketchy knowledge of science),they carried out researches on topics such as acoustics,optics,ballistics,and thermometry which were remarkable for their originality and depth. Their personal influence was rather small - there was no 'Wuxi school' - but through their translations they helped to create a climate of opinion in which 'science' came to be seen as an indispensable part of progress,even if what 'science' meant was rather ill-defined. To understand the complex interplay between the quiet,scholarly world of the *gezhijia* 格致家 [scientists] and late Qing society we need first to examine the milieu in which they arose.

They all came from a wealthy area of the Lower Yangzi valley,long famous for producing talented and unorthodox scholars,a centre for book production noted for its fine libraries. Their education seems to have given them the determination and the intellectual self-confidence to turn to what more ambitious men would have seen as the alien and worthless field of Western studies. They allied themselves with the more progressive of the Self-Strengtheners,first

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[740] Zhao Erxun(ed.)*Qingshigao* 46.14015

[741] See Jonathan Porter,'The scientific community in early modern China' in *ISIS* **73**,269(1982),529-544.

Zeng Guofan and later Li Hongzhang and Zhang Zhidong,but also,more unconventionally,worked closely with the foreign missionaries who were beginning to translate scientific and mathematical works in Shanghai. Their proximity to the most Westernised city in China was a key factor in the development of the Wuxi science community. There they found Westerners who were relatively knowledgeable and enthusiastic about natural science,whose Chinese was good enough to communicate the ideas directly,and who happened to need Chinese collaborators for their own,evangelistic translation programme. Shanghai was also far enough from the capital for them to be able to consort with foreigners without arousing too much suspicion.

The time at which they became active was just when the first modern Government schools and arsenals were being opened,and they both found careers associated with these new institutions: the Arsenals in Anqing,Nanjing,Shanghai,Tianjin,Shandong,and Hanyang;the translation bureaux; and of course the Shanghai Polytechnic.

Their attitude to Western science,although clearly positive,was not uncritical. Once they had access to Western books such as *Bowu xinbian*,they did not merely absorb their contents,but tried to repeat the experiments the books described,and,in doing so made new and unexpected discoveries.[742] Indeed,they may well have felt that their understanding was deeper than that of their Western counterparts. As Li Shanlan is reported to have said about

[742] Xu Shou was sceptical of the diagrams in some of the optical texts they studied(See Jiang Shuyuan. The text they used here may well have been *Guanglun* 光論 [On light](1853) translated by Li Shanlan and Zhang Fuxi.) Xu Shou is also said to have carried out experimental checks on the formulae for the trajectories of shells. (See *Qingshigao*, 46.13929: I suspect that the formulae came from the text *Zhongxue* 重學[Mechanics] which Li Shanlan and Joseph Edkins had translated in 1858. See Figure 33.)

his discovery of a new method for calculating logarithms:

> Although <u>they</u> [the Westerners] can just calculate the numbers,yet they are ignorant of the principle.[743]

Whilst unusually open to Western ideas,they do not appear to have seen themselves as outside the mainstream of Chinese culture: on the contrary,as far as it can be discovered,their view of themselves was as reformers and revivers of a long and ancient native tradition of natural philosophy,working with the methods of their predecessors in the *kaozheng* movement.[744]

It is perhaps remarkable how little attached they seem to have been to the traditional concepts of *li* 理,*qi* 氣,*yin-yang* 陰陽 and *wuxing* 五行 and so on. I suggest that this is partly because they did not come from a background in which such concepts had any real meaning or function in everyday discourse,unlike their medical colleagues who were(and still are) in daily touch with a system which uses *wuxing*五行 and *qi* 氣 as an explanatory and diagnostic system. Divorced from practice for non-medical practitioners,the traditional concepts had long lost any emotional or even intellectual power,whereas the new concepts of force,energy,acceleration,element and compound,provided them with an explanatory framework which in its rational view of the universe was not at all incompatible with the *ethos* of traditional Chinese science. *Li* 理,*qi* 氣,*yin-yang* 陰陽 and *wuxing* 五行 were not 'refuted' by Western science: they were for the most part ignored as the new ideas poured into China. It is significant that only in the medical field was

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[743] Wylie,*Chinese researches*,193

[744] See also Hu Shih,'Religion and philosophy in Chinese history' in Sophia H.Chen Zen,*Symposium on Chinese culture*,25-58,and especially pp.54-58 for the connections between science and the 'rational philosophy' native to China.

there any serious attempt, by writers such as Tang Zonghai 唐宗海 (1851-1908) and Zhang Xichun 張錫純 (1860-1933), to make any connection, let alone a compromise, between Western science and traditional Chinese views[745].

I suggest that these two men did indeed form part of a *scientific community* in Wuxi[746] for a short period (from about 1855 (or slightly earlier) to 1861)[747], after which they moved to Anqing and became involved in the process of shipbuilding, which probably left little time for pure research. The Wuxi period was of great importance, as it shows both the difficulties they were working under and also how well, in some respects, the methods of *kaozheng* scholarship had prepared them to receive Western science, both on a technical level, with its respect for the evidence and attention to detailed observation; and, more broadly, the central *kaozheng* myth of the restoration of lost knowledge gave a moral purpose to their studies which went beyond mere curiosity. The development of this scientific community, whilst apparently spontaneous, benefitted from being so close to Shanghai where the new science was being promulgated through Li Shanlan and the learned Protestant missionaries of the Mohai

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[745] Tang Zonghai argued in *Zhong-Xi huitong yijing jingyi* 中西匯通醫經精義 [The essential meaning of the medical classics in the light of Chinese-Western eclecticism] (1892) that Western medicine was inferior to Chinese but that it could be used as a supplement, and thus help to purify and revive a lost tradition. Zhang Xichun believed that in fact the two traditions are identical. See Zhao Hongjun 赵洪钧, 'Chinese versus Western medicine: a history of their relations in the twentieth century' Nathan Sivin trans. in *CS* **10** (1991), 21-37.

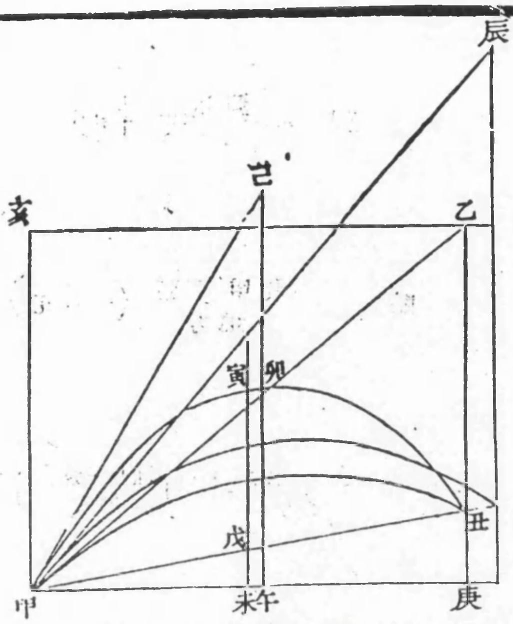
[746] Wuxi is also remarkable as being the home of the first *baihua* 白話 [colloquial] journal in China, the *Wuxi Baihua Bao* 無錫白話報 (1898), run by the first Chinese woman journalist Qiu Yufang 裘毓芳. (Britton, 97-98)

[747] See David C. Reynolds, 'Redrawing China's intellectual map: images of science in nineteenth century China' in *Late Imperial China* **12**, 1 (June 1991), 27-61.

平綫亦等戊午戊未路亦等所以甲寅寅庚爲等長且

等勢綫

第二款 從某點將物拋出求斜面上拋綫界



如圖甲爲某點甲乙爲拋物方
向甲丑爲斜面乙庚爲經過界
點之垂綫甲庚爲地平面先求
若干秒中拋物至甲丑面命乙
甲丑角爲角甲乙丑角爲亢甲
丑乙角爲氐丑甲庚角爲房甲
丑庚角爲心乙甲庚角爲尾則

Figure 33. A diagram of the trajectory of a projectile from *Zhongxue*[Mechanics],11.3b(1866 edition) [This text was originally translated by Li Shanlan and Joseph Edkins in 1858,and may have been the source whose mathematical formulae Xu Shou decided to check.]

Shuguan, and where not only books but also scientific equipment became available. The relatively peaceful and leisured existence in Wuxi before the arrival of the Taiping rebels allowed Xu Shou and his colleagues the time to experiment and to think, checking the hypotheses and explanations in their foreign textbooks against their own experience. The devastation of the Taiping Rebellion, and the external threats to China of the late nineteenth century, forced them to leave their homes but also indirectly compelled them to become involved in the applications of science in military technology. They thus became, in a pattern familiar in the modern world, scientists who owed their living to military research, which took as its primary aim improvements in the armaments and armoured vessels which China needed to defend itself.

As they began working in Anqing, and even more at the Jiangnan Arsenal, the purely scientific aspect of their work seems to have faded away as they became increasingly involved in solving practical problems and in the exhausting and often uncreative process of translation. The faithful translations they generated must nevertheless have given them what was at that time in China an unrivalled understanding of the science of the day, yet they had little opportunity to transmit their knowledge directly. The universities where they could have trained the next generation of Chinese scientists had not been built, and the few institutions teaching science (such as the Tongwenguan) were staffed mainly by foreigners. Expertise in science became associated with foreign study: by the end of the century thousands of Chinese students were being sent abroad, mainly to Japan, to receive their science education. There was in short little encouragement in China itself for those Chinese who had already taught themselves science: they were soon to be overtaken in their career paths by *liuxuesheng* 留學生 [students studying abroad] who had learnt their science in Tokyo, Paris, Edinburgh or London rather than the Shanghai Polytechnic.

This had a serious effect on the future of China's science,as the scientific work they did in Wuxi was not only real science(that is,a cumulative growth of knowledge and understanding firmly based on interactive experience[748],but in many ways was more real than the science called 'useful knowledge' which John Fryer and missionary organisations such as the Society for the Diffusion of Useful Knowledge,were promoting. For the 'diffusion of science' as they conceived it required its recipients to be passive onlookers. It is perhaps not entirely coincidental that this intellectual passivity was a reflection of the political passivity on which the Western powers were counting in their dealings with China.

The model of science which the foreigners brought to China was,as David C.Reynolds has hinted,that of a *secular gospel*[749],as an accumulation of dead knowledge which has to be learned,assimilated,displayed and then diffused,rather than a lively,uncertain and participatory,practical process of learning and discovery. In this sense the work Xu Shou and his colleagues carried out in Wuxi was far in advance of the approach of their Western missionary colleagues,and it was tragic that their original scientific researches were cut short by the demand for new technology.

The intrinsic originality of the work of the Wuxi group should not conceal the fact that these early modern Chinese scientists were very few in number,and however

[748] I mean by 'interactive experience' that the act of doing an experiment or carrying out an observation leads the experimenter to ask more questions and to form more hypotheses,rather than simply to watch.

[749] See David C. Reynolds 'Redrawing China's intellectual map',32. Indeed,a contemporary newspaper called Fryer and his colleagues 'secular missionaries'.(See *NCH*(26th December,1872),548-549.)

brilliantly they mastered the new technologies it was impossible for them to do more than slow the relative weakening of China's military capability in the face of increasingly insolent and well-armed Western aggression. If anything,in the short term the development of an interest in Western science actually undermined China's ability to resist Western advances,as China came to rely for several decades on Western teachers (or on Chinese students travelling abroad) and Western technology,and this made China more rather than less dependent on the West. Science as practised in China became involved with the solution of short-term problems such as acid and gunpowder manufacture,less concerned with the nature of the world than a means to an end.

The scientific community in Wuxi,which built on the earlier *kaozheng* scholarly networks,seems in retrospect a brilliant episode,a false dawn or intellectual stillbirth which was prevented by a variety of historical factors from leading to a full renaissance of the native tradition of science in China Sidetracked by the desperate military needs of the time,native scientific originality had no choice but to give way to the desperate need to develop indigenous versions of foreign technology. A China-based military-industrial technology was the pressing need: a permanent *scientific* community,which could afford the time to follow wherever intellectual curiosity would lead,was for China a luxury which would have to wait.

These men nevertheless provided vital link between the *kaozheng* cultural heritage and the new networks of Western science,bringing the authority of the scholarly elite to a new way of perceiving the natural world. They played the role of what Daiwie Fu[750] has called *bilinguals*,able to converse within both the old and new paradigms(even if they

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[750] Fu,'Problem domain',127-131

rejected the 'impure' aspects of the former),and thus demonstrated through their lives and work the essential continuity of the Chinese and Western traditions of science,and were therefore particularly well-equipped to translate the new ideas into a Chinese idiom. For the foreign agents of transmission,mainly missionary educators,who hoped through Western science to open the eyes of the Chinese to their religion,these 'bilinguals' were of incalculable value,although their help and expertise were often barely acknowledged by the Western 'translator'.[751]

We now turn to consider the new institutions which formed part of the network in which Western science was taught and propagated,and through which it eventually became part of modern Chinese culture.

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[751] '[Produced] by the aid of an intelligent native' was for instance how Benjamin Hobson described one of his medical compilations. (Wong and Wu,365)

Chapter 10: Science in the new institutions

10.0 Introduction

In this chapter I shall consider how Western science came to be accepted as part of the education curriculum in late Imperial China. In 1850 China had no system of modern government schools: traditional education based on the Confucian Classics almost ignored natural science[752]; foreign missionary colleges were few in number and fewer still taught natural science. Yet by 1900,there were government establishments teaching technical subjects in many major cities,some missionary schools had begun to take science teaching seriously,and there were journals edited by foreigners and Chinese in many provinces regularly carrying articles of scientific interest.

One reason for this sea-change was the rise of the official government Tongwenguan schools.(Initially all of these institutions were called Tongwenguan or 'Interpreters' Colleges',in order to deflect criticism from the conservatives who objected to any teaching of Western studies.) Although the Tongwenguans did teach foreign languages,they gradually introduced mathematics,science and related disciplines into their curricula. The Chinese government tried to prevent Christianity being introduced by the foreign teachers,as many though not all the foreigners in the Tongwenguans were missionaries or ex-missionaries who hoped to incline the minds of the young Chinese towards the Western way of thinking. The missionary schools initially concentrated more on teaching

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[752] For the traditional education system in China,see Knight Biggerstaff,*The earliest modern government schools in China*(Ithaca,N.Y.:Cornell University Press,1961); Sally Borthwick,*Education and social change in China*(Stanford:Hoover Institution Press,1983) Chapters 1 and 2; Miyazaki Ichisada,*China's examination hell* Conrad Schirokauer trans.(New Haven:Yale University Press,1981).

English,a subject which by the 1890s was coming to be in demand,but there were outstanding colleges where natural science was a central part of the curriculum,the most remarkable example being Dengzhou College,run by Julia and Calvin Mateer.

10.1 Science in the modern government schools

10.11 The Beijing Tongwenguan[753]

The Beijing Tongwenguan was set up in 1862 as part of a series of measures by the Self-strengthening faction in the Tongzhi administration,as a result of a memorial to the

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753 The primary sources on the Beijing Tongwenguan are: *Calendar of the Tungwen College*(Beijing,1879); *Calendar of the Tungwen College*(Beijing,1888); and W.A.P.Martin,*A cycle of Cathay*,293-327.

The secondary literature includes: Knight Biggerstaff,'The T'ung Wen Kuan' in *The Chinese Social and Political Science Review* **18**(1934),307-340; Knight Biggerstaff,'The secret correspondence of 1867-1868: views of leading Chinese statesmen regarding the further opening of China to Western influence' in *Journal of Modern History* **22**(1950),122-136; Peter Duus,'Science and salvation in China: the life and work of W.A.P.Martin 1827-1916' in *POC* **10** (1956),97-127; Chang Hao,'The anti-foreignist role of Wo-jen (1804-1871)' in *POC* **14**(1960),1-29; Liu Kuang-ching, 'Early Christian colleges in China' in *JAS* **20**,1(November,1960),71-78; Knight Biggerstaff,*The earliest modern government schools in China*(Ithaca,N.Y.:Cornell University Press,1961); Shu Xincheng 舒新城 *Zhongguo jindai jiaoyushi ziliao*中國近代教育史資料[Materials on the history of modern education in China]3 vols.(Beijing:Renmin jiaoyu chubanshe 人民教育出版社,1961),121-128; Liu Kwang-ching,'Politics,intellectual outlook and reform: the T'ung-wen-kuan controversy of 1867' in Paul A.Cohen and John E.Schrecker (eds.)*Reform in nineteenth- century China*(Harvard:East Asian Research Center,1976),87-100'; Su Jing 蘇精,*Qingji Tongwenguan ji qi shi-sheng* 清季同文館及其師生[The Qing dynasty Tongwenguans,their students and teachers](Taibei: Su Jing,1985); Xu Zhenya,'Jingshi Tongwenguan zhong de huaxue jiaoyu'; Wang Yangzong 王扬宗 'Jiangnan zhizaoju fanyiguan shilüe'江南制造局翻译馆史略 [A brief account of the Translation Department of the Jiangnan Arsenal]'in *ZGKJSL* **9**,3(1988),65-74; Jin Fu 金福, 'Jingshi Tongwenguan kaishe tianwen suanxue shimo 京师同文馆开设天文算学始末 [An account of the establishment of the teaching of astronomy and mathematics at the Beijing Tongwenguan] in *ZRBZFTX* **14**,6(1992), 62-66.

Throne by Prince Gong(Gong qinwang 恭親王),Wenxiang文祥(1818-1876)[754] and Guiliang 桂良(1785-1862)[755]. It was modelled on the Russian Interpreters' School *Eluosiwen guan*俄羅斯館 [Russian language school] which had been established in the Qianlong period[756],and funded by revenue from the Imperial Customs Service directed by Robert Hart. Similar institutions were also started in Shanghai,Fuzhou and Guangzhou. At first it was to teach only foreign languages[757],but in 1867 it widened its curriculum to include mathematics and natural science,in the face of bitter criticism from conservatives,who even blamed the Tongwenguan for the severe drought which occurred in the same year.[758] The opposition was led by Grand Secretary Woren 倭仁 (1804-1871),President of the Hanlin Academy,who regarded it as shameful that Chinese should regard

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[754] Hummel,853-855

[755] Hummel,428-430.

[756] Biggerstaff,'The T'ung Wen Kuan',307

[757] John Fryer taught English there from 1863 to 1864,being succeeded by W.A.P.Martin.

[758] Jin Fu,63

barbarians as having anything worthy of teaching.The resistance also took the form of the pasting up of satirical couplets and slogans.[759]

In its contempt for 'techniques' and emphasis on the 'minds of the people',Woren's polemic has echoes in a much more recent phase of China's history. Woren's opposition was certainly xenophobic,but it has to be admitted that in his fear of the consequences of allowing foreigners to teach in Chinese institutions he was prescient: the acceptance of Western studies(along with many other factors) would indeed result in a tearing of the fabric of the traditional order,a loss of identity which even in the late twentieth century has not been fully resolved.

Initially the Tongwenguan attracted few good students,the scholarly families being unwilling to risk their sons' education by sending them to a foreign institution,and a majority of the students were those of mature years who had failed to find positions elsewhere. From 1867 graduates from the Guangzhou and Shanghai Tongwenguans came to Beijing for further study,but little real progress was made until William Martin returned to the College in 1869 and reorganised it,incidentally putting science teaching on a firmer footing.

10.111 Students and their science teachers at the Beijing Tongwenguan

The students' living conditions were excellent,and some official position was more or less guaranteed.[760] They were sometimes well into middle age and some found the

[759] *ibid.*,63

[760] Biggerstaff,'The earliest modern government schools',141

difficulties of learning a foreign language beyond them.[761] They preferred to go to the lectures of Li Shanlan rather than expose themselves to the humiliation of learning from foreigners, leading one writer to conclude

> Education would enlighten them; but they refuse to be educated.[762]

Despite all these difficulties, natural science formed an important part of the curriculum from a surprisingly early stage in the life of the Tongwenguan, and the institution attracted some excellent teachers. Apart from the formidable W.A.P.Martin himself, one of the most notable professors was the French chemistry graduate Anatole Billequin, who taught chemistry at the Tongwenguan from 1870[763] to 1893, returning to France where he died a year later[764]. He translated two important chemistry textbooks as *Huaxue zhinan* 化學指南 and *Huaxue shanyuan* 化學闡原, and was instrumental in the building of a chemistry laboratory in 1876. After his death his post was occupied by Carl

[761] See M.J.O'Brien, 'The Peking College' in *NCH*(25th January, 1870), 63-66. O'Brien was an English teacher at the Tongwenguan: he reported that in his "Junior" class only two of the students were under 30, many of the rest being in their forties or even fifties. Not surprisingly, some of these "fossils" (as he called them) made little progress, one being

> so old that his organs of speech were enfeebled by the weight of years, and his attempts to articulate the outlandish sounds in the English syllabary proved fatal to the waggish young fellows of 40 and 50 his comrades. (*ibid.*, 64)

[762] *NCH*(25th January, 1870), 59

[763] He was appointed in 1867 but did not arrive until 1870. See *Calendar of the Tungwen College*(1879), 32. He was also Professor of Physics 1867-1888.

[764] The Chemistry department did not open officially until 1870. (See 1879 *Calendar of the Tungwen College*, 32)

Stuhlmann, a graduate of Hamburg, who taught chemistry and mining.

From 1869 Li Shanlan from the Translation Department of the Jiangnan Arsenal came as professor of mathematics, where he stayed until his death in 1882, when he was succeeded by his student Xi Gan 席淦, who had originally been a student at the Shanghai Guang Fangyanguan .

W.A.P.Martin himself, having originally been a teacher of English, taught mathematical physics there when he returned to take on the office of President of the College in 1869. C.H.Oliver(1857-1937) became Professor of Physics from 1888-1900, and in 1894 Oliver took over the post of Vice-President of the College from Billequin, finally becoming President in 1895.[765]

A suitable occupant for the chair of astronomy proved difficult to find. The first Professor of Astronomy to be appointed was the self-styled 'Baron' Johannes von Gumpach who was appointed in 1866, but proved to be a (somewhat entertaining) impostor and never took up his duties, his connection with the College ending rather pathetically in a court case in which he sued Robert Hart for breach of contract[766]. It was not until 1877 that Mark Harrington of the University of Michigan was appointed to replace him, and his stay only lasted a year, followed by a hiatus with H.Fritsche of the Russian Observatory as acting Professor, before the arrival of S.Marcus Russell(of Queen's

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[765] Oliver taught his science courses in Chinese, and by 1898 physics and chemistry were being taught in German and Russian as well as Chinese. See Biggerstaff, *The earliest modern government schools in China*, 127.

[766] W.A.P.Martin, *A cycle of Cathay*, 304. Von Gumpach claimed to have developed a system which would overthrow the Newtonian theory of gravitation. See also Biggerstaff, *The earliest modern government schools in China*, 120 n.50.

Figure 34. William Alexander Parsons Martin, science lecturer and first President of the Beijing Tongwenguan

College,Belfast) in 1879[767].

In 1871 a medical class was also set up under Dr John Dudgeon,an Edinburgh graduate.[768]

There was an enormous disparity between the pay of the foreign teachers and the Chinese: W.A.P.Martin received £3,600 p.a.,Billequin £1,000 p.a.,whereas a Chinese teacher was given only a small fraction of this amount[769].

10.112 The curriculum of the Beijing Tongwenguan

Students were expected to attend class every day,with two semesters separated by two vacations of four to five weeks each,although foreign professors had Sundays free[770]. Four foreign languages,English,French,German and Russian,were taught,science classes being taught either in English or Chinese[771].

From 1872,the main course lasted eight years,with a curriculum laid down as follows:

Year 1.Reading,writing and speaking[Chinese][772]
Year 2.Reading,grammar,and translation of

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[767] *Calendar of the Tungwen College*(1879),35. Russell remained at this post until 1900.

[768] Dudgeon stayed in post until 1895. See Biggerstaff,*The earliest modern government schools in China*,145

[769] John Fryer received £800 as Director of the Jiangnan Arsenal Translation Department.

[770] Biggerstaff,'The T'ung Wen Kuan',328

[771] *Calendar of the Tungwen College*(1879),18

[772] The speaking aspect of the course was necessitated by the fact that many students were Manchu Bannermen's children,for whom Chinese was a second language.

sentences;exercises in speaking(continued through the whole course)

Year 3.Geography,history,exercises in translation

Year 4.Arithmetic,algebra,translation of despatches

Year 5.Natural philosophy[physics],geometry;trigonometry,plane and spherical;exercises in translation

Year 6.Mechanics,theoretical and practical;the calculus,differential and integral;navigation and surveying;exercises in translation

Year 7.Chemistry,astronomy,international law,translation of books

Year 8.Astronomy,geology and mineralogy,political economy,translation of books

There were also lectures for 'a select class' on physiology and anatomy.[773] Chemistry was clearly reckoned to be one of the hardest subjects in the course as it was left until the penultimate year.

Students who were not learning a foreign language(often those who were already advanced in years) could follow a five-year course:

Year 1.Arithmetic,algebra,and Chinese mathematics

Year 2.Algebra(*siyuanjie* 四元解);geometry;and plane and spherical trigonometry

Year 3. Natural philosophy[physics],chemistry,mathematical physics(*zhongxue cesuan* 重學測算)

Year 4.Differential and integral calculus,navigation and surveying,and theoretical and practical mechanics

Year 5.International law,political

[773] *ibid.*,19. The curriculum in 1888 was identical.

economy,astronomy,geology and mineralogy[774]

The single year each spent on physics and chemistry could not have been expected to result in a very deep study,and this is confirmed by the examination questions(See below Section 10.113),which show considerable variation in the knowledge expected in the various branches of science.

The statistics for the numbers of students in science classes at the Beijing Tongwenguan in the years 1879 to 1898 are given below.

<u>Table 11. The numbers of students studying science,mathematics and medicine at the Beijing Tongwenguan</u>

subject	1879[775]	1888[776]	1893[777]	1898[778]
astronomy	6	5	7	11
chemistry	12	20	10	34
mathematical physics	7	4	3	0(i)
mathematics	33	20	25	30
medicine	-	9	7	0
physics	-	-	20	4
physiology	8	9	7	(ii)

774 Biggerstaff,'The T'ung Wen Kuan',329

775 *Calendar of the Tungwen College(1879)*,12-13

776 *Calendar of the Tungwen College*(1888),12-13

777 Xu Zhenya,36

778 Xu Zhenya,36

Notes: (i)Presumably the classes in physics that were offered from 1893 meant that mathematical physics no longer attracted so many students.

(ii)No figure is given for the physiology class in 1898.

It is interesting to note the relatively large numbers in the chemistry class,no doubt due in part to Billequin's enthusiastic teaching over a period of more than twenty years,but also to the growth in Government Arsenals where chemistry had some application. According to Martin,they were unable to expand the teaching of medicine because the ministers in charge of the Tongwenguan

> feared encroaching on the domain of the Tai-i-yuen[*Taiyiyuan* 太醫院],an effete college of medicine which has charge of the Emperor's health and is supposed to possess a monopoly of medical science.[779]

This was one of the disadvantages of a college situated in the cockpit of conservatism,and probably why Shanghai proved to be much more fertile ground for science journalism and other populist ventures than Beijing.

The Beijing Tongwenguan held examinations at the end of each month,each semester,each academic year,and a final examination.

10.113 The teaching of chemistry at the Beijing Tongwenguan

A chemical laboratory and mineralogical museum were

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[779] W.A.P.Martin,*A cycle of Cathay,*320. On the Taiyiyuan,see E.V.Cowdry,*The Office of Imperial Physicians,Peking*(Chicago: American Medical Association,1921).

built in 1876[780],followed in 1888 by an observatory and physics laboratory.One of the attractions of the chemistry course at the Tongwenguan was the emphasis which Billequin put on practical work,and also the parallels which he drew with Chinese alchemy. According to Martin

> Quick of apprehension and patient in application,Chinese students succeed well in scientific studies. They have always shown a marked preference for chemistry,perhaps because it is the offspring of Chinese alchemy,of which they have read so much in native literature. One day,after the close of a chemical lecture,a member of the class was discovered to be on fire. Out of zeal for science he had purloined a stick of phosphorus and secreted it in his vest pocket.[781]

In this emphasis on the Chinese tradition Billequin was markedly different from John Fryer and Xu Shou,who deliberately avoided making comparisons with traditional Chinese science in their works. Xu Shou is known to have had trenchant views on traditional Chinese science,and this too may account for his lack of interest in the alchemical tradition.

Students who missed classes,especially practical classes,and who failed to do homework,had to make up the time,and this seems to have been a considerable problem for the Tongwenguan,many of whose students were married,and their family commitments must have made study difficult.[782]

According to Qi Rushan 齊如山,a Tongwenguan student,the

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780 W.A.P.Martin,*Calendar of the Tungwen College*(1879),33

781 Martin,*A cycle of Cathay,*314

782 Xu Zhenya,32

first month of the chemistry course was spent first explaining the use of filter funnels, crucibles(*rongguo*融鍋), the spirit lamp, with glass tubes, thermometer, etc taking a further two or three months.[783]

The chemical syllabus was as follows:

> Chemistry is based upon elements(*yuanxing* 原行) as the origin of all matter, and of these elements there are altogether 67, divided into non-metals and metals. Each element has its own properties, with those of similar properties forming a family. The two types [metals and non-metals] are each divided into five families. [There are] those which when reacted with oxygen form acids, [and] those which form bases[*fansuan* 反酸] ;acids and bases react to form salts. Anyone studying mineralogy need to be able to analyse samples. Some are decomposed by dissolving[*xiao* 消], others by melting, some change when they are in contact with acid, others change when in contact with heat. There are methods of separating gold, silver and lead, and the manufacture of iron; the method for making copper, making silver, making gold, making platinum.[784]

The main books used to teach chemistry were *Gewu rumen* 格物入門 by W.A.P.Martin, *Huaxue zhinan* 化學指南, translated by A.Billequin; *Huaxue ghanyuan* 化學闡原 also translated by Billequin; and *Fenhua jinliang* 分化津梁[An aid to analysis] translated by Carl Stuhlmann and Wang Chongxiang 王重祥.

<u>*10.114 Examples of Beijing Tongwenguan examination science*</u>

[783] *ibid.*, 32

[784] *ibid.*, 32

questions[785]

The examples of Annual examination questions cited in the *Calendar of the Tungwen College* are not given any further explanation there,so that it is not certain whether these were for the final (Year 5 or Year 8)examinations,nor whether they were all attempted by all candidates,or even whether they had to be answered in English.

In astronomy

(1879)Find the time of sunrise and sunset at Peking on the first day of the Chinese New Year - January 22nd,1879.

(1888)Supposing Mars revolves on its axis in 24 hours and that an inner satellite revolves around Mars in exactly the plane of its equator in $7^h\ 39^m\ 14^s$,also that this satellite is 4,000 miles from Mars,calculate to a spectator on Mars how long this satellite would remain above his horizon(diameter of Mars is 4,200 miles).

In mathematics

(1879) Find the area of an ellipse in terms of its major and minor axes.

(1888) 100 men in 20 days excavate 40 yards of canal,how many men are required to excavate 80 yards in 4 days?

In physiology

(1879)Give an account of the vertebral column.

(1888) Give the composition of milk and eggs,and show that they are sufficient by themselves to maintain life.

In chemistry

(1879)Given a mixture of chloride of sodium and chloride of potassium,how may these substances be separated?

(1888) The principal minerals of silver are the following:native silver,silver sulphide,silver chloride,silver arsenide;what are the various methods for

785 These examination questions are taken from the 1879 *Calendar*,21-24 and the 1888 *Calendar*,23-27.

extracting pure silver from them?[786]

It can be seen that these question vary widely in difficulty within each subject,and from subject to subject,with much more expected in astronomy and mathematics than physiology or chemistry. This reflects both the fact that the students at the Tongwenguan varied widely in background,some having already had several years of teaching at other Tongwenguan and therefore able to attempt rather advanced questions,others having barely begun the course;and the wide variations in time allotted to the various subjects.

10.115 The science graduates of the Beijing Tongwenguan

According to the 1888 *Calendar*,most of the Beijing Tongwenguan graduates obtained jobs as interpreters with the Zongli Yamen and provincial offices,or as advisers on foreign affairs. Very few seem to have had posts which directly used their knowledge of science.

The Tongwenguan graduates here suffered the fate of pioneer experts: their knowledge was by definition mostly of value only in the very institutions(Arsenals,Tongwenguans)they were in the process of creating. The 1888 *Calendar* noted that Wang Wenhao became teacher of chemistry to the Office of City Guards; Cheng Lin 承霖 went to work at the Tianjin Arsenal[Tianjin junxieju 天津軍械局] and Xi Gan became Professor of Mathematics at the Beijing Tongwenguan itself. Wang Chongxiang 王重祥 was assistant chemistry lecturer at the Beijing Tongwenguan 1887-1898. This was not a very impressive record of graduate employment after 26 years of

[786] The original questions were set in French(presumably by Billequin) in 1888,but had been set in English in 1879.

the existence of the Tongwenguan,as its purpose was supposed to be supplying trained scholars,yet the brutal truth was that there was little demand for their services. Nevertheless the Tongwenguan helped to create an ambience in which Western science was regarded if not as of practical use at least worthy of study,and thus prepared the way for the more wholehearted attempts at science education in the early twentieth century.

In 1898 the National University,the forerunner of today's Beijing University,was founded as part of the Hundred Days' Reform,and all science teaching was transferred there from the Tongwenguan,which survived only four years before being amalgamated with the new institution.[787]

10.12 The Shanghai and Guangzhou Tongwenguans[788]

The Shanghai Tongwenguan was founded in 1863. In 1870 its name was changed to Guang fangyanguan 廣方言館 [Languages College],and it moved to the site of the Jiangnan Arsenal becoming in effect one of the departments of the Arsenal,[789] receiving its financial support from Shanghai shipping dues and maritime customs revenues.[790]

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[787] Knight Biggerstaff,'The T'ung Wen Kuan',340

[788] The primary source for the Shanghai Tongwenguan is 'Guang Fangyanguan quan'an' 廣方言館全案 [A complete account of the Shanghai Tongwenguan] (1894) in 杨逸 (ed.) *Shanghai tan yu Shanghai ren congshu* 上海滩与上海人丛书 [The Shanghai Bund and Shanghai People collection](Shanghai guji chubanshe 上海古籍出版社,1989),101-163. See also Biggerstaff,*The earliest modern government schools in China* and Nancy Evans,'The Banner-School background of the Canton T'ung-wen Kuan' in *POC* **22A**(1969),89-103.

[789] See Biggerstaff,*The earliest modern government schools in China*,167 and 'Guang fangyanguan fang'an',117.

[790] Biggerstaff,*The earliest modern government schools in China*,176-177.

A contemporary foreign description ran:

> [....The college is] a rather handsome piece of Chinese architecture,enclosing a square,and having verandahs all round,both inside and out. The whole upper storry[sic] is to be devoted to the translation department.
>
> The course of instruction to be pursued by the students of the college will have reference to the work carried on in the arsenal,and will be practical as well as theoretical. It is proposed to begin with a course of mathematics,geography,drawing and other elementary subjects; but eventually the students will be divided into classes for mining and metallurgy,the manufacture of firearms,steam-engines,and other machinery,naval architecture,seamanship and navigation,and naval and military tactics.[791]

There was a (justifiable) fear that students would be corrupted by Christian teachings of the foreign lecturers,most of whom were ex-missionaries,and who tended to see their educational work as part of a wider mission to Christianise the Celestial Empire,with Western science an 'auxiliary to the Gospel' [792]

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[791] *NCH*(11th January 1870),22

[792] See Li Hongzhang's memorial of 11th March 1863[Tongzhi 2.1.22] quoted in 'Guang Fangyanguan quan'an',107-109,in which Li quotes from Feng Guifen's *Jiaobinlu kangyi*,expressing contempt for the 'linguists' of Guangzhou and stresses the need for translations of books on mathematics,science and manufacture. In another memorial on 13th April of the same year,an imperial edict is quoted,mentioning the dangers of foreign teachers teaching Christianity by stealth [*jie duan ying she jiang Tianzhujiao an zhong chuanxi* 藉端影射將天主教暗中傳習](*ibid.*,109) . See also W.A.P. Martin,'Western science as auxiliary to the spread of the gospel' in *CR* **29**(1897),111-116.

The best graduates were sent to the Beijing Tongwenguan.[793] There were originally ambitious plans for a fully developed scientific and technical programme,but the reality fell far short of this.[794] According to Guo Songtao,writing in 1879,there were classes in Chinese,in English(being taught by Young J.Allen and Shu Gaodi 舒高第 [Dr V.P.Suvoong],an American-born Chinese (both of whom also worked as translators at the Arsenal)),and a class in French,taught by John Fryer. The 'Western studies' classes included [engineering] drawing(*huatu* 畫圖)and the study of marine engineering; mathematics,artillery and shipbuilding,all taught by foreigners. There was no homework,and students were given a monthly stipend.[795]

In the 1870 plans,students were to be divided into two classes,a junior and a senior. In the junior class,they studied international law,arithmetic,algebra,logarithms,geometry,mechanics,astronomy,geography and drawing. Those who were training to be translators,also studied Western languages,studied in the morning,each chapter for seven days,at the end of which time they were given positions,and the top students given prizes. At the end of the year there was another examination which allowed them to move to the senior class,where they studied 'the arts'.

The senior class was to be subdivided into seven branches of learning: prospecting for minerals,and the extraction of metals; the use of metals to make machinery; the manufacture of timber or iron; the drawing of plans for

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[793] Biggerstaff,*The earliest modern government schools in China*,115.

[794] Biggerstaff,*The earliest modern government schools in China*,164

[795] Guo Songtao 郭嵩焘,*Lundun yu Bali riji* 伦敦与巴黎日记(Changsha:Yuelu shushe 岳麓书社,1984),922-923 dated 6th April,1879 [Guangxu 5.3.15].

steam engines and the running of machines; navigation; sea and land warfare; foreign languages,and the customs and government of foreign countries.[796]

Yet,according to John Fryer,speaking in 1880 to Guo Songtao

> "The Shanghai Guang fangyanguan is all but a dead letter (*juwen* 具文). At first an English department(*ju* 局) was set up,later a French department,but now only a few [students] remain: there are just 20 youths,and it seems akin to a primary school. Moreover,a mining department,a machine department,and a navigation department were set up,all run by foreigners,none of whom could speak Chinese. None of their students knew foreign languages,so they had to hire interpreters,and [as a result,the students] were more concerned with paying their [interpreters'] salaries and did not ask about the subject-matter of their studies."[797]

One reason for the low morale were the poor career prospects for its graduates,even as interpreters,let alone in the fields of science and technology[798],another probably the relative ease of finding work with the foreign firms in Shanghai once a reasonable grasp of a foreign language had been obtained. In referring to his work in the Translation Department of the Jiangnan Arsenal,Fryer commented despairingly on the neighbouring school

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[796] 'Guang fangyanguan quan'an',122 and also Biggerstaff,*The earliest modern government schools in China*,172

[797] Quoted by Guo Songtao,*Lundun yu Bali riji*,923-924. Guo commented "Everything is hard at the outset,but if at the start it is a dead letter it is particularly difficult to rectify it. Hearing Fryer's words,I gave a deep,melancholy sigh."

[798] Biggerstaff,*The earliest modern government schools in China*,180-181

> Strange to say,there are schools which have existed for several years in the Kiangnan[Jiangnan] Arsenal where these books are published[...] without making any use of these translations. They are taught by foreigners who neither speak nor write Chinese,to scholars who had to begin with no knowledge of foreign languages. The fact that such classes are carried on in close proximity to this Department would seem to furnish strong proof of the uselessness of the whole work of translation. Like many other things in China,it is difficult to account for. It must be acknowledged however,that some of these scholars have made very fair progress in their studies and reflect great credit on their instructors,who have laboured under such immense disadvantages.[799]

Fryer's jaundiced view cannot be taken entirely at face value,as he had reason to feel pique at the lack of interest in his department's translations,but it does appear that pure science played a much less important part in the curriculum of the Shanghai Guang Fangyanguan than in the Beijing Tongwenguan,probably because the main purpose of the Arsenal was supposedly to make ships and weapons,and to train Chinese engineers who would be able to carry out this work for themselves. Evidently the managers of the Arsenal did not believe that 'pure' science was needed by such students,a grievous mistake for which China would pay dearly in the years to come.

Nevertheless,Biggerstaff points out that a surprisingly large number of its modest number of graduates did rise to

[799] John Fryer,'An Account of the Translation Department'(*NCH* version)',81

positions of prominence, including Xi Gan [800], who succeeded Li Shanlan as Professor of Mathematics at the Beijing Tongwenguan in 1886, but none seems to have achieved prominence in the fields of science or technology .

The Guangzhou Tongwenguan opened in 1864 with 20 students mainly from the Manchu and Han Chinese Bannermen families of the Guangzhou garrison. As in the Shanghai Tongwenguan, the abler graduates were sent on to Beijing to complete their studies. Progress was disappointing, as the interpreters had little to do, and, as in Shanghai, the abler students soon left to develop their careers in more conventional ways. As Nancy Evans records:

> After they have studied for one or two years and know a bit of the language and literature, all make excuses, say they are ill, and leave the school to plan their careers. Students who work hard are rare [among them].[801]

It seems that little more than elementary science was taught at the Guangzhou Tongwenguan.[802]

10.13 Science teaching at the Fuzhou Shipyard Fore-Academy[803]

The Fuzhou Academy, founded in December, 1866 on the

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[800] Xi Gan was originally a student of English at the Guang Fangyanguan, later being sent to the Beijing Tongwenguan in 1868. See 'Guang Fangyanguan quan'an', 115 and Su Jing, 108.

[801] Evans, 95

[802] Fryer, *Educational directory for China*, 82

[803] See Steven A. Leibo, *Transferring Technology to China*; Gideon Chen, *Tso Tsung-t'ang*; and Fang Aiji, 'Woguo zuizao de zaochuan zhuanke xuexiao: Fuzhou chuanzhengju qianxuetang'.

site of a former temple,was based in the Naval Shipyard,and divided into two departments,Naval Architecture and Navigation,known in Chinese as respectively the 'Fore-academy' *Qianxuetang* 前學堂)' and 'Aft-academy' (*Houxuetang*後學堂)' .The Fore-academy was the French-language school of naval construction,including naval construction,ship design and apprentices; the Aft-academy was the English-language school of navigation,including theoretical navigation,practical navigation and engine-room.[804] The naval construction department of the Fore-academy included some teaching of physics and mechanics as well as the required mathematics.[805]

The students in the French division were aged 13 to 18 and mostly came from Fuzhou,being allowed entry after examination; in the English division some came from Guangdong or Hongkong.[806] Their parents had to promise not to take their sons away for long holidays,and,apart from Chinese New Year,only at the Mid-Autumn and Dragon Boat Festivals were they allowed to take three days' holiday.[807] They were given a subsistence allowance and a stipend of four taels of silver per month. The majority of the teachers were French(apart from the teachers of Chinese language)until 1883,brought from France by Prosper Giquel. They were generally not well qualified,and the teaching was conducted at a low level,with one teacher covering several subjects.[808] Lessons were ill-prepared,and the content tended to be very out-of-date.It is not surprising to

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[804] Biggerstaff,*The earliest modern government schools in China*,210 and 222

[805] *ibid.*,211

[806] Fang Aiji,57; Biggerstaff,*The earliest modern government schools*,225

[807] Fang Aiji,58

[808] *ibid.*,57

discover that the student drop-out rate in the naval construction department alone was around sixty percent.[809]

The course lasted for 8 years,the first 3 years being devoted to learning French,studying Chinese and mathematics. From the fourth year they studied physics, chemistry,geometrical drawing,mechanics,statics,mining and surveying. The textbooks used were in French,and the same textbooks were used for several decades,and there was little practical work,what little there was being concentrated in the months leading to the examination.[810]

During the period of Chinese management,running from Giquel's departure in 1874 until 1895,a new electricity department was added. Although the Shipyard itself was no longer run by foreigners,the academies seem to have had some foreign teachers.[811] In 1877 Giquel took a group of students from Fuzhou to Europe,where he and Li Fengbao 李鳳苞 were to act as joint supervisors.[812] Twelve went to Britain to study ship operation,surveying and science,the most famous being Yan Fu,the translator of Thomas Huxley's *Evolution and ethics*. Nine went to France,where they studied ship construction,ship's engines,mining and metallurgy.Those who studied the latter two subjects were also sent to Germany to investigate German mines and metal refineries. [813] Further groups of students from Fuzhou

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809 *ibid.*,211. Biggerstaff states that of 105 students admitted to this department in 1867,only 39 remained by 1873,60 having been dismissed,often for non-attendance,and 6 had died,an alarmingly high mortality rate.

810 Fang Aiji,58

811 Biggerstaff,*The earliest modern government schools in China*,223

812 *ibid.*,232

813 *ibid.*,233-235.

went to Europe in 1882,1886 and 1897,and by this time there was a marked increase in the number of applicants to the school,reflecting the increased interest in Western studies after the war with Japan.[814]

During the Franco-Chinese War of 1884-1885,the foreign teachers were evacuated by the French Navy,the Shipyard and the Academies were severely damaged by French bombardment. Nevertheless the Qing government implored the foreign teachers to return,and only with great reluctance allowed a Chinese returned student Zheng Qinglian 鄭清濂 to teach as an assistant lecturer on a far lower salary than the foreigners were paid.[815]

By the 1890s it had become increasingly difficult to recruit students,as there were so few naval appointments available,and a new policy of recruiting younger students was implemented,which proved rather successful.[816]

10.131 Graduate opportunities at the Fuzhou Shipyard Fore-Academy and its decline in the 1890s

The teachers excused their low standards by saying that the Fuzhou Academy was preparing students to study in France,but even if they did,on their return to China it was hard to find work which used their knowledge. In 1881 six students from the Academy went to France to study,where several were allowed to change from shipbuilding to law,and

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[814] Biggerstaff,*The earliest modern government schools in China*,235,237,241-242

[815] Biggerstaff,*The earliest modern government schools in China*,224,234,235,245. The same practice of remunerating foreign teachers far more generously than their Chinese colleagues continues in contemporary China,for the very practical reason that few foreigners could be induced to teach for a local teacher's salary,which might easily be 10% or less of the pay he or she could command in the West.

[816] Biggerstaff,*The earliest modern government schools*,227 and 242

two to mathematics,physics and chemistry,which they presumably saw as better career prospects. Of the fourteen who of the third group to go to France,only six studied shipbuilding,and of those one died and one failed the final examination.[817]

In 1875,a group of graduates were,despite their inadequate teaching,able to design and build a 200 horsepower wooden ship,but after leaving Fuzhou most were unable to find positions which required their engineering skill. A notable exception was Chen Zhao'ao 陳兆翱 who built several steamships on his return to China. He is said to have died at the age of 40,vomiting blood on being told that all his ships had been sunk by the Japanese during the war of 1894-1895.[818] The ships the Fuzhou Shipyard built were 'outmoded and incapable of defending China'[819],and the Manchu director Yulu 裕 祿 admitted in 1897 that rapid technological progress in the West had made the yard's products obsolete.[820]

10.14 Other government schools

Important government schools teaching science were also set up at Tianjin[821],Nanjing[822] and Wuchang[823]. Yet by the

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[817] Fang Aiji,59

[818] Fang Aiji,59 and Biggerstaff,*The earliest modern government schools*,229,234,235,245. Even more poignantly,several early Fuzhou graduates actually commanded ships in the Battle of the Yalu in 1894.(Biggerstaff,249)

[819] Biggerstaff,*The earliest modern government schools*,246

[820] *ibid.*,247

[821] The Imperial Chinese Northern Government telegraph College(founded 1879),the Imperial Naval College,the Imperial Military College and the Medical College. See Fryer,*Educational directory for China*(Shanghai:Educational Association of China,1895),85-86

1890s the Fuzhou Shipyard Schools,the Guangzhou and Shanghai Tongwenguans were all in a sad state of decline,at the very time when public interest in science began to develop,an interest which very few institutions in China were prepared to satisfy.[824]

10.2 'Public science': The Shanghai Polytechnic Institution and Reading Rooms[825]

The Shanghai Polytechnic arose out of a proposal in a letter by Walter Medhurst,British consul in Shanghai,in a letter on 5th March,1874 to the *North China Herald*,in which he proposed a 'Chinese Reading Room'[*Gezhi Shuyuan* 格致書院,translated by Medhurst as 'School for Search after Knowledge']826,whose object was

> to extend the knowledge of the Chinese in regard to Foreign countries and topics generally,and thereby to

[822] The Imperial Naval College(Fryer,*Educational directory for China*,84)founded in 1890.

[823] The Government Mining and Engineering College of the Hubei Board of Mines,founded in 1892(Fryer,*Educational directory for China*,86)

[824] Fryer,*Educational directory for China*,82

[825] The best general account remains Knight Biggerstaff, 'Shanghai Polytechnic Institution and Reading Room: an attempt to introduce Western science and technology to the Chinese' in *Pacific Historical Review* **25**,2 (May 1956),127-149; a much less reliable account is Wang Zhihao 王治浩 and Yang Gen 杨根, 'Gezhi shuyuan yu *Gezhi huibian*: jinian Xu Shou shishi yibai zhounian 格致书院与格致汇编纪念徐寿逝世一百周年 [The Shanghai Polytechnic and *Gezhi huibian*:commemorating the centenary of the death of Xu Shou] in Yang Gen(ed.)*Xu Shou*,142-153,which makes several errors in its chronology and generally overestimates Xu Shou's contribution to the work of the Polytechnic. See also Yao Wennan姚文枬 (comp.)*Shanghai Xian xuzhi* 上海縣續志[A supplementary gazetteer of Shanghai](1918; reprinted Taibei:Chengwen chubanshe 成文出版社,1970),9.17b-18a and Shu Xincheng,*Zhongguo jindai jiaoyushi ziliao*,67-68.

[826] The term *shuyuan* 書院 'academy' was well-established in China. See Suzanne Barnett,'Foochow's academies'.

promote good feeling between Foreigners and Chinese[827]

The term *gezhi* 格致 was commonly used as a translation of '[Western] science' at that time,and literate Chinese would have not been surprised to discover that its true object was as much the introduction of science as 'promoting good feeling'. Article 9 of Medhurst's prospectus stated that

> The rooms [are] to be supplied with maps,philosophical [i.e. scientific] instruments of various kinds,and any models of steam engines,locomotives,telegraphic apparatus,& c.,that can be procured.[828]

and Article 12. made the scientific emphasis still clearer

> Lectures on scientific subjects of practical value or general topics to be delivered in the Chinese language,now and then,as the Committee may arrange.[829]

Medhurst presumably hoped that science would present foreigners in a more benign light than the martial displays of the two Opium Wars,and that the Chinese public would be therefore support a more liberal and open attitude to foreign nations.

The initial committee consisted of Medhurst,Fryer F.B.Forbes,Alexander Wylie and the comprador Tang

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[827] John Fryer *First Report of the Shanghai Polytechnic Institution and Reading Rooms*(Shanghai:North China Herald Office,1875),4. There had in fact been an even earlier suggestion in an editorial of the *NCH*(26th December,1872),548 that 'a Reading Room be got up for Chinese'.

[828] John Fryer,*First Report*,4

[829] *ibid.*,4

Jingxing[Tong King-sing] 唐景星.[830] By the second meeting of the Committee in 1874,it had been decided to build a purpose built Polytechnic,named after the institution in Regent Street,London,and Xu Shou and Wang Ronghe 王榮和 [831] were invited to join the Committee.[832] The academy was modelled on the early Qing *shuyuan* 書院,to which students came to learn from a famous scholar,the *shanzhang* 山長 or 'mountain elder'.[833] By the Polytechnic's aims were expressed rather differently

> [...]to bring the Sciences,Arts and Manufactures of Western Nations in the most prominent manner possible before the notice of China.[834]

There followed a period of fund-raising,led by Xu Shou,who proved to be adept at persuading Chinese sponsors such as Li Hongzhang to lend their support and money.[835] In January 1875 Xu Jianyin was also invited to join the committee,with Fryer as Hon. Secretary and Walter Medhurst as Hon.Treasurer.[836] The new version of the aims of the institution was identical with that above save for the

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830 *ibid.*,5

831 Wang Ronghe was a translator at the Guang Fangyanguan.

832 *ibid.*,5

833 Xu Shou was the first *shanzhang*. After his death,the post was filled by Wang Tao 王韜 (1828-1897). See Chen Yuanhui 陈元挥,Yin Dexin 尹德新 and Wang Bingzhao 王炳照(eds.)*Zhongguo gudai de shuyuan zhidu* 中国古代的书院制度 [The academy system in ancient China](Shanghai:Shanghai jiaoyu chubanshe 上海教育出版社,1981),107-108.

834 *First Report*,5

835 *ibid.*,6.

836 *ibid.*,6

alteration of 'prominent' to 'practical'.[837] A 'Home Committee' to support the Institution was founded in

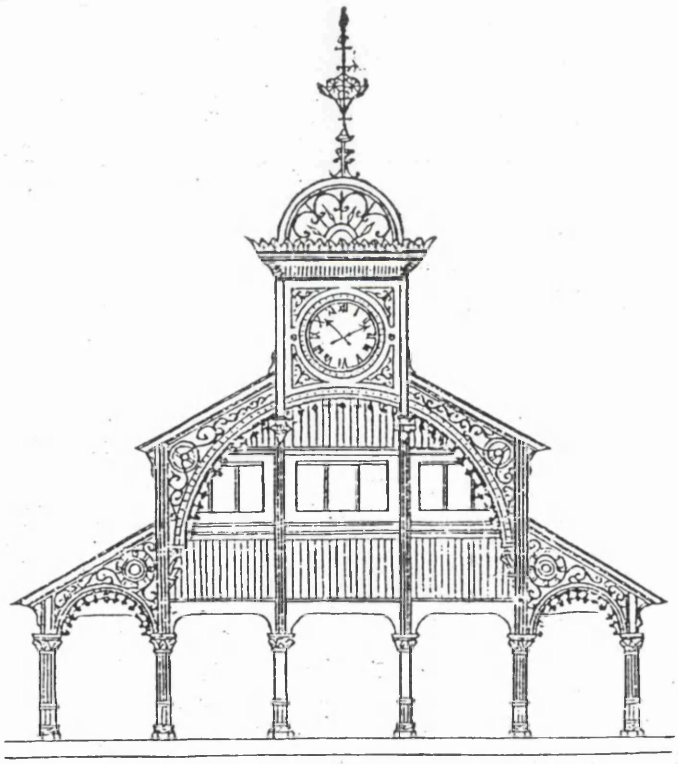

Figure 35. A drawing of the planned Shanghai Polytechnic, from *Gezhi Huibian* **2**,1(March,1877),6b

[Reproduced by kind permission of the British Library, India Office and Oriental Collections]

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837 *ibid.*,6

London[838],and a sister Institution was set up in Xiamen[Amoy].[839]

<u>*10.21 The early Shanghai Polytechnic: 'empty halls and incipient decay'*</u>

The Shanghai Polytechnic formally opened in June 1876,but its initial effect on the scientific education of the Chinese was almost negligibly small. The Reading Rooms attracted few visitors[840],and the library consisted of only a few hundred volumes.[841] The foreign members of the Committee seem to have done little to help,and the Chinese members had an agenda which gradually diverged from the public institution which Medhurst and Fryer had planned. By 1877 the failure had become public knowledge. The publicity surrounding the Polytechnic,initially entirely

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[838] *ibid.*,7. A leading figure in the Home Committee was John Bourne,a scientific instrument manufacturer.

[839] *ibid.*,10

[840] John Fryer *Second Report on the Chinese Polytechnic Institution and Reading Rooms,Shanghai* (Shanghai:North China Herald Office,1878),6. (To Fryer's shame,the Amoy Reading Room had proved to be far more successful than its 'parent' in Shanghai.(*ibid.*,6))

The earlier account of the Polytechnic in Fryer's journal *Gezhi Huibian* had been rather more optimistic. Noting that more Chinese visitors came in the morning,and foreigners in the afternoon,Fryer described the contents as including a globe,high-temperature electrical thermometer,with everyday objects such as needles,fish-hooks and buttons,and a large map showing China and its neighbours,and indicating suitable routes for railway lines.(*GZHB* **1**,6(July 1876),11b-12a)

[841] John Fryer,*Second Report*,7. Liu Xihong 劉錫鴻 wrote disparagingly in his *Diary* in 1876 that the Polytechnic should be called a 'Hall of a Forest of Arts'(*Yilintang* 藝林堂) rather than an 'academy for the extension of knowledge'. See Liu Xihong *Yingyao siji* 英軺私記 [Private notes on a journey through England] in Zhong Shuhe 忠叔河 (ed.)*Zou xiang shijie congshu* 走向世界叢書 [The *Going out into the World* collection](Changsha:Yuelu shushe 岳麓書社,1986),50-51.

positive,began to take on a more critical and even hostile tone. According to an editorial in the *North China Herald* of 15th March,1877

> [...]Mr Medhurst drew a contrast between the Museum at Hongkong and the Polytechnic at Shanghai.The former,he tells us in a letter read at the last meeting of the Shanghai Polytechnic,is crowded with Chinese visitors who take an intelligent interest in the specimens exhibited;the latter is practically deserted,or honoured at odd intervals by the visit of some passing stranger,who,hearing of its high-sounding name,has turned his steps thitherward to find empty halls and the incipient decay which seem to be the fate of all Chinese undertakings from their very commencement.[...]we[...]find H.E.Li Hung-chang[Hongzhang] appointing officials in connexion with the affairs of the institution -- in other words that it is being made part of that curious net within which the Viceroy of Chihli [Zhili] is striving to enfold every interest in the Empire. To monopolise the carrying trade of the Empire at the expense of the trade pretended to be fostered,and to steadily repress all private enterprise in any form likely to confer a tangible good on the country,are not sufficient for the aims of the present party in power. Beyond these,it strives to attain to the same pre-eminence in matters intellectual,and steadily to put down any attempt at freedom of thought as of freedom of trade or locomotion. The manner in which it deals with the Press is one instance of this,and we may add the Polytechnic is another.[842]

This extraordinary diatribe illustrates several interesting points. Firstly,that Xu Shou and Xu Jianyin

[842] *NCH*(15th March,1877),261

were perceived by at least a section of foreign public opinion as agents of Li Hongzhang,and this probably explains much of the reluctance of the foreign traders to take an active interest,as they felt that they were,to use a modern term,in danger of being 'nationalised' by their association with the Chinese government. Secondly,the Polytechnic was even after a year of operation still very little frequented,and had excited little interest amongst the Chinese public.[843] Foreign firms were not tempted by the carrot of China trade,which they surmised would not be effectively promoted by the Polytechnic; the Chinese themselves seem to have regarded it with a wary eye partly probably because it was foreign,but also because it frankly had little to offer them.

The only public event in the first year was a lecture on electricity by Calvin Mateer,held in June 1877,attracting fifty to sixty people [844]. John Fryer explained that 'To be able to sit quietly and listen to a lecture lasting for an hour or two is beyond the capacity of an ordinary Chinaman.'[845],that few foreigners able to lecture in Chinese,and also pointed out,rather implausibly,that the great variety of dialects in Shanghai made it hard for the audience to follow what was being said. The latter reason seems rather lame,as the audience were going to be the more educated classes of society who would probably have little difficulty in understanding Mandarin even if they could not speak it. A major

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[843] It did however warrant a brief reference in a guidebook to Shanghai Ge Yuanxu 葛元煦 ,*Huyou zaji* 滬遊雜記 [Record of a tour of Shanghai],dated 1877.

[844] *Second Report*,7. Fryer does not name the lecturer,but the account in *GZHB* **2**,5(June 1877),16a states that the lecture was an American called Di 狄,which makes it likely to have been Calvin Mateer[*Dikaowen* 狄考文],who is known to have specialised in electrical demonstrations,and who later contributed an article on dynamos.

[845] John Fryer,*Second Report*,7

disappointment was the difficulty of persuading Western manufacturers to send samples of their machinery for display,partly apparently out of fear that they would be copied by Chinese artisans[846]. As Fryer had to admit,by 1878 there had been 'but little progress'.[847]

Fryer himself was preoccupied with his sick wife,Anna(who by 1878 was in the last stages of her illness)and with editing *Gezhi Huibian*,a venture which proved more successful than the institution in whose name it was published. These factors,together with his translation work at the Jiangnan Arsenal,must have put him under increasing pressure,and made it more difficult to oversee the work at the Polytechnic,the burden of which increasingly fell to his Chinese colleagues.

By 1883,in his *Third Report* Fryer had to admit that little had happened in the previous five years other than the raising of funds(mainly by Xu Shou) and the assembly of a collection of chemical and electrical apparatus.[848] There had been about one hundred visitors per month,those who had come some distance being offered accommodation. According to Fryer 'the doors [were] open from morning to night throughout the year. Hua Hengfang was the Curator,and Xu Shou lived on the premises for 'days at a time',entertained visitors and gave 'special explanations to his special friends when desired'. Xu Shou also carried out chemical analyses of "iron and other ores"[849].

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[846] *ibid.*,8

[847] *ibid.*,10

[848] John Fryer 'Third Report of the Chinese Polytechnic Institution and Reading Rooms,Shanghai,March 1878 to March 1883' in *NCH*(18th April,1883),432-434

[849] *ibid.*,433

Xu Shou showed another aspect of his talent in developing a small-scale commercial venture on the site,selling sets of physics and chemistry apparatus,and he also made a considerable sum for the Institution by renting out the nearby houses which it owned. The planned permanent exhibition which initially one of the most attractive features of the building(and which led to invidious comparisons with the Crystal Palace[See Figure 35]) failed to materialise in the way that was hoped,reflecting the general lack of interest of the merchants in the venture,and by 1883 the project was abandoned,and the London committee which had been set up to promote the exhibition was disbanded[850].

Fryer proposed with some desperation in the *Third Report* that lectures and classes on science should be established; and that a school for mining,metallurgy and chemistry should be set up,[851] subjects which the 'Readers' Queries' section of *Gezhi Huibian* had revealed to be of particular interest to his readers,but funds were not forthcoming and this scheme too died a natural death.

By the time of the *Fourth Report*[852] in 1885,Xu Shou had died,and Fryer at last had the opportunity to make radical changes in the way in which the Polytechnic was run. The picture he now painted was considerably bleaker than that of the *Third Report*: far from having 'about a hundred visitors per month',it was almost deserted,kept locked and barred to the outside world,serving more as a private residence for the Xu family and a warehouse for

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[850] *ibid.*,433

[851] *ibid.*,432

[852] John Fryer,'Fourth Report of the Chinese Polytechnic Institution and Reading Rooms,Shanghai,from March 1883 to March 1885' in *NCH*(10th July,1885),44-45

decaying scientific equipment than a place of public enlightenment[853]. It had become,Fryer said,'for one or two years been dead to the outside world' although it would have been truer to say it had been stillborn. Foreign interest had declined to almost nothing,and few Chinese people seemed aware of its existence. It was just at this time that Fryer was privately at his most desperate,contemplating abandoning all his scientific translation and educational work amongst the Chinese for the sake of a Unitarian crusade in China.[854] His disappointment was immense,no doubt to the satisfaction of his enemies in the foreign community in Shanghai,yet his perseverance and determination led eventually to a reborn Polytechnic,to which at last the Chinese public seemed willing to turn for enlightenment.

10.22 The revived Polytechnic: 'alive with busy workers'

For the revived Polytechnic a new set of rules were drafted in 1885,giving the foreign-controlled Management Committee much stronger control,particularly in respect of the Curator,who it was said should be

> a trustworthy native possessed of a reasonable amount of Western knowledge[...]He shall live entirely on the premises and take charge of them night and day,giving his whole time and attention to the books and apparatus,to entertaining or answering the questions of visitors and enquirers and to promoting and advancing the purposes for which the Institution was founded.[855]

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[853] See *ibid.*,44

[854] John Fryer to Head of the Unitarian Association(*FP*: Box 1 Folder 6)

[855] *Fourth Report*,45

To prevent the problems which the Xu family's occupation had entailed,Article 8 stipulated that the Curator's family were not allowed to live on the premises[856]. A Prize Essay competition was started,from 1885 some science classes were operating,and in 1890 an English scientist called Cosmo Innes Burton was employed to begin lectures on mining,metallurgy and mineralogy.[857] He set to with great enthusiasm,preparing his courses and laboratories,but unfortunately died before he could commence teaching.[858]

From 1895,regular free classes were run on Saturday nights,some taken by Fryer or his son John,and others by a Chinese lecturer,Lu Rentang 陸仁堂 [859]. Afternoon preparatory classes in arithmetic and algebra of from 15 to 30 students[860],and higher classes held from 7 to 8 p.m. were instituted as the applicants were found to be weak in this subject. Regular homework was a feature of the course:

> About 15 original problems in arithmetic have been printed and issued every Saturday evening as home work for the next week. The students have had to purchase their own text books and read up very carefully all that concerned these problems. Forms have also been issued,on which the solutions have been written and these papers have been delivered to me for correction on the next Saturday evening.[861]

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[856] *ibid.*,45

[857] *NCH*(15th August,1890),196

[858] *GZHB* **5**,3(Spring 1890),45a-46b and **5**,4(Winter 1890),43a-43b.

[859] *NCH*(21st February,1896),286. Permission to start the classes had been given by the Committee in May 1894.

[860] *NCH*(16th July,1897),128. The classes started at 4 o'clock.

[861] *ibid.*,286

Examinations,strictly invigilated by Fryer himself,were held,with 75% as the pass mark,and certificates as below given to the successful candidates.

Chinese Polytechnic Institution,Shanghai

> This is to certify that Mr.-------- of the district of -------,prefecture of ---------,in the province of -------,aged------,has in my presence satisfactorily passed in a written examination in ---------,in which he has obtained ------marks out of a possible hundred.
>
> On passing each subject of his course of study a certificate similar to this one will be given. When the entire course has been completed these will be exchanged for the full certificate of the Institution.
>
> -------------------- *Examiner*
>
> Shanghai,------- --------------,189---
>
> No.----- [862]

....

Fryer went on to describe the classes themselves:

> From four o'clock on Saturday afternoon when the beginners receive their lessons up to half-past eight when the advanced class is dismissed and the magic lantern lectures commence,the building is alive with busy workers,and there is a continuous succession of visitors or enquirers coming and going,who are allowed

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[862] *ibid.*,286

> to sit on the side seats and see what is going on. Seats and tables or desks are arranged for forty students,but next year more must be added.
>
> The magic lantern lectures are open to the students and their friends. They were commenced early in the autumn[of 1895]. During the Chinese year the following six subjects have ben treated,most of them with two lectures each. "Mines and mining operations","Lady Brassey's tour round the world in the *Sunbeam*","Physiology and Anatomy","The Viceroy's new road and other objects of interest at Nanking","The Chicago Exposition",and "Zoology".These six subjects were enlivened by various other smaller sets of lantern slides of an amusing or instructing character. It is proposed next year to take up the various departments of Natural Philosophy one by one and to illustrate them in the same manner. Many questions are asked by the audience as the lectures proceed,and as this adds much to their interest such questions are encouraged.[863]

There is sadly no record of the audience's response to Lady Brassey's travels,nor any the other topics covered: in fact,there is more than a suspicion that the somewhat idiosyncratic range of subjects chosen were primarily those of interest to Fryer himself. For all that,the classes were well attended,and soon syllabuses and sets of problems were published. The students were from the 'literary or student class',including one who was already a holder of *juren* the 舉人 [provincial] degree. Fortunately we have accounts

[863] *ibid.*,287. Similar classes in Britain also found they had to broaden the scope of the subjects covered in order to attract audiences. The Manchester Mechanics' Institution,founded in 1824,had after 1840 to include lectures on poetry,travel,elocution,drama and history in order to hold its students' interest. See Robert H.Kargon,*Science in Victorian Manchester: enterprise and expertise*(Manchester:Manchester University Press,1977),24.

of the 1897 science classes from both English and Chinese sources. John Fryer wrote in the *North China Herald*:

> At 8 o'clock lectures in Chinese are given by myself and accompanied by magic lantern illustrations. The hall was frequently over-crowded with students and their friends. The subjects were scientific as well as accounts of voyages and travels and descriptions of industrial processes. At the commencement of present year these popular lectures were resumed by one of my assistants,aided by Mr Lu the Chinese science teacher. The subject of chemistry was chosen. The study of an elementary text book in Chinese was commenced[864],and explanations with experiments were given. Up to the present time oxygen,hydrogen,nitrogen and chlorine had been attempted. The thanks of the Committee are due to my assistant Mr Lan for his labours in this direction which have been quite voluntary[865].

One of these students,Luan Xueqian 欒學謙 [866](who is the 'Mr Lan' mentioned above)wrote in an early issue of *Kexue* 科學[Science] some thirty years later

> In recent years many books on chemistry had been

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[864] This seems to have been *Huaxue jianyuan* 化學鑑原.

[865] *NCH*(16th July,1896),128

[866] Luan Xueqian translated *Huaxue weisheng lun* 化學衛生論 [On chemistry and health]in several parts in *Gezhi Huibian* with John Fryer. This is known to have been an influential chemical text,mentioned by Lu Xun as one of the books he read at the Jiangnan Naval Cadet College in Nanjing around 1898(See Lu Xun,*Nahan* 吶喊[Warcry](Beijing:Renmin wenxue chubanshe人民文学出版社,1973),2 and Wang Guangquan,*Lu Xun nianpu* 魯迅年譜(Harbin: Heilongjiang renmin chubanshe 黑龙江人民出版社,1979),9-10.

Luan Xueqian(whom Fryer refers to as 'Mr Lan') also managed the Chinese Scientific Book Depot after Fryer's departure. See *CR* **29**(March 1898),132.

translated in China, but it was regrettable that those who had browsed through them had obtained only superficial knowledge(*jin zhi pi mao* 僅知皮毛), and were not able to gain a full understanding. There were amongst such people one or two brilliant scholars who were able to understand things [theoretically] for themselves, but, as they had never stooped to try out experiments, in the end this created an obstacle [for them]. Presently, there were many who were resolute in pursuit of this subject. [...] Now I myself knew a little [chemistry] and had some friends who were also keen on this subject, and who had graduated from the Polytechnic, so I was not afraid of being too ignorant, and since the [recent] opening of the Polytechnic[867], every Saturday evening we went through a few sections of *Huaxue jianyuan*. The first few sections of that book are about the laws of chemistry, and its principles are very profound: for the audience it had the flavour of chewing wax. For in learning chemistry, it is not possible to skip over these matters: you have to explain it gradually. Anyone who studied for a few evenings, although [thinking they] had not understood a lot at the beginning, when [they] began again from the early chapters [they] obtained sudden enlightenment.

From this time we began studying oxygen in the second *juan* 卷[chapter], and then continued with hydrogen: all this was about real substances and real things(*shi zhi shi* 實質實事), and was [therefore] easier for students to understand. After this we did three experiments, the first being on oxygen, for which we used potassium

[867] Presumably this means the opening to public classes in 1895.

chlorate[868] with manganese dioxide(for which the Chinese name is *wumingyi* 無名異),which we ground to a powder and put in a copper pot(freshly made on the spot)and heated strongly,obtaining oxygen,and collected it in a gas jar[*cangqitong* 藏氣筒],which was then changed for a glass flask. A burning candle was put in the bottle,and it glowed very brightly. Another flask of oxygen was obtained and burning charcoal put in it,and this also burned very fiercely,because oxygen is the best gas for supporting combustion(*yang huo* 養火) and so,although the candle or charcoal had only a slight glimmer of flame when put in the gas,it all ignited. After combustion we took some blue litmus paper(*lan shizhi* 藍試紙)and put it in the flask to test it,and the paper turned red,thus we knew that the gas in the flask had become acidic(*suanzhi* 酸質); it had changed into carbon oxide gas(*tanyangqi* 炭養氣)[carbon dioxide],because the oxygen had combined with the carbon in the candle and charcoal and made carbon oxide gas. We then took another flask of the gas and put burning sulphur in it,and the sulphur burned with a bright bluish-purple light. When we tested it with blue litmus paper it also turned red. However,the acid which turned it red was not carbon [di]oxide,but sulphur [di]oxide,which is also a gas. Later we used steel wire bent into a spiral and put it in the oxygen,but it did not burn. One reason was that the flask was too small,another that there was not enough oxygen,another that the wire was too thick and there was some sulphur on the end of the wire which burned and used up the oxygen in the flask,and thus there was

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[868] *jiayang.luyang* 甲氧綠氧 Reardon-Anderson *The study of change*,49 translates this as 'potash,chlorine oxide',apparently unaware of the Berzelian dualistic formulae still in use at this time.

not enough to burn the steel[869] wire. We wanted to burn some phosphorus in the oxygen,but because we did not have a large enough flask we were unable to do so. These were the two experiments we did before the fourth lunar month.

In the middle of the fourth lunar month John Fryer returned to Shanghai,and accompanied Xiu Yaochun 秀耀春[E.T.James][870] to the Polytechnic to watch the demonstration,which on the evening of the twentieth day was making hydrogen. Firstly we took zinc granules and put them into sulphuric acid to obtain hydrogen,and stored it in a gas-jar. We then took a flask and inverted it,putting a lighted candle into the tube,and the candle immediately went out,whilst at the mouth of the tube the hydrogen burned spontaneously. When we took the candle out,it burst into flames again: thus we knew that hydrogen was by nature combustible,and was completely different from oxygen. If we inverted the flask,the hydrogen rushed out and burned with a loud report. In the second experiment we tried burning charcoal,but it did not light [in the hydrogen].We also tried burning sulphur,but it went out,and there was a slightly foetid smell,like rotten eggs: thus sulphur and hydrogen make hydrogen sulphide gas. We took another glass flask,and,having freshly filled it with hydrogen,and inserted a fine tube,we lit the mouth,whereupon the hydrogen burned with a flame as yellow as a bean. Putting glass tubes of different lengths and thicknesses with pinched mouths in the fire they all made a noise. The larger or smaller the

[869] The text gives *tong* 銅 'copper'.

[870] E.T.James worked as a translator at the Jiangnan Arsenal 1897-1898. Presumably here Fryer is giving him an introductory tour of the Polytechnic.

tube the clearer or duller,higher or lower the sound,and it filled the whole room. Afterwards we mixed the two gases hydrogen and oxygen together,and passed them into soapy water,so that bubbles rose up,and we lit them with burning paper,whereupon they exploded loudly. We did this several times,and whether they were high or low they exploded. Some rose so fast we could not light them. In the end we bubbled the two gases directly into the soapy water,and made many bubbles,piled up like eggs. We then lit them,and there was a deafening explosion: you could say it was an "oxyhydrogen gun". We did this several times,and the audience laughed out loud. They were some distance away,and to one side: had it really been fired directly at them,it would have hit them.[871] Trying this was certainly dangerous,so we warned them to be careful,as if by mistake we let the fire get into the gas-jar,there would be a huge explosion,which would have caused a diaster. Those who watched from the side would be terrified,whilst those actually doing it could not avoid [being hurt]. If you only tried oxygen,there would be no explosion,and if you only tried hydrogen there was no sound,but if you put the two gases together then there would be an explosion if they were lit: because oxygen and hydrogen have an affinity,both being gases,[and] if they burn,they become water,and the volume decreases. In contracting suddenly,there is a vacuum,and the air rushes to fill up the space with enormous force,and the shock wave makes a sound,and there is a bang. The principle is the same as gunpowder exploding but the effect is the opposite,as the volume of gunpowder is originally small,but when lit it expands,and rushes out in all directions,producing an explosion.

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[871] I suggest that *zhen* 真 should be emended to *zhi* 直.

> After the experiment was over,Fryer said: "I think that everyone has understood the method of these experiments,but sadly not many people have come. We plan to ask all the curators and scholars at the Polytechnic to carry out more experiments to broaden their horizons. This sort of thing is not strange in Western countries,but rarely seen in China,so that when someone does by chance see it they are apt to sigh and say it is a new marvel." Afterwards I and Lu Rentang tried these experiments ourselves [in order to] satisfy the minds of the students,although [we were] only novices,and were unable to do them all. The apparatus the Polytechnic had was damaged and incomplete,[some of it] could not be used,and needed to be replaced,so in two hours it was hard to do everything,it was not that we grudged doing experiments,but because we did not try to hide our inadequacies by keeping quiet,the students forgave us. From this time on,we taught about the principles of nitrogen and chlorine,up until the 10th day of the sixth month,then having a holiday of one month. The Polytechnic reopened on 10th of the seventh [lunar] month and until the seventeenth day performed experiments on nitrogen. Afterwards we continued to teach and perform experiments term by term.[872]

This unique record of the Chinese view of what was happening at the Polytechnic classes shows firstly that the textbook used was probably quite unsuitable for the students. (This is particularly striking as Luan himself had translated a chemical treatise and was therefore far

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872 Luan Xueqian 欒學謙,'Gezhi shuyuan jiaoyan huaxue ji 格致書院教演化學記[A memoir of teaching chemistry at the Shanghai Polytechnic' in 'Sanshi nian qian wuguo kexue jiaoyu zhi yi ban三十年前吾國科學教育之一班 [A science education class in China thirty years ago] in *Kexue* 8,4(1924),430-432

more knowledgeable than most students would have been). In fact *Huaxue jianyuan* 化學鑑原 probably does not explain enough of the principles of chemistry, launching too quickly into an account of the chemistry of the various elements. The experiments performed are on the other hand impressive, if rather hazardous: for the most part they would not be permitted in school laboratories nowadays. There is an element of showmanship about the exploding bubbles which was likely to appeal to a lay audience even if they had no real interest in the subject matter. The poor state of the apparatus is not surprising, given that much of it was at least twenty years old and had never been properly looked after or even used for most of this time. It seems from this account and that of Fryer himself above, that it was Mr Lu (and Luan Xueqian) rather than Fryer who actually did the experiments, Fryer taking on a more supervisory role.

10.23 The Shanghai Polytechnic after Fryer

John Fryer continued to take an interest in the Shanghai Polytechnic after his departure for California in 1896, and entrusted its running to a succession of individuals who seem to have done their best to develop it and sustain its role.

E.R.Lyman from California took over in 1898, enthusiastically proposing a detailed plan for the development of the programme, beginning with

> a thorough knowledge of elementary mathematics, chemistry and physics[...]With this preparation, the students should be able to begin real technical work by a thorough training in chemistry, geology, mineralogy and essaying, also of agriculture or various other technical subjects or groups of subjects depending

> upon what particular branch of technology the students intend to follow. *This much is absolutely essential.*[873]

It is not clear what exactly happened to Professor Lyman or his plan,but the latter seems not to have proved practicable. Lyman seems to have run a course of lectures in English at the Polytechnic in 1900,on Mondays a lecture on geology,and on Wednesdays on astronomy,whilst on Fridays there were lectures on assorted scientific topics in Chinese.[874] By 1901 the Director was A.P.Parker,a medical missionary of long standing,who had been involved in the Educational Association of China Committee for the Standardisation of Technical Terms. By then only fifteen residential pupils were enrolled,which suggests that matters had already deteriorated since the heyday of 1896[875]. They were taught by a Mr I.C.Suez,a Chinese graduate of St John's College in Shanghai,and they studied English in the morning and Mathematics and Science in the afternoon. Parker himself also gave lectures every Thursday evening on subjects such as 'The Government of the United States','Electricity','The Position of Women in Western Lands',and 'Current Events'. The Prize Essay Scheme was continued,and the best essays were still being bound and

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[873] *NCH*(8th August,1898),259. See also *CR* **29**(September 1898),451 for an extract of Lyman's plan.

[874] *CR* **31**(October 1900),519. Lyman also wrote an article 'Science for the Chinese' published in *CR* **31**(December 1900),620-625.

[875] It seems possible that the political events of 1898-1900 cast a shadow over the Polytechnic,although there is no direct evidence of this. Shanghai was one of the centres of activity for the 1898 reformers,and it is likely that the Polytechnic was associated(at least indirectly) with their activities. The Boxer Rebellion of 1900 would also have discouraged interest in such an obviously foreign-built enterprise.

sold in the local bookshops.[876]

The brief heyday of the Polytechnic as a teaching institution came to an end in 1904. Classes were no longer run and the Polytechnic was eventually sold in 1917 to the Shanghai Municipal Council,on condition that steps would be taken for the establishment of a school on the same site,in which science subjects would be taught.[877]

A Polytechnic Middle School was built on the site,an institution which appears still in existence as the *Shanghai Gezhi Zhongxue* 上海格致中學 [878]

10.24 The Shanghai Polytechnic:Conclusion

In the early years of the twentieth century there was a rapid expansion of science teaching both in missionary and government schools,so that the role of the *ad hoc* and somewhat amateurish Polytechnic programme began to be superseded by more professional academies. Nevertheless,it seems to have sparked an interest in science amongst a small but significant number of Chinese people at a time when there were very few if any other places of adult education teaching natural science,and its significance should not be lightly dismissed. It is true that it did not live up to the hopes of the founders,but these were probably wildly unrealistic. It never had enough financial support from the Chinese officials to run more than a handful of classes,and its albeit meagre Chinese backing

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[876] *NCH* **32**(29th January,1901),180

[877] F.Hawks Pott *A short history of Shanghai*(Shanghai:Kelly and Walsh,1928),122

[878] I have written to this institution but have had no reply. For a brief contemporary account of the Shanghai Polytechnic,see also Xu Run 徐潤 'Shanghai zaji' 上海雜記 [Miscellaneous records of Shanghai](n.d.,c.1909) in *Yangwu yundong* Vol.8,341

made foreign interests suspicious and unwilling,with a few individual exceptions,to give more than token support.

Its difficulties were intellectual as well as practical:Western science was not easy to acquire,and there were very few people,foreign or Chinese,with sufficient knowledge or enthusiasm to teach it effectively. As we have seen,the textbooks,even so-called 'elementary' works,proved hard to digest by students to whom so many of the terms were alien and who also had very limited knowledge of the Chinese tradition of natural science.

It depended for its success on a very small number of extraordinary individuals such as Fryer,Lu Rentang,Luan Xueqian,Lyman and Parker. In view of the obstacles it faced,the Polytechnic can be regarded as a brave and important attempt to introduce a lay Chinese audience to Western science. Although in terms of formal education it was superseded by the middle of the first decade of the twentieth century,yet in the access it gave to ordinary adult Chinese to free science classes,and as the only Chinese public library in Shanghai[879] it was many decades ahead of its time.

Its initial influence was greatest not through its classes but in the translations it generated through *Gezhi Huibian* 格致彙編 and the essays entered for the Chinese Prize Essay Scheme,but in the 1890s it inspired many similar institutions.[880]

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[879] Hu Daojing 胡道靜,'Shanghai tushuguanshi' 上海市圖書館史 [A history of the libraries of Shanghai] in *Shanghai Shi Tongzhiguan Qikan* **4**(1935),1356-1357

[880] Shu Xincheng,*Zhongguo jindai jiaoyushi ziliao,*68-69 for the setting up of a *Gezhi-shixue shuyuan* 格致實學書院[Academy for Science and Practical Studies] in Shaanxi in 1896.

10.3 'Eradicating superstition': Science in the missionary schools[881]

Science teaching was not a high priority in most missionary schools,partly because they did not have teachers competent to teach it but also because the main focus of their efforts was evangelisation. Only a few missionaries in this period saw natural science as of significance. In many,but not all,cases they were themselves medical doctors,who saw that if China was to have its own doctors they would have to have some background in basic science.

10.31 The Guangzhou premedical classes

The earliest mention of science classes which I have come across were taught by the medical missionary Benjamin Hobson in Guangzhou in the 1850s. Hobson himself expressed interest in science classes in the year 1844

> "This leads me to express the interest I feel in the establishment of a medical class of from 6 to 10 boys,and I embrace this opportunity of soliciting the countenance and support of the gentleman of the Committee to the proposed measures." [...] Dr Hobson proposed to begin with their instruction in premedical subjects(physics,chemistry,biology,etc)and then continue with hospital practice and occasional anatomical demonstrations.[882]

One of Hobson's Cantonese students,He Liaoran 何瞭然,went on

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[881] See Wong and Wu (eds.)*History of Chinese medicine*; G.H.Choa,*"Heal the Sick" was their motto:The Protestant medical missionaries in China*(Hongkong:The Chinese University Press,1990); Gu Changsheng 顾长声,*Chuanjiaoshi yu jindai Zhongguo*传教士与近代中国 [Missionaries and modern China](Shanghai:Shanghai renmin chubanshe 上海人民出版社,1981).

[882] Wong and Wu,359

to work with Dr.John Glasgow Kerr,a younger medical missionary in Guangzhou,in translating David Wells' *Principles and applications of chemistry*,and in the introduction to the translation He Liaoran referred to his first teacher:

> When I was young I visited the class of the Western doctor Hobson(Hexin 合信),and by the time I had finished the course we had covered arithmetic(*shuli*數理),geometry,optics,heat,mechanics,botany and zoology,but as for the 'changes' involved in chemistry[883],I had not gone deeply into them.[884]

John Kerr,who took over from Peter Parker at the Canton Medical Missionary Hospital in 1855,in the 1860s continued this tradition of scientific education,obtaining chemical apparatus in 1868 for a class of twelve pupils[885]. It was to meet the need of his classes that he translated *Huaxue chujie*,already mentioned above,the first modern chemistry text written in Chinese. According to He Liaoran

> In the spring of 1869,the American doctor Kerr(Jia 嘉)taught chemistry in Guangzhou and I spent my days listening to [him expound]its principles. I asked if I could be the translator,so as to act as a guide for my fellow students,and Kerr was delighted,[...]he translated [it] orally and ordered me to write it down,as he really wanted the book to be completed.[886]

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883 The term for 'chemistry' *huaxue* 化學 means 'the study of changes'.

884 *Huaxue chujie*,1.1b

885 Wong and Wu,*History of Chinese medicine*,392

886 *Huaxue chujie*,1.1b

It is probable that Daniel Jerome Macgowan was also giving some kind of scientific instruction at Ningbo,where he had been working since November 1843. He certainly took scientific instruction seriously:

> The mere practice of medicine and surgery should not be considered the more important part of the professional labours of the medical missionary. It behoves him to instruct native practitioners in anatomy and physiology,to give them works on the collateral sciences in their own language[...][887]

and is known to have written a work of his own *Bowu tongshu* 博物通書 on electricity and to have published a magazine on religious and scientific matters.[888]

Little is known about these classes other than their existence,and that they were associated with the missionary hospitals where Hobson,Kerr and Macgowan worked.

10.32 'The lighthouse of Shandong': science teaching at the Dengzhou College[889]

Dengzhou College was founded as a boys' high school by Julia and Calvin Mateer in September,1864,with just six pupils. Tuition to local students was free,but parents had to sign an indenture that the boys would study for at least

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[887] Wong and Wu,*History of Chinese medicine*,348

[888] *ibid.*,350

[889] See *Catalogue of Tengchow College,Tengchow,China*(Shanghai:American Presbyterian Mission Press,1891); *The Tengchow College*:a chapter by an unknown author,lodged in Yale Divinity Library R.G.11A Box 6VA Folder 85y; and *Shan-tung College(generally known as the Teng Chow College): its history,outlook and endowment 1864-1902*(The Board of Foreign Missions of the Presbyterian Church in the U.S.A.,156,Fifth avenue,New York). W.A.P.Martin called it the 'lighthouse of Shandong' in *Shan-tung College*,9.

six years. Most of the pupils were from poor homes,as wealthier families would not entrust their sons' education to a foreign missionary's care. Of the first six students,only one completed the course.[890]

Dengzhou College emphasised the study of the traditional Chinese curriculum as much as Western studies,and by 1877 there were thirty pupils,with the school developing a reputation as its graduates were now beginning to pass the literary examinations with creditable rank.[891] By 1881 numbers had increased to 45,and the Dengzhou Boys' High School was organised into the Dengzhou College. By 1889 they reached 100,their numbers drawn by now from the Chinese Christian community.[892]

The aim of the school was

> to give to as many young men as possible a liberal education in the Chinese language,fitting them to study Theology or Medicine or to teach in the mission and other schools,this making them influential members of society and fitting them to become leaders in the native church.[893]

10.321 Science teaching at the Dengzhou College

Calvin Mateer held strong views - as he did on many other matters - on the importance of science education for Chinese Christian ministers in China:

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890 *Catalogue of the Tengchow College*,8

891 *ibid.*,9

892 *ibid.*,9

893 *ibid.*,10

The character of Chinese classical education is such,that it is neither practicable nor desirable that Christian ministers should excel in it,and depend upon it for position and influence with the people.It is better in every way that they should depend for their reputation and influence with the people,upon a knowledge of Western science. Western learning,though as yet little known in China,has yet a great reputation,so that a native pastor who has a good knowledge of Geography,Natural philosophy[physics],Chemistry and Astronomy,will have a good reputation and an influence which he could secure in no other way. Thus furnished he will be more of a match for the village magnates,who are the chief agency in holding the minds of the people in bondage to heathenism. Having at his command a knowledge of science and of facts,which the haughty scholars of China can neither gainsay or resist,he would compel their respect and secure the confidence of the people. Not only is such an education valuable as a means of influence,but it is also the very best means of eradicating the remnants of superstition from the mind of the preacher himself and making him a safe and reliable expositor of Scripture truth. Christianity is truth,and all truth is related. Hence a true philosophy of mind and matter is the best adjunct and support of Christianity. It will preserve from extravagance in doctrine,and from insidious encroachments on human superstition. That Chinese pastor who has the best knowledge of science will be,other things being equal,the best and safest expounder of the Bible,as well as its ablest defender.[894]

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[894] *Records of the General Conference of the Protestant Missionaries of China,held at Shanghai May 10-24,1877*(Shanghai,1878),171-180

Figure 36 The Rev Zou Liwen, Calvin Mateer's collaborator in the translation of mathematics and science textbooks at Dengzhou College (From *Shan-tung College*, facing page 10) [Reproduced by kind permission of the Presbyterian Church, U.S.A., Department of History and Records Management

It is interesting to see that science was regarded as Mateer as much an instrument for the propagation of religion,and a talisman giving protection against heathenism,as a means to the modernisation of China,although he would have seen both as complementary and necessary conditions for improvement.

Science and mathematics were taught at Dengzhou over a six year course:

Year 1:Algebra
Year 2:Geometry;Conic Sections
Year 3:Trigonometry and Mensuration
Hydraulics,Pneumatics,Heat,Sound and Magnetism
Year 4:Surveying; Navigation
Geology,Mineralogy,Optics,Electricity
Year 5 Analytical geometry; Mathematical Physics
Chemistry
Year 6:Calculus
Astronomy;Qualitative Chemistry[895]

Dengzhou College held examinations in physics,chemistry,astronomy,geometry and algebra at the end of each term. Students who failed to make the grade had to re-study with the next class,and for repeated failure were dismissed.[896]

Mateer wrote his own textbooks in colloquial Mandarin for geometry,algebra and arithmetic[897].

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895 *Catalogue of the Tengchow College,* 1-2

896 *ibid.*,7

897 See Section 8.22 for examples from his mathematics textbook.

He took great pride in the collection of scientific apparatus he had made,much of it in the early days made with his own hands:

> The college is supplied with a large assortment of philosophical apparatus,especially in electricity and steam. Experiments are made weekly,by which the principles taught are thoroughly illustrated. A well-furnished workshop is connected with the college and a trained workman constantly employed,by which means the apparatus is kept in constant repair and the supply is being continually increased.[898]

Dengzhou College was extremely unusual in this respect: of the well-funded Government Tongwenguans,only that in Beijing showed a comparable commitment to practical demonstrations of scientific principles. Mateer himself emphasised electricity and steam,the two 'useful' aspects of science which had the most immediate application in the world outside,and in which he had become expert.[899]

In chemistry,they followed *Huaxue jianyuan xubian* 化學鑑原續編 and *Huaxue jianyuan bubian* 化學鑑原補編,the two volumes of Fryer and Xu Shou's translation of Charles Loudon Bloxam's *Chemistry*,and for which Mateer had apparatus and chemicals sufficient to show all the experiments mentioned.[900]

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[898] *ibid.*,4

[899] He was the first lecturer at the Shanghai Polytechnic in 1877,with a talk on electricity,and he spent part of his 1879-1881 furlough at the Baldwin Locomotive Works,and part of his 1892-1893 furlough in the World Columbian exposition in Chicago studying machinery and electricity(See *Cheloo* Chapter 3,p.7). Mateer was said to have diagnosed the fault in the locomotive which was pulling his train on the Trans-Siberian Railway during a journey in 1902: such was his formidable skill and self-confidence.(See *Cheloo* Chapter 3,pp.6-7)

[900] *Catalogue of the Tengchow College,*5

In astronomy he used Elias Loomis' *Treatise on Astronomy* and Young's *General Astronomy*. The College had its own equatorially mounted ten-inch Newtonian reflector telescope[901],and the astronomy course included the finding of latitude and longitude. For physiology he had a human skeleton and a 'mannikin showing the internal organs'.[902] Geology and mineralogy were taught by means of field trips in the vicinity of the College and students were shown how to identify ores by blowpipe analysis.[903]

Despite the impressive array of apparatus which Mateer had collected (and which in the making had taught him a great deal of science[904]),it seems that the Dengzhou students themselves did not carry out any experiments. This was a serious weakness in the current science teaching methods in most Western countries,but perhaps for the Chinese students was particularly unfortunate. Mateer's policy of refusing to teach foreign languages was also particularly disadvantageous for those who went on to become teachers themselves,as their lack of a foreign language meant that they were dependent on the inadequate range of rapidly dating translated science textbooks,which in themselves were,as we have seen above,not always helpful to the isolated student.

10.33 Science in other missionary schools

Dengzhou College was exceptional but not unique in its

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[901] Purchased for the school with funds from two American benefactors,Mr Stuart of New York and Mrs Baird of Philadelphia. He also persuaded Cyrus W.Field,a submarine cable engineer,to give his school a dynamo which he used to light the classrooms.See *Cheloo*,Chapter 3,p.7

[902] *Catalogue of the Tengchow College*,5

[903] *ibid.*,5

[904] They also had a five-inch transit theodolite,and a one-horse-power steam engine and boiler.See Calvin Mateer,quoted in Charles Mills 'Boys' High School,Tengchow' in *CR* **13**(1882),151.

attention to natural science. John Fryer, in his *Educational directory for China* mentions over forty mission school teaching some science,but in most of these it seems to have been very elementary instruction. By the turn of the century other enterprising missionaries were setting up science courses with equipment rivalling or surpassing that of the schools in their home countries,such as that of Dr William Wilson,a missionary with the China Inland Mission in Yantai 烟臺(Chefoo) and later at Suiding 綏定 [905] in Sichuan.[906]

[905] Present-day Da Xian 達縣.

[906] See *China's Millions*(1901),101-103; Dr William Wilson 'A science lecture at Sui-ting Fu,Si-chuen' in *China's Millions*(December 1903),167-168 and Dr William Wilson 'Hsu Ting Fu Science Hall: a practical course for the construction of electrical apparatus' in *CR* 37(April 1906),200-205

Table 12. Missionary schools teaching Western science around 1895[907]

Place	Name of college (page reference in John Fryer *Educational Directory for China*)	Founda-tion date	Student roll since founda-tion [b]	Types of natural science taught[c]	Textbooks used[d]	Mission
Beijing	Beijing University (45-48)	1890	about 20	chemistry	-	MECM
	Truth Hall(27)	1868	200+	general science	Martin, *Gewu rumen* Martin, *Tiandao suyuan*	APM(N)
	Presbyterian Girls' School(27)	1874	175	general science	Martin, *Gewu rumen* Martin, *Tiandao suyuan*	APM(N)

[907] This information is taken from John Fryer *Educational Directory for China*(Shanghai:Educational Association of China,1895)

Dengzhou 登州	Dengzhou College(28-29)	1864	300	astronomy, chemistry, geology, mineralogy, physics	Hayes, *Tianwen jieyao* Hayes, *Guangxue jieyao* Hayes, *Shengxue jieyao* Fryer, *Huaxue xuzhi* Martin, *Tiandao suyuan*	APM(N)
	Dengzhou Girls' High School(29)	1873	85	science	As for Dengzhou College	APM(N)
Fuzhou 福州	Anglo-Chinese College(39-40)	1881	347	astronomy, botany, chemistry, physics	Steele, *Physics** Steele, *Chemistry** Craig, *Botany** Newcomb and Holden, *Astronomy**	MECM
	Banyan City College(7)	1853	373 (since 1890)	Western sciences	Fryer, *Huaxue xuzhi* Martin, *Gewu rumen*	ABCFM
	Primary day-schools(7)	-	-	astronomy	-	ABCFM

	Theological College(32)	1880	150	natural theology	Williamson, *Gewu tanyuan* Martin, *Tiandao suyuan*	CMS
	American Board Female Seminary(8)	1854	959 (since 1879)	Western sciences	-	ABCFM
	Ponasang Hospital Medical School(8)	1872	20	Western sciences	-	ABCFM
Guangzhou	Mens' Training and boarding school(19-20)	1879	several hundred	astronomy, chemistry, natural theology	Fryer, *Huaxue xuzhi*; Williamson, *Gewu tanyuan*; Martin, *Tiandao suyuan*	APM(N)
	College(78)	1867	6 on roll	science	-	BLM
	Canton Female Seminary and Training School for Women(20)	1872	176 on roll	elementary sciences	Martin, *Tiandao suyuan*	APM(N)

Hainan 海南	Na-doa Training School(23-24)	1886	31(on roll)	astronomy, chemistry, physics	Fryer, *Huaxue xuzhi* Martin, *Gewu rumen*; Williamson, *Gewu tanyuan*; Martin, *Tiandao suyuan*	APM(N)
Hangzhou 杭州	Hangzhou High School(24)	1845	70	astronomy, chemistry, physics	Fryer, *Huaxue xuzhi*; Hayes, *Tianwen jieyao*	APM(N)
	Girls Boarding School(73-74)	1868	165	astronomy	-	ASPM
	Medical Training College(33)	1886	-	-	-	CMS
Hankou 漢口	Elementary day-schools(16)	-	270(on roll)	natural philosophy	-	APEM
Huangxian 黄縣	Huangxian Baptist School (51)	1894	28(on roll)	science	-	ASBM
Jiading [Kiading] 嘉定	Anglo-Chinese School(60)	1888	200	elementary sciences	-	MEM,S

Jinan Fu 暨南府	The Jinan Fu Boys' School(22-23)	1870	29 on roll	-	Martin, *Tiandao suyuan*	APM(N)
Jingjiang 靖江	Methodist Episcopal Mission Girls' School(38-39)	1884	68	astronomy, botany, natural history	Williamson, *Zhiwuxue*; Fryer, *Tianwen xuzhi*; Fryer, *Natural History*; Martin, *Tiandao suyuan*	MECM
Jiujiang 九江	Jiujiang Institute(41-42)	1883	300	chemistry, physics	Tyndall, *Guangxue*; Tyndall, *Shengxue*; Martin, *Tiandao suyuan*	MECM
	Mulberry Grove Academy	1873	37(on roll)	zoology	Martin, *Tiandao suyuan*	MECM
Nanjing	Boys' Boarding School (25)	1886	30(on roll)	natural sciences	*Martin, *Tiandao suyuan*	APM(N)
	Girls' Boarding School(25)	1884	50	natural sciences	#Martin, *Tiandao suyuan*	APM(N)

	Nanjing University(43-45): College of Liberal Arts	1893	16	astronomy, chemistry, physics	-	MECM
	Boarding College(79)	1890	50	Western sciences	-	FCMS
Nianhang-li[a]	Boys' Boarding School (55)	1868	486	elementary science	-	BAM
Ningbo 寧波	Girls' Boarding School(26)	1844	300	elementary science	-	APM(N)
Pangzhuang, Shandong	The Station Class for Men(10)	?	28 on roll	-	Martin, *Tiandao suyuan*	ABCFM
Qingzhou Fu 青州府 [Shandong]	Gotch-Robinson Training College(36-37)	1886	72	elementary science	#Martin, *Tiandao suyuan*; Williamson, *Gewu tanyuan*	EBM
	Guangde shuyuan(37)	1886	80	Western sciences	-	EBM
Shanghai	Anglo-Chinese College(60)	1882	2,000	science	-	MEM,S
	Clopton School(61)	1858	50 since 1885	elementary science	-	MEM,S
	Elementary Free Day-schools(49)	1890	22	elementary science	-	SDBM

	Girls' Free Boarding School(49)	1885	18	elementary science	-	SDBM
	Boys' Boarding School(50)	-	18	elementary science	-	SDBM
	Free Day-schools at St Catherine's Bridge and West Gate(50)	1891 and 1894	36	elementary science	-	SDBM
	Lowrie High School(26)	1860	200	elementary science	Martin, *Tiandao suyuan*	APM(N)
	Medical School(17-18)	1881	18	chemistry	Fryer,*Huaxue xuzhi*	APEM
	St Johns College	1879	500	botany, chemistry, physics	Lockyer, *Astronomy*;* Steele, *Chemistry*;* Steele, *Geology*;* Steele, *Physics*;* Fryer,*Huaxue xuzhi;* Fryer, *Handbook on physics;* Owen,*Dixue zhilue*	APEM
	St Marys Hall(18)	1880	51 on roll	elementary science	-	APEM

Suzhou 蘇州	Buffington College(61)	1879	250	botany, chemistry, geology, physics	Martin, *Gewu rumen*; Martin, *Tiandao suyuan*; Wylie, *Tantian*; Hayes, *Tianwen jieyao*; Owen, *Dixue zhilue*;	MEM,S
Tianjin 天津	Training School for Native Preachers(6)	1870	10 on roll	elementary science	-	LMS
	Hall Memorial Theological Seminary(65)	1874	-	science	-	MNCM
Tongtan (?) 通灘 [Thong-than-ka] [Sichuan]	Free Boarding Seminary(60)	1884	6 on roll	elementary science	-	RM
Tongzhou 通州 [Beijing Shi]	North-China College(12)	-	21 on roll	biology, geology, physics	Martin, *Gewu rumen*; Owen, *Dixue zhilue* ;Holbrook, *Huowuxue*	ABCFM

	Academic Department of North-China College(13)	1867	44 on roll	natural philosophy	Martin, *Tiandao suyuan*	ABCFM
Wuchang 武昌 [Hubei]	The Boone School(18-19)	1875	300	physics	-	APEM
Wujingfu 五經富	Elementary School(58)	-	-	elementary science	-	EPM
Xi'an Fu 西安府	Primary Day-school	1892	140 on roll	astronomy	#Martin, *Tiandao suyuan*	EBM
Xiamen 廈門 [Amoy]	Amoy Boys' Academy(30)	1880	200	astronomy	Kip, *Astronomy*	AR(D)CM
Yantai 烟臺 [Chefoo]	Chefu Normal School(21-22)	1888	100	astronomy, chemistry, geology, physics	#Martin, *Tiandao suyuan*	APM(N)

Notes. a.I have not been able to identify this place,but it is probably in the Hongkong area.

b.In some cases the current roll,rather than the cumulative total,is given.

c.Medicine,physiology,mathematics and geography are not included.

d.Asterisked textbooks are in English,the others are all in Chinese. Their titles are given very briefly,and cannot always be identified with certainty. I have taken "Fryer's *Chemistry*" to mean *Huaxue xuzhi* 化學須知.

e. "#Martin,*Tiandao suyuan*" means that Martin's book is not specifically mentioned,but it very likely that it was the text used.

f.Key to missions

ABCFM:American Boards of Commissioners of Foreign Missions
APEM:American Protestant Episcopal Mission
APM(N):American Presbyterian Mission(North)
AR(D)M:American Reformed (Dutch) Mission
BAM:Basel Mission
BLM:Berlin Mission
CMS:Church Missionary Society
EBM:English Baptist Mission
EPM:English Presbyterian Mission
FCMS:Foreign Christian Missionary Society
LMS:London Missionary Society
MECM:Methodist Episcopal Church Mission
MEM,S:Methodist Episcopal Mission,South
MNCM:Methodist New Connexion Mission
RM:Rhenish Mission
SDBM: Seventh Day Baptist Mission

Table 13. Science textbooks used in missionary schools in 1895 [908]

Chinese title(date of publication)	Translators	Source texts	Notes
Dixue zhilue 地學指略 (?)	Rev.G.Owen	Page,*Introductory Textbook [of Geology]*	
Gewu rumen 格物入門 (1868)	W.A.P.Martin	?	See Chapter 7
Gewu tanyuan 格物探原 (1875)	A.Williamson	?	See Chapter 7
Guangxue 光學(1879)	Carl Kreyer and Zhao Yuanyi	John Tyndall,*Lectures on Light*	
Guangxue jieyao 光學揭要(?)	W.M.Hayes	Ganot,*Physics*	Prepared for Dengzhou College
Huaxue xuzhi 化學須 (1886) 知	John Fryer	?	
Huowuxue 活物學 (?)	Dr.Holbrook	?	Prepared for Tongzhou College
Shengxue 聲學(1874)	Tyndall	John Fryer and Xu Jianyin	

908 The information for this table comes from John Fryer,*Educational directory for China*(1895) and *Descriptive catalogue and price list of the books,wall charts,maps & c.,published or adopted by the Educational Association of China*(Shanghai:American Presbyterian Mission Press,1894).

Shengxue jieyao 聲學揭要(?)	W.M.Hayes	Ganot,*Physics*	Prepared for Dengzhou College
Tantian 談天 (1879)	A. Wylie and Li Shanlan	Herschel	
Tiandao suyuan 天道溯原 (1867)	W.A.P.Martin	-	-
Tianwen jieyao 天文揭要(?)	W.M.Hayes	Loomis,*Astronomy*	Prepared for Dengzhou College
Tianwen xuzhi 天文須知(1887)	John Fryer	?	
Zhiwuxue 植物學 (1859)	A.Williamson and Li Shanlan	Lindley	

It can be seen that the missionary schools usually offered little more than a taste of science, sometimes, though not always, directly linked to a Christian message via the natural theology of Alexander Williamson's *Gewu tanyuan* and W.A.P.Martin's *Tiandao suyuan* 天道溯原['Following the Way of Heaven to its source' usually known as *Evidences of Christianity* in English][909], the latter not strictly a science textbook at all, but rather an introduction to Christianity via natural theology.

One is struck by the restricted range of textbooks available, and in some cases their remarkable longevity, not to say senility: yet for those who, unlike Calvin Mateer, Dr Holbrook or William Hayes, could not write their own texts, the schoolbooks of the Educational Association of China were the only suitable alternative, even though they were sometimes many decades old, and scandalously out of date.[910]

Institutions such as Calvin Mateer's Dengzhou College, where science was taught to a fairly high level by a skilled experimenter, were very rare, but by the turn of the century he had some rivals, such as Dr William Wilson in Suiding 綏定, Sichuan, who assembled a remarkable collection of electrical apparatus and seems to have had a special interest in the development of radio.[911]

<u>10.4 Science in the new institutions: Overall conclusion</u>

The institutions which taught Western science grew up in

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[909] See Chapter 12

[910] It is remarkable, for example to find the botany textbook *Zhiwuxue* translated in 1859 still in use in the 1890s. One could argue that botany had perhaps not changed very much in the interim, but for chemistry the situation had, as we have seen in Chapter 7, become little short of scandalous.

[911] Dr William Wilson, 'A science lecture at Sui-ting Fu, Si-chuen', 167-168.

the mid-to-late nineteenth century with little in China's past to guide them. The teaching of natural science(as distinct from astronomy,mathematics or medicine) as a discrete subject was completely new in China,and the struggle surrounding its introduction in the Beijing Tongwenguan revealed the depths of the opposition to the Western influence which it would inevitably bring in its train.

This opposition was not,as some writers have portrayed it,simply reactionary: the opponents of Western learning at the Tongwenguan showed a keen sense of history in their passionate objections to accepting foreign teachers on the sacred soil of the capital.[912] The objection was not only to their foreignness,but also to the implication that what they were teaching had no parallel in the traditional Chinese curriculum:the admission that China's needs could not be met from its own intellectual and moral resources. Not since the introduction of Buddhism over a millennium earlier had the Chinese invited foreigners to teach them,and for many Confucian scholars Buddhism was still regarded as a foreign religion which had brought nothing but trouble to the Middle Kingdom.

The introduction of science at the Beijing Tongwenguan was an admission at the highest level that the literary curriculum alone would not suffice;within thirty years the demand for change was to sweep aside the examination system itself.

The content of the science actually taught by many of these institutions seems meagre by modern standards. There seemed to be no clear idea what needed to be taught,and

[912] 'to be taught by a foreigner is the deepest degradation possible for a scholar'(O'Brien,64)

even the larger academies at Guangzhou,Fuzhou and Shanghai seemed barely able to run effective natural science courses for their students. The decision-makers were simply unaware of the connection between technology and the natural science on which it was based,a connection they could only be expected to make if they themselves had received at least a modicum of science education,which naturally in almost every case they had not.

The Beijing Tongwenguan was outstanding amongst the government schools in the attention it paid to science,largely because of the direction given by W.A.P.Martin,who did his best to ensure the science teaching was of a good standard. It would appear that in chemistry at least the Beijing Tongwenguan was providing a good grounding,but in thoroughness,breadth and depth it was perhaps surpassed by Calvin Mateer's Dengzhou College,which was a unique example of what single-minded determination and rigorous scholarship could achieve. The graduates of Dengzhou College were,it seems,the best equipped in all China at that time in their knowledge of science,although because of its role as a trainer of evangelists,few of them seem to have gone on to make use of their knowledge of science directly. More striking in its influence was the Shanghai Polytechnic,which,despite early problems,began in the 1890s to influence leading intellectuals through its publications.

An educational project which had been grandiose in its initial conception was the Shanghai(later called the 'Chinese') Polytechnic Institution and Reading Rooms. Intended as a model for the whole of China in science education,it achieved little in the first twenty years of its life,only beginning to see its potential realised in

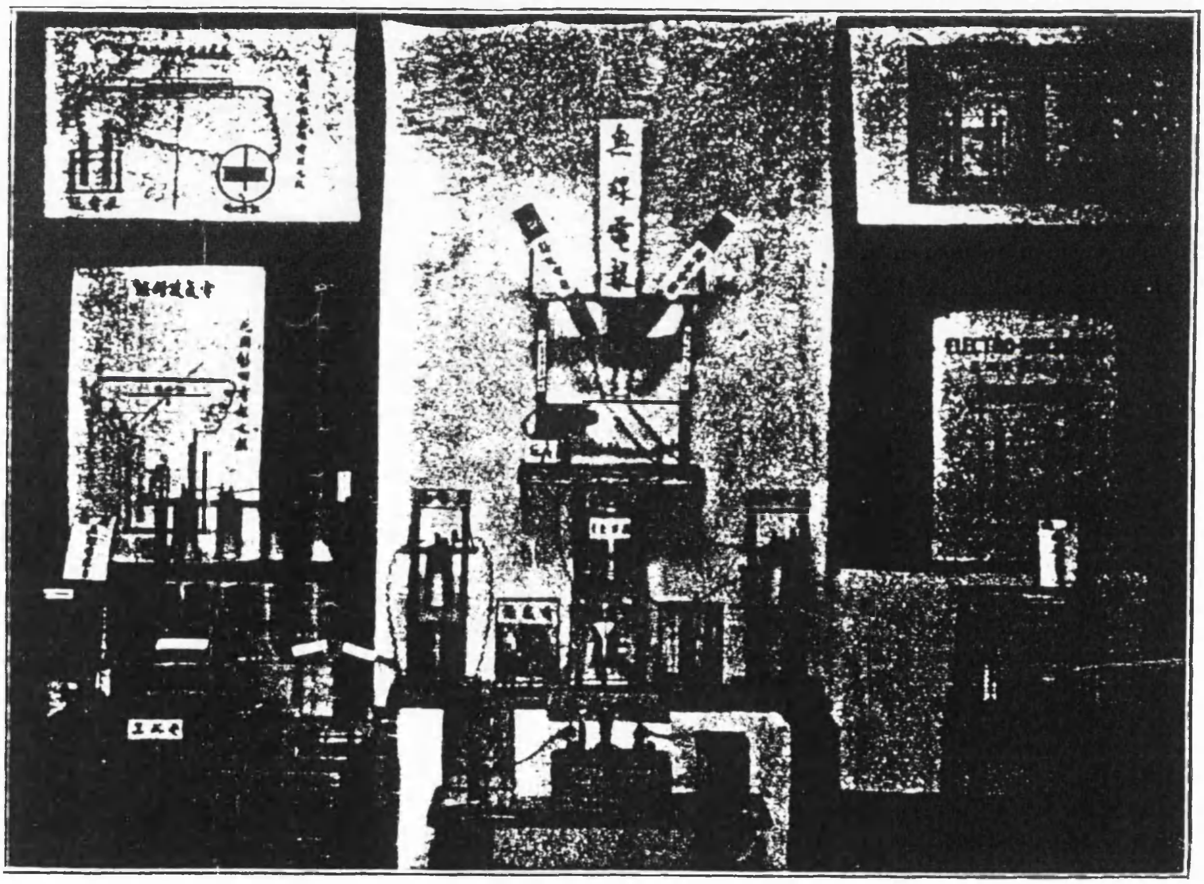

Figure 37. Apparatus used in science lectures by William Wilson in Suiding,Sichuan.From *China's Millions*(December 1903),167

the mid-1890s,just as John Fryer,its chief sponsor,was making his decision to quit China for good. In its way it was a striking demonstration of the difficulties which real progress in the transmission of science to China faced. Merely displaying specimens of Western arts and manufactures to the Chinese visitors proved a dismal failure,and nor did the Reading Room with its translated science texts attract any more interest. The founders of the Polytechnic had assumed that the curiosity of the Chinese would be aroused by charts,maps,machines and translations of Western science textbooks,but in all but a very few cases it was not. Only in the 1890s,when regular lectures and classes were begun,stimulated perhaps by the growing recognition of China's technological backwardness after the Sino-Japanese war,did interest begin to quicken.

The Shanghai Polytechnic is a case study of cultural misunderstanding,only towards the end of its life beginning to serve the function its Western founders intended. It is hard to know how Xu Shou saw the enterprise,but he presumably intended it to be more academic and less accessible to the public than did John Fryer. It proved to be surprisingly controversial,with Western businessmen fearing that it would teach the Chinese too much about their technology,and the Chinese public mainly treating it with indifference. Its illustrious Chinese sponsors did not seem to mind the fact that little was going on there for its first two decades: perhaps its existence was enough to serve as a symbol of their willingness to modernise. Although the influence of the Shanghai Polytechnic itself is debatable,its journal *Gezhi Huibian* did attract interest from all over the coastal region,and was undoubtedly read by many intellectuals,notably Kang Youwei,Liang Qichao and Tan Sitong. It does seem to have influenced their ideas quite directly in some of their writings(See Chapter 12).

Why was there so little public interest in Western science? The sheer foreign-ness of it alienated many people. For many Chinese people the 'foreign devils' were seen as bringers of humiliation,gunboats and death rather than anything they might view as 'useful knowledge' and enlightenment. With hindsight,the subject matter seems forbidding and difficult,and unlikely to attract more than a few enthusiasts. The books that were translated,were often far too difficult for the ordinary reader to grasp unaided,partly because of the nature of the subjects but also due to the strings of awkward new terms which the reader encountered,quite often with little or no clear explanation. To put the question crudely,what did the Chinese have to gain from an interest in Western science as distinct from technology? Intellectual curiosity was of course present but for individuals less gifted than Li Shanlan and Xu Shou,and who were not already familiar with the native tradition,Western science must have seen alien and impenetrable,an impression which the translated textbooks would have done little to relieve.

The surprise should not lie in the early lack of Chinese interest in Western science but rather that within such a relatively short time - a mere five decades - Western science had been assimilated into the popular and official consciousness at least in the coastal cities to such a degree that after 1900 science was to have an unquestioned part in the reformed education system.

The practical aspect of science which is today taken for granted even in primary schools in the West was lacking in all these institutions: most science teaching was done by demonstration and lecturing,with relatively little practice for the students in handling materials. This was partly due to practical matters of cost and lack of equipment,but also a result of the educational methods of the period(Chinese and Western),which expected students to be passive recipients rather than active seekers of knowledge.

This was particularly damaging for the Chinese students,who already had to contend with formidable linguistic and cultural barriers in coming to grips with scientific ideas,and for whom therefore practical experience was vital if they were to have more than the most superficial understanding. They were,as Martin commented,able and industrious students,and given the opportunity many showed themselves to be gifted,but during this period very few had the opportunity to do science rather than just read about it. Even Lu Xun's generation,a decade later,learnt science fact by fact,as a catechism,rather than through practical understanding[913]. Science seemed hard to acquire,dry in content,and of little practical use.

These institutions had different aims,none of which was directly to do with the education of a cadre of scientists,nor even the creation of a scientifically-educated elite. The most able students went abroad to study,whilst China's own science institutions struggled to survive. Of little prestige,they found it hard to recruit able teachers and students,although there were outstanding exceptions in both respects.

This was to have an important though little-studied effect on the course of Chinese politics over the next fifty years: very few of the leaders of the revolutionary movements had any knowledge of natural science. Not only did this shape their own view of the world,but also,I

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[913] How science can be learnt and how it is taught are both still matters of controversy. In Britain,the so-called 'heuristic' or 'discovery' methods of the Nuffield courses of the 1970s,which emphasised process over content,are now replaced by the more fact-based approach of the National Curriculum.

suggest,made them more susceptible to the claims of pseudo-science,its prophets and their utopias.

Chapter 11. 'Access to truth'[914]: science journalism in China 1840-1900[915]

11.0 Introduction

One of the more surprising aspects of late nineteenth-century China is the richness and variety of its popular scientific journalism.[916] In a country where there were hardly any institutions teaching science seriously,there were a number of journals wholly or in part devoted to disseminating scientific knowledge to the Chinese. Addressed to a mass audience,they were almost certainly read by those who would have never attempted to read works such as *Huaxue jianyuan*. It is to the contents of these journals we now turn.

11.1 Liuhe Congtan(1857-1858) [917]

Liuhe Congtan 六合叢談 ['Talks on matters from all directions',subtitled *The Shanghae Serial*] was edited by Alexander Wylie and published by the London Missionary Society Mohai shuguan [Inkstone Press]in Shanghai.It contained regular articles by William Muirhead,Joseph Edkins and Alexander Williamson,typically four or five

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[914] See Young J.Allen's remarks quoted below.

[915] The most useful general secondary source on the journals of this period is Roswell S.Britton,*The Chinese periodical press 1800-1912*,but see also Lin Yutang,*A history of the press and public opinion in China*(Oxford:Oxford University Press,1937),which is more entertaining but less reliable.

[916] The growth of popular journalism in China reflects the situation in Europe,where the 1870s saw a rapid growth in the founding of newspapers,and the establishment of journalism as a respectable and relatively well-paid profession. See Alan J.Lee, *The origins of the popular press in England 1855-1914*(London:Croom Helm,1976),108-109.

[917] See Britton,52. I have examined the copy in the British library,which runs to thirteen issues,from January 1857 to February 1858.

longer articles followed by a miscellany of news from around the world. The longer articles included some about Western culture such as 'Greek - the stem of Western literature'[918],the Greek poets[919],Latin histories[920]Julius Caesar[921],Cicero[922],Plato[923],Homer and Thucydides[924]as well as overtly religious ones. The journal was reprinted in Japan,excluding the religious articles.[925]

The most interesting from a scientific point of view are those on geography[926] by William Muirhead(1822-1900) and on natural theology by Alexander Williamson[927]. Muirhead's article mentions the 62 chemical elements(*yuanzhi* 元質) and includes the earliest known use of the term *huaxue* 化學) for 'chemistry'[928],but in a context which suggests that the term was invented some time before,probably at the Mohai shuguan in the early 1850s.[929] Alexander Williamson's articles were later published first in *Jiaohui Xinbao* and *Wanguo Gongbao*,and finally in book form as *Gewu*

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[918] *LHCT* **1**,1(January/February 1857),4b-6a

[919] *LHCT* **1**,3(March/April 1857),3b-4a

[920] *LHCT* **1**,4(April/May 1857),4a-5a

[921] *LHCT* **1**,2(February/March 1857),6b-8a

[922] *LHCT* **1**,8(September/October 1857),3b-4b

[923] *LHCT* **1**,11(December 1857/January 1858),3b-4b

[924] *LHCT* **1**,12(January/February 1858),3a-5b

[925] Britton,52

[926] *LHCT* **1**,1 to **1**,6

[927] Williamson was the author of *Gewu tanyuan*. See Section 7.9.

[928] *LHCT* **1**,1(January/February 1857),1a

[929] I am not aware of any earlier use of the term *huaxue*化學,but its apparent status as a standard term suggests that a thorough search of the materials published in Shanghai and Ningbo in the early 1850s might well uncover one.

tanyuan(1875).

11.2 Jiaohui Xinbao(1868-1874)[930]

Young J.Allen arrived in Shanghai in 1860,a missionary with the Southern Methodist Mission,but he soon found that preaching to the Chinese was a very ineffective way of getting the Christian message across[931]. He accepted a half-time appointment at the Shanghai Tongwenguan teaching English in 1864[932],but according to Bennett and Liu

> [he] found his students and colleagues were more often interested in science than in the English language. Since scientific instruction in the college had not yet started,questions on chemistry and electricity were sometimes put to him. Although his first contract was only for six months,he found himself,even after his service had ended,conducting chemical experiments at home for the benefit of his Chinese friends.[933]

These experiences convinced him that science could be used as an auxiliary to the Gospel:

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[930] See Britton,53; A.A.Bennett and Kwang-ching Liu 'Christianity in the Chinese idiom: Young J.Allen and the early *Chiao-hui hsin-pao* 1869-1870' in J.K.Fairbank(ed.)*The missionary enterprise in China and America*(Cambridge,Mass.:Harvard University Press,1974),159-196; A.A.Bennett *Research guide to the Chiao-hui hsin-pao(The Church News)1868-1874*(San Francisco:Chinese Materials Center,1975); Adrian A.Bennett,*Missionary journalist in China: Young J.Allen and his magazines 1860-1883*(Athens,Georgia:University of Georgia Press,1983)

[931] A.A.Bennett and Kwang-ching Liu 'Christianity in the Chinese idiom',162-164

[932] Su Jing,*Qingji tongwenguan ji qi shi-sheng*,102

[933] Bennett and Liu,'Christianity in the Chinese idiom',164

> The day of miracles has passed but the sciences skilfully illustrated in China would be almost as invincible and wonderful.[934]

He was reappointed to the Shanghai Tongwenguan in January 1867,and in the summer of that year he

> immersed himself in the study of chemistry and electricity. The small laboratory at his home now included an electromagnetic machine with a galvanic battery. Allen delighted in showing his friends and students how scientific apparatus worked. "I would explain the phenomena this illustrated and endeavour to show them the folly and falsehood of many of their superstitious beliefs[...]and thereby produce the way of access,if possible,for the approach of truth to their minds'[935]

Young J.Allen took over the editorship of *Shanghai Xinbao* 上海新報 [*Shanghai Gazette*](the weekly version of *North-China Daily News,*in May 1868 from John Fryer,who had left to work as Director of the Translation Department of the Jiangnan Arsenal[936]. Allen spent three afternoons a week on the paper,which then had a circulation of 350,mainly amongst Chinese merchants in Shanghai and other coastal cities,and he continued to edit it until 1871,even after he began editing the *Jiaohui Xinbao.*[937]
教會新報[Church News]

He founded the *Jiaohui Xinbao* in September 1868,and a

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[934] *ibid.*,165

[935] *ibid.*,166

[936] See Chapter 8.

[937] Bennett and Liu,'Christianity in the Chinese idiom',168-169

number of science articles and translated books were serialised such as *Gewu rumen* by W.A.P.Martin and *Huaxue jianyuan* by Xu Shou and John Fryer and *Gewu tanyuan* by Alexander Williamson.

11.3 Wanguo Gongbao(1875-1883; 1889-1907)[938]

In 1875,Allen changed the name of *Jiaohui Xinbao* to *Wanguo Gongbao* 萬國公報('News from a myriad countries',subtitled *The Chinese Globe Magazine*),with an enlarged news section,and a more secular orientation. It was,according to its front cover

> devoted to the extension of knowledge relating to geography,history,civilization,politics,religion,sci- ence,art,industry,and general progress of Western countries.

By 1876,the circulation was 1800 weekly[939]. In 1879 the format was changed from that of a book to a broadsheet newspaper. It was suspended in 1883,because Allen was now involved in running the Anglo-Chinese college. It resumed in 1889,with a new English subtitle *The review of the times*,managed by the recently-formed Society for the Diffusion of Christian and General Knowledge among the Chinese,and ran until 1907.

Yizhi Xinbao 益智新報(1876-78) was also edited by Young J.Allen ,and was seen as the scientific affiliate of *Wanguo Gongbao*. It was 'A repository of papers on religion,popular science,history,geography,travels and miscellaneous

938 Britton,53-55

939 *ibid.*,54

intelligence'[940],but it did not survive long,perhaps because it was too similar to *Gezhi Huibian*.

Wanguo Gongbao was one of the foreign journals which had most influence during the 1880s and 1890s on the reformers and progressive provincial leaders.Kang Youwei[941] and Tan Sitong[942] both named it as one of the periodicals they read regularly.

11.4 Zhong-Xi Wenjian Lu(1872-1875)[943]

Zhong-Xi Wenjian Lu 中西聞見錄['A record of things heard and seen in China and the West',subtitled *The Peking Magazine*] was edited in Beijing by W.A.P.Martin,Joseph Edkins,and John Shaw Burdon,and was published from August 1872 to August 1875 as the organ of the Society for the Diffusion of Useful Knowledge in China, founded by Joseph Edkins,W.A.P.Martin and John Shaw Burdon,who were also its editors.[944] Aiming to tell Chinese readers about the Far West,it included a range of topics including

> the astronomy,geography,chemistry,mechanics,medicine and physics of the Western countries and the laws and literature of all nations,together with the study of plants,flowers and trees,birds,beasts,fishes and insects,studies which are becoming more profound year by year. Research has revealed new ideas and principles for whose exposition there are no words to express. If more books are not translated,how are Chinese people to gain sufficient knowledge of these

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940 *ibid.*,60

941 Kang Youwei,'Kang Nanhai zibian nianpu' 康南海自編年譜 in Jian Bozan (ed.)*Wuxu bianfa*(4),116

942 Shu Xincheng,*Zhongguo jindai jiaoyushi ziliao*,929

943 Britton,59.

944 Britton,59

大清光緒二年

萬國公報

開嵓詩亞

西歷一千八百七十六年

七月初一日

八月十九日

VOL. IX. SATURDAY, AUGUST 19TH, 1876 No. 401.

第九年四百零一卷

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本館主小照

大清國 京報全錄 閏五月二十三日至二十七日五本

安徽屬地殺害天主教神甫傳聞 上海至吳淞初造鐵路幷輪車

圖

大美國 公舉新皇嗣位 賀觀百年大會博物院票洋清單

大日本國 在英國包造鐵甲船兩隻將到 國皇北巡回京

大俄國 與喀什噶爾立約 俄皇與奥皇面議土耳機事

大北德意志國 中國派武職前往學習軍旅之事

大日斯巴尼亞國 議加捐欵

土耳機國 前殺德法兩國領事尚未結案

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續滇游日記

韋廉臣先生 罪惡緣起第一卷第一章

通察天下大局策引

續論亞伯罕之信

倫敦會近事

瞽子漁先生 夕惕 指歴 容罪寓言三則

原價告白在後

銀洋市價 新舊告白

上海八仙橋東林華書院售

Figure 38. The front cover of *Wanguo Gongbao* (19th August, 1876) [Reproduced by kind permission of the British Library, India Office and Oriental Collections]

Figure 39. A portrait of Young J.Allen,from *Wanguo Gongbao*(19th August,1876).[Reproduced by kind permission of the British Library,Oriental and India Office Collections]

things? [945]

The writers were centred on the Beijing Tongwenguan,and as well the editors,included John Dudgeon,Li Shanlan and Xi Gan.

At least half the magazine was devoted to news items from around the world. Scientific and technical articles covered topics such as river control[946],geology[947],iron-making[948],optics[949],telegraphy[950]. There were lives of scientists such as Archimedes[951] and Aristotle[952] by Joseph Edkins,and medical articles on the heart[953],veins and arteries[954] by John Dudgeon.

The mathematical articles included one on the origins of algebra[955],and there were regular sections including mathematical problems. Li Shanlan contributed a number of articles on mathematical topics,such as root-finding[956],but he also on broader issues such as an attack on the *wuxing*五

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945 *ZXWJL* **1**(August 1872),1a

946 *ZXWJL* **1**(August 1872),3a-9a and following issues.

947 By J.S.Burdon [Baoerteng 包爾騰] in *ZXWJL* **1**(August 1872),10a-12a and following issues.

948 W.A.P.Martin,'Western methods of iron-making' in *ZXWJL* **5**(December 1872),13a-17b.

949 *ZXWJL* **33**(May 1875),1a-5b

950 *ZXWJL* **34**(June 1875),2a-5b

951 *ZXWJL* **4**(November 1872),6a-10a.

952 *ZXWJL* **32**(April 1875),7a-13b

953 *ZXWJL* **20**(March 1874),7a-11b

954 *ZXWJL* **26**(October 1874),6a-11b

955 *ZXWJL* **7**(February 1873),9a-13a

956 *ZXWJL* **2**(September 1872),13a-17a and following issues.

行 [Five Phases]theory,and on astrology[957],and poetry on subjects such as the sufferings of a filial beggar[958]

In 1876,as a result of lack of interest in the capital,and the amount of work for the editors,it was absorbed into John Fryer's *Gezhi Huibian*.[959]

11.5 Gezhi Huibian(1876-1878;1880-1882; 1890-1892) [960]

Gezhi Huibian 格致彙編 was edited by John Fryer and published under the auspices of the Shanghai Polytechnic,although in practice for many years it was the *only* public activity undertaken by the Polytechnic.[961] It

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957 *ZXWJL* **12**(July 1873),3a-3b

958 *ZXWJL* **16**(November 1873),1a-1b

959 Britton,59

960 See Britton,60-61. The classic study of the 'Notes and queries' section of *Gezhi Huibian* is Li San-po,'Letters to the Editor in John Fryer's *Chinese Scientific Magazine* 1876-1892: an analysis' in *BIMH* **4**(1974),729-777.

The Nanjing reprint of *Gezhi Huibian* is seriously defective in a number of respects,and cannot be relied upon. The cover page of each issue is usually missing,and the sections seem to have become badly disordered,so that the *Huxiang wenda* query numbers are not in sequence,and the dates of the issues in the list of contents are similarly unreliable. Only by reference to the originals can the true order be safely reconstructed.

I have examined the British Library copy of *Gezhi Huibian*,which does not include the 1890-1892 issues,in order to confirm the correct dating of the articles and queries. The page numbers for 1876-1882 inclusive are all checked against the British Library copies; for 1890-1892,I have had to use the Nanjing reprint pagination.

961 It was published February 1876 to January 1878,monthly; then February 1880 to January 1882,monthly; and finally Spring 1880 to Winter 1892,quarterly. The hiatus of 1878-79 was due to the Fryers' returning to England because of Anna's ill-health; the 1882-90 interval seems initially to have been caused by John Fryer's world voyage with his second wife Eliza,but the length of the suspension cannot be entirely due to this. It may also have been connected with his disillusion with the Shanghai

was the first Chinese journal to be entirely devoted to scientific topics. Fryer was careful to exclude political or religious topics,and even mathematics was given little space after the first few issues.

The range of topics covered was enormous,and cannot all be detailed here. I have divided them into the following categories:

A.Descriptions of devices,machines,etc.
B.Accounts of manufacturing processes
C.Mathematical problems(*suanxue qiti* 算學奇題)
D.Readers' Queries(*huxiang wenda* 互相問答)
E.Miscellaneous science news(*gewu zashuo* 格物雜 説)
F.Basic science
G.Natural history
H.Agriculture,horticulture,arboriculture
I.Military
J.Travelogues
K.Medical matters
L.Famous scientists and explorers
M.Mineralogy and mining technology
N.Miscellaneous
O.Advertisements

In order to show the great variety of topics which Fryer chose to include,examples follow below:

A.<u>Descriptions of devices</u>
steam hammers[962]; saws[963]; steam engines[964]; printing

Polytechnic,his rift with the Xu family and his commitments at the Jiangnan Arsenal. It also coincides with his toying with the idea of leading a Unitarian campaign in China.

[962] *GZHB* **1**,1(February 1876),8b-9a

[963] *GZHB* **1**,1(February 1876),11a-11b

machines[965]; automatic meteorological instruments[966]; windmills[967]; typewriters[968]; textile machinery[969]; locomotives and railways[970]; ships[971]; fire-extinguishers[972]; chemical apparatus[973]; high-temperature thermometers[974]; ice-makers[975]; husking machines[976]; rock-drills[977] fire-extinguishers[978]; machines for manufacturing gunpowder[979]; Edison's phonograph[980]; rice-husking machines[981]

B. Accounts of processes

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964 *GZHB* **1**,2(March 1876),4b-6b

965 *GZHB* **1**,3(April 1876),3b-4b

966 *GZHB* **1**,3(April 1876),5b

967 *GZHB* **1**,4(May 1876),4b-5a

968 *GZHB* **1**,7(August 1876),6b

969 *GZHB* **1**,10(November 1876),6a-8b

970 *GZHB* **2**,2(April 1877),1b-11b

971 *GZHB* **2**,3(May 1877),1a-9b

972 *GZHB* **2**,11(December 1877),1a-11a

973 *GZHB* **1**,6(July 1876),3b-5b

974 *ibid.*,5b-6b

975 *GZHB* **1**,7(August 1876),6b-7b

976 *GZHB* **1**,10(November 1876),10b-11a

977 *GZHB* **2**,10(December 1877),6b-8b

978 *GZHB* **2**,11(December 1877),1a-11a

979 *GZHB* **4**,1(February 1881),11a-14b

980 *GZHB* **6**,2(Summer 1891),46a

981 *GZHB* **7**,2(Summer 1892),14a-15a

sugar-making[982]; coal-mining[983]; cotton manufacture[984]; iron smelting[985]; glass-making[986]; brick-making[987]; bridge-building[988]; lithography[989]; photography[990];

C. Mathematical problems

This was a regular section from February 1876 to January 1877, from May 1877 to September 1877, and again from Summer 1890 to Autumn 1892.

D. Readers' queries

See Section 11.51

E. Miscellaneous Science News *Gewu zashuo* 格物雜説

Fryer used this section to include short notes and articles about items which had some scientific interest but were sometimes less serious than the main articles: planting trees in cities[991]; proof that the Earth is

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982 *GZHB* **1**,1(February 1876),11b-13b

983 *GZHB* **1**,4(May 1876),2b-4a

984 *GZHB* **1**,7(August 1876),7b-8b

985 *GZHB* **2**,7(September 1877),1a-4b

986 *GZHB* **2**,7(September 1877),11a-13a

987 *GZHB* **2**,10(December 1877),1a-4a

988 *GZHB* **2**,9(October 1877),1b-5a

989 *GZHB* **2**,10(December 1877),8b-12a

990 *GZHB* **3**,9(October 1880),10a-13b

991 *GZHB* **1**,2(March 1876),11a-11b

THE

Chinese Scientific Magazine:

A MONTHLY JOURNAL

OF

POPULAR SCIENTIFIC INFORMATION,

WITH WHICH IS INCORPORATED

The Peking Magazine.

VOL. I. NO. 1

FOR

1876.

SECOND EDITION

PRICE—ONE MEXICAN DOLLAR PER ANNUM, PAYABLE IN ADVANCE.

Advertisements will be inserted at rates which may be obtained on application.

The Office for publication is at the Chinese Polytechnic Institution and Reading Rooms, Shanghai.

JOHN FRYER,

EDITOR.

Figure 40. The back cover of *Gezhi Huibian* 1,1(September 1876)

[Reproduced by kind permission of the British Library, Oriental and India Office Collections]

round[992]; making artificial gemstones[993];large telescopes[994]; earthquakes[995]; using a microscope for blood-typing[996]; a competition between bicycles and horses[997]; making *mantou* 饅頭[steamed bread rolls] from sawdust[998]; making sugar from waste cotton[999]; and public telephones[1000].

F.Basic science

'Outline of science'[1001]; 'Science theory'[1002]; on the chemical affinity of elements[1003]; on tides[1004]; on phosphorus[1005]; *The chemistry of common life*[1006]; the chemical elements in a human being[1007]; sulphur contained

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[992] *GZHB* **1**,2(March 1876),11b

[993] *GZHB* **1**,2(March 1876),12b

[994] *GZHB* **1**,3(April 1876),11b-12a

[995] *ibid.*,12a-12b

[996] *GZHB* **1**,4(May 1876),10a-10b

[997] *GZHB* **1**,4(May 1876),11a-11b

[998] *GZHB* **2**,9(October 1877),15a-15b. Attempts to find cheap substitutes for grain have continued into recent times. Bao Ruo-wang(Jean Pasqualini),*Prisoner of Mao*(London: Penguin Books,1977),216-219 recounts fatal experiments,involving prisoners being fed 'food substitute' made from paper pulp during the famine in the early 1960s.

[999] *ibid.*,15b

[1000] *GZHB* Spring 1891

[1001] *GZHB* **1**,1(February 1876),2a-6b

[1002] *GZHB* **1**,8(September 1876),10a-10b

[1003] *GZHB* **2**,8(October 1877),10a-12a

[1004] *GZHB* **2**,9(October 1877),5a-8a

[1005] *GZHB* **2**,9(October 1877),11b-12b

[1006] *GZHB* **3**,1(February 1880),10a-13b

[1007] *GZHB* **2**,9(October 1877),14b

in fur and hair[1008]; and electricity[1009]

G.Natural history

ants[1010]; the Indian tiger[1011];a comparison of the rate of blood circulation in humans and whales[1012]; fossil birds[1013]; entomology[1014]; ornithology[1015]

H.Agriculture,apiculture,arboriculture,etc

the planting of trees in cities[1016]; bee-keeping [1017] planting sugar-cane[1018]; putting plants in sandy places[1019]

I.Military matters and hardware

torpedoes[1020]; guns[1021]; a request for China to look to its

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1008 *GZHB* **2**,9(October 1877),15a

1009 *GZHB* **6**,2(Summer 1891)24b-27a and subsequent issues,by C.H.Oliver[Oulifei 歐禮斐],professor of physics at the Beijing Tongwenguan.

1010 *GZHB* **1**,9(October 1876),12a

1011 *GZHB* **2**,1(February 1877),16a

1012 *GZHB* **2**,9(October 1877),14b-15a

1013 *GZHB* **2**,9(October 1877),16b

1014 *GZHB* **6**,1(Spring 1891),38a-40a

1015 *GZHB* **7**,4(Winter 1892),26a-37a

1016 *GZHB* **1**,2(March 1876),11a-11b,by Daniel Jerome Macgowan.

1017 *GZHB* **1**,10(November 1876),8b-10a and following issues

1018 *GZHB* **5**,4(Winter 1890),34a-41a

1019 *GZHB* **6**,1(Spring 1891),28b-29a,by Daniel Jerome Macgowan

1020 *GZHB* **1**,3(April 1876),5b-8a

1021 *GZHB* **2**,6(August 1877),1a-14a

military preparations[1022]; a letter from a German military official to Li Xing 李星 advising that China should use Western methods for training soldiers[1023]; essentials of naval warfare[1024]

J. Travelogues and geographical information

the perils of crossing icy mountains[1025]; the hairy Ainu of Japan[1026]; Western peasant women(illustrated)[1027]; a journey to Japan[1028]; an account of Russia[1029]

K. Medical

the teeth [1030] and the damage which eating sugar can do to them[1031]; saving people from drowning[1032]; on veins and arteries[1033]; curing opium addiction[1034]; the tongue[1035]; on breathing[1036];blood transfusions[1037]; the role of iron

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[1022] *GZHB* **3**,1(February 1880),14a-14b

[1023] *GZHB* **4**,5(June 1881),15a-16b

[1024] *GZHB* **4**,6(July 1881),13a-13b and **4**,7(August 1881),10a-12b

[1025] *GZHB* **2**,1(February 1877),9a-9b

[1026] *GZHB* **1**,12(January 1877),11a

[1027] *GZHB* **1**,3(April 1876),9b-10a

[1028] *GZHB* **1**,5(June 1876),7a-9b

[1029] *GZHB* **3**,5(June 1880),13a-15b and **3**,6(July 1880),12a-14b

[1030] *GZHB* **1**,8(September 1876),7b-9a

[1031] *GZHB* **2**,9(October 1877),15b

[1032] *GZHB* **1**,11(December 1876),6a-8a,by Daniel Jerome Macgowan

[1033] *GZHB* **1**,11(December 1876),8a-9a. A translation by Shu Gaodi 舒高第 (V.P.Suvoong).

[1034] Two articles by D.J.Macgowan in *GZHB* **1**,12(January 1877),12a-12b

[1035] *GZHB* **2**,3(April 1877),12a-12b,translated by Shu Gaodi.

[1036] *GZHB* **2**,4(May 1877),9b-11a

in the blood[1038]; extracts from a Western pharmacopoeia[1039]; domestic hygiene[1040]

L. Famous scientists and explorers

Benjamin Franklin[1041]; Li Shanlan[1042]; Xu Shou[1043]; Pascal[1044], Linnaeus[1045]; Christopher Columbus[1046]; Xu Guangqi, Matteo Ricci and Adam Schall von Bell[1047].

M. Mineralogy and mining technology

the analysis of Chinese iron ore[1048]; pumping water out of mines[1049]; China ought to invite Westerners to prospect for minerals[1050]

N. Miscellaneous

1037 *GZHB* **2**,8(September 1877),16b

1038 *GZHB* **3**,3(April 1880),14a,by Xu Jianyin

1039 *GZHB* **5**,3(Autumn 1890),27a-33a

1040 *GZHB* **5**,4(Winter 1890),28a-34a

1041 *GZHB* **2**,1(March 1877),7b-8a

1042 *GZHB* **2**,5(July 1877),1a

1043 *GZHB* **2**,9(October 1877),1a

1044 *GZHB* **3**,2(March 1880),13a-13b

1045 *GZHB* **3**,7(August 1880),14a-14b

1046 *GZHB* **4**,4(May 1881),15b-16b

1047 *GZHB* **5**,4(Winter 1890),(i)a-(ii)b

1048 *GZHB* **2**,3(April 1877),12b-14a by Anatole Billequin of the Beijing Tongwenguan.

1049 *GZHB* **2**,8(September 1877)

1050 *GZHB* **2**,8(September 1877)

a new history of England[1051]; a letter from General Gordon to Li Hongzhang[1052]; the origins of the Chinese language [1053]; lessons in Western art[1054]; book reviews[1055]

O. Advertisements

The advertisements which ended each issue were of various types of machines and scientific instruments, some of which were also mentioned in the articles of the same issue. Individual manufacturers took a keen interest in the journal and its associated Shanghai Polytechnic.[1056]

11.51 Huxiang wenda 互相問答

The 'Readers' Queries' section of *Gezhi Huibian* was one of the most interesting and innovative aspects of the journal, as Fryer invited readers to send in their questions to him.

> Letters come to the Editor from all parts of the Empire asking what are sometimes very intelligent questions of general interest and to which careful replies are given; while on the other hand some of the questions are of such a frivolous kind they can receive only a passing notice.[1057]

The classic study of these questions and answers is by

[1051] *GZHB* **2**,8(September 1877). Translated by Joseph Edkins

[1052] *GZHB* **3**,8(September 1880),14a-15a

[1053] *GZHB* **5**,3(Autumn 1890),18a-22b

[1054] *GZHB* **5**,1(Spring 1890),6a-9b and following issues

[1055] *GZHB* **6**,3(Summer 1891),48b-49b

[1056] John Bourne, a scientific instrument maker, was a leading mmeber of the Home Committee of the Polyetechnic. See John Fryer, *First report of the Shanghai Polytechnic Institution*, 9.

[1057] John Fryer, *Second Report of the Chinese Polytechnic*, 8

Li San-po; the present account does not attempt to supersede that of Li,but tries to consider what these questions(and Fryer's answers) tell us about how Western science is being transmitted and received.

We are not always even told the writers' surnames or where they come from,but when we are it is clear that most are from the Treaty Ports,but there are also correspondents from Taiwan,Japan,and from the remoter provinces such as Yunnan. The same correspondent does occasionally appear to have written more than one question,although as no *ming*名 are given one cannot be certain of this. Mr Guo 郭 of Amoy seems to have written six times[1058],Mr Hu 胡 of Tianjin twice,another Mr Hu 胡 of Suzhou twice,Mr Shen 沈 of Hangzhou twice,and so on. The letters reveal little about their writers,although they do vary greatly in their knowledge of science,some asking questions with the directness of a novice,others with a subtlety which is only likely after long study.

A. Requests for explanations of their own observations of natural phenomena

This category is one of the most interesting and various: it includes queries about the source of the sparks produced when a cat is stroked[1059]; why ice causes a water-container to crack[1060] -but frozen mercury does not damage a thermometer[1061]; what causes the tides in Shanghai[1062]; what causes the sulphurous smell generated when the hands

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[1058] Queries #86,#209,#234,#239,#250,#269

[1059] Query #1 *GZHB* **1**,1(February 1876),14a

[1060] Query #2,*ibid.*,14a

[1061] Query #48 *GZHB* **1**,7(August 1876),9b

[1062] Query #18: *GZHB* **1**,3(April 1876),11b are rubbed together[1063]; why cats' eyes reflect light [1064]; the nature of spiders' webs [1065]; Mr Zhang 張 of Shanghai asked why hair is smooth when stroked from root to tip and not the other way[1066]; the source of marine phosphorescence[1067]; the shape of a light-beam produced by a square hole[1068]; why black hair doesn't turn white when it falls [1069]; the cause of echoes[1070]; the explanation of 'magic' mirrors,which seem to reflect marks on the <u>back</u> of the mirror[1071]; why paper ignites quickly when fire is beneath it,but slowly when the fire is above the paper[1072];why acid chars wood[1073]; why sounds are clearer at night[1074]; why red worms appear in water-butts[1075] ; and why faeces are a different colour from the food that is eaten[1076].

They express a keen curiosity about the natural world which Fryer did his best to satisfy,but also tantalisingly

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1063 Query #19 *ibid.*,11b

1064 Query #32 *GZHB* **1**,5(June 1876),10b

1065 Query #33 *GZHB* **1**,5(June 1876),10b

1066 Query #34 *GZHB* **1**,5(June 1876),10b

1067 Query #36 *GZHB* **1**,5(June 1876),11a

1068 Query #68 *GZHB* **1**,9(October 1876),9b

1069 Query #106 *GZHB* **2**,1(March 1877),15b

1070 Query #134 *GZHB* **2**,4(June 1877),12a-12b

1071 Query #173 *GZHB* **2**,8(October 1877),15a and Query #179 **2**,9(October 1877),12b-13a

1072 Query #175 *GZHB* **2**,8(October 1877),15b

1073 Query #170 *GZHB* **2**,8(October 1877),14b

1074 Query #193 *GZHB* **2**,10(December 1877),14a

1075 Query #229 *GZHB* **3**,2(March 1880),15b

1076 Query #235 *GZHB* **3**,3(April 1880),16a suggest that some correspondents were not merely making casual observations but were actually carrying out their own experiments(see category C).

B.<u>Requests for more information about the explanations given by Western science for natural phenomena</u>

In this category one can see the traditional Chinese explanations - sometimes in terms of folklore - being placed alongside the 'new' Western one. Fryer often uses queries of this type to point out the errors in the 'superstitious' beliefs of the Chinese,a role for science which he and many other missionaries sought to emphasise in showing the superiority of their civilisation.

The most impressively technical of these are on astronomy,a science in which the Chinese had excelled long before Western contacts began. Chemical theory,by contrast,posed considerable problems,and was one of the areas in which most scepticism about Western ideas was expressed. It seems that the concept of chemical combination - still not generally understood by the British lay public today - caused more than one reader difficulties,in particular the notion that something as obviously solid,opaque and black as carbon could be hidden inside something as white as sugar,or be contained in something as flimsy and transparent as air. Mr Wang 汪 of Hankou 漢口 asked how it could be <u>proved</u> that sugar contains carbon[1077]; one questioned whether it can be true that there is carbon in air[1078],whilst another asked where the carbon in oil goes when the lamp is burnt[1079]. A reader in Suzhou also found it hard to believe that water was really

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[1077] Query #88 *GZHB* **1**,11(December 1876),11a

[1078] Query #251 *GZHB* **3**,7(August 1880),16b

[1079] Query #133 *GZHB* **2**,4(June 1877),12a made of two gases[1080]. Mr Lin 林 of Shantou asked what the subscript numbers meant in chemical formulae[1081]. Other more straightforward chemical queries were about making hydrogen from zinc and nitric acid[1082]; how *sanxiandan* 三仙丹[mercury(II) oxide] could be made from mercury[1083]; why atmospheric oxygen is never exhausted[1084]; how phosphorus may be obtained[1085]; the use of silver to detect bad eggs[1086]; and the paradoxical use of an ice lens to make fire[1087]

Mr Sun of Suzhou asked whether it was true,as the *Bencao gangmu* 本草剛目[Chinese pharmacopoeia] said,that *machimi* 馬齒莧 [the plant *Portulaca*] contains mercury,showing that Western science is sometimes being used as an authority against which the Chinese explanation can be judged.[1087A] A reader from Dengzhou 登州 quoted the saying *Han pa yin tian,lao pa qing*. 旱怕陰天潦怕清 [Drought abhors overcast weather,floods fear a clear sky.] and asked for a scientific explanation.[1088] Mr Li 李 of Laizhou 萊州 asked whether the traditional saying *Xue zhao nian feng*. 雪兆年豐 [Snow portends a good harvest] had any basis in

1080 Query #197 *GZHB* **2**,10(December 1877),14b-15a

1081 Query #128 *GZHB* **2**,3(May 1877),15a-15b

1082 Query #121 *GZHB* **2**,3(May 1877),14b. A curious query,as hydrogen is not reliably obtained from zinc and nitric acid.

1083 Query #243 *GZHB* **3**,5(June 1880),17a-17b

1084 Query #183 *GZHB* **2**,9(October 1877),13b-14a

1085 Query #128 *GZHB* **2**,3(May 1877),15a-15b

1086 Query #199 *GZHB* **2**,11(December 1877),13a

1087 Query #182 *GZHB* **2**,9(October 1877),13b

1087A #47 GZHB 2,5 (July 1877), 15b

1088 Query #175 *GZHB* **2**,8(October 1877),15b fact.[1089]

A number of other questions related to meteorological phenomena: Mr Hua 華 of Jinkui asked about the shadows cast by the Sun[1090]; someone from Ningbo asked why,if the Sun is the same distance from the Earth throughout the day,the temperature on Earth is hotter at noon[1091]; a writer from Wusong 吴淞 asked about the reasons for the Yellow River flooding[1092]; another from Qingzhou 青州 asked about the traditional explanation of rainbows

> Chinese books say that the rainbow[*hong* 虹],also called *didong* 螮蝀 [1093],is the improper [*yin* 淫] *qi* of Heaven and Earth,[caused by] the prolonged intercourse of sun and rain: it is the intercourse of those [things] which ought not to engage in intercourse,and is thus the improper *qi* of Heaven and Earth. How do scientists explain it? [1094]

[1089] Query #284 *GZHB* **4**,10(November 1881),16a

[1090] Query #54 *GZHB* **1**,7(August 1876),10b

[1091] Query #177 *GZHB* **2**,9 (October 1877),12b. This query echoes a passage in the *Liezi* 列子 in which a precocious youth interrogates Confucius about similar matters. See Joseph Needham *SCC* Vol 3.,225-226.

[1092] Query #11 *GZHB* **1**,2(March 1876),11a

[1093] This term is the name of a mythical serpent-like creature,and like the term *hong* includes the 'insect' radical in the character. The phonetic elements of *didong*,*dai* 帶 'girdle' and *dong* 東 'east',suggest that the term *didong* may originally have meant 'girdling the east'(which is the direction in which rainbows most often appear).

[1094] Query #223 *GZHB* **3**,1(February 1880),15a-15b.My translation,based on that of Li San-po 'Letters to the Editor' p.757. The impropriety is due to the *yang* nature of the sun and the *yin* nature of water.

A correspondent from Wenzhou 温州 asked for the scientific explanation of the appearance of fish on land after heavy rain[1095]. Other queries included whether dew and frost really fall from the sky[1096]; the origin of whirlwinds[1097]; the cause of hail[1098]; the connection between sunspots and the weather[1099]; and the use of barometers in weather prediction[1100]

Mr Zhang 張 of Ningbo was puzzled as to why the attraction of the Moon should occasion two tides per day[1101]; Mr Shen 沈 of Tongxiang 桐鄉 asked about the relative influence of the Sun and Earth on tides[1102] . Mr Tao 陶 of Xiushui 秀水 asked why,given the existence of North and South poles,there are no East or West poles[1103]. One writer asked about magnetic deviation[1104]; and another how the magnetism of iron objects might be increased.[1105]

One of the most interesting theoretical queries related to whether heat had mass. A Shanghai correspondent,noting that heat makes things expand and that water also causes swelling,asked whether,like water,heat causes things to get heavier. Fryer explained that in the

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1095 Query #227 *GZHB* **3**,2(March 1880),15a

1096 Query #195 *GZHB* **2**,10(December 1877),14a-14b

1097 Query #217 *GZHB* **2**,12(January 1878),15a

1098 Query #241 *GZHB* **3**,4(May 1880),16b

1099 Query #279 *GZHB* **4**,8(September 1881),15a-15b

1100 Query #287 *GZHB* **4**,10(November 1881),16b

1101 Query #166 *GZHB* **2**,7(September 1877),15b-16a

1102 Query #181 *GZHB* **2**,9(October 1877),13a-13b

1103 Query #25 *GZHB* **1**,4(May 1876),8a

1104 Query #44 *GZHB* **1**,6(July 1876),11a

1105 Query #218 *GZHB* **2**,12(January 1878),15a-15b

past it had been believed that caloric [*reqi* 熱氣] had mass but that this idea had proved incorrect.[1106]
Mr Chen 陳 made the ingenious suggestion that the reason why the Earth is an oblate spheroid - wider at the Equator than the poles - is that the equatorial soil has expanded because of the heat.[1107]

Perhaps referring to Darwinian ideas of evolution,Mr Wu 吴 of Hangzhou asked how islands surrounded by water could have such diverse populations of animals and plants[1108], and Mr Xiang 項 of Hubei wondered of what use harmful insects like flies could be.[1109]

C.<u>Evidence of independent investigations</u>

The transmission of science was by no means only a question of passive acceptance by the Chinese readers of the information Fryer and others chose to impart. Some of the letters reveal that the writers were carrying out their study of science and conducting their own experiments,whilst others proposed original explanations for phenomena using the Western paradigms. Mr Wu 吴 of the Fuzhou Shipyard asked what books on science were suitable

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1106 Query #194 *GZHB* **2**,10(December 1877),14a. Li San-po misinterprets this as referring to phlogiston(*huoqi*火氣),which,though also supposed to be a fluid,was a quite different conception. See Li San-po 'Letters to the Editor',758.

1107 Query #202 *GZHB* **2**,11(December 1877),13a-13b

1108 Query #105 *GZHB* **2**,1(March 1877),15a-15b. There had been no translation of any of Darwin's books into Chinese at this time,but this does of course not preclude some kind of oral transmission. There is a brief mention of Darwin in *Dixue qianshi* 地學淺釋[A simple account of geology](1873),a translation of the 10th edition of Charles Lyell's *Elements of geology*.

1109 Query #312 *GZHB* **6**,3(Autumn 1891),49a for a novice.[1110]

The authentic voice of the experimenter,struggling with intractable equipment and obscure practical instructions,appears with Mr Zhou 周 of Wuchang 武昌,who wrote

> I love science,and have bought several science books and many types of apparatus. I have tried out all the recipes[*fang* 方]and techniques contained therein,but they have not worked. I do not know whether there are mistakes in the books or whether the equipment is faulty,or whether it is because I am not following the instructions properly during my experimentation. [1111]

Another frustrated correspondent from Shanghai said that he had tried to make a copper-zinc cell himself but that he was unable to make sparks or to electroplate with it [1112].Electroplating seemed to excite considerable interest: a reader from Hangzhou complained that copper sulphate was expensive for electroplating,which suggests that he may well have been trying to do it himself.[1113]

Interest in the profitable possibilities of Western technology were revealed by a reader in Suzhou,who reported that some people in Shanghai were buying sulphuric acid to extract gold and copper from silver ingots *yuanbao* 元寶 [1114]. Mr Zhou 周 of Amoy had asked whether it was true that gold was not oxidised when heated strongly,as he had conducted

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[1110] Query #186 *GZHB* **2**,10(December 1877),13a

[1111] Query #132 *GZHB* **2**,4(June 1877),12a

[1112] Query #165 *GZHB* **2**,7(September 1877),15b

[1113] Query #240 *GZHB* **3**,4(May 1880),16a-16b

[1114] Query #35 *GZHB* **1**,5(June 1876),10b-11a some careful experiments and found there was actually some mass lost on heating: Fryer seemed to agree with him that there was some oxidation [1115],although it seems more likely that the gold was impure.

Mr Wang 王 of Wuchang had observed the Moon with his telescope,and asked about the possibility of life there[1116]; Mr Shen 沈 of Shanghai also asked about the use of microscopes[1117].

D.Queries relating to mineralogy,metallurgy and mining technology

A number of correspondents sent in sacks of mineral ores for identification. Samples were analysed and often turned out to be lead ore with very little silver[1118]. There were also questions about removing lead and tin from silver.[1119] Mr Wang 王 of Guangzhou sent a rock he hoped contained gold,and Mr Wu 武 of Guxun 古 昀 sent another which he thought contained lead and tin,but both samples turned out to be only mica.[1120] More than one mineral which arrived turned out to be merely iron pyrites,marcasite or copper pyrites(*zirantong* 自然銅).[1121] There were also more practical questions,about mining

[1115] Query #141 *GZHB* **2**,5(July 1877),15a

[1116] Query #107 *GZHB* **2**,1(March 1877),15b-16a

[1117] Query #115 *GZHB* **2**,2(April 1876),16b117a

[1118] Query #29 *GZHB* **1**,5(June 1876),10a; Query #90 *GZHB* **1**,11(December 1876),11a-11b

[1119] Query #244 *GZHB* **3**,5(June 1880),17b

[1120] Query #108 *GZHB* **2**,2(April 1877),16a and Query #253 *GZHB* **3**,8(September 1880),15a-15b

[1121] Query #109 *GZHB* **2**,2(April 1877),16a and Query #276 *GZHB* **4**,7(August 1881),16a-16b technology[1122]; gold extraction from rivers[1123]; and the capital needed to open a mine[1124]

E. Astronomical queries

These included the transit of the Sun by Venus(*Jinxing*金星) [1125]; why the number of stars differed in ancient and modern times[1126]; on the distance of the Moon and Sun from the Earth[1127]; on Saturn [1128]. Mr Hu 胡 of Suzhou asked why the Sun and Moon seem to be of different sizes at different times[1129]

F. Foreign commodities

Commodities which were inquired about included matches(*yangmeitou* 洋熶頭); rubber [1130](Mr Guo of Amoy(Xiamen), already noted as one of the most frequent correspondents, made the ingenious suggestion of using rubber to prevent damage from collisions between ships[1131]); kerosene[1132]; cocoa and chocolate[1133]; cork

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[1122] Query #62 *GZHB* **1**,8(September 1876),12b and Query #212 *GZHB* **2**,12(January 1878),14a

[1123] Query #117 *GZHB* **2**,2(April 1877),17a

[1124] Query #286 *GZHB* **4**,10(November 1881),16a-16b

[1125] Query #3 *GZHB* **1**,1(February 1876),14a and **1**,2(March 1876),8a-8b

[1126] Query #6 *GZHB* **1**,1(February 1876),14a and **1**,2(March 1876),9a-10b

[1127] Query #38 *GZHB* **1**,5(June 1876),11a-11b

[1128] Query #98 *GZHB* **2**,1(March 1877),14b

[1129] Query #174 *GZHB* **2**,8(October 1877),15a-15b

[1130] Query #12 *GZHB* **1**,2(March 1876),11a and **1**,3(April 1876),11a

[1131] Query #239 *GZHB* **3**,4(May 1880),16a

[1134]; beer[1135] and cider[1136].

G. Western technology

Many correspondents were curious about aspects of Western manufactures of acids[1137]; metal plating [1138] agricultural machinery[1139]; photography[1140]; smokeless lamps[1141]; safety lamps[1142]; guncotton[1143]; icemaking equipment[1144]; bicycles[1145]; bleaching[1146]; mending

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1132 Query #21 *GZHB* **1**,4(May 1876),7b and Query #210 **2**,12(January 1878),14a

1133 Query #30 *GZHB* **1**,5(June 1876),10a

1134 Query #42 *GZHB* **1**,6(July 1876),10b

1135 Query #43 *GZHB* **1**,6(July 1876),10b

1136 Query #101 *GZHB* **2**,1(March 1877),15a

1137 Query #5 *GZHB* **1**,1(February 1876),14a and **1**,2(March 1876),8b-9a; Query #240 *GZHB* **3**,4(May 1880),16a-16b; Query #294 *GZHB* **4**,12(January 1882),16a-16b

1138 Query #7 *GZHB* **1**,1(February 1876),14a and **1**,3(April 1876),10b

1139 Query #9 *GZHB* **1**,2(March 1876),10b and **1**,3(April 1876),10b

1140 Query #20 *GZHB* **1**,3 (April 1876),11b; Query #26 **1**,4(May 1876),8a-8b; Query #27 **1**,4(May 1876)8b; Query #89 **1**,11(December 1876),11a; Query #306 **6**,2(Summer 1891),48a and Query #307 **6**,2*ibid.*,48a; Query #310 **6**,3(Autumn 1891),49a and Query #311,*ibid.*,49a

1141 Query #23 *GZHB* **1**,4(May 1876),8a and Query #94 **1**,12(January 1877),11b

1142 Query #31 *GZHB* **1**,5(June 1876),10a-10b

1143 Query #152 *GZHB* **2**,6(August 1877),15a

1144 Query #265 *GZHB* **3**,10(November 1880),16a-16b

1145 Query #288 *GZHB* **4**,11(December 1881),15b

1146 Query #297 *GZHB* **5**,3(Autumn 1890),48a porcelain[1147]; and lithography[1148]. Electrical devices excited particular curiosity,including undersea cables[1149]; telegraphy[1150]; the telephone[1151]. Mr Wu 吴 of Taicang 太倉 asked about electroplating[1152],whilst Mr Xu 許 of Hangzhou made a rather macabre inquiry about electroplating human corpses[1153].

H.Western medicine

treatment for someone with cement in their eyes[1154]; the best food for weaning infants[1155]; deaf-aids[1156]; the teaching of the deaf and dumb[1157]; the treatment of burns and scalds[1158] and of asthma[1159]; quinine sulphate(*jinashuang* 雞那霜)[1160]; dental caries[1161]

1147 Query #301 *GZHB* **6**,1(Spring 1891),42b

1148 Query #304 *GZHB* **6**,1(Spring 1891),43a

1149 Query #222 *GZHB* **3**,1(February 1880),15a

1150 Query #208 *GZHB* **2**,11(December 1877),14b

1151 Query #73 *GZHB* **1**,9(October 1876),10a-10b,Query #135 **2**,4(June 1877),12b,Query #207 **2**,11(December 1877),14a,Query #305 **6**,2(Summer 1891),47a-48b

1152 Query #180 *GZHB* **2**,9(October 1877),13a

1153 Query #314 *GZHB* **7**,1(Spring 1892),49a-49b. Xu had heard that 'rich people have gold or silver plating,the poor are plated with copper'.

1154 Query #28 *GZHB* **1**,4(May 1876),8b

1155 Query #56 *GZHB* **1**,8(September 1876),11b

1156 Query #60 *GZHB* **1**,8(September 1876),12a-12b

1157 Query #230 *GZHB* **3**,2(March 1880),15b-16a

1158 Query #83 *GZHB* **1**,10(November 1876),11b-12a and Query #163 **2**,7(September 1877),15a

1159 Query #87 *GZHB* **1**,11(December 1876),11a

1160 Query #104 *GZHB* **2**,1(March 1877),15a the use of amalgam for filling teeth[1162]; treating people who have swallowed opium[1163]; the setting up of hospitals[1164]; halitosis[1165]; electrotherapy[1166]; sputum[1167]; iron as a medicine[1168],including its use as a cure for opium addiction(a reply by Xu Jianyin)[1169]; ether as an anaesthetic[1170]; vaccination[1171]; false teeth(*xiangchi* 鑲 齒)[1172]; nitrous oxide as an anaesthetic[1173]; hypnotism[1174]; and consumption[1175]

11.52 An analysis of the subject areas of articles in Gezhi Huibian

Percentages are calculated as $\frac{\text{titles on subject area}}{\text{total article titles}} \times 100$

[1162] Query #262 *GZHB* **3**,10(November 1880),15b

[1163] Query #145 *GZHB* **2**,5 (July 1877),15b. Swallowing opium was a common method of suicide.

[1164] Query #184 *GZHB* **2**,9(October 1877),14a

[1165] Query #187 *GZHB* **2**,10(December 1877),13a

[1166] Query #221 *GZHB* **3**,1(February 1880),15a

[1167] Query #232 *GZHB* **3**,2(March 1880),16a-16b

[1168] Query #236 *GZHB* **3**,3(April 1880),16a-16b

[1169] Query #246 *GZHB* **3**,6(July 1880),16a-16b

[1170] Query #258 *GZHB* **3**,9(October 1880),15b

[1171] Query #264 *GZHB* **3**,10(November 1880),15b-16a

[1172] Query #274 *GZHB* **4**,6(July 1881),16a-16b

[1173] Query #283 *GZHB* **4**,10(November 1881),15b-16a

[1174] Query #299 *GZHB* **5**,3(Autumn 1890),48b-49a

[1175] Query #308 *GZHB* **6**,2(Summer 1891),47b-48b

Subject areas:

a: machinery,instruments,devices
b: materials,processes,manufactures,methods of manufacture
c: agriculture,apiculture,arboriculture
d: mathematics
e: chemistry
f: physics
g: biology,anthropology,natural history
h: general science
i: medicine
j: minerals,mining,geology
k: travel,geography,exhibitions
l: astronomy
m: military
n: education
o: biography

Table 14. The percentages of articles on various subject-types in *Gezhi Huibian*(1876-1892)

Issue	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
1,1 (February 1876)	31	23	8	8			15	8				8			
1,2 (March 1876)	33	11	11	11	11					11	11				
1,3 (April 1876)	55		9	9					9	18					
1,4 (May 1876)	24	11	6	6	11		17	7	11	6	6				
1,5 (June 1876)	25	8	8	8	8		25			8	8				
1,6 (July 1876)	22	22		11							25			22	
1,7 (August 1876)	30	20	10	10		10		10		10					
1,8 (Sept 1876)	10	20		10				20	20	20					
1,9 (Oct 1876)	7	7	13	7			33		7	13	7	7			
1,10 (Nov 1876)	22	11	11	11			22		22						
1,11 (Dec 1876)	10		10	10			20		40						

1,12 (Jan 1877)	36	6	6	6					42						
2,1 (March 1877)	21	7	7	7					21	7	14			7	7
2,2 (April 1877)	28		14					14	14		14				14
2,3 (May 1877)	9	9	9	9				9	36	9	9				
2,4 (June 1877)	29	14	14					14	14						14
2,5 (July 1877)	25			13					25	13				13	13
2,6 (Aug 1877)	20			20					20				40		
2,7 (Sept 1877)	30	30	8				10	30							
2,8 (Oct 1877)	8	25	7			17		8	33	8					
2,9 (Oct 1877)	19	19			19	6	6	6	19						6
2,10 (Dec 1877)	50	50													
2,11 (Dec 1877)	33	11					11		22		11	11			
2,12 (Jan 1878)	40	20	10				10	10					10		

3,1 (Feb 1880)	25	25			25								25		
3,2 (March 1880)	20	20			20								20		20
3,3 (April 1880)	20	20			20				20				20		
3,4 (May 1880)	20	20	20		20								20		
3,5 (June 1880)	20	20			20						20		20		
3,6 (July 1880)	20	20			20						20		20		
3,7 (August 1880)	17	17			17	17					17				17
3,8 (Sept 1880)	25	25			25						25				
3,9 (Oct 1880)	20	40			20	20									
3,10 (Nov 1880)	25	25			25	25									
3,11 (Dec 1880)	20	40			20	20									
3,12 (Jan 1881)	25	25			25						25				

4,1 (Feb 1881)	40	20			20						20				
4,2 (Mar 1881)	40	20			20			20							
4,3 (April 1881)	40				20			40							
4,4 (May 1881)	34				17			17					17		17
4,5 (June 1881)	20				20						20		40		
4,6 (July 1881)	20				20						20		40		
4,7 (August 1881)	34	17			17						17		17		
4,8 (Sept 1881)	40				20						20		20		
4,9 (Oct 1881)	43	14			14						14		14		
4,10 (Nov 1881)	28				14						28	14	14		
4,11 (Dec 1881)	40				20						40				
4,12 (Jan 1882)	17	17			17	17					34				

5,1 (Spring 1890)	25	25	6				6		18						18
5,2 (Summer 1890)	38		8	8			8		24		8			8	
5,3 (Autumn 1890)	30	6	6	6			6		23		6	6	6	6	
5,4 (Winter 1890)	21		14	7					21		7		14	7	7
6,1 (Spring 1891)	11	11	14	5			9	11	14		20	3	6		
6,2 (Summer 1891)	22	6	6	3		6		10	25	3	10		3	3	
6,3 (Autumn 1891)	6	3	6	6		3	3	6	39		12			18	
6,4 (Winter 1891)	16		8			8		8	38	8	16				
7,1 (Spring 1892)	12	12		6		12			31		19		6		

7,2 (Summer 1892)	13	21		4		4	26		4	4	9	4	4		4
7,3 (Autumn 1892)	7	27		13			13				13	7	7	7	
7,4 (Winter 1892)	13		13				25		13		25		13		

Notes 1.In some months there were two issues,in others none,so that care has to be exercised in establishing the exact date of each issue. The Nanjing reprint has no cover page for some issues,making this very difficult.

2.I have ignored articles on topics such as art and history.

3.The figures have been rounded to the nearest integer

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There is a consistently high percentage of articles on technological matters,with relatively few on matters of a purely scientific nature. This reflected Fryer's attempt to induce foreign companies to play a larger role in the introduction of science to the Chinese,a role which they were reluctant to play. Towards the 1890s there is an increased tendency for articles to include more biological or anthropological material,reflecting - and creating - the increased interest amongst Chinese intellectuals in the philosophical and political ideas of the West rather than mere technological practice.

11.6 Gezhi Xinbao (1898)[1176]

Gezhi Xinbao 格致新報,which had French and English subtitles *Revue Scientifique* and *Scientific Review,*was apparently edited by reformist Chinese Catholics in Shanghai. It is remarkable as the first Chinese-edited scientific journal.

The front cover was decorated with the Latin alphabet and Arabic numerals.It was published from January to August 1898,and carried articles rather like those in *Gezhi Huibian* - although much shorter - with a section for readers' queries. After the sixteenth issue it was taken over by the French Jesuits at Siccawei[Xujiahui 徐家

[1176] Henceforth abbreviated as *GZXB*. I have examined the incomplete set at the Needham Research Institute,Cambridge,which holds issues 1,4,5,11,13-16. See Britton,58 and 95.

匯)and absorbed into their journal *Yiwenlu* 益聞錄,which had been published since 1878[1177],and was now called *Gezhi Yiwen Huibao* 格致益聞匯報,and included current affairs as well as popular science.

11.61 Readers' Queries in Gezhi Xinbao

These included questions such as 'Why can you warm cold hands with your breath yet you can cool tea with the same method?'[1178]; 'Why is it that if iron and felt are at the same temperature,felt feels warm and iron feels cold?[1179]; the shapes of water droplets on leaves[1180]; 'Is it true that drowned women face upwards,and men face downwards? Could it be that women are *yin* 陰 and therefore face the Sun?[1181]; 'Why are there no tides in ponds?[1182],etc.

The quality of the answers seems more variable than those in *Gezhi Huibian*,with the scientific understanding shown by the editors decidedly shaky. In answer to a query as to why gases do not sink[1183],the editor wrote that 'Gases issue from within the Earth,[so] their force is outwards,it is not of themselves that they do not sink.' Another reader,asking why iron falls faster than paper,was told that the Earth's attraction for iron is greater than that for paper,a pre-Galilean view of the causes of motion.[1184]

1177 Britton,58 and Lin Yutang,93

1178 Query #21 *GZXB* 4.11b-12a

1179 Query #22 *GZXB* 4.12a

1180 Query #146 *GZXB* 11.15a

1181 Query #156 *GZXB* 11.15b

1182 Query #179 *GZXB* 14.14b

1183 Query #220 *GZXB* 16.13a-13b

1184 Query #240 *GZXB* 16.17a-17b

11.7 Science journals and science societies of the Hundred Days' Reform Period[1185]

The period 1894-1900 showed a remarkable number of new journals whose content was partly scientific, and the growth of societies with varying degrees of scientific purpose associated with the journals.

The most influential of these was *Shiwu Bao* 時務報['Current matters', subtitled *The Chinese Progress*] of Liang Qichao and Wang Kangnian 汪康年, founded in August 1896. It carried articles on many aspects of technological reform.[1186]

The main centre of activity was naturally Shanghai, where a spate of specialised magazines appeared, including *Tongxue Bao* 通學報 [General knowledge Journal](1897-)[1187] and *Nongxue Bao* 農學報 [Agriculture Journal](1897-1906)[1188], for whose associated Shanghai Agriculture Society Tan Sitong drafted the regulations.[1189] *Suanxue Bao* 算學報[Mathematics Journal](?1897) [1190]; *Xinxue Bao* 新學報[New Studies Journal](1897-) [1191], which included articles on mathematics, science, medicine and government; and *Shixue Bao* 實學報[Physical Science](1897). Dong Kang 董康 and Zhao Yuanyi 趙元益, the latter a medical translator at the

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[1185] See Pan Junxiang 潘君祥 'Wuxu shiqi de woguo ziran kexue xuehui' 戊戌时期的我国自然科学学会[Natural science societies during the Hundred Days' Reform Period] in *ZGKJSL*(1983,1),28-30

[1186] Britton,92-94

[1187] Britton,94

[1188] *ibid.*,94-95.

[1189] *TSTQJ*,271-273

[1190] Pan Junxiang,29

[1191] Britton,95

Jiangnan Arsenal,founded the *Yishu Gonghui* 譯書公會 [Translation Society] in 1897.

In August 1897 *Kuangxue Bao* 礦學報[Mining Journal] was founded in Nanjing[1192],where in the same year,with the encouragement of Tan Sitong and Yang Wenhui 楊文會 [1193],the *Celiang Xuehui* 測量學會[Surveying Society] was founded.[1194]

For all its traditional xenophobia [1195],Hunan was particularly excited by Western studies at this time,with the *Xiangxue Xinbao* 湘學新報[Hunan Studies Newspaper]in Changsha,and Tan's colleague Tang Caichang 唐才常 produced the *Xiang Bao* 湘報[Hunan News],both of which included articles on technological and scientific subjects. Other provinces also had their scholarly societies,such as the *Zhixue Hui* 質學會[Chemical Society[1196]] in Hubei,and another *Suanxue Hui* 算學會[Mathematical Society] in Fujian.

11.71 Yaquan Zazhi: the first chemistry journal in China[1197]

[1192] Tan Sitong,'Chuang ban *Kuangxuebao* gongqi' 創辦"礦學報"公啓 [A public announcement of the founding of the *Mining Journal*] in *TSTQJ*,266-268

[1193] A leader of the late Qing Buddhist revival in China.

[1194] Pan Junxiang,29

[1195] Paul A.Cohen,*China and Christianity: the missionary movement and the growth of antiforeignism 1860-1870*(Cambridge,Mass.:Harvard University Pres,1963),47

[1196] At the turn of the century *zhixue* 質學[the study of matter]was the most popular term for 'chemistry'.

[1197] See Zhang Zigao 张子高 and Yang Gen 杨根,'Jieshao you guan Zhongguo jindai huaxueshi de yi xiang cankao ziliao *Yaquan zazhi*'介绍有关中国近代化学史的一项参考资料 "亚泉杂志" [Introducing an item of reference material on the history of modern chemistry in China -- *Yaquan Journal*] in Yang Gen (ed.)*Xu Shou he Zhongguo jindai huaxueshi*,219-235. A complete set is held by Beijing University

Yaquan Zazhi 亞泉雜志[Yaquan Journal],the first journal in China to be devoted to modern chemistry,lasted from November/December 1900 to May/June 1901,going through ten fortnightly issues. It was named after its editor Du Yaquan杜亞泉,and was notable for giving the earliest account in Chinese of the Periodic Table of the Elements[1198],and for introducing the discoveries of several new elements such as helium,argon,radium[1199] and polonium. The majority of the articles were translated from Japanese,a reflection of the strong influence of Japan on the post-Shimonoseki Chinese intellectuals.[1200]

11.8 Conclusion

The remarkable richness of popular science journalism,and the development of science societies in the late Qing should not conceal the fact that no more than a tiny minority of the Chinese people - even of the educated classes - had any interest in natural science. Until 1895 even in Shanghai there were no classes which the lay public could attend to extend their knowledge,and there is no evidence of a clamour for such classes to be put on.

How widely circulated were they? John Dudgeon,writing in 1882,reflected gloomily that

> The literary vacuum is supplied by the political daily papers and the weekly or monthly magazines. Even these latter do not as yet pay,nor is the demand for them very great. Two hundred copies of the *Scientific Magazine* [*Gezhi Huibian*] and two or three dozen of the

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Library.

1198 *ibid.*,221-226.

1199 At this time the character for 'radium' was 鈤. See Lu Xun 'Shuo ri' 説鈤[On radium](1903) in Gong Dun,70-75.

1200 *ibid.*,220.

> *Globe* [*Wanguo Gongbao*] and *Illustrated* magazines satisfy the demands at the capital.[1201]

The available evidence suggests that Dudgeon's view was quantitatively correct(See Table 12).

Table 15. The circulations of some late Qing periodicals[a]

Name of journal	Daily	Weekly	Monthly
Gezhi Huibian	-	-	4,000[b] [1876-1882]
Jiaohui Xinbao	-	700[c] [700]	-
Wanguo Gongbao	-	1,800[d] [1876]	1,800[e] [1898]
Shiwu Bao 時物報	-	10,000[f] [1898]	-
Shen Bao 申報	15,000[g] [1895]	-	-
Hu Bao 滬報[i]	10,000[h] [1895]		

a.These figures are all taken from R.Britton,*The Chinese periodical press* b.Britton,61 c.Britton,53
d.Britton,54 e.Britton,55 (It became a monthly in 1889.)
f.Britton,93 g.Britton,68 h.Britton,51
i.*Hu Bao* was the Chinese edition of the *North-China Daily News*,and was founded in 1882.(Britton,51)

Although the comparisons are inexact,we can see that,although small on an absolute scale,the circulation of *Gezhi Huibian* compared quite well with the general newspapers of its day such as *Shen Bao* and *Hu Bao*,and no worse than *Wanguo Gongbao* which,though it contained some brief scientific articles,was mainly concerned with foreign news. Circulation in any case tells us little about

[1201] John Dudgeon,'Review of a new medical vocabulary' in *CR* **13**(1882),33. The *Illustrated* magazine he refers to may have been *Yinghuan Huabao* 瀛環畫報,an illustrated news monthly which started in 1877.(Britton,69); or,more likely,the *Tuhua Xinbao* 圖畫新報[Chinese Illustrated News],which was founded in 1880(Lin Yutang,93).

readership. We know that many of the most progressive officials and intellectuals read these periodicals and drew many of their ideas from them.

The efforts of the science journalists were thus not in vain. Their works were read,if only by an eccentric minority,and some of the readers were taking science seriously enough to attempt their own experiments,although with rather little encouragement from the editors: a noticeable feature of the articles is how little attempt there is to suggest simple experiments that readers could so for themselves. The tone is didactic,solemn,and probably rather forbidding,although we have no direct evidence of Chinese reactions to them.

Gezhi Huibian was the longest-running and most important popular science journal of its time. Through its correspondence column we can see - even though inevitably filtered through John Fryer's editorial decisions - the range of interests shown by Chinese readers and the sometimes complex relationships between the old and new paradigms. The variety and detail may be misleading however: taking China as a whole,there were still only very few people who took Western science - rather than Western commodities or Western technology - seriously.

Chapter 12. Winging the arrow[1202]: The intellectual impact of Western science *via* natural theology in nineteenth century China

12.0 Introduction

Western science was mostly ignored by Chinese intellectuals in the nineteenth century,even when a number of translated works were available had they wished to discover what the Western scientists had been doing.

Although a number of reasons - not least the sheer foreign-ness of Western science - could be cited to account for this phenomenon,I would suggest the main cause lay in the perceived nature of Western science. As Liu Yueyun 劉獄雲 wrote in *Gewu Zhongfa* 格物中法 [Chinese methods for the investigation of things] in 1897

> The techniques of the barbarians are all merely those of artisans[*gongren* 工人]: gentlemen regard them as not [pertaining to] *Dao* 道,whilst scholars and officials regard them as base. [1203]

This was a fundamental distinction: Chinese culture was

[1202] 'Science might wing the arrow,but religion should be its point.' (W.A.P.Martin,'Western science as auxiliary to the spread of the Gospel',116)

[1203] Liu Yueyun,'Gewu Zhongfa xu'[Preface to *Chinese methods of the investigation of things*] in *Shijiude Zhai jizhu* 食舊德齋雜著[A collection of works from the Studio for Absorbing Ancient Virtue],1.71a. Zhong Tianwei 鐘天緯 put it slightly differently:

> China values *dao* and despises the arts(*yi* 藝): thus its 'seeking after knowledge'(*gezhi* 格致)emphasises righteousness(*yi* 義) and principle(*li* 理); Western counties value arts and despise the *dao*: thus their 'science'(*gezhi*格致) inclines towards the 'principles of things'(*wuli* 物理). (*GZKYHB*,4.15b(1889))

grounded in *Dao* 道,the Way along which a refined scholar was expected to tread. Its contrast,*qi* 器,was mundane and mechanical,the realm of the *xiaoren* 小人,the 'little people',who involved themselves directly in the dirty,practical tasks which were required to keep the state functioning. Western science and technology - for the two were hardly distinguished at this period - were considered firmly in the realm of *qi* 器,and it is not surprising that so few men of quality took any interest in them.

It was this philosophical,or moral,void - this lack of *Dao* -in the Western science which they encountered which led most Chinese either to ignore it altogether, or to dismiss it as trivial and base. No-one seriously disputed that the Westerners had superior weaponry,but until very late in the century this was seen as due to their possession of clever technologies - 'skilful techniques'- rather than a deeper understanding of the natural world than the Chinese. The extraction of metals,the identification of minerals,the behaviour of light as it passes through a prism,how to make a steam engine,or calculate the trajectory of a shell.......were all interesting enough,but for someone educated as a Chinese scholar in the late Qing dynasty,there seemed little in all these 'tricks' which connected with the moral concerns which he had been taught to value. Nor even,if he were concerned with the peril which China was facing,internally and externally,was there much in science to indicate solutions to what had become a spiritual,as well as a military and political crisis.

Western science was not merely empty of *Dao* 道 but,in its heavy emphasis on military purposes,actually inimical to it. It was precisely this apparent bleak emptiness in the materialist view of the phenomenal world to which Western natural theology was addressed,and why,when Chinese scholars such as Tan Sitong and Kang Youwei eventually discovered that science could be given a spiritual interpretation,their response was so enthusiastic.

12.1 The Chinese origin of Western science[1204]

The theory that all wisdom ultimately emanated from China was an ancient idea,and can be traced back to Mencius,who is said to have remarked that "I have heard of the Chinese converting barbarians to their ways,but not of their being converted to barbarian ways." [1205] At the first Chinese encounter with another great civilisation,when Buddhism entered China during the first few centuries of the Christian era,the legend of Lao Zi 老子 [1206] travelling to the Western Regions was revived,coupled with the notion that he had 'converted' the people in the West: the Buddhist missionaries were merely returning to China what they had once received.[1207]

A similar response had occurred when the Jesuits came to

[1204] See Quan Hansheng 全漢昇,'Qingmo fandui Xihua de yanlun 清末反對西化的言論 [Late Qing arguments against Westernisation] in *Lingnan Xuebao* **5**(1936),122-166; Quan Hansheng 全漢昇,'Qingmo de "Xixue yuanchu Zhongguo" shuo' 清末的"西學源出中國"說 [The late Qing theory that "Western studies originated in China"' in Li Dingyi 李定一(ed.)*Zhongguo jindaishi luncong* Vol.5 中國近代史論叢(Taibei:Zhengzhong shuju 正中書局,1956),216-258; George H.C.Wong,'China's opposition to Western science during late Ming and early Ch'ing' and Nathan Sivin 'On "China's Opposition to Western science during late Ming and early Ch'ing"'.

[1205] *Mencius* D.C.Lau trans.,103.

[1206] The founder of Daoism[Taoism]. Li Fengbao 李鳳苞,ambassador to Germany in the late 1870s,remarked that the long hairstyles he saw in Paris were evidence that these were descendants of Lao Zi. See Li Fengbao 'Shi De riji' 使德日記 [Diary of an embassy to Germany] in Jiang Biao 江標 (ed.)*Lingjiange congshu* 靈鶼閣叢書 9 *ce*,21b.

[1207] Quan Hansheng,'Qingmo de "Xixue yuanchu Zhongguo" shuo',216-217. The legend is known in Chinese as *Lao Zi hua hu*老子化胡[Lao Zi converting the barbarians].

China in the sixteenth century, when the mathematics and astronomy they brought with them was also seen as originally deriving from China[1208]. The mathematician Mei Wending 梅文鼎 (1633-1721)[1209] pointed out that the algebra the Jesuits taught was essentially the same as the Chinese method called *litian yuanyi* 立天元一 ,and said that the term 'algebra' meant *donglaifa* 東來法[Method from the East],and 'the East' must have indicated that it came from China.[1210] The Kang Xi 康熙 Emperor himself wrote:

> Those who contend that the ancient[Chinese] methods are different from modern [Western] methods are deeply ignorant of their origins,as they originated in China and were transmitted to the Far West. The Westerners preserved them so they were not lost,but [the Westerners] could not exhaust [their profundity],and over the years they were augmented and nurtured(*zengxiu* 增修) [...][1211]

The exact Chinese source of the transmission to the West was unspecified in the early Qing dynasty,but as the nineteenth century missionary writings began to be known,the mathematician and scientist Zou Boqi 鄒 伯奇 (1819-1869) was the first to suggest that the works of Mo Zi 墨子 were the origin of Western science. Mo Zi was also credited with the transmission of writing[1212] and even of

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[1208] Quan Hansheng,'Xixue yuanchu Zhongguo',218-225

[1209] Hummel,570-571

[1210] Wong,39; Hummel,569. See also Nathan Sivin,'Biography of Wang Hsi-shan',161.

[1211] Quan Hansheng,'Xixue yuanchu Zhongguo',219

[1212] *ibid.*,244

being the inspiration of Christianity.[1213]

The most systematic exposition of the 'Chinese origins' theory was by Wang Renjun 王仁俊,who wrote two books on the Chinese origins of science,*Gezhi guwei* 格致古微[Ancient secrets of science] and *Gezhi jinghua lu* 格致精華錄 [A record of the magnificence of [Chinese] science]. In both he collected quotations from the Chinese Classics,histories and other sources illustrating the scientific achievements and knowledge in ancient China. Less detailed comparisons can also be found in the writings of Tan Sitong 譚嗣同 [1214] and Tang Caichang 唐才常 [1215].

The theory was not simply chauvinist: it also allowed orthodox scholars to study Western science without feeling

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[1213] *ibid.*,244. See also *GZKYHB*,2.3b((1887) for a discussion of the Mohist antecedents of Western science.

[1214] For instance in 'Shijuying Lu bizhi.Sipian ' 石菊影廬筆識.思篇[Notes from the Calcareous Slate Shadows Studio:Thoughts] in *Tan Sitong quanji* 譚嗣同全集 (Beijing:Zhonghua shuju 中華書局,1981),especially sections 3-6(pp.123-126).

Tan explains in section 41 of this work(p.146) his rather unusual title for his studio: his home county of Liuyang 瀏陽 had a rock called *juhuashi* 菊花石 ['chrysanthemum flower stone',a kind of calcareous slate],often used for inkstones,hence his brushstrokes were the 'shadows' of the inkstone,and his studio he named "Shijuying lu" [Calcareous Slate Shadows Studio]. He also made this more cryptic comment about this unusual rock: '[It is] gentle and yet intense,wild and yet cultured',and I am its "shadow"; [...] I would like to explain what I mean [by this],[yet] I cannot.'

This may relate to his almost pantheistic view of nature,which is developed to its full in *Renxue* 仁學[An exposition of benevolence].

[1215] See 'Zhu Zi yulei yi you Xiren gezhi zhi li tiaozheng 朱子語類已有西人格致之理條證[Proof that the *Classified conversations of Zhu Xi* contain the principles of Western science] in Tang Caichang 唐才常,*Tang Caichang ji* 唐才常集[The collected works of Tang Caichang](Beijing:Zhonghua shuju 中華書局,1980),172-177

they were betraying their own culture,and could therefore be seen as promoting an essentially liberal attitude to Western learning. Chinese envoys who travelled to the West were often struck by parallels with their own culture,and even commented that the barbaric West seemed to have preserved vestiges of the Chinese civilisation of high antiquity. The comment *gu yi you zhi* 古已有之[[We] had it [in China] in ancient times] became a cliche of the scholarly diarist looking at Egyptian hieroglyphics or even at decorated crockery.[1216]

12.2 Western science in Christian tracts

From the Jesuits onwards,Christian missionaries in China saw natural theology as a major weapon in the arsenal of

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[1216] Zeng Jize noted a likeness between the decorated household pots of the West and the vessels of the Zhou dynasty. Commenting on the ingenious machines of the West,he suggested that Chinese civilisation had,by becoming too prosperous,over-emphasised refinement and elegance:

> In the past China had countless machines,but,as it grew wealthy,people became lazy,and the transmission of the [ingenuity] was lost. Seeing the Far West of today,you can know the China of High Antiquity; seeing the China of today,you can see the Far West in future generations: there must come a day when brute force(*zhuo* 拙) will be valued above cleverness(*qiao* 巧),and simplicity(*pu* 朴) above elegance(*jing* 精). For the products of the earth are numbered,and insufficient to provide for all the countries in the universe to prosper: thus it is that circumstances make the refined become coarse. (Zeng Jize 曾纪泽,*Zeng Jize yiji* 曾纪泽遗集 Yu Yueheng 俞岳衡(ed.)(Changsha:Yuelu shushe 岳麓书社,1983),363)

Zeng is echoing the sentiments of Lao Zi,who said in Chapter 45 of the *Daodejing* 'Great cleverness(*qiao*) is like stupidity(*zhuo*).' The term *zhuo* 拙 is connected by Zeng with what he sees as the manual skill needed,in an impoverished society,to handle machines,contrasted with the verbal wit required to survive in a rich,cultured civilisation which has outgrown the need for machinery.

truth.[1217] We have already seen in Chapter 2 how Ricci attempted to convince the Chinese of the falsity of their chemical theories: this was but one aspect of the explanation of the natural world in the light of Christianity.

The fundamental thesis of natural theology was that only the existence of an intelligent Creator could explain the marvels of the natural world. The orderliness of Nature bespoke the mind of God,bringing order out of chaos and light from darkness,who as the maker of the natural world,'comprehended its construction and designed its use'.[1218]

As we have seen in Chapter 7,the early modern science textbooks were heavily influenced by natural theology. Conversely,Christian tracts often included references to scientific analogies to strengthen their case. The banal nature of some of these analogies should not conceal how striking they seemed to Chinese intellectuals reading them for the first time. The 'spiritualisation' of science which they represented accorded well with the traditional Chinese view of the essential unity of the physical,human and

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[1217] Science and religion are today often thought of as inimical,but before the twentieth century many Christians saw science as a means of defending religion.(See P.M.Rattansi, 'Science and religion in the seventeenth century' in M.Crosland(ed.)*The emergence of science in Western Europe*,79-87,the writings of Calvin Mateer quoted in Section 8.2.) In our own century,one of the leaders of the new physics could write

> Religion and natural science are fighting a joint battle in an incessant[...]crusade against scepticism and against dogmatism,against disbelief and against superstition,and the rallying cry in this crusade has always been,and always will be "On to God."
> (Max Planck,*Scientific autobiography and other papers*,187)

[1218] William Paley,*Natural theology or,the evidence of the existence and attributes of the Deity,collected from the appearances of Nature*(London:R.Faulder,1802),4 spiritual worlds. The sympathetic treatment of traditional concepts such as *qi* 氣 and *wuxing* 五行 in some writings - such as those of W.A.P.Martin - also led some intellectuals to believe that there was indeed a connection between modern Western science and traditional Chinese thought,and then to adapt Western scientific ideas for their own purposes.

12.21 William Paley in China

The influence of William Paley can be seen most clearly in the writings of two of the most energetic missionary agents of transmission,W.A.P.Martin and Alexander Williamson.

We have already met Williamson as the author of *Gewu tanyuan*[1219],and as a major contributor to the journal *Liuhe Congtan*[1220]. Williamson's approach was a straightforward transplanting of Paley's ideas into a Chinese context,with relatively little concession to Chinese sensibilities or acknowledgement of the existing Chinese paradigms for understanding the natural world.

> Long ago there was a boy walking in a garden,when suddenly he saw some seedlings which had just begun to

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[1219] See Section 7.9.

[1220] See Section 11.1. His articles in *Liuhe Congtan* have the following titles(as given in the English contents pages):

Natural theology - existence of God(*LHCT* **1**,2)
God the origin of all things(*LHCT* **1**,3)
God's infinity(*LHCT* **1**,4)
Eternity of God - Unity of God(*LHCT* **1**,5)
Advantages of science(*LHCT* **1**,6)
God's omnipresence - God's omniscience(*LHCT* **1**,7)
God's spirituality - God's dominion over the Universe(*LHCT* **1**,8)
Depravity of human nature(*LHCT* **1**,9)
The soul (*LHCT* **1**,11)

a scheme clearly derivative of Paley's *Natural theology*.

> sprout. They were arranged in rows,and they formed the letters of his name! He was amazed,and ran to tell his father,who said that it was quite natural,and nothing to be surprised about. However,the boy did not believe him,and said that it could not be natural,and asked his father to go and see it. His father again said that it was formed naturally,and was not at all surprising. the boy still did not believe him,and his father smiled and said,"When I sowed the seeds,I played a game.Thus I tell you,that Heaven and Earth and all the Myriad Things are not formed naturally,they are all made by God."
>
> When the boy saw the seedlings forming his name,he was amazed. Do you not know that your body's viscera,muscles,blood,veins and skin,ears,eyes,mouth,nose,hands and feet are all amazing and wonderful? If they arose naturally,and there were no supremely skilful director managing them,then your eyes would grow from your back,your ears from your abdomen,and your hands and feet would be in inappropriate positions. There are a billion people on Earth,and yet their Five Organs and Four Limbs are all in the right places,appropriate to their uses,and not a single one is misplaced. Could this be the case if there were no God directing them?[1221]

Knowing the respect with which the written language was held in China,Williamson continued his analogy of the"language" of nature

> If I go into a city and happen upon a house with which I am not familiar,and see several characters written

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[1221] Alexander Williamson,writing in *LHCT* 1,2(February/March,1857),3b

> upon a desk,I should not say they were there naturally,but that the owner is able to write;and if the characters were connected together to make the sentences of an essay with a fine style,then I should know the owner is a man of ability. Now which is the harder,the writing of an essay or the making of all the things we know,including intelligent human beings? If I see the essay I cannot say that the characters have become connected spontaneously: when I see nature and human beings,how can I say that they have been formed naturally?[1222]

On of the most highly-regarded and popular nineteenth-century Protestant missionary tracts was W.A.P.Martin's *Tiandao suyuan* 天道溯原 ['The Way of Heaven traced to its source'; usually known as *Evidences of Christianity*],first published in 1867 and running to many editions.[1223] As we have seen in Chapter 10,*Tiandao suyuan*,although not intended as a science textbook at all,was sometimes the only Chinese text used in the missionary schools which introduced Western science,and its influence was therfore rather powerful. A much more subtle thinker and Chinese prose writer than Williamson,Martin made efforts to incorporate the ideas of *qi* 氣 and *wuxing* 五行 in order to show his readers that Western science was not as alien as they might fear.

> God [*Tianzhu* 天主][1224]is a spirit,and has no visible

[1222] *LHCT* **1**,2(February/March,1857),4a

[1223] Fryer mentions that it was one of the most popular books in his Chinese Scientific Book Depot. See *NCH*(28th December,1887),703.

[1224] The missionaries had fierce debates over the correct term for 'God'. *Tianzhu* [Lord of Heaven] was used by the Roman Catholics,and,some Protestants; most Protestants were divided between *Zhenshen* 真神[True Spirit] and *Shangdi* 上帝[Supreme form,yet his wonderful works are evident and easily seen. Thus it is as if the invisible were visible. Above,we can see the phenomena of heaven,below we can investigate the markings of earth; near at hand we can investigate the human body,far away we can investigate the nature of things;they all suffice to see the wonderful works of God.

And yet some do not believe in the Lord of Creation. How can this be so? For the Sun,the Moon and the stars are all moving things. If there were no Lord to control them,how could they be thus from antiquity? For although there are so many types of things,in the end there are only two,matter and spirit. Spirit can move of itself,but matter cannot. Things made of the Five Phases[*wuxing* 五行] are matter,and they rely on the spirits of human beings to be able to move.[1225]

12.22 Attraction and God's love

Gravitational attraction was a natural analogy for God's love[1226],and for the coherence of Creation:

For attraction(*xili* 吸力)may be seen in the great and the small. In the morning,dew forms as spherical droplets: this is [due to] attraction. The Five Phases coagulate to form the Earth: this is [due to] attraction. [...]Human beings can measure it,but can never fathom its origin,the God who created them in the beginning. Although God stimulated the primal *qi* [*yuanqi* 元氣][1227]in the beginning to create Heaven and

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Emperor]. See Douglas G.Spelman 'Christianity in Chinese: the Protestant term question' in *POC* **22A**(1969),25-52.

[1225] *Tiandao suyuan*(1867),1.1a

[1226] See Thomas Kuhn *The Copernican revolution: planetary astronomy in the development of Western thought*(Cambridge,Mass:Harvard University Press,1985),130-131 for the use of solar imagery for the Christian God,and its influence on Copernicus and Kepler.

[1227] See Section 2.22.

> Earth,He has never rejected it,[and] He still dwells within it,superintending its changes.[1228]

Another writer in Young J.Allen's *Jiaohui Xinbao* 教會新報 made explicit the analogy between the Sun and the Deity:

> The *qi* 氣 of the Sun attracts everything,just as the Lord's love saves everyone. Thus,the love of the followers of Jesus for each other is like the planets' attraction for the Sun,and their mutual attraction for each other.The planets are attracted to the Sun and have not yet fallen into it: since ancient times men have been loved by the Lord,yet have rejected the light and approached the darkness,and have fallen into hell. The Lord sent Jesus to save them,to take them out of hell and lift them up to heaven. The Earth and the planets cannot save themselves,how can they save each other? The Sun gives forth its great *qi* 氣 and attracts things upwards. Only the Sun can save the planets; only the Lord can save the world.[1229]

From the gravitational attraction of the Sun,it was a natural development to give light itself a spiritual meaning.

12.23 The Light of the World

Light could be used not only to show Christianity as banishing darkness,but also to explain by an optical analogy what might otherwise have proved baffling to a Chinese reader,the doctrine of the Trinity.[1230]

1228 *Tiandao suyuan*(1897),3b

1229 *JHXB*(16th July,1870),2.216a-216b.

1230 See Geoffrey N.Cantor,'Weighing light: the role of metaphor in eighteenth-century optical discourse' in Andrew E.Benjamin,Geoffrey N.Cantor and John R.R.Christie,*The figural*

> The light of the Sun comes originally from heaven. The origin of Christianity is [also] from heaven. The light of the Sun is very high,very bright,and very great,as is the Way of Jesus.[...]Light has three basic colours,and Jesus has three titles[*zhifen* 職分]. If the three be combined,we can speak of them as the One Sun; if the three titles [of Jesus] be combined we can speak of them as the One Way,the same as the One Jesus.[1231]

Thus far the analogies drawn from nature have all been demonstrating the truths of revelation,yet the ideas of the religious text which had the most direct influence on the young reformer Tan Sitong were taken from a more impersonal,self-reliant approach to salvation.

12.24 The ether and the power of thought: Zhixin mianbingfa 治心免病法

Zhixin mianbingfa 治心免病法 (1896)[A method for preventing disease by controlling the mind] was a translation by John Fryer of *Ideal suggestion through mental photography* by Henry Wood(1834-1909),an advocate of mental healing and the power of positive thinking. With no mention of a personal,spiritual saviour,Wood proposed that

> Man must free himself from the "law of sin and death" by grasping his higher and spiritual selfhood; and this is no impossible or chimerical attainment.[1232]

To achieve this aim it was necessary to deploy the "great

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and the literal: problems of language in the history of science and philosophy,1630-1800 (Manchester:Manchester University Press,1987).

[1231] *JHXB*(9th October,1869),2.33a-33b

[1232] Henry Wood,*Ideal suggestion through mental photography*(Boston:Lee and Shephard,1893),59 force called thought",which

> has scientific relations,correlations and transmutations;[..]its vibrations project themselves in waves though the ether,regardless of distance and other sensory limitations; [...]they strike unisons in other minds and make them vibrant; [...]they relate themselves to like and are repelled by the unlike; [..]their silent though forceful impact makes a distinct impression; in fact they are substantial entities,in comparison with which gold,silver and iron are as evanescent as the morning dew.[1233]

Fryer's translation of Wood's work on mental healing was to have a profound influence on several of the leading Chinese intellectuals during the period of intense debate between the Sino-Japanese War(1894-95) and the Hundred Days' Reform of 1898. In his otherwise meticulous translation,Fryer inserted at certain points more scientific elucidation than in Wood's original work,including his explanation of the term *ether*.

12.3 Confluence: attempts at a synthesis of Chinese philosophy with Western science

Very few of the key scholars in the ruling elite were converted by the nineteenth-century missionaries: certainly no-one as eminent as Xu Guangqi 徐光启 became a Christian in late Imperial China. Yet,although the most striking case is undoubtedly that of Tan Sitong,he was by

[1233] *ibid.*,63

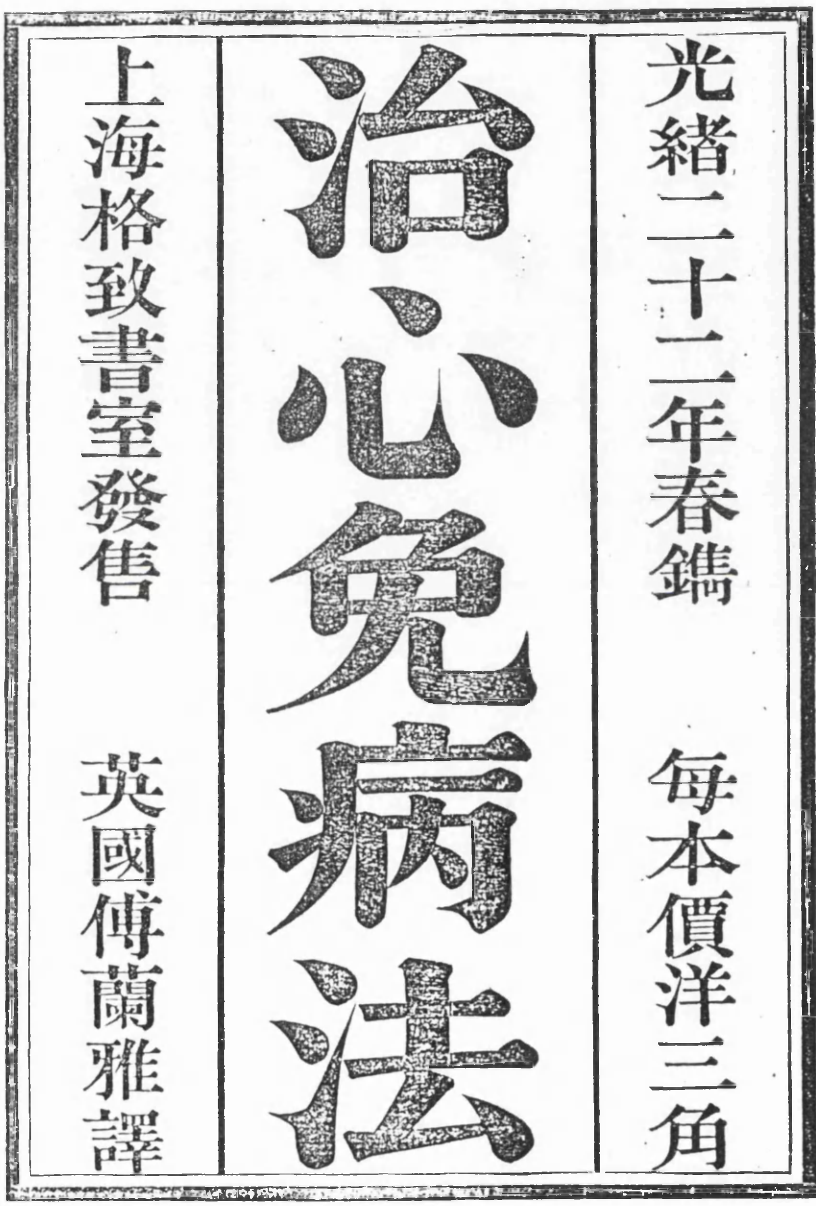
光緒二十二年春鐫
每本價洋三角
治心免病法
上海格致書室發售
英國傅蘭雅譯

Figure 41. The front cover of *Zhixin mianbingfa*(1896)
[Reproduced by kind permission of the East Asian Library,University of California,Berkeley]

no means the only writer to use both scientific and religious ideas derived from Christian teachings in his writings.

It was the Western writers who presented science in a moral context who seem to have had the greatest influence: none of the Chinese intellectuals discussed here as far as is known actually studied science in a formal way,nor had they any direct involvement in the early industrialisation of China. They read about Western science seeking confirmation and development of ideas they had already derived from Confucian and Buddhist sources,and were delighted to find that missionary textbook writers often supplied them with the analogies they required.

12.31 aili 愛力: the power of love

The scientific term *aili* 愛力 had been introduced by John Fryer and Xu Shou in *Huaxue jianyuan* 化學鑑原 [The mirror of chemistry:a source-book],a translation of David Wells *Principles and applications of chemistry*. In *Huaxue jianyuan*,*aili* means simply 'chemical affinity',and is an abbreviated form of *ainieli* 愛攝力,in which the *nie*攝 component also appears in the term *nieshi* 攝石,meaning 'lodestone'.

However,in *Zhixin mianbingfa* John Fryer gave a much deeper meaning to *aili*,the 'power of love'

> Whenever someone else is harmful to me,the origin of it is in my own mind. The love I have for others is the love the other person has for me: it never fails to be rewarded in the minutest degree. Who can know the limits of the great power of love(*aili* 愛力)? With the power of men,there is nothing in the world it cannot do. People weak in body or mind,or with their four limbs paralysed,as soon as the power of love passes through them their chronic complaint

> immediately disappears. Electricity can cure sickness,it can make boats sail and vehicles move,it can extract metals[from their ores]. It really is marvellous. Similarly the power of love has the ability to move mortal men,to transform enemies into friends,and to change sickness into health.[1234]

The journalist Wang Kangnian 汪康年(Wang Rangqing 穰卿)(1860-1911)[1235] in his article 'Using the power of love [*aili* 愛力] to transform the fortunes of [Chinese] state'(1896) wrote

> The state: what is it? It takes its power[*neng* 能] from [its] strength[*wangu* 完固].Atoms split apart and form [material] things. If they were not transformed by the air,they would not separate from one another: this is the principle that things of the same type are unable to damage one another. Take metals,for example: they must already have been rusted and corroded,and only then can they can be damaged by metal of the same type. Or else there has to be a blade [already in existence]; only then is it possible to hammer and to file it. Or take wood: it must have already rotted,as it could not be damaged by other wood of the same type,otherwise you would [first] have to employ an axe to hew and trim it,only then could you hammer and strike it.[1236] The [Chinese] state is also like this:

[1234] *Zhixin mianbingfa,*1.28b

[1235] Wang was the manager of the *Shiwu Bao* 時務報 newspaper in Shanghai,of which Liang Qichao was the editor.See Hummel,822.

[1236] This is an interesting example of eclecticism. On the one hand Wang refers to the Chinese theory of Five Phases(*wuxing*五行)each of which is able to overcome another,in the following sequence: Water,Fire,Metal,Wood,Earth. Thus we would expect Metal to overcome Wood(hence his reference to a [metal] axe hewing the wood),and Fire to overcome Metal. Yet with respect to

> it stands on the Earth like other states,and [yet],being regarded as weaker than other states,it must have 'internal alienation' [*neili* 內離][1237] in its basic nature. What is 'internal alienation'? It is the loss of the power of love. Beginning with mutual forgetting ends in mutual rejection. [Whereas] beginning with mutual love,ends in mutual fulfilment.[1238]

The analogy between the attractive power of the lodestone and human love was not new: another term for a magnet was *cishi* 磁石 the first term of which is homophonous with *ci* 慈 'compassion': the magnetic stone was drawing iron towards itself by its "power of love".[1239]

Wang was not the only one to seize on the metaphysical overtones of *aili* 愛力. The young reformist Tan Sitong in his book *Renxue* 仁學 [1240] refers several times to this concept in his description of the *yitai* 以太 or 'ether',as he tries to show that *yitai* is a vector of *ren* 仁[benevolence]. Tan refers to the Christian concepts of "loving others as oneself" and "seeing one's enemy as one's friend",before referring to the power of love(*aili*) as a species of attraction,and related to the "impartial love" [*jian'ai* 兼愛] of Mo Zi,for

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Metal Wang is clearly referring to the Western theory of rusting,in which oxygen,not Fire,'overcomes' Metal by oxidation.

[1237] Wang may have invented this term himself

[1238] Wang Kangnian,'Yi aili zhuan guoyun shuo' 以愛力轉國運説[On using the power of love to transform the fortune of the [Chinese] state] in Wang Kangnian,*Wang Rangqing yizhu* 汪穰卿遺著,1.12b-16a

[1239] Joseph Needham,*SCC* Vol.4 Part 1,232.

[1240] See Chan Sin-wai trans.,*An exposition of benevolence*(Hongkong:The Chinese University Press,1984)

> Attraction(*xili* 吸力)is another name for affinity(*aili*). Thus those who value the application of love have a high regard for "impartial" love.[1241]

Yet,for Tan,despite his remarkable knowledge of Western science,the physical world is of little importance. It was the mind,and mental power,which held the key to China's salvation.

12.32 xinli 心力:mental power

Xinli 心力 was originally a Mahayana Buddhist term[1242],which by the nineteenth century had become assimilated into the everyday language,and is found in a variety of contexts,usually meaning something like 'will-power'.[1243]

Wang Kangnian in the article quoted above went on to extol the 'mental power',by which he means a kind of social cohesion and cooperation which,he says,is exemplified by Westerners but not by Chinese:

> The affairs of the Westerners all rely on the mental power(*xinli* 心力)of the mass of the people in order to be achieved,whereas China has not united the mental

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[1241] *TSTQJ*,302. My translation,based on *AEOB*,83-84.

[1242] Chang Hao,*Chinese intellectuals in crisis:the search for order and meaning(1890-1911)*(Berkeley:University of California Press,1987),78

[1243] For instance,in *Gewu tanyuan*(1876),3.23a,Xu Jianyin's article on opium addiction in *GZHB* 3,6(July 1880),16a. In *Zhixin mianbingfa* it usually translates the English terms 'mind' or 'thought-power'.

power of the people to achieve a single thing.[1244]

For Tan Sitong *xinli* was both psychological and political,an ability both to know others' minds and to influence them,to achieve a new kind of social relationship based on love and compassion rather than the bonds of Confucian morality.[1245]

12.33 The ether as qi 氣 [1246]*: Western science as an influence on Kang Youwei and Tan Sitong*

The ether was a concept which became widely known in China only in the last decade of the nineteenth century. Its mysterious nature,its imponderability,its ubiquity and its role as a medium for communication,attracted a number of Chinese writers,especially Kang Youwei 康有為(1858-1927) and Tan Sitong 譚嗣同(1865-1898).

[1244] Wang Rangqing,'Yi aili zhuan guoyun shuo',14b

[1245] *TSTQJ*,295,352,361 and 365.

[1246] One of the earliest accounts of the ether in Chinese is in *Guangxue* 光學[Optics](Shanghai:Jiangnan Zhizaoju 江南製造局,1876),a translation by Carl Kreyer and Zhao Yuanyi 趙元益 of *Lectures on Light* by John Tyndall.It is also mentioned in the *Readers' Queries* section of *GZHB*(September 1880),15b-16a(Query #254),writing of an 'ocean of *qi*' between the Sun and the earth,through which light waves propagate,later in the same article referring to it as *yunguang zhi qi* 運光之氣 [light-carrying *qi*] and *guangqi* 光氣 [luminous *qi*];and in John Fryer trans.,*Guangxue xuzhi* 光學須知[Elementary optics](1895),where it is called *yituoqi* 以脱氣. The connection between ether and *qi* was made quite explicit by Calvin Mateer in a technical glossary in 1904,identifying it as *yuanqi* 元氣 [primal *qi*].(Mateer,*Technical terms*(1904),156).

For the early modern Western concept of ether and the scientific role of subtle fluids,see Simon Schaffer 'Godly men and mechanical philosophers: souls and spirits in Restoration natural philosophy' in *Science in Context* **1**,1(1987),55-85 and the references in Wright,'Tan Sitong and the ether reconsiderd',558-563.

Kang Youwei was the intellectual leader of the late Qing reform movement which culminated in the Hundred Days' Reform. After the failure of the Reform,Kang escaped to Japan,but continued to be an influential figure in the following decade,even though his ideas of a constitutional monarchy became increasingly marginalised by events. A follower of the New Text School of Confucianism,his ideas did not appear in book form until after 1900.[1247] From around 1879,Kang made an earnest though unsystematic study of Western science,and his readings convinced him that there were connections between the Primal *Qi* 氣 and the materialistic theories of the Westerners,referring to entities he called *qidian* 氣點 [particles of *qi*],which played a role akin to atoms,giving *qi* 氣 itself a more significant role than was customary in orthodox Neo-Confucian thought.[1248]

In *Meng Zi wei* 孟子微[The secrets of the *Mencius*] Kang Youwei wrote

> The nature of [one's] natural disposition is like [one's] ability to "love [*hao* 好] Admirable Virtue(*yide*

[1247] See Fung Yu-lan,*History of Chinese philosophy* **II**,676ff and Hsiao Kung-chüan,'The philosophical thought of K'ang Yu-wei: an attempt at a new synthesis' in *MS* **21**(1962),129-193.

[1248] See Kang Youwei,'Kang Youwei zibian nianpu' 康有為自編年譜[The self-compiled annalistic biography of Kang Youwei] in Jian Bozan 翦伯贊(ed.)*Wuxu bianfa* 戊戌變法[The Hundred Days' Reform](Shanghai:Shenzhou Guoguangshe 神州國光社,1953)Vol.4,115-117;Richard C.Howard.'K'ang Yu-wei: his intellectual background and early thought' in Arthur F.Wright and Denis Twitchett (eds.)*Confucian personalities*(Stanford: Stanford University Press,1962),294-316; Kang Youwei,*Chunqiu Dongshi xue*春秋董氏學 [A study of the *Abundant dew of the annals* of Dong Zhongshu](Beijing: Zhonghua shuju 中華書局,1990),124 and 128; and Hsiao Kung-chuan,'The philosophical thought of K'ang Yu-wei',138.

> 懿德)"[1249]. [Its] "love" is like a magnet attracting iron,[or like] a needle attracting mustard seeds: [whatever] one's ether(*yitai* 以太) contains can combine with Admirable Virtue and attract it,in the same way as positive and negative electricity attract each other.[1250]

Kang Youwei here is following the Mencian notion that human beings intrinsically possess quality of benevolence called *ren* 仁,which is present in what he calls the 'ether'(*yitai*). What is new is in giving the physical analogy of electrical attraction,and suggesting that the quality of *ren* is contained in *yitai*.

Kang uses the same electrical analogy in explaining *ren* 仁

> [The term]*ren* 仁 [derives etymologically from] 'two people'. In moral law,it has the significance of "pairing [through] attraction(*xili* 吸力)",which is the 'power of love' [chemical affinity] (*aili* 愛力). People all possess this 'love of others',and thus *ren* 仁 is 'human' 人.[1251]

Kang further developed the idea that this

[1249] The term *yide* 懿德 comes originally from the Book of Songs,and is quoted by Mencius in Book 1 Part 1 Chapter 6 Verse 8(J.Legge trans. *The Four Books*,403). *Yide* is almost homophonous with *yitai* 'ether' - in fact,closer in sound to 'ether' than *yitai* - and Kang seems to be hinting at a connection between the two,as if the ether were the vector of Admirable Virtue.

[1250] Kang Youwei,'*Meng Zi* wei' 孟子微 in *Kang Nanhai xiansheng yizhu huikan* 康南海先生彙刊 Vol.5 (Taibei:Hongye shuju 鴻業書局,1976),146

[1251] Kang Youwei,'Zhongyong zhu' 中庸注[Annotations to the *Doctrine of the Mean*] in *Kang Nanhai xiansheng yizhu huikan* Vol.5,45 'compassionate heart' was present in all human beings,when he wrote from personal experience of our capacity to sympathise with the sufferings of others in his masterpiece *Datongshu* 大同書,in the section entitled 'Seeing the many sufferings entailed in entering the world'. He says:

> I have my own body;if someone else is suffering,what has it to do with me? And yet I feel sad and deeply affected by it,troubled when I am walking and pondering it when I am sitting. Why is this? Why does it affect me in this way? [....] When Bismarck burned the city of Sedan in France[1252],I was only ten *sui* or so old,and had no feeling of grief,yet when I saw pictures[1253] of it,I was deeply distressed.Seeing corpses strewn out in the forest,burning buildings,I was deeply moved.[...] What is the reason behind this? Is it what the Europeans call *yitai* 以太? Is it what was called in ancient times the 'heart which cannot bear the sufferings [of others]?' Is it the case that everyone has this 'compassionate heart'? [1254]

Although *ren* 仁 was important for Kang Youwei,for Tan Sitong it was the compassionate force responsible for the cohesion of the entire universe through its mysterious vector *yitai* 以太 or ether. Tan tells us that reading *Zhixin*

[1252] Emperor Napoleon III of France suffered a severe defeat at the hands of the Prussian army at Sedan on 1st September,1870. The Franco-Prussian War was well-known in China through the writings of Wang Tao,especially his translation *Pu-Fa zhanji* 普法戰紀[A record of the Franco-Prussian War](Zhonghua yinshu zongju 中華印書總局,1873).

[1253] Kang uses the expression *yingxi* 影戲 [shadow-play],the contemporary term for magic lantern slides.

[1254] Kang Youwei,*Datongshu* 大同書 Zhang Xichen 張錫琛and Zhou Zhenfu 周振甫(eds.)(Beijing:Jinghua shuju 京華書局,1956),2

mianbingfa had a profound effect on him[1255],and this and his reading of Buddhist and Neo-Confucian texts led him to build a system in which the ether played a vital role.[1256] Tan's conception of *yitai*/ether was complex,but it clearly derived both from the Western notion of the ether and from the ancient Chinese idea of primal *qi* 氣,permeating everything,connecting everything,adhesive,intangible,infinite and eternal. In its physical aspect it was the cause of chemical and gravitational attraction,manifested in electricity,chemical affinity(*aili* 愛力) and 'mental power'(*xinli* 心力). In its generative aspect,*yitai*/ether was the origin of the material world,including the chemical elements. In its ethical aspect,it was both the *vector* of *ren* 仁[benevolence] and its *manifestation* through the Buddhist concept of compassion[*cibei* 慈悲] and in Christ's injunction to 'love others as ourselves'[*ai ren ru ji* 愛人如己].[1257] It was this ether which Tan believed bound all human beings together into a single consciousness,which in a reformed China would allow a new moral authenticity,and would ultimately entail the dissolution of all artificial boundaries between human beings.[1258]

[1255] *TSTQJ*,357,459 and 461. The definition of ether which Fryer inserted into *Zhixin mianbingfa*,1.13a was probably taken from the section 'Ethereal condition' of David Wells,*Principles and applications of chemistry*,which appears on page 19 of the 5th edition.

[1256] See Richard H.Shek,'Some Western influences on T'an Ssu-t'ung's thought' in Paul A.Cohen and John E.Schrecker(eds.)*Reform in nineteenth-century China*(Harvard:East Asian Research Centre,1976),200 and David Wright,'Tan Sitong and the ether reconsidered' in *BSOAS* lvii(1994),551-575..

[1257] Wright,'Tan Sitong and the ether reconsidered',570

[1258] *ibid.*,571

12.4 The intellectual impact of Western science: conclusions

The intellectual impact of Western science of Chinese intellectuals was almost negligible until the last decade of the nineteenth century,when political circumstances led to a new openness to ideas from outside China. This chapter has attempted to show the important role Christian religious tracts played in the process of assimilation.

Although the intention of the missionaries was clearly to attract new converts to their religion,the moral and transcendental dimensions they introduced into accounts of natural science proved highly appealing to certain individuals,and the result was a synthesis of Chinese thought,Neo-Confucianism and Buddhism[1259] - with Christianity and Western science. As happened later with the sinifying of Marxism,the Chinese component in the mixture remained dominant. At this stage there was no questioning of the whole edifice of Chinese thought in itself. Although as we have seen the most radical of the late Qing reformers Tan Sitong was prepared to jettison most of the superstructure of Chinese civilisation such as the institution of monarchy and the traditional family ties of obligation,it was still in the name of a purer Chinese tradition which he hoped to reform in the same way that Martin Luther had reformed Christianity.

To make science acceptable to Chinese scholars,the latter had to be convinced that it pertained to *Dao* 道 and was not merely *qi* 器: this the missionaries with what may seem their crude appeals to natural theology succeeded in doing. However,by shaping their nomenclature to be as close as possible to Chinese terminology,they perhaps unintentionally suggested that certain traditional concepts

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[1259] The late Qing revival of Buddhism also played a significant part. See Chan Sin-wai,*Buddhism in late Ch'ing political thought*(Hongkong:The Chinese University Press,1985) (such as *qi* 氣 [1260]) could be preserved within the new science. This led to a degree of confusion as the 'rules' of the new science-translation language-game were sorted out,but also to a kind of intellectual excitement as the layers of meaning were discovered and employed in novel ways,for instance,as we have seen above,the Chinese concept of *qi* 氣 was seen by both Kang Youwei and Tan Sitong as a spiritual substance which brought life and consciousness to otherwise inert matter[1261],that was related to electricity and magnetism,and was capable - in its role of the ether/*yitai* 以太 - of even transmitting compassion. It was thus in religious discourse on the natural world,which still allowed the possibility of a spiritual dimension,that Chinese intellectuals first found meaning in Western science.[1262]

The intellectual impact of Western science was,in the end,profound. Highly corrosive of the traditional views of nature,it also implicitly challenged the political structure by providing criteria for truth outside those of

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1260 See Guo Songtao,*Lundun yu Bali riji*,797,dated 15th November,1878 [Guangxu 4.10.22],quoting Norman Lockyer(1836-1920) as saying that 'all things come from a single *qi*',and that the origin of all things was hydrogen(*qingqi* 輕氣). This refers to the hypothesis of William Prout(1785-1850),who had suggested in 1815 that hydrogen is the "first matter" out of which all other elements are composed,an idea which persisted amongst those who felt that chemistry with its 90 or so elements was too untidy,and who looked for a unifying idea such as ether from which all the elements could be derived. See Ihde,164-155.

1261 See also 'Shengqi shuo' 生氣說 [On vital *qi*] in *GZHB* **2**,12(January 1878),11b-12b for an interesting attempt to relate *qi* 氣 to Western biology and chemistry.

1262 Henry Wood's *Ideal suggestion* was,despite its frequent references to 'science',profoundly idealistic(in the philosophical sense),and explicitly rejected atomism. See *ibid.*,90 and *Zhixin mianbingfa*,26b.

the traditional authorities.[1263] The 'walls of obstruction' as John Fryer called them[1264] were deeply undermined, if not finally destroyed, by the coming of Western science. The part science played in changing attitudes towards the old political system has been generally undervalued in writings on this period, which mainly concentrate on the purely technological contribution science was making to Self-Strengthening. The emotional and intellectual power of the new outlook on the natural world was for thinkers like Kang Youwei and Tan Sitong a major(if not decisive) factor in directing their thoughts towards reform. It is not coincidental that the most articulate and iconoclastic of the late Qing reformers, Tan Sitong, was also the most deeply affected by the new science.

[1263] It still sometimes plays such a role even in contemporary China. See the article 'Shijian shi jianyan zhenli de weiyi biaozhun 实践是检验真理的唯一的标准 [Practice is the sole criterion of truth] in *Guangming Ribao* 光明日报(11th May, 1978), 1, which initiated a reconsideration of the deification of Mao and the policies of the Cultural Revolution, and Fang Lizhi 方励之, *Bringing down the Great Wall: writings on science, culture and democracy in China*(New York: W.W.Norton, 1990), which reflects on science and democracy in China in the light of the 4th June, 1989 massacre in Beijing.

[1264] John Fryer, 'The commerce of China' (22nd October, 1898), 29 in *FP*: Carton 1.

Chapter 13 The translation of Western science to China: Conclusions

13.0 Introduction

The movement of Western science into China during the nineteenth century was a cultural invasion with consequences which are still being felt in our own time. By the mid-twentieth century,for the first time in Chinese history a system of essentially European thought had become,to a greater or lesser degree,part of the intellectual background of most educated Chinese. Such a massive importation of foreign ideas was not unprecedented - Buddhism was at least as alien when it arrived via Central Asia during the first few centuries of the Christian era - but whereas the progress of Buddhism had taken many centuries,within fifty years of the first translations of modern Western scientific texts Chinese government schools had science on their curricula,and by 1919, 'Mr Science' was hailed,alongside 'Mr Democracy',as a saviour of the Chinese nation. For the period under study this relatively high regard for science was still in the future,it is true,and in some sense the importance of natural science in China may still today be held in question,but given the odds against which the transmission occurred,the progress made by 1900 was impressive if not dramatic.

The reason why Western science was allowed access to China was not,in the first five decades of this study,the seductiveness of its ideas,but because the applications of natural science seemed to be the route by which the West had acquired its awesome military strength and self-confidence. It was this technological dimension which determined the radical change in attitude to Western science which had occurred since the time of Macartney's mission. The gentle,philosophical instruments which Macartney brought to impress the Qianlong Emperor had given way to weapons of such superior destructiveness that most of the highest levels of the official class had to acknowledge that something could be learned from the West,however distasteful it might be to admit foreigners as teachers of the Celestial Empire.

Science in China was never politically neutral: to be an advocate of Western science in China meant being for *change*,and change in a direction oriented towards the West,and therefore a challenge to the *status quo*. The reformers of the 1890s read science texts not because they wanted to find out how to make sulphuric acid but because they sensed a new attitude toward change and towards the future. The random but law-governed movements of atoms,and the clash of unseen forces,seemed to suggest a ferment of change which they found intoxicating.

Yet this transmission was not,as some contemporary Westerners liked to suppose,'useful knowledge' coming to fill up the vacuum of ignorance in China. The Chinese were not simply 'recipients' of another,scientifically more advanced,culture,but actively participant in its transmission. The group whom in Chapter 9 I have called the 'Chinese scientists' were remarkably few in number,but they exercised great influence both through their translations and through their advocacy of the new science as essentially continuous with,and not alien to,the Chinese tradition. This I have suggested was at least partly due to the strength of the Qing *kaozheng* 考證 movement which,whilst not in itself particularly concerned with natural science,encouraged a critical view of received texts,the orderly collection of data,and above all the formation of a scholarly community which could interchange and discuss accumulated knowledge.

From the matrix of the *kaozheng* tradition amateur scientists,usually wealthy officials who could afford to buy imported scientific apparatus,began to make their own investigations.[1265] The *Readers' Queries* section of *Gezhi Huibian* gives us direct evidence that such people were reading the available translated texts,and carrying out experiments in their own homes. These people represented the growth of a popular interest in practical science largely unrelated to career ambitions,and they were probably in the long run at least as significant in the development of a public consciousness of its importance for China's future.

One consequence of this study is that it reveals that science was not,as one writer puts it,'a literary affair'[1266],but did involve some Chinese at least in a very practical application of scientific principles. The expectation that,because the traditional education system emphasised literary studies,the Chinese were culturally programmed to respond to it in a bookish manner,is an example of what Andrew Nathan has called a 'close,deterministic view of what outside ideas members of a culture are capable of understanding'[1267],and prevents us from looking carefully at what actually happened,which is

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1265 Fryer reported in 1878 that scientific apparatus worth several thousands of dollars was being sold annually in Shanghai(*Second Report of the Chinese Polytechnic*,8). Fryer's Chinese Scientific Book Depot also sold scientific equipment from 1884(*GZHB* **5**,1(Spring 1890),1b.)

1266 Reardon-Anderson,49

1267 Andrew Nathan,'The place of values in cross-cultural studies: the example of democracy in China' in Paul A.Cohen and Merle Goldman(eds.)*Ideas across cultures: essays on Chinese thought in honor of Benjamin I.Schwartz*(Cambridge,Mass.:Council on East Asian Studies,1990),307. Nathan is referring to the way in which Western China scholars in the 1970s assumed that the Chinese were culturally programmed to reject the idea of democracy.

a good deal more complicated and more interesting than Chinese scholars reading books on Western science and misunderstanding them.

The pace of transmission was determined not by intellectual matters but by the Chinese political scene,and the dominance within the political élite of particular groupings who were more or less hostile to the transmission. Here we can see the 1840s,1860s and 1890s as periods relatively encouraging to science,the former two as a direct result of the First and Second Opium Wars and the perceived urgency of technological change; the 1890s,especially after 1895,marking the beginnings of a movement which radically questioned the *status quo*,following the defeat by Japan.

I shall now consider some models which may assist in understanding this complex set of processes.

13.1 Models of transmission

A number of models for the transmission of science are available: firstly the *diffusion model*,which uses the analogy of a substance like ink spreading through water,or of the vapour of a volatile liquid suffusing the air. Implicit in this model is the *unchanging* nature of what is transmitted The analogy of diffusion seems unsatisfactory for the transmission of modern science in China,for a number of reasons. Science does not spread spontaneously like ink through water: its transmission was a conscious,willed process,the result of various motives which had as much to do with the cultural and political situation as the internal nature of science. The diffusion model implies that nothing is altered in the transmission,whereas as we have seen the act of transmission involves a complex array of adjustments taking account of existing paradigms in the recipient culture. It also suggests that the recipient culture is merely a passive matrix for science,rather than an active participant in the process of transmission: in China this was far from the case. Indeed it was only when significant numbers of Chinese students of science began to study it seriously that the transmission really became fully established. It also suggests that there was 'nothing' there before the transmission took place,whereas in China one of the most interesting questions is to what extent the existing science paradigms interacted with Western science.

The *colonial model*,which can be applied to countries like India,is obviously only of limited relevance to China,which was never a colony in the strict sense,yet it is of some value in stressing the historical and political nature of the process,and also in identifying the stages through which modern science passed as it became part of the native culture. The colonial model is also a valuable counterpoise to the 'internalist' approach of the diffusion model,which looks only at the spread of scientific ideas without seeing how the ideas related to the social and political matrix.

Although no historical model can be more than a crude approximation,I propose that a *translation model*[1268] of transmission is richer and more fruitful in the case of nineteenth-century China. Translation is used here in five distinct but related senses: (1)the *physical movement of equipment and people*. This involves several phases: firstly,the arrival of Western guns and steamships was but one example of this; the coming of the

[1268] See Bruno Latour,*Science in action: how to follow scientists and engineers through society*(Milton Keynes:Open University Press,1987),for interesting uses of the term 'translation',especially p.111 on the suasive uses of science.

missionaries,translators and educators[1269],was the second phase; the third phase was the movement of the students who studied abroad,and then returned to China,and who were to become the first generation of modern Chinese research scientists.

(2)the *translation of texts* from Western languages into Chinese

(3)the *translation of institutions* which could teach science

(4)the *inoculation* of Western scientific ideas into Chinese philosophical discourse

(5)the *translation of the ideas of science for religious or political purposes*,what I have called the *suasive* use of science.

13.2 The translation of people and technology

(a) The translation of foreigners

In all five types of 'translation',there were ambiguities about the roles of the Chinese and of the foreigners. The foreigners regarded themselves as teachers,as bringers of intellectual sustenance in a 'vast desert of ignorance'. Yet as we have seen the Chinese at first either ignored Western science altogether,or saw the foreigners as returning to China some of its ancient lost treasures which they had,in their ignorance and

[1269] These were not mutually exclusive groups.

simplicity,somehow preserved,as a magpie might keep a bright jewel,'nurtured and augmented'. The Chinese certainly did not see science as proof of the Westerners' superior culture,but rather as a prized *Chinese* possession which had been lost and was now being restored.

The physical translation of foreigners into China was forced upon the Chinese in the most humiliating circumstances,and the attempts by foreign missionaries to encourage them to join a new religion filled many ordinary Chinese as well as the *literati* with rage. Science was associated with *force*,with aggression through steamships and guns,and the carving up[*guafen* 瓜分] of China 'like a melon' into spheres of influence,and the need for comparable reactive force was the driving motive of the Chinese officials who became involved in the Self-Strengthening Movement. It was only towards the very end of the period that they realised that attempting to catch up with Western technology without understanding the principles which lay behind the weaponry was doomed to failure.

The physical translation of technological hardware which was the initial spur to the opening to science,took place in relatively few establishments,mainly coastal arsenals and shipyards,set up by enterprising and optimistic officials who seem to have thought that the building of a modern military forces would be relatively easy once the skills had been passed to Chinese artisans. The technology proved much more intractable han they imagined,and worse still the rapid improvements in military technology during the nineteenth century meant that even when they did master the techniques these were soon superseded by new methods,making them obsolete.

From the foreigners' point of view,the translation

which to them seemed so wholly necessary to China's progress,was blocked by the forces of reaction. Fryer's disappointment at the career of the Shanghai Polytechnic is but one example of many of these
decades. Yet one has to admit that the 'reactionaries' like Woren 倭仁 were proved correct in their perception which Western studies posed: the study of the Western sciences was bound in the end to devalue the status of the traditional literary curriculum,and to lead to further shaking of Chinese self-confidence.

Another ambiguity in this aspect of translation was the role of Western business interests. It might have been assumed that they would have welcomed and encouraged the growth of Western science and technology,but there seems to have been a reluctance to take any positive steps in educating the Chinese in science. It may have been,as John Fryer suggested,that the businesses actually feared that the Chinese would take up science all too quickly,and that their manufactures would be imitated by skilled Chinese artisans. They may well also have not wanted the Chinese to lose their 'ignorance' too soon: it was after all to Western advantage to deal with a relatively backward country which could hardly defend itself,and which had to hire Westerners to work its factories and shipbuilding yards.

<u>*(b)The translation of Chinese scholars*</u>[1270]

[1270] See Shu Xincheng 舒新城,*Jindai Zhongguo liuxueshi* 近代中國留學史[A history of study overseas in modern China](Shanghai:Zhonghua shuju 中華書局,1927); Shu Xincheng 舒新城,*Zhongguo jindai jiaoyushi ziliao* 中國近代教育史資料[Materials on the history of modern education in China](Beijing:Renmin jiaoyu chubanshe 人民教育出版社,1961); and Qu Lihe 瞿立鶴,*Qingmo liuxue jiaoyu* 清末留學教育[Education overseas in the late Qing](Taibei:Sanmin shuju 三民書局,1973).

The movement of Chinese scholars has an internal and an external aspect,both closely related to the political conditions of the time. Internally,the cataclysm of the Taiping Rebellion caused a migration of scholars to the relative safety of Shanghai during the 1850s and 1860s,where for the first time some of them came into contact with modern Western science.

The movement of Chinese students of science out of China began in 1872 with the group of thirty students taken by Yung Wing to the United States[1271],followed by two more groups,but in 1878 they were all recalled to China,due to fears that they were becoming too Westernised and susceptible to Christian indoctrination.In 1875 a group of students from the Fuzhou Shipyard School were sent by Shen Baozhen 沈葆楨 to France to study navigation and manufacturing[1272],and two years later another batch were sent by Li Hongzhang to France,Britain and Germany[1273],and this group included some who studied mining and chemistry. In 1896,Xu Jianyin visited the Fuzhou Shipyard to discuss further overseas study,and in 1897 a group left for France.[1274] The students who studies in Europe included some from the Beijing Tongwenguan,such as Li Jinggao 李景鎬,Wu Kuangshi 吳匡時 and Chen Zuliang 陳祖良,who in 1907 set up the "European Branch of the Chemical Society of China" in Paris,and Wu Kuangshi went on to be head of China's first chemical research unit,the "Industrial Laboratory"(*Gongye Shiyansuo* 工業試驗所) in 1915,and a lecturer

[1271] Yung Wing,*My life in China and America*(1909; reprinted New York:Arno Press,1978),180-190; Qu Lihe,68ff

[1272] Qu Lihe,102ff

[1273] Qu Lihe,106ff

[1274] Qu Lihe,112-113

at Beijing University.[1275] Studying in Europe they also came into contact with revolutionary Marxist politics,an influence which would in time lead many to join the Chinese Communist Party.

The war with Japan led to a reassessment of the neighbouring country which had been traditionally looked on as the source of 'dwarf pirates',and yet which had shown itself more than a match for the Chinese fleet. In 1897[1276],the first group of students travelled to Japan,and were followed in 1898 by one hundred from Hubei and fifty from Hunan,encouraged by the progressive Governor Zhang Zhidong who pointed out that Japanese was much easier to learn than Western languages.[1277]

In addition to studying science,they also came into contact with radical politics,whether Chinese(carried on by followers of the exiles Liang Qichao,Kang Youwei and Sun Yat-sen)or Western Marxist. These experiences were to lead some to participate in the revolutionary struggles of the following decades. [1278]

13.3 The translation of texts

The translation of texts is sometimes presented in a diffusionist style,with the number of texts somehow gauging the spread of scientific knowledge. As I have tried to show,this needs to be questioned: the translation of books in itself neither ensures that they are read nor that the

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[1275] Xu Zhenya,'Jingshi Tongwenguan',28

[1276] Qu Lihe,129ff

[1277] Qu Lihe,131.

[1278] Lu Xun,who had arrived in Japan in 1902,began studying medicine in 1904,but in 1906 he forsook his medical studies to change the 'sick' attitudes of the Chinese people through his writings,after seeing a magic lantern slide of a Chinese informer being beheaded by the Japanese Army in Manchuria,watched by a passive Chinese crowd.(Lu Xun,*Nahan*,3) ideas they contain are understood. The little direct evidence we have suggests that the textbooks of this period were not in fact very good at transmitting the ideas of science,and we therefore need to be cautious in taking the number of textbooks translated as a measure of the spread of scientific understanding.

These texts,being chosen in a somewhat arbitrary manner,were representative not of the most advanced chemistry of their time,but rather that which the translators felt the Chinese ought to know,and which they themselves felt most comfortable with. The list of books which were translated is,on one level,impressive,but it does seem likely that the reading of books was not in itself a primary means of transmission. And yet - the very act of translation was a statement about the importance of their subject matter,and I would therefore also argue that,even though these books were often barely read,this does not mean that they were an insignificant factor. Their *existence* on the bookshelves of the literati,and in the catalogues of the Jiangnan Arsenal and Beijing Tongwenguan,showed that Western science was becoming part - albeit a minor part - of Chinese culture.

For,as Kang Youwei implied,these texts were opening the minds of the Chinese to a new world,a world in which they would only gradually become fully integrated

> If we wish to open mines under the ground,we should first open the mines that are in our minds and before our eyes. How to open the minds that are in our minds and before our eyes? Simply by establishing mining schools and translating books on mining.[1279]

[1279] Kang Youwei,*Riben shumu zhi* 日本書目志(?1897),2.11a,cited in Kung-ch'uan Hsiao,*A modern China and a new world: K'ang Yu-wei,reformer and Utopian,1858-1927*(Seattle:University of Washington Press,1975),307

13.31 The choice of terms

The 'textbook' view of science was,as we have seen,frequently decades out of date by the time it reached China,and,particularly in chemistry,tended to represent science as a Gradgrindian accumulation of facts rather than as a product of human imagination.

The difficulty of forming new terms in Chinese,a language is due to its resistance to phonetic loans,and the Chinese script,which tends to reinforce the tendency to draw on its own resources for new terminology. The experience of the Buddhist translators,and of the Jesuits was drawn upon in many ways,partly out of necessity,and the solutions which were found bear many resemblances to those of early periods of cultural transmission,except in chemistry for the resurrection of obsolete characters,which were on the whole successfully used to avoid 'clumsy' transliterations. This raises the issue of how far translated terms could successfully convey the new ideas without distortion.

13.32 The translatability problem

A key aspect of the transmission of science to China was language,and the translation of Western science into Chinese. The complexity of this problem is partly due to the nature of scientific discourse,which operates on several levels,and also on the nature of translation itself.

'The language of science' is actually a *family of languages*,which may,like the members of the Romance,Teutonic or Sino-Tibetan families,not always be mutually intelligible. For instance,words like 'element','atom','molecule' were not,in nineteenth-century science,used in quite the same way by physicists and chemists,and there were even within the chemical community what My Gyung Kim calls 'layers of language'.

13.33 The role of the bilinguals

The roles of the 'bilinguals'[1280] such as Li Shanlan,Xu Shou,Xu Jianyin and Hua Hengfang(and,in a different sense,those of Kang Youwei and Tan Sitong) were of great importance in the translation process. Western science and traditional Chinese science are examples of theories which Thomas Kuhn has called 'incommensurable',that is the concepts within one have no direct correspondence with those within the other. The apparent 'translation failure'[1281] between the Chinese and Western theories was not a problem for radical bilinguals such as Xu Shou and Li Shanlan: they rejected the *wuxing* 五行,*li* 理 and *qi* 氣 as irrelevant,and learned to converse in the new language of Western science,using their access to both 'languages' to impart the new knowledge via textbooks and articles and oral teaching.

Pragmatic bilinguals - usually with a political,religious or philosophical agenda - such as Kang Youwei and Tan Sitong,attempted in the 1890s to *reconcile* the two systems of discourse,by,for example,identifying ether with *qi* 氣,and equating compassion with chemical affinity(*aili* 愛力).

Although at first sight these responses seem very different,I would suggest that they are not. The two systems were,it is true,strictly irreconcilable,for the concepts of Western science were not translatable into *li* and *qi*. Yet through the activities of the bilinguals the new science could be expressed in language

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1280 Daiwie Fu,'Comparativity'

1281 Howard Sankey,'Translation failure between theories' in *Studies in the History and Philosophy of Science* **22**,2(1991),223-236 intelligible(though difficult or even misleading at times) for those who were monolingual in the traditional Chinese paradigms,precisely because the new terms were inevitably saturated with the old ideas. The gulf which separated the new from the old science was enormous,but much of this was simply not evident to the reader,because every translation,however sensitive and skilful,was constrained by the language and the semantic space available to the monolingual. Only practical experience - such as that offered in the classes of the Shanghai Polytechnic - would have really opened up the 'mines of the mind'.

This paradox - the translation of the untranslatable - can be understood by considering the process of translation as described in Chapter 5. The 'new' terms were rarely completely new,and,if they were true novelties,they were nearly always nouns descriptive of chemical types,occupying new semantic spaces. Most of the other terms were built from the existing terminology,combining terms in new ways. Thus the break with the past was present but disguised by the nature of the script,and by the existence of a pre-existing alchemical tradition. Even the iconoclastic Xu Shou preferred to use existing terms rather than transliterations. The discussion of the new science was thus not in practice conducted in a new language,merely in a sub-dialect within the 'nebulous mass' of everyday language. The 'everyday language' itself insinuated a way of looking at the world which was deeply influenced by that past views of nature.

13.34 The status of Western chemical language

To understand what was happening in China,it is essential also to understand what was happening in contemporary Western science. Some of the criticism that has been unjustly directed at the early translations has come about through the critics not having realised how different nineteenth-century science was from the science we know today. The lack of confidence in the atomic hypothesis,the use of equivalent rather than atomic formulae,the dualistic notation of Berzelius.....all these make it hard even for a reader with a good modern scientific background to understand these texts and to evaluate them fairly.

13.35 The culture of translation

The nature of translation as an essentially second-order activity - what I have called 'imaging',also produced an attitude towards science as a datum,rather than as a process. As Nakayama points out

> In the absence of participation and feedback in the paradigm-elaboration process,the paradigm brought in from abroad is treated as an established canon to be faithfully translated.[1282]

And once again the parallel between the transmissions to China of the Buddhist *dharma* and the gospel of modern science is striking. Although we can point to examples such as Xu Shou who did take a somewhat sceptical attitude towards the new learning,such independence of mind was exceptional. Translation is,by and large,an act of submission to the author of the source-book,and encourages an attitude of imitation rather than of independence of mind. The aim is to produce as sharp and faithful an 'image' as possible,without questioning or testing the truth of the original. The culture of 'translation' was never going to produce science capable of its own discoveries in China,only a low-level copy of the more superficial aspects of 'normal' science.

13.4 The translation of institutions

[1282] Shigeru Nakayama,*Academic and scientific traditions in China,Japan and the West*(Tokyo:University of Tokyo Press,1984),194

In 1840 there was not a single institution in the whole of China devoted to teaching Western science,and twenty years later little had changed,but in the years following the settlement of the Second Opium War(1856-60) there began a series of central government schools which in time began to include Western studies in the curriculum.

The institutions were in the long run far more important than the books,because it was they that confirmed the novices in the detailed understanding of the new ideas through practical application of the principles,whether in engineering ships and guns,or in the analysis of coal and iron ore. The 'cultural inoculation' of science was initiated here,in the Shanghai Polytechnic,in Dengzhou College and other mission schools,and in the Tongwenguans,which because of their official ethos hold a special importance in this stage of the transmission. Looking back,we can see that the 1867 controversy over whether to allow the Beijing Tongwenguan to teach 'Western studies' was a great turning point: breaching the walls of the most conservative city in the Empire,under the noses of those like Woren 倭仁,for whom the very existence of Westerners in the capital city was hard to bear,let alone regarding them as fit to be the teachers of the Chinese. Again,the quality of the science taught seems often to have been relatively poor,and the opportunities for its science graduates were few and far between. Yet the symbolic value of natural science on the curriculum of an imperial college was enormous.

13.41 Institutional support for scientific studies

The existence of what Nakayama calls 'support groups'[1283] for the transmission of science to China was very important in the early stages during the 'Wuxi period',but sadly their importance was not recognised by

[1283] Nakayama,202

the Chinese government,which seems to have set more store by translation of books and the purely technological or routine aspects of the transmission.[1284] The Wuxi scientists whose activities were so far ahead of their time,both in content and in methodology,were given no encouragement to continue their researches once they had moved to the Jiangnan Arsenal; indeed there seems little evidence of <u>any</u> true research(as distinct from chemical analysis and other routine 'normal' science)in China before the twentieth century.

Yet the very existence of the Shanghai Polytechnic,the Beijing Tongwenguan,and even the Translation Department of the Jiangnan Arsenal provided some support to the scientific enterprise. It was only in the last decade of the century,with the growth of industrial enterprises requiring chemical analysis(such as the Kaiping and Daye Mines)that working laboratories began to be set up,and positions for qualified chemists became available.

The changes in the state examinations,which first allowed questions on science and mathematics in 1887[1285], were only really effective once the post-Boxer reforms had changed the whole education system.

<u>13.5 The inoculation of science into philosophical discourse</u>

Science was taken seriously only very late in the century,by intellectuals who began to feel the need for radical change. They came to know of science not through direct study but via articles on popular science in journals such as *Gezhi Huibian* and *Wanguo Gongbao*.

[1284] By 'routine' I mean activities such as the analysis of mineral ores which had an obvious and direct economic benefit.

[1285] Morgan,*The teaching of science to the Chinese*,66

The popularisation of science in this period was largely due to missionaries who published journals including articles on popular science,often liberally laced with natural theology.The readers of these journals,mostly in the coastal Treaty Ports,were introduced to a heady world of seemingly constant innovation and discovery,and in which mysterious forces such as electricity,and imponderable fluids like the ether were mentioned alongside inventions such as the telephone.

When we speak of 'paradigms' we tend to think of relatively tidy conceptual clusters,organised around an expression in terms of mathematical formulae. The Western science to which the readers of these journals were introduced did not seem tidy at all: the rush of the new seemed rather chaotic,with few signposts as to what,if anything,it all meant. Technology was at least concrete,and could not be argued with. Yet the science supposedly driving the technology seemed to be in the background,able to explain some phenomena rather well,others hardly at all. The popularisations tended to avoid all but the simplest theories,and it is not surprising that some Chinese readers came to the conclusion that there was nothing really new in Western science,or at least nothing which posed a real threat to the Chinese paradigms,and as a result produced amalgams of Chinese philosophy and Western scientific thought that appeared bizarre and puzzling to the popularisers.[1286]

The 'inoculation' of Western science into China was,I suggest,from a historical perspective,a slow but relatively smooth process,with little obvious sign of

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[1286] See Roger Cooter and Stephen Pumfrey,'Separate spheres and public places: reflections on the history of science popularisation and science in popular culture' in *HS* **32**(1994),237-267 p.249.

rejection of an alien way of thinking. In the early stages,when all that was known was the relatively factual and almost concept-free descriptions of phenomena,this is perhaps understandable,but in the 1890s we see the beginnings of syncretism,with 'Chinese' concepts such as *ren* 仁 being freely intertwined with Western ones like the ether. This suggests that these ideas (and the ideas of Darwinian evolution which were to influence the next generation)were not all as alien as might be imagined from a late twentieth-century perspective,accustomed to label Chinese science as 'organic' or 'holistic',and to contrast it with the 'mechanistic','reductionist','analytical' science of the West. Late nineteenth-century Western science was far from being a monolith of atomistic materialism,and Western scientists were sometimes at least as metaphysical in their ideas as the Chinese whom they indirectly influenced. This 'inoculation' was only a transitory phase in the intellectual response to Western science. As Chinese students had the opportunity to study science more deeply,the connections with traditional Chinese thought were usually quietly discarded,and the Chinese science paradigms became increasingly irrelevant outside the field of medicine.

13.6 Translation into politics or religion: the suasive uses of science

Since the time of Lord Macartney,much of the transmission of Western science(as distinct from Western *technology*)had aspects of a 'archaeology of progress',in which the artifacts of the 'progressive' culture were excavated,packaged,transported and reassembled for the recipient culture,to be viewed and marvelled at,rather than to be interrogated.[1287] This use of translation,as a means

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[1287] See Michel Foucault,*The archaeology of knowledge*(1972; reprinted London:Routledge,1992),170-1. Foucault's use of the term 'archaeology' emphasises temporal discontinuities. Here I am also using it to point out the delay between scientific discovery and its transmission,and the selective nature of the to extra-scientific ends,such as cultural domination,political change or religious conversion,was never completely absent,and often seems to have been the dominant motive of several of the agents of transmission.

The use of science as an aid to the spreading of the gospel was an idea to which many missionaries held firmly,and to which Fryer,Mateer and Martin gave much of their lives. In some respects it turns out that their enthusiasm was misguided: there is some evidence that there was if anything an <u>inverse</u> correlation between a serious interest in science and the rate at which Chinese people became converted to Christianity in the early decades of the twentieth century. The *xian* 縣 (counties) of Zhejiang and Jiangsu provinces in which the first members of the Science Society of China had,on average,a *lower* conversion rate to Christianity than the surrounding districts,according to a study by Peter Buck. Yet this can also be explained in other ways: the Science Society students came from wealthy families who could afford to send them away to study. Such families were,on the whole,not those from which Christian converts came. They were,after all,doing quite well in the traditional system,and had more to lose by joining a foreign religion. The mission schools tended to attract families from the lower strata of society,and their sons would have been unlikely to be sent to study abroad.

The missionaries would no doubt have replied that their aim was to produce not <u>scientists</u> but <u>good Christians</u>,who would be helped in gaining status in their communities by having a knowledge of science. We thus need to distinguish between *having a science education* and *becoming a professional scientist*. The mission schools certainly provided a science education to some of their students,but

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transmission,as a curator chooses artifacts for 'display archaeology'.

relatively few of them would have had the wherewithal to go abroad to study, and at the turn of the century it was only by going abroad that it was possible to obtain the science education which equipped them to become professionals.

Another important aspect of the suasive translation of science was its role in supporting and corroborating certain political ideas. The translators of influential books such as *Zhixin mianbingfa* 治心免病法 and *Tianyanlun* 天演論 may not have had political intentions, but these books appeared at such a critical time in Chinese history, when intellectuals were seeking new ideas from all manner of sources, and for the first time for many centuries were willing to look seriously at foreign scientific and political ideas. At first the political notions were somewhat vague: science was linked to a general need for reform, but later this became more specific, linked to ideas such as the ether, and the power of love, which were supposed to be able to form a new world order. Beyond the Utopian schemes of Kang Youwei and Tan Sitong were the political ideas of the early Republican period, when some of the ideas of Social-Darwinism were seen as evidence for the Marxist conflict between classes being a reflection of the laws of nature.

One of the most interesting connections which this study has shown is the importance of the religious dimension to science translation: missionaries played a central role in the transmission of science, and the *suasive* aspect of the translation process needs to be studied carefully in order to assess its full significance. Western missionaries during this period in China saw science as an ally, an 'auxiliary of virtue', not an enemy to be countered. Science was in itself a demonstration of the superiority of Western civilisation. The Chinese, on the contrary - once they had recognised its importance - claimed Western science to have a *Chinese* ancestry,and had therefore little if anything of substance to quarrel with over its ideas and methods. The Westerners,barbarous though they were,had somehow preserved the transmission which the Chinese had lost,and were now returning it,'augmented and nurtured' to its motherland. The suasive aspect of the transmission was thus perversely successful: the Chinese,for the most part,simply ignored the overtly Christian part of the missionaries' messages in their science texts,and took from them the ideas they wanted,ideas which were then used within a fundamentally Chinese universe of discourse to reinforce their political or religious views.

13.7 Comparisons with the transmission of Western science into Japan and India [1288]

[1288] In the case of Japan,I have referred to: John K.Fairbank, *The influence of modern Western science and technology on Japan and China;* W.W.Smith,*Confucianism in modern Japan; a study of conservatism in Japanese intellectual history*(Tokyo:Hokuseido Press,1959); Marius B.Jansen,*Changing Japanese attitudes towards modernization*(Princeton:Princeton University Press,1965); Albert Craig,'Science and Confucianism in Tokugawa Japan' in *ibid.*,133-160; Genpaku Sugita,*Dawn of Western science in Japan* Ryozo Matsumoto trans.(Tokyo:Hokuseido Press,1969); Shimao Eikoh,'The reception of Lavoisier's chemistry in Japan' in *ISIS* **63**,218(September 1972),309-320; Huang Fuqing 黃福慶,*Qingmo liuRi xuesheng* 清末留日學生 (Taibei:Zhongyang yanjiuyuan jindaishi yanjiusuo 中央研究院近代史研究所,1975); Marius B.Jansen,'Japan and the Chinese revolution of 1911' in Denis Twitchett and J.K.Fairbank (eds.) *The Cambridge history of China*(Cambridge:Cambridge University Press,1980),339-374; Shigeru Nakayama,*Academic and scientific traditions in China,Japan and the West* Jerry Dusenburg trans.(Tokyo:University of Tokyo Press,1984); Thomas C.Smith, *Native sources of Japanese industrialisation 1750-1920*(Berkeley:University of California Press,1988); James R.Bartholomew,*The formation of science in Japan: building a research tradition*(New Haven:Yale University Press,1989);and Togo Tsukahara,*Affinity and Shinwa Ryoku*.

On modern science in India: H.J.C.Larwood,'Western science in India before the 1850s' in *JRAS*(1961)62-76; D.M.Bose,S.N.Sen and B.V.Subbarayappa,*A concise history of science in India*(New

Why was it that the advent of Western science in China took such a different course from that followed in other Asian countries with native scientific traditions such as Japan and India? By 1900 Western science was certainly far more deeply established in the latter countries than in China,and yet it was China which might,in view of its long scientific and technological tradition,to have been at foremost in its acceptance of modern science.

13.71 China and Japan

John K.Fairbank identifies four stages in the acquisition of Western science: (1)recognition of Western military superiority; (2)recognition of Western scientific technology as the basis of military superiority; (3)recognition of the need to train military personnel in Western military technology (4)recognition that scientific technology in the military sphere is but part of Western science and technology in general and that in order to develop it the pure sciences and general learning of the West need to be imported,for example mathematics and Western languages. Fairbank judges these stages to have been 'simultaneous' in Japan,whereas in China they were consecutive,and decades apart.[1289]

Delhi:Indian National Science Academy,1971; reprinted 1979),especially Chapter 10; Erik Baark and John Sigurdson(eds.)*India-China comparative research: technology and science for development*(London:Curzon Press,1981); A. Vasantha,'The "Oriental-Occidental" Controversy" of 1839 and its impact on Indian Science' in Patrick Petitjean,Catherine Jami and Anne Marie Moulin(eds.)*Science and empires*(Dordrecht:Kluwer Academic Publishers,1992),49-56; V.V.Krishna,'The colonial "model" and the emergence of national science in India 1876-1920' in *ibid.*,57-72; Dhruv Raina and S.Irfan Habib,'Technical content and social context: locating technical institutes. The first two decades in the history of the Kala Bhavan,Baroda(1890-1910)' in *ibid.*,121-136.

[1289] Fairbank,*The influence of modern Western science and technology on Japan and China*,250

In the case of Japan,one factor was its smaller size: China is so vast that changes in the coastal ports took a long time to affect the interior[1290]; another its social system: Japan's feudal structure,which in John Fryer's view 'was of great use in forming the character of the people,fostering and preserving in them the virile qualities that are generally lacking in the Chinese'[1291] The military arts certainly had a relatively higher prestige in Japan,which encouraged the adoption of Western methods.[1292] There were also some incipient capitalist and entrepreneurial tendencies,which allowed a more flexible response.[1293]. The different educational system in Japan,which placed less emphasis on the writing of *wenzhang* 文章 [literary essays] than in China,also played a part [1294]. Yet of more immediate significance than any of these was the extraordinary phenomenon of an aristocratic revolution in nineteenth-century Japan,in which the *samurai* class identified themselves with change and reform to a degree which was quite unlike the situation in China.[1295]

In the transmission of science,another major difference in outlook derived from Japan's experience of being the student of its great neighbouring culture of China: the Japanese did not feel it as such a humiliation to learn

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[1290] Fairbank,255-256 and John Fryer,*Why Japan has developed differently from China*(A lecture delivered to the Commerce Club,California Hall,on November 28th,1906)(*FP*:Carton 1),12.

[1291] John Fryer,*Why Japan has developed differently from China*,14

[1292] Fairbank,*The influence of modern Western science and technology on Japan and China*,254

[1293] *ibid.*,254

[1294] John Fryer,*Why Japan has developed differently from China*,17-20.

[1295] Thomas C.Smith,*Native sources of Japanese industrialization*,Chapter 5 from foreigners.

The Chinese accounts of the West such as *Haiguo tuzhi* 海國圖志 were read avidly in Japan,and seen as a warning of what might come to Japan if it did not modernise[1296]. Thus China's example of what could happen to a weak oriental nation was itself a spur to the modernisation process in Japan. In the years after 1860,Japan was seen by many of the Chinese Self-Strengtheners as a model of what could be achieved through adopting Western methods without loss of national pride. Yet the pace of change in China was desperately slow compared to that in Japan.

After the war of 1894-95 Japan became the place where thousands of Chinese went to study[1297] from just thirteen students in 1896 the number rose to between six and twenty thousand in 1906[1298]. Students such as Zhou Shuren 周樹人 (Lu Xun 魯迅) learned Western science from a nation which had only opened its doors to the West a few decades earlier,and whose 'translation culture' tended to reinforce that of China,with its view of science as being something that was created elsewhere. The development of chemistry in Japan nevertheless demonstrates how distinctly different the two societies were in their early adoption of science.

If we look at the progress of Western chemical ideas in Japan,we discover that the Japanese were some decades ahead of the Chinese,through the 'Dutch learning' or Rangaku 蘭學 movement of the Edo period. Aochi Rinsō 青地林宗 (1772-1833) was the first to Introduce Lavoisier's ideas through in his book *Kikai kanran* 気海觀瀾 [Contemplation of the waves in the ocean of *qi* 氣] published in 1837,and written in

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[1296] Jansen,'Japan and the Chinese revolution in 1911',340-341

[1297] Jansen,'Japan and the Chinese Revolution',348-349

[1298] *ibid.*,350

literary Chinese. Although the book is mainly on physics, it mentions the gaseous elements nitrogen [*chikki* 窒 'suffocating air'] and oxygen[*seiki* 清 気 'pure air']; he also mentions alternative terms for oxygen *seiki* 生 気 'vital gas' and *sanki* 酸 気 'acid gas', the latter being the closest in meaning to Lavoisier's term 'oxygen'.], hydrogen[*nenki* 燃 気 'inflammable air'], and the compound gas carbon dioxide[*koki* 硬 気 'hard[i.e. fixed] air'], and the oxygen theory of acids.[1299]

The most celebrated of the early Japanese chemistry textbooks is *Seimi kaisō* 舍密開宗 of Udagawa Yōan 宇田川庵(1798-1846). It is an abridged translation of Lavoisier's *Traité de chimie*, written in Japanese, and made further developments in nomenclature, some of which are still in use in contemporary Japan. Udagawa used *sansō* 酸素 for 'oxygen', *suisō* 水素 [water for 'hydrogen', and *sassō* 殺素 for 'nitrogen'[1300]

Udagawa came from a distinguished family of physicians, and was therefore able to relate his knowledge of drugs and pharmacy in the Japanese tradition to the Western ideas. The Japanese seem to have regarded Western science more pragmatically than the Chinese. According to Nakayama

> Japanese modern science was freed from its European philosophical roots: Japanese accepted the paradigms as self-evident and were concerned only with mastering them technically.[1301]

[1299] Shimao, 310-311

[1300] Shimao, 313

[1301] Nakayama, 207

The influence of Japan on China in the early stages of its modernisation programme was relatively slight,with perhaps a few of the Japanese terms being adopted by the translators in China.[1302] The Beijing Tongwenguan did not even teach Japanese until 1896,but was forced to close in 1899 because there were too few students.[1303] Yet the influence of Japan was beginning to increase. In 1897 Liang Qichao founded the Datong yishuguan 大同譯書館 in Shanghai,devoted mainly to the translation of Japanese texts.[1304]

13.72 China and India

China had during the transmission of Buddhism absorbed a number of aspects of Indian philosophy via the translation of Buddhist texts,yet the Buddhist of Indian views on the material world had a relatively insignificant impact. The Buddhist four-element theory,and the Indian ideas on atoms seem to have had little effect on the course of the development of Chinese science and medicine.

India was by the mid-nineteenth century in effect a British colony,and large parts were under British administration. The Indian experience of the transmission of Western science is therefore initially via a colonial system,which founded scientific institutions which it believed beneficial to the colonial development of the country. Yet,as in Chinese,there existed a native tradition of science whose paradigms differed considerably from those

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[1302] For example,Hoashi Banri 帆足萬里 in Kyuritsu 窮理通 [A compendium on the fathoming of principles],published in 1837,used the term *yuanzhi* 原質 for 'element',which was later used by W.A.P.Martin for the first time in *Gewu rumen*.See Tsukahara,111.

[1303] Huang Fuqing,151

[1304] Huang Fuqing,152

imported from the West.

The existence in China of a central administration,which,however weakened,still had to be acknowledged,made the situation in China very different from that in India,where the pace was at first set by the colonial administrators. Another particularly striking difference between the two countries was the way in which science was seen by its transmitters. Whereas,as we have seen,in China it seems to have been assumed that science and Christian civilisation were allies,whereas in India the East India Company introduced science with the specific intention of counteracting the missionary effort: the East India Company Charter of 1813,believing that

> by fostering both Oriental and Occidental science a reliable counterpoise,a protecting breakwater against the missionaries,could be created.[1305]

set aside a lakh of rupees every year for the

> revival and improvement of literature and the encouragement of the learned natives of India,and for the introduction and promotion of a knowledge of the sciences among the inhabitants of the British territories in India.[1306]

This is a reflection of the potential economic threat posed by the missionary activity in India as perceived by the Company. In China,exactly the opposite effect operated,with foreign business interests in China reluctant to become involved with the science popularisation activities of the Shanghai Polytechnic,where the 'secular

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[1305] A Vasantha,'The Oriental-Occidental controversy in India',50,quoting J.A.Richter,*A history of missions in India*(London,1908),152.

[1306] Vasantha,50

missionaries' of China such as John Fryer may have been seen as posing a threat to imported goods by encouraging the growth of native industries.

There was considerable debate over the appropriate language for the transmission of learning,with proponents of English(the 'Anglicists'),of Sanskrit or Arabic(the 'Orientalists'),and of the Indian vernaculars[1307],whereas in China there was never any serious question of teaching science via any foreign language: the argument,such as it was,was between the use of the Chinese literary or colloquial idioms. Although in India there were some translations into Sanskrit and Persian,there was a rapid development of scientific literature in the vernacular in India in the final decades of the nineteenth century. Between 1875 and 1896 there were nearly 1,000 publications in Indian vernacular languages on mathematics and natural sciences,contrasting with fewer than 400 in Chinese. The exact numerical comparison of numbers of textbooks is in any case of little help in understanding the rate of transmission of science[1308]

The scientific research establishments set up by the colonial administration,were run by colonial

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[1307] See John Clive,*Thomas Babington Macaulay: the shaping of the historian*(London:Secker and Warburg,1973),Chapter 12 and A.Vasantha,'The "Oriental-Occidental Controversy" of 1839 and its impact on Indian science'. Macaulay was a firm believer in the importance of English as a medium of education,stating in his famous 'Minute on Indian Education' in 1835 that 'a single shelf of a good European library is worth the whole literature of India and Arabia'(Clive,372),and his view carried the day.

[1308] Many of these translations were in Bengali,reflecting the cultural dominance of the Bengal region. See Tsuen-hsuin Tsien, 'Western impact on China through translation',315 for the Chinese data. Tsien's figures refer to 1850-1899,making the contrast even more striking,although I believe that Tsien's figures may be too low,as he himself suggests that his Chinese sources discount many missionary publications,which in this period were very important in the transmission of science.

scientists,whose role was seen by administrators as fact-gatherers in the service of the better running of the Empire. Yet despite the colonialist attitudes towards Indian advancement,by 1900 there were Indian scientists carrying out world-class research in chemistry and physics.[1309]

The institutional development of science in India was usually quite different from that in China,as generally the colonial power set up colleges at which science was taught,but the Kala Bhavan,a technical institute in the Native Indian State of Baroda founded in June 1890,provides an interesting contrast to the Shanghai Polytechnic and other Chinese institutions.[1310] The Kala Bhavan was founded to train technical manpower to 'develop the existing industries of the State as well as to help in introducing new industries calculated to improve the economic condition of his Highness'[that is,Sayyaji Rao of Baroda]many subjects'.[1311] The prime mover was the chemist and Sanskrit scholar,T.K.Gajjar,a graduate of Elphinstone College,Bombay. By 1909 the Kala Bhavan included schools of mechanical technology,weaving technology,architecture and civil engineering,commercial technology,a School of Art,and of dyeing and chemical technology. Two-thirds of the time was spent on practical applications,the remaining third on theoretical studies.[1312]

Unlike the Shanghai Polytechnic,the Kala Bhavan appears to have been an Indian initiative,closely linked to emerging industry. There was an active translation scheme

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[1309] See V.V.Krishna,'The "colonial" model and the emergence of national science in India'

[1310] See Raina and Habib,'Technical content and social context'.

[1311] *ibid.*,122-123

[1312] *ibid.*,123-124

for translating science texts into Gujarati,and the students also used textbooks specifically written in Gujarati by Indian authors.[1313] It will be recalled that one of Fryer's more poignant complaints was that his books were not even used in the Jiangnan Arsenal where his Translation Department was situated. In the Kala Bhavan at least it seems that translation into the vernacular was successful and the books were actually used. The close connection between Kala Bhavan and the dyeing industry was enhanced by the employment of two German scientists,Schumacker and Ebehardt,whilst a German chemical firm set up scholarships in the institute's school of chemical technology.[1314]

13.8 The sinicising of Western science: importing new paradigms into an ancient culture

The development of modern science in China happened in the Lower Yangzi valley,the very region which had been the intellectual cradle of the *kaozheng* movement in the late Qing. It was a social milieu in which intellectual self-confidence was fostered by economic prosperity and a long history of providing the most brilliant scholars for the imperial bureaucracy. From here it spread to the major cities,including the capital,with the setting up of government schools,in which science had an honoured place. At the same time,as we have seen in *Gezhi Huibian* and *Gezhi Xinbao*,there was a growth in amateur interest in science. For wealthier families,the collection of apparatus and scientific experimentation became a respectable,if somewhat

[1313] *ibid.*,125

[1314] *ibid.*,129

eccentric,pastime.[1315]

The wholesale abandonment of the old paradigms was - at least among the intellectuals - virtually complete within three generations.[1316] This was not merely a paradigm shift -and certainly not a 'scientific revolution' - but a virtually complete discarding of a way of thinking which had been more or less accepted in China for over two thousand years. The discourse of natural science was now conducted in a completely new way,in a semantic space which was still being created well into the twentieth century. It was the language of 'modern Chinese science',of course a part of world science,but still developing to some extent along parallel lines. This is,it will be seen,somewhat different from Needham's view that modern science is essentially a unity,an ocean into which the rivers European,Islamic,Indian and Chinese science have all flowed. I tend to prefer to apply Nakayama's view of Japanese science to China,namely that,since its discourse is conducted largely in Chinese,between Chinese people,and is thought about in Chinese,it remains to some degree separate from and different to 'Western' science.

\ Although Western science has been 'translated' to China in all the senses described above,the act of translation alters the content of what is being translated. 'Western' science conducted in China,discussed,thought and written

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[1315] John Thomson,*Thomson's China*(Hongkong:Oxford University Press,1993),209 recounts a meeting in the late 1860s or early 1870s with a Mr Yang in Beijing,who had set up his own laboratory in the ladies' quarter of his house,where he experimented with electricity,photography and chemistry.

[1316] Chinese medicine is of course excluded from this generalisation. I should also add that the concepts of *wuxing* 五行 and the ideas derived from the *Zhouyi* 周易 still survive in that part of the population which still holds to traditional Chinese beliefs in astrology and 'siting'(*fengshui* 風水) .

about in Chinese, is not quite the same as 'Western science' conducted in England and America, thought, discussed and written about in English. Of course, we can still, to a first approximation, communicate with one another; experiments will still give the same results - or, if not, we can reconcile the differences - yet the two experiments are not quite the same thing, being conducted by people from two different cultures in countries which are so different from one another, and discussed in two different languages. Translators usually will admit to the impossibility of a 'complete' translation, and that, in translation, something is 'lost', although it is often impossible to say clearly what 'it' is. During this initial stage, *when Western science was transmitted to China, it was no longer (simply) Western science*, but a new species, related to both its Chinese and Western parents.

It was as the first, foreign-dominated, phase of translation ended, and as the first Western-trained Chinese scientists (such as the geologist Ding Wenjiang) began to return to China and set up their own research laboratories, that Chinese students really began to take Western science seriously. As Charlotte Furth points out in the case of geology, what could apply to all the natural sciences:

> In the classroom the Western instructors were limited in their ability to communicate the subject. They were also an ambiguous, indeed distasteful, scholarly model for young Chinese. [...]When geology was at last taught in Peking by competent Chinese, then and only then did student enrolments begin to rise.[1317]

No longer dependent on the missionaries, Chinese scientists began to write their own textbooks, and to

[1317] Charlotte Furth, *Ting Wen-chiang*, 41 translate textbooks from Japanese rather than Western languages. The first stage of the transmission was centred(as it had been for Buddhism) on foreign missionaries with a limited knowledge of Chinese(and sometimes a limited grasp of science as well). In the next generation it would be the foreign-trained Chinese professionals who would set the pace,fix the nomenclature for the major areas of science and create the first professional scientific societies and journals. The emphasis on the translation of texts gave way to the translation of scientific institutions,modelled on those in the West or Japan,which could carry out the at least the minimal science requirements of an industrialised society such as chemical analysis.

Whilst the *achievements* of this period in science and technology were few and hard-won,with little official or popular support,the change in *attitudes* to Western science was immense. Whilst on a tour of Asia,Europe and America in 1906,Kang Youwei wrote

> the root of China's weakness lies in not knowing well enough to develop science and technology. The Chinese civilization,which is thousands of years old,is actually the foremost on earth. But it has placed undue emphasis upon ethics and philosophy,and is extremely deficient in science and technology[......] I pity my countrymen who have lost their way in a quagmire of futile discourses on lofty themes; for their enlightenment I offer my essay on National Salvation through Material Understanding.[1318]

[1318] This essay *Wuzhi jiuguo lun* 物質救國論[On the salvation of the country [through] material things] was published in Shanghai in 1919. This translation comes from K.C.Hsiao,*A modern China and a new world*,520.

The transmission of Western science into China is one the great cultural movements of the last two hundred years,and its effects are still being felt. The enormous potential of China as a great scientific nation has yet to be fully realised,partly because the philosophical implications of a fully modern scientific world-view are still to have their impact on a political culture in which largely nineteenth-century views of science - promoted via the writings of Marx,Engels,Lenin and Mao - still hold sway.

During this great transmission,the period 1840 to 1900 stands as the period of *translation*,in which the movement of science,the ideas of science,and even the language of science were largely controlled by the agents of transmission,who were,in the main,foreigners. From 1900 onwards we see a great change,with the collapse of the traditional examination system,with increasing numbers of Chinese students learning science abroad,especially in Japan,and with increasing autonomy within the Chinese scientific community,culminating in the formation of the Science Society of China in 1914,and the establishment of the first Chinese-run research projects. By 4th May,1919,Western science was no longer regarded as a collection of ingenious curiosities,but as a force for political progress,and an indispensable part of modern Chinese culture.

Bibliographies

Abbreviations

Bibliography A: translated works and compilations

Bibliography B: published works in Chinese and Japanese

Bibliography C: published works in Western languages

Bibliography D: unpublished works in Western languages

Abbreviations

Note Chinese titles are given in full in Section 1 of Bibliography B

AEOB Chan Sin-wai, *An exposition of benevolence*

AS *Annals of Science*

BIHP *Bulletin of the Institute of History and Philology*, Academia Sinica

BIMH *Bulletin of the Institute of Modern History, Taibei*

BJHS *British Journal for the History of Science*

BSOAS *Bulletin of the School of Oriental and African Studies*, London University

CHC *Cambridge History of China*

CSWT *Ch'ing-shih Wen-t'i*

CR *Chinese Recorder*

CRP *Chinese Repository*

CS *Chinese Science*

DFZZ *Dongfang Zazhi*

DSB *Dictionary of Scientific Biography*

FEQ *Far Eastern Quarterly*

GZHB *Gezhi Huibian*

GZKYHB Wang Tao (ed.) *Gezhi keyi huibian*

GZXB *Gezhi Xinbao*

HJAS *Harvard Journal of Asian Studies*

HS *History of Science*

JAS *Journal of Asian Studies*

JCBRAS *Journal of the China Branch of the Royal Asiatic Society*

JCE *Journal of Chemical Education*

JHXB *Jiaohui Xinbao*

JNCBRAS *Journal of the North China Branch of the Royal Asiatic Society*

JRAS *Journal of the Royal Asiatic Society*

KJSWJ *Kejishi Wenji*

LHCT *Liuhe Congtan*

MS *Monumenta Serica*

NCH *North China Herald*

POC *Papers on China*

SCC Joseph Needham, *Science and civilisation in China*
TSTQJ Tan Sitong, *Tan Sitong quanji*
WGGB *Wanguo Gongbao*
YYJXYYJ *Yuyan Jiaoxue yu Yanjiu*
ZGKJSL *Zhongguo Keji Shiliao*
ZGYW *Zhongguo Yuwen*
ZRBZFTX *Ziran Bianzhengfa Tongxun*
ZRKXYJ *Ziran Kexue Yanjiu*
ZXWJL *Zhong-Xi Wenjian Lu*

Bibliography A: Translated works and compilations on science

This contains the translated works and compilations consulted in this thesis,arranged alphabetically by Chinese title. The identities of the source-texts(*diben* 底本),where known,are given in parentheses,although sources often differ markedly. The information is obtained from the following sources:

a.The preface of the Chinese text
b.John Fryer,'An account of the Department of the Translation of Foreign Books at the Kiangnan Arsenal,Shanghai',originally published in *North China Herald*(29th January,1880). The version I have used is held in the Bancroft Library,University of California,Berkeley *Fryer Papers*,and,unlike the newspaper article,gives details of the books translated at the time.
c.*Gezhi Huibian*(September 1880 and October 1880)
d.John Fryer,*Catalogue of educational books,works of general knowledge,scientific and technical treatises,& c.*(1894)
e.John Fryer,*Descriptive catalogue and price list of the books,wall charts & c.,published or adopted by the Educational Association of China*(1894)
f.*Jiangnan zhizaoju yishu tiyao*(1909)
g.A.A.Bennett,*John Fryer*(1967)
h.Yang Gen 杨根 (ed.)*Xu Shou he Zhongguo jindai huaxueshi*(1986)
i.Pan Jixing 潘吉星'Ming-Qing shiqi(1640-1910) huaxue yizuo shumu kao'(1984)
j. Li Nanqiu 黎难秋,'Shijiu shiji Zhongwen huaxue shuji bukao'(1985)
k.Xu Zhenya 徐振亚 and Ruan Shenkang 阮慎康,'Xu Shou fu-zi,zusun yizhu jianjie'(1986)
l.Wang Yangzong 王扬宗,'Guanyu *Huaxue jianyuan* he *Huaxue chujie*'(1990)

m.Wang Genyuan 王根元 and Cui Yuntian 崔云昊'Guanyu *Jinshi shibie* de fanyi,chuban he diben'(1990)
n.Pan Jixing 潘吉星 'Ming-Qing shiqi yicheng Hanwen de baizhong huaxue zhuzuo'(1993)
o.Walravens,Hartmut,*Catalogue of Chinese books and manuscripts in the library of the Wellcome Institute for the History of Medicine*(1994)

The libraries holding the texts are as follows:

CUL: University Library,Cambridge
OIOC:British Library,Oriental and India Office Collections
SOAS:School of Oriental and African Studies,London University
UBC: University of California,Berkeley
WIHM:Wellcome Institute for the History of Medicine,London

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Bisuan shuxue 筆算數學 [Written arithmetical calculations] by Calvin Wilson Mateer (Dikaowen 狄考文). (Preface by Zhang Zhidong dated 1892; reprinted Tianjin:Wubei xuetang 武備學堂,1897[a])[Fielter,*School arithmetic*][c(Sept 1880),9a;e,1](OIOC)

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Careers in Western Science in Nineteenth-Century China: Xu Shou and Xu Jianyin

DAVID WRIGHT

Introduction

The Western science and technology which invaded China during the mid-nineteenth century, in the wake of European military and economic aggression, entered a culture with a long indigenous tradition of natural philosophy, formed by extraordinary figures such as Zhang Heng 張衡 (78–139), Sun Simiao 孫思邈 (581–682), Ge Hong 葛洪 (*c.* 281–341), Shen Gua 沈括 (1031–1095) and Song Yingxing 宋應星 (*c.* 1587–1665).[1] Moreover, as modern research has shown, China was, at least until about A.D. 1400, more advanced scientifically and technologically than Western Europe in many respects. The small minority of late Qing scholars who showed any interest in the natural world or in technology could console themselves that they were working within a noble but neglected side-stream of Chinese culture.[2]

Since the sixteenth century the Jesuits had made the Chinese *literati* aware of the existence of European natural philosophy, and they thereby stimulated something of a renaissance in native mathematics and astronomy, but in general Westerners were not seen as possessing knowledge or commodities which were of especial interest or concern to the inhabitants of the Middle Kingdom, so "vast in area and rich in resources". The embassy of Lord Macartney in 1792–4 had tried to impress the Chinese with Western arts, sciences and manufactures, even to the extent of including a planetarium in his gifts, but the Qianlong Emperor made it clear in his famous letter to the English king that such trifles were of little interest to the ruler of the Celestial Empire:[3] the sciences of the Westerners

[1] Surveys of the field of traditional Chinese science and medicine may be found in: Joseph Needham and collaborators, *Science and Civilisation in China* (Cambridge, 1954–); Nathan Sivin and Nakayama Shigeru, *Chinese Science: Explorations of an Ancient Tradition* (Cambridge, MA, 1973); Nathan Sivin, "Why the scientific revolution did not take place in China – or didn't it?", *Chinese Science* 1982, 5, pp. 45–66; Ho Peng Yoke, *Li, Qi and Shu: an Introduction to Science and Civilization in China* (Hongkong, 1985); Nathan Sivin, *Traditional Medicine in Contemporary China* (Ann Arbor, 1987); and Nathan Sivin, "Science and medicine in imperial China: the state of the field", *Journal of Asian Studies*, XLVII (1988), pp. 41–90.

[2] It was not unusual for scholar-officials to have such knowledge of agriculture or military matters as their roles in government required, but in terms of their careers a deeper interest in what we would call science or technology usually brought no material rewards. See Christopher Cullen, "The science/technology interface in seventeenth-century China: Song Yingxing 宋應星 on *qi* 氣 and the *wu xing* 五行", *BSOAS*, LIII 2 (1990), pp. 296–7.

[3] See Zhang Shuhong, "Historical anachronism: the Qing court's perception of and reaction to the Macartney Embassy", in Robert A. Bickers (ed.), *Ritual and Diplomacy: the Macartney Mission to China 1792–1794* (London,

JRAS, Series 3, 5, 1 (1995), pp. 49–90

were not generally to be regarded as worthy of study by the aspiring scholar until very late in the nineteenth century.

The apparent catalysts for this serious re-appraisal of Western studies were the First Opium War (1839–42) and the Second Opium War (1856–60). However, important though these conflicts with Western powers were, they directly affected only a small coastal region of the vast empire. Far more significant in breaking down official complacency was the massive social upheaval of the Taiping Rebellion (1851–64), which came close to destroying the Qing dynasty. During his early naval battles with the Taiping rebels (when his shame at his defeats brought him close to suicide) the eventual saviour of the dynasty, Zeng Guofan 曾國藩 (1811–72), came to recognise the military importance of Western steamships and guns. At first depending on the purchase of foreign ships, he later resolved that China should no longer be reliant on foreign engineers, and determined to set up a Chinese-run shipyard:

After the foreign vessels and cannons have been purchased we must recruit resourceful scholars and clever mechanics to practise on them first, and then try to imitate them.[4]

Zeng set up the Anqing Arsenal (*Anqing junxiesuo* 安慶軍械所) in late 1861, soon after the recapture of the city from the Taiping rebels,[5] and he gathered there a group of "resourceful scholars", including Li Shanlan 李善蘭 (1811–82), Hua Hengfang 華蘅芳 (1833–1902), Xu Shou 徐壽 and his son Xu Jianyin 徐建寅, in the hope that they would be able to develop a purely Chinese shipbuilding and armament industry. Despite the difficulties they encountered, they were successful enough to encourage Zeng and his fellow Self-Strengthener Li Hongzhang 李鴻章 (1823–1901) to set up a much larger-scale venture at the Jiangnan Arsenal (*Jiangnan zhizaoju* 江南製造局) in Shanghai to build ships, manufacture guns and to embark upon a programme of translation of Western scientific and technical books into Chinese.

The Xus differed from earlier Chinese natural philosophers firstly in their crucial role in the introduction of a new set of paradigms – those of Western science – which would in time supersede or marginalise the traditional Chinese view of nature;[6] and secondly in their direct involvement with the military applications of science.[7]

Yet the failure of the attempt to build a modern military-industrial complex around the Jiangnan Arsenal, whether in shipbuilding or in armament manufacture, demonstrated by

1993), pp. 34–6; and Harriet T. Zurndorfer, "Comment la science et la technologie se vendaient à la Chine au XVIIIe siècle", in *Études chinoises* VII 2 (1988), pp. 59–90.

[4] Gideon Chen, *Tseng Kuo-fan: Pioneer Promoter of the Steamship in China* (Beiping, 1935), p. 35.

[5] Anqing was the second most important Taiping city, and its loss to the Qing "was a decisive turning point in the war". See Colin Mackerras, *Modern China: a Chronology from 1842 to the Present* (London, 1982), p. 84.

[6] This does not apply in the same way to Chinese medicine, whose paradigms continued (and even today still continue) to develop parallel to and separate from those of Western medicine.

[7] I do not mean to imply that in former times the great figures of Chinese science were *impractical*, but rather that their talents were seldom employed by the government of the day to further its military purposes in the way that Zeng Guofan employed the technical experts of his *mufu* (private secretariat). A rare contrary example would seem to be the ancient philosopher Mo Zi 墨子 who is supposed to have built defensive machinery (see A. C. Graham, *Later Mohist Ethics and Science* (Hong Kong and London, 1978), pp. 3–15).

Although we now take it for granted that science and technology are interdependent, this close connection is a relatively modern affair both in China and the West. See Christopher Cullen, "The science/technology interface in seventeenth-century China", p. 295.

China's disastrous defeat in the Sino-Japanese War (1894–5), illustrated how far China had to go before it could become a self-sufficient modern military power. Active though the Xus had been in the early phase of the modernisation, they were more aware than most of their contemporaries of the immense gulf that had to be bridged, a gulf which required above all a cadre of able scientists and technicians, proficient in the practical arts as well as having a firm grasp of the theoretical principles which lay behind the manufacture of the steamships and guns which were humiliating the Qing empire. Xu Shou strongly identified with the scepticism he discovered within modern science, a scepticism which by the end of the century had spread to the extent that some radicals were willing to challenge fundamental institutions within China such as the monarchy and even the traditional Chinese family itself.

The rapid growth in the esteem for Western scientific knowledge amongst influential thinkers, especially in the last decade of the nineteenth century, owed a great deal to the translations of the Xu family and to ventures such as the Shanghai Polytechnic (*Shanghai Gezhi Shuyuan* 上海格致書院) and the *Gezhi huibian* 格致彙編 [*The Chinese Scientific Magazine*, later *The Chinese Scientific and Industrial Magazine*] with which they were closely associated.

The immensity of the change in intellectual outlook is personified in these two men. In Xu Shou we find a scholar trained in the methods of the *kaozheng* 考證 [evidential research] movement, who explicitly rejected the key concepts of the Chinese science paradigm: *li* 理 [Principle], *qi* 氣,[8] *wuxing* 五行 [Five Phases] and *yin-yang* 陰陽, devoting the latter part of his life to a whole-hearted exploration of the sciences of the Westerners (becoming incidentally the first Chinese scientist to have an article published in *Nature*), yet nevertheless seeing himself as the inheritor of an ancient though moribund Chinese tradition which could be revived and strengthened through the influx of Western science.

Xu Shou's second son Xu Jianyin gave little time to theoretical discussions. The older paradigms seemed to hold no interest for him. He did not, like his father, denounce them: they were simply ignored as he became increasingly involved in applying the principles of Western science to the enterprises of the Self-Strengthening movement. The Self-Strengtheners, led by Zeng Guofan and Li Hongzhang, hoped to restore the dynasty's fortunes by modernisation of its military hardware and by rapid military industrialisation in the aftermath of the Taiping Rebellion and the Opium Wars. With restless energy, Xu Jianyin devoted himself to a succession of his sponsors' Self-Strengthening projects such as shipbuilding, the translation of works on Western technology, and the practical problems of running acid plants and gunpowder works. After a technological reconnaissance mission to Western Europe, Xu Jianyin became markedly more pessimistic about China developing its own manufacturing base without political changes. He became involved with a group of political reformers around Liang Qichao 梁啓超 (1873–1929) in

[8] There is no adequate single translation for this term, which basically means "vapour" or "breath", but has a wide range of extended meanings which have been rendered variously (but unsatisfactorily) as "matter-energy", "ether" and "basic stuff". The Stoic term *pneuma* may be the best approximation, as *qi* never lost its ethical dimension. See Nathan Sivin, *Traditional Medicine in Contemporary China*, ch. 11 for a useful summary.

Fig. 1. Xu Shou, a portrait in *Gezhi huibian* October 1877 (reproduced by kind permission of the British Library).

Shanghai, and during the Hundred Days' Reform of 1898 he briefly held high office in Beijing, but as the reform movement collapsed, and the threat to his country's integrity intensified after the Boxer Rebellion (1900–1901), he went to work for Li Hongzhang's rival Self-Strengthener Zhang Zhidong 張之洞 (1837–1909) at the Hanyang 漢陽 Arsenal, where his efforts to make smokeless gunpowder ended in tragedy.

Both men made their careers in Western science, an eccentric pursuit for which most of their contemporaries showed only contempt. Their fortunes illustrate the slow and erratic process of the assimilation of scientific ideas from the West, and the immense difficulties faced even by those who were well-versed in the native scientific tradition. Yet, by the time of Xu Jianyin's death, natural science had become accepted even by intellectuals who understood little about it as of great importance for China's future. The new government schools, established as a result of the late Qing reforms which followed the Boxer Rebellion, were expected to include science in their curricula, and waves of Chinese students were sent abroad to study science in Japan, Europe and America. This enormous change in intellectual climate can be attributed in part to the work of the Xu family in translating Western science into a Chinese idiom, and in showing how vital its applications were to China's future security.

Xu Shou 徐壽 (1818–84)

An outline of his life[9]

Xu Shou (Xu Xuecun 雪村 or 邨) was born and grew up in Wuxi 無錫, a city near Lake Tai 太湖, lying on the Grand Canal between Changzhou 常州 and Suzhou 蘇州. This area was one of the richest and most densely populated parts of China in the late Qing dynasty, an area noted for its merchants, artists and scholars. It was also a region which

[9] The primary sources on Xu Shou's life are John Fryer's article, "An account of the Department for the Translation of Foreign Books at the Kiangnan Arsenal", in *North China Herald* (29th January, 1880), pp. 77–81; Zhao Erxun 趙爾巽 (ed.), *Qingshi gao* 清史稿 [Draft history of the Qing dynasty] (Beijing) Vol. 46, 505.13929–13930; Hua Yilun 華翼綸, "Erpin fengdian Zhili houbu zhifu Xuecun Xu hui jun jiazhuan" 品封典直隸候補知府 雪村徐徽君家傳 [An account of the family of the Second-rank Expectant Prefect in Zhili Xu Xuecun [Xu Shou]] in Min Erchang 閔爾昌 *Beizhuan buji* 碑傳補集 [Supplementary collection of epitaphs] 43.12b–13b; Cheng Peifang 程培芳, "Xu Xuecun xiansheng zhuan" 徐雪村先生傳 [Biography of Mr Xu Xuecun] in *ibid.*, 43.13b–15a; Hua Shifang 華世芳, "Ji Xu Xuecun xiansheng yishi" 記徐雪村先生軼事 [Anecdotes about Mr Xu Xuecun], in *ibid.* 43.15a–15b; Qian Jibo 錢基博, "Xu Shou zhuan" 徐壽傳 [Biography of Xu Shou], in *ibid.*, 43.15b–18b; Cheng [Pei] Fang 程 [培] 芳, "Xu Xuecun xiansheng xiang xu" 徐雪村先生像序 [An introduction to the portrait of Mr Xu Xuecun], in *Gezhi huibian* 格致彙編 [The Chinese Scientific and Industrial Magazine] (October, 1877), 1a; Zeng Guofan 曾國藩, *Zeng wenzheng gong shoushu riji* 曾文正公手書日記 [The handwritten diary of Zeng Guofan] (Shanghai, 1909); *Wuxi Jinkui Xian zhi* 無錫金匱縣志 [Gazetteer of Wuxi and Jinkui Counties] (1881; reprinted Taibei, 1970); *Shanghai Xian xuzhi* 上海縣續志 [A sequel to the Gazetteer of Shanghai County]; John Fryer, *Fryer Papers* held in the Bancroft Library, University of California, Berkeley.

For secondary sources, the most useful is the excellent collection, Yang Gen 杨根 (ed.), *Xu Shou he jindai huaxueshi* 徐寿和近代化学史 [Xu Shou and the history of modern Chinese chemistry] (Beijing, 1986), hereafter abbreviated as *Xu Shou*; Xu Shou is also mentioned in Gideon Chen, *Tseng Kuo-fan: Pioneer Promoter of the Steamship in China*, pp. 40–3; Song Ziliang 宋子良, "Zongguo diyi sou zhengqichuan" 中國第一艘蒸汽船 [China's first steamship], in *Ziran bianzhengfa tongxun* 自然辩证法通讯 [Journal of Dialectics of Nature] XIV, 1 (1992) pp. 50–6; Cao Yuanyu 曹元宇 *Zhongguo huaxueshi hua* 中國化学史话 [On the history of Chinese chemistry] (Taibei, 1984) pp. 294ff; Du Shiran 杜石然, *Zhongguo kexue jishushi gao* 中国科学技术史稿 [A draft history of Chinese science and technology] (Beijing, 1982) pp. 259–63; Yuan Hanqing 袁翰青, *Zhongguo huaxueshi lunwenji* 中国化学史论文集 [A collection of essays on the history of Chinese chemistry] (Beijing, 1956) pp. 270ff.; Zhang Zigao 张子高 and Yang Gen 杨根, "Xu Shou fu-zi nianpu" 徐寿父子年谱 [A chronology of Xu Shou and his sons], in *Zhongguo keji shiliao* 中国科技史料 [Historical materials on Chinese science and technology] 1981 (4), pp. 55–61; *Qingdai renwu zhuangao* 清代人物传稿 [Draft biographies of personalities in the Qing dynasty] (Beijing, 1984); Li Dingfang 李鼎芳, *Zeng Guofan ji qi mufu renwu* 曾国藩及其幕府人物 [Zeng Guofan and the personnel of his private secretariat] (Beijing, 1985; reprint of 1947 edition); Xu Zhenya 徐振亚 and Ruan Shenkang 阮慎康, "Xu Shou fu-zi, zusun yizhu jianjie" 徐寿父子祖孙译著简介 [A brief introduction to the translations of Xu Shou, his sons and grandsons], in *Zhongguo keji shiliao* 中国科技史料 [Historical materials on Chinese science and technology] VII, 1 (1986), pp. 48–55; and James Reardon-Anderson, *The Study of Change: Chemistry in China 1840–1949* (Cambridge, 1991), ch. 2.

had been the seat of several official academies of the Jiangnan 江南 *kaozheng* 考證 movement which flourished in the Lower Yangzi area in the late Imperial period. The Changzhou scholars in particular had revived the New Text School's unorthodox interpretation of Confucius as a "messianic sage",[10] but had also more generally encouraged a scepticism about certain traditional ideas and conventional institutions which was to influence late nineteenth-century reformers such as Liang Qichao, Kang Youwei 康有為 (1858–1927) and Tan Sitong 譚嗣同 (1865–98). This independence of mind, perhaps related to the economic power of the region, made it fertile ground for the growth of new ideas. During the Taiping Rebellion Wuxi was occupied by the rebels, and many of its residents fled to the relative safety of Shanghai, where by the 1850s foreign intellectual influence – particularly that of the Protestant missionaries – was beginning to be felt.

Xu Shou was just five *sui* 歲[11] when his father died, and was brought up by his mother. Having attempted and failed the "youth examinations" *tongzishi* 童子試 several times, Xu Shou decided in his middle age to reject literary studies and to devote himself to the native Chinese writings on astronomy, mathematics, acoustics, chemistry, mining and medicine.[12] His failure to pass the examination did not mean that Xu Shou was lacking in ability: the highly competitive examination system, in which only a certain quota of scholars from Wuxi were allowed to pass, and his original cast of mind may well also have counted against him.[13] However, this humiliation must have had a profound effect on him and forced him to consider other outlets for his prodigious talents.

For a scholar, he had unusually practical interests, being a skilled maker of replicas of ancient musical instruments[14] and scientific apparatus such as magnetic compasses and quadrants,[15] an interest which led him later into a creative study of acoustics and also to make one of the finest collections of scientific equipment in China.[16] In a curious episode, he even managed to make brilliantly successful counterfeit silver coins which the missionary Alexander Williamson (1829–90) is said to have sent to the British Museum.[17] Xu Shou's combination of intellect, practical skill and self-publicity was later to bring him to the notice of the reform-minded officials who were seeking Chinese engineers in their attempt to create the first native-built steamship.

[10] See Benjamin Elman, *From Philosophy to Philology* (Cambridge, MA, 1990), p. 23.

[11] Hua Yilun, p. 12b. [12] *Ibid.*, p. 12b and Cheng Peifang, p. 14a.

[13] Wuxi was noted as a place which produced many brilliant scholars. See Ping-ti Ho, *The Ladder of Success in Imperial China: Aspects of Social Mobility 1368–1911* (New York, 1962), p. 254.

[14] Hua Yilun, p. 13b. Music was of far more than academic interest in China: a proper study of harmony was believed to be essential to the harmonious order of the world. See Joseph Needham, *Science and Civilisation in China*, Part iv, 1 (Cambridge, 1962).

[15] Hua Yilun, p. 12b, Cheng Peifang, p. 14a, Hua Shifang, p. 15a and Qian Jibo, p. 16a. Cheng places particular emphasis on Xu's skill as an instrument-maker, saying that it was this that drew Xu Shou to Zeng Guofan's attention. Wang Tao 王韜 (1828–97) quotes Hua Hengfang as saying that Xu Shou "is peerless in ingenuity and wisdom, and the strange and novel things that he makes are comparable to those of the Westerners. [His] chiming clocks and magnetic compasses are extremely intricate and marvellous. Having climbed onto a steamship, and having seen its wheels, shafts and machinery, he immediately knows how to make it: he really is extraordinarily clever (see Wang Tao, *Wang Tao riji* 王韜日记 [The diary of Wang Tao] (Beijing, 1987), p. 92: diary entry for 9 March 1859). [16] *North China Herald* (24 June 1876), pp. 617–18.

[17] Qian Jibo, pp. 16a–16b. Unfortunately there seems to be no trace of them in the present British Museum coin collection (personal communication from Helen Wang, Curator of Far Eastern Coins).

Xu Shou was known in Wuxi for his practical expertise not only in the somewhat arcane realm of ancient music but also in the very practical matter of silk filatures. The Wuxi silk industry had been badly damaged by the competition of nearby Western factories: Xu Shou developed ovens for baking the silkworm pupae and a mechanical reeling device, which helped to save the local silk filatures from disaster.[18] This story shows Xu Shou as the expression of a conventional paternalistic-scholarly ideal, the *fumuguan* 父母官 "father-mother official" helping the local people through the exercise of his superior knowledge. It is noteworthy that this is the only recorded example of Xu Shou using his knowledge directly to benefit ordinary people. His somewhat introverted character meant that in general he preferred to work alone or with very small groups of other scholars on projects which had applications within the agenda of the scholarly élite; it was also much later to lead him into conflict with the efforts at popularisation of the foreign sponsors of the Shanghai Polytechnic.

Early scientific studies

Sometime after 1852 Xu Shou, his second son Xu Jianyin and his friend Hua Hengfang 華蘅芳 (1833–1902) travelled to Shanghai where they met the mathematician Li Shanlan, who was by then working at the Mohai shuguan 墨海書館 [Inkstone Press] run by the London Missionary Society, translating scientific books with Protestant missionaries such as Alexander Wylie (1815–87) and Alexander Williamson.[19] Whilst in Shanghai Xu Shou bought some electrical equipment and showed his friends how a paper figure could be made to dance under the influence of static electricity.

I howled with laughter and could not figure out how it worked.

recorded Hua Shifang 華世芳, the younger brother of Hua Hengfang.[20] It was with Hua Hengfang and Xu Jianyin that Xu Shou carried out some of the first modern scientific experiments in China.

According to the account of his translator colleague John Fryer (1839–1928):[21]

It was in this busy little city [Wuxi] that a little *coterie* of intelligent scholars was formed, all deploring the hollow and unsatisfying nature of the ordinary routine of Chinese studies. They determined to push their investigations in a more useful and promising field by endeavouring to become acquainted with the great laws of nature, and to gather as much information as they possibly could respecting the various branches of science and art.

[18] See *Qingshigao*, 13930, and Reardon-Anderson, *The Study of Change*, pp. 20–1.

[19] According to Wang Tao, Hua Hengfang came to Shanghai in the year *dingsi* 丁巳 (1857–8), travelling with Alexander Williamson, and left after having stayed at the Inkstone Press for three months. In the same entry Wang Tao says that he has known Xu Shou for several years (see Wang Tao, *Wang Tao riji*, p. 134: diary entry for 15 Feb. 1860).

[20] Hua Shifang, p. 15b. Translated in Reardon-Anderson, *The Study of Change*, p. 22.

[21] See A. A. Bennett, *John Fryer: the Introduction of Western Science and Technology in Nineteenth-Century China* (Cambridge, MA, 1967); Jonathan Spence, *The China Helpers: Western Advisers in China 1620–1960* (London, 1969); and James Reardon-Anderson, *The Study of Change*, chs 1 and 2 for brief accounts of Fryer's work in China.

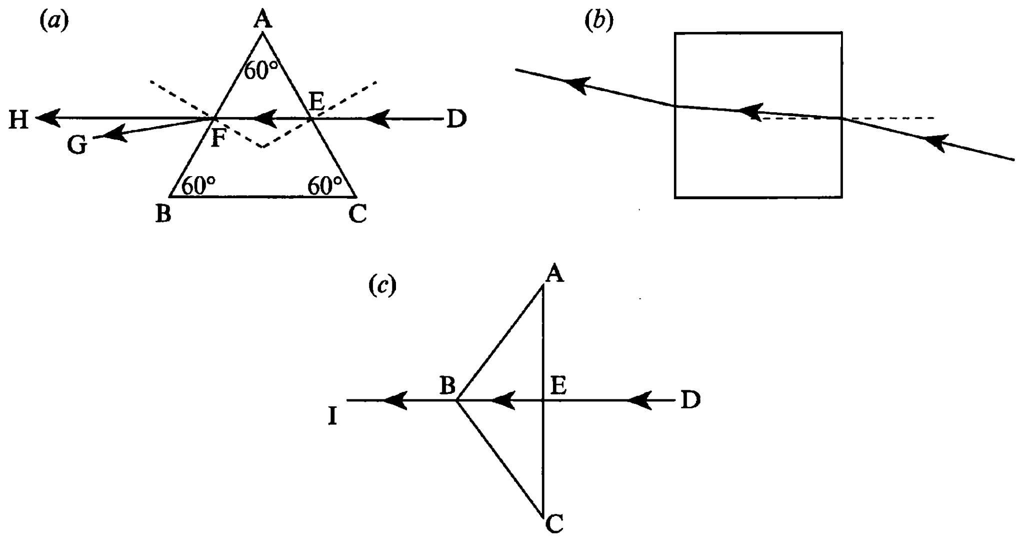


Fig. 2. (a) A reconstruction of Xu Shou's conjecture of the light-path through an equiangular triangular glass prism (after Jiang Shuyuan). (b) The light-path through a glass block. (c) A reconstruction of Xu Shou's comments on the light-path through a prism in which the incident ray is perpendicular to one of the sides.

Without organizing themselves into a Society these aspirants for intellectual light used to have occasional meetings of an informal kind for mutual improvement, each person explaining any new facts or ideas he had acquired. The works of the early Jesuit fathers on Mathematics, Astronomy and kindred subjects were carefully read, as well as original native works.[22]

This account suggests that these three men at least were deeply involved in their study of natural science before they had any direct influence from nineteenth century foreign sources.[23]

They carried out a number of experiments, some at least as a result of having read *Bowu xinbian* 博物新編 [*A new account of natural philosophy*] which had been compiled for the students of the premedical classes run in Guangzhou[24] by an English medical missionary, Dr Benjamin Hobson (Hexin 合信) (1816–73), and published in Shanghai in 1855.[25] *Bowu xinbian* contained sections on physics, chemistry, astronomy, geography and zoology, and was very influential in its day, as the earliest widely available compilation in Chinese devoted entirely to modern science. According to Fryer:

This book, although of a very elementary character, was like the dawn of a new era upon their minds, enabling them to leap at one bound across the two centuries that had elapsed since the Jesuit fathers commenced the task of the intellectual enlightenment of China, and bring them face to face

[22] John Fryer, *North China Herald* (29 Jan. 1880), "An account....", p. 77.

[23] Benjamin Elman, *From Philosophy to Philology*, pp. 174–6.

[24] One of his students was He Liaoran 何瞭然, who with Dr John Kerr went on to translate one of the first chemistry textbooks in Chinese, *Huaxue chujie* 化學初階 [*First steps in chemistry*] (see He Liaoran's preface to *Huaxue chujie*, 1.1a).

[25] John Fryer, "An account...", p. 77. Another even earlier scientific text, *Bowu tongshu* 博物通書 [A general account of natural philosophy], by the American Baptist medical missionary Daniel Jerome Macgowan (1814–93) (who is often confused with his near-contemporary the English missionary John Macgowan), was published in 1851, and was mainly devoted to electrical phenomena. It is possible that Xu Shou did have access to this text or something similar before 1855.

with the results of some of the great modern discoveries. Apparatus was extemporised at their homes to perform the various experiments described in its pages, and every new theory or law put to the test as far as their limited means would permit. Frequent papers were written and circulated from one to another, while queries were continually started by individuals asking for more information on difficult subjects. A pile of such manuscripts accumulated in the house of Mr Hsü [Xu Shou], who with his son formed a sort of centre for this little oasis in the midst of a vast desert of ignorance. Unfortunately, however, these manuscripts were all destroyed when the Taiping rebels captured the city, and the little company were glad to escape with their lives to the neighbouring hills among which they found a temporary refuge.[26]

This account has many interesting features. Leaving aside Fryer's somewhat patronising tone, and the nature of the "enlightenment" which Westerners brought to China, it confirms the important role Xu Shou's dexterity played in their work, and suggests significant parallels with the *kaozheng* 考證 [evidential scholarship] tradition of the Jiangnan region.[27]

Fryer was slightly too pessimistic about the fate of the documents relating to their experiments: two letters from Xu Shou to Hua Hengfang, probably written during the 1850s, have been discovered, and they confirm the impression given by his biographers of his sceptical attitude. In one letter Xu Shou wrote of his doubts about the account he had read of the way in which light is refracted through an equilateral triangular prism.

I cannot but doubt the theory you previously [proposed] about the angles of refraction [*guangcha* 光差] being the equal [for light transmitted by] an equiangular glass [prism]. [According to this theory], if light leaves the rare medium [i.e. air] and enters the dense one [i.e. glass], then [say it follows] the line DE which is parallel to the [side of the triangle] CB [see Fig. 2(a)].[28] Since the angle [of the prism] is 60° the light ray has to go from E to F. It then leaves the denser medium and enters the rarer along the path FG, and the angle F [the complement of the angle of refraction] is smaller than the angle at E [the complement of the internal angle of incidence]. Now if we had to make this accord with your theory of equal angles [of refraction],[29] the line FG would have to be moved upwards, and also be parallel with CB, so that if we made it like the line FH it would be correct. The light rays [travelling through] flat [pieces of] glass *are* like this[30] [see Fig. 2(b)], but I have not observed such behaviour with rays passing through a triangular [prism]. At the moment we possess no instruments to test it, so we cannot check it, but I think that the diagram you made of the ray

[26] John Fryer, "An account...", p. 77. See also Wang Yangzong 王杨宗, "Jiangnan zhizaoju fanyiguan shilue" 江南制造局翻译馆史略 [A brief account of the history of the Translation Department of the Jiangnan Arsenal], in *Zhongguo keji shiliao* 中国科技史料 [China historical materials of science and technology] 9, 3 (1988), pp. 65–74; Keizō Hashimoto 橋本敬造 Jon Furaiyā "Kōnan seizō kyoku honyaku jigyō ki" yaku chū, ジョン＝フライヤー「江南製造局翻訳事業記」訳注 [Annotated translation of *An Account of the Department of the Translation of Foreign Books at the Kiangnan Arsenal Shanghai (1880)* by John Fryer] in 関西大学社会学部紀要 23, 2 (1992), pp. 1–29.

[27] See Benjamin Elman, *From Philosophy to Philology* (Cambridge, MA, 1984).

[28] I have translated the Heavenly Stem terms (*jia* 甲, *yi* 乙, ...) used by Xu Shou as letters of the alphabet. Unfortunately his letter does not contain the diagrams to which these letters refer, so any interpretation of what he is saying is somewhat uncertain.

[29] This theory is, in general, incorrect. Only for one angle of incidence (that of minimum deviation) are the angles of entry and exit for the light rays passing through any particular prism equal. Dr Christopher Cullen has pointed out that for thin prisms the relationship *does* hold for a range of angles of incidence to a first approximation, and it may be this to which Xu Shou is referring.

[30] Rays of light travelling through parallel-sided glass blocks emerge parallel to the incident ray unless they are internally reflected.

DE making a right angle with the side of the triangle AB is also erroneous. For if the line DE makes a right angle with the side AC, [the ray] ought to pass straight through without refraction, and then [meeting] the angle B opposite the side AC, it leaves the dense medium [glass] and enters the rare medium [air] and goes straight through to I, without refraction [see Fig. 2(c)].[31] In order to calculate what the refraction is, you have to know with respect to which side it is calculated. The triangle you drew in your diagram is not equilateral. I am anxious to obtain suitable apparatus to test it out to resolve my doubts. If you have any further wonderful explanations, I hope you will reveal them to me. Because I have been waiting for Chai Feng 茝峰 to get me *On telescopes*, I have been delayed one day. This afternoon I will certainly go back home.[32]

It was precisely to investigate this problem that sometime later he seems to have hit on the idea of grinding a rock crystal chop to make a triangular prism[33] (see Fig. 3).

In the other letter he wrote to Hua Hengfang about his investigations of a mercury thermometer:

I suspect there is an error in [my understanding of] the nature of mercury in the thermometer (*hanshubiao* 寒暑表) because the experiments have not gone well. Today I have carried out experiments based upon the method we discussed previously, and I find that its nature is [such that] it is able to expand and contract. It was a quick matter to establish [its behaviour] [whether by] using fire to bake (*hong* 烘) it, [or] using my breath to warm (*ke* 呵) it.

I then put it outside, to test the warmth and cold of Nature, and everything also went well. On the 25th and 26th days of the first lunar month the weather was fine, and I put it in the open air early in the morning [and then] put it in the midday sun, and estimated [the difference] as 5 degrees, and found I could judge it to [within] one per cent. [Even if the thermometer] were made ingeniously, this [amount of inaccuracy] would not be a matter for regret.

Regarding the nature of the expansion and contraction of mercury, have we not looked at each other and laughed at the way in which, in the past, because we did not understand it, we used *li* 理 and *qi* 氣 to discuss this matter, seeking profundity through suchlike superficialities!

However, when I used the fire to heat it, yet another doubt arose. Having made a mark on the thermometer of the temperature it had reached when in the sun, I then brought the thermometer near the fire, and, contrary [to my expectations], the mercury contracted: thus it would appear that the nature [of mercury] with respect to warmth and cold must be subdivided into [two different natures, with respectively] a gradual and a rapid aspect, and that its nature [when subjected to] rapid heating is *opposite* to that [when subjected to] gradual heating. I have still not fathomed the principle [governing this]. What do you make of it?[34]

The reason which would nowadays be given for Xu Shou's observations is that, when heated by a fire the poor thermal conductivity of the glass containing the mercury means

[31] My interpretation of this part of the passage is different from that of Jiang Shuyuan. It seems to me that Xu Shou is describing a ray passing directly through one of the vertices of the triangular prism rather than being internally reflected, as Xu Shou specifically says there is no deviation.

[32] Jiang Shuyuan 蒋树源, "Xu Shou de liangfeng qinbixin" 徐寿的两封亲笔信 [Two letters from Xu Shou written in his own hand], in *Zhongguo keji shiliao* 中国科技史料 5, 4 (1984), pp. 52–4. The book Xu Shou refers to is *Yuanjing shuo* 遠鏡說 [On telescopes], the original being a work on telescopes by Girolamo Sirturi, published in Frankfurt in 1618, and translated by the German Jesuit Johannes Adam Schall von Bell (Tang Ruowang 湯若望) (1591–1666). Another book to which Xu Shou may have had access was *Guang lun* 光論 [On light], which was translated by Joseph Edkins (1823–1905) and Zhang Fuxi 張福僖 (?–1862) and published in 1853, and later excerpted in *Jiaohui xinbao* 教會新報 [Church news] 2, 56 (9 October 1869), pp. 28b–30b. See Wang Jinguang, 王锦光, *Zhongguo guangxueshi* 中国光学史 [A history of Chinese optics] (Changsha, 1985), p. 147. [33] *Qingshi gao*, 13929. [34] Jiang Shuyuan, pp. 52–3.

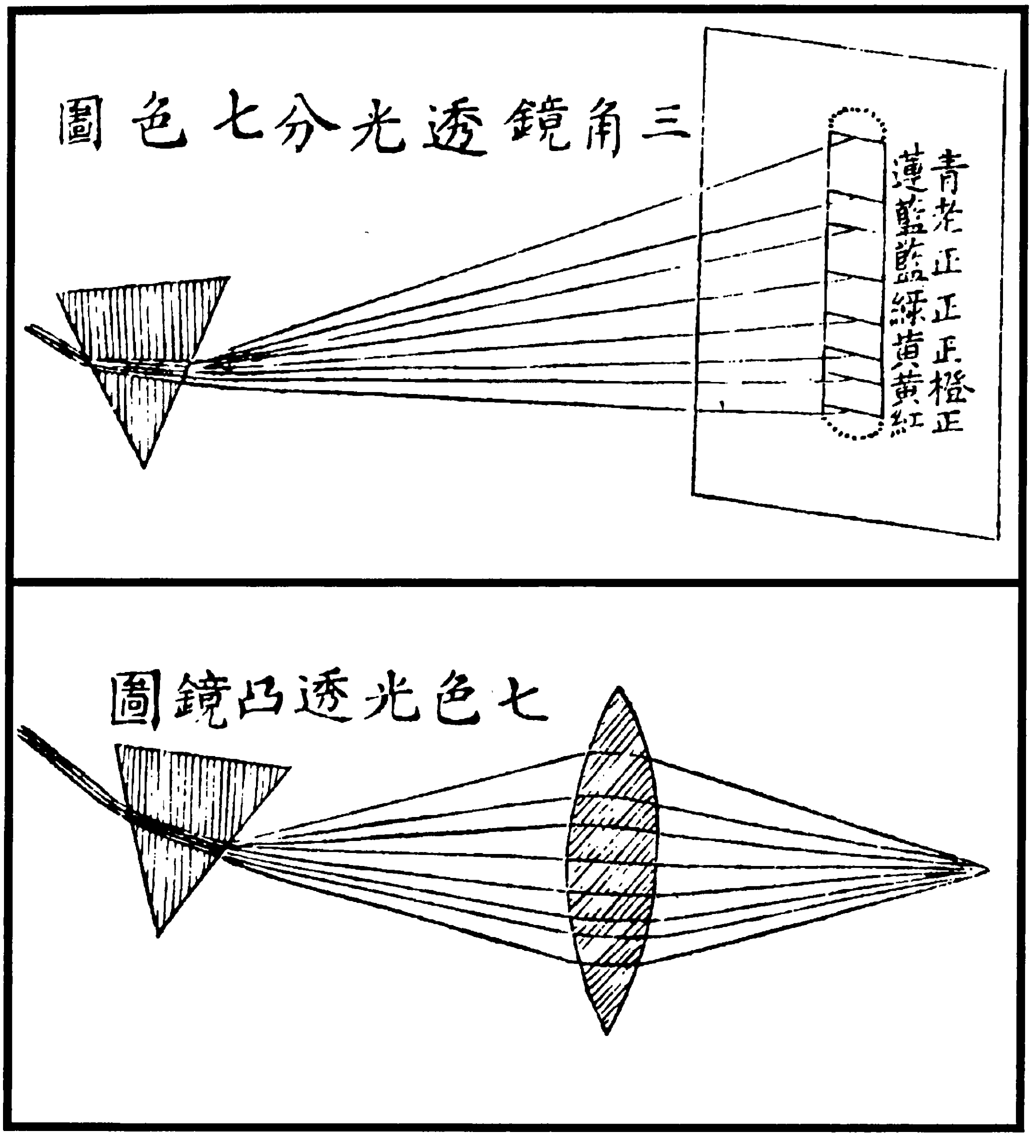


Fig. 3. An illustration from *Bowu xinbian* showing light passing through a glass prism (reproduced by kind permission of the Wellcome Institute Library, London).

that the glass absorbs radiant heat and expands relatively quickly, before the mercury inside has had time to warm up, thus causing the mercury inside to appear to contract. With slow heating, on the other hand, the heat has time to pass through the glass to the mercury, bringing them more or less into thermal equilibrium, so that the mercury *does* expand as expected.

These two letters reveal a brilliant mind, making subtle observations of complex natural phenomena and attempting to bring them within a fragmentary theoretical framework, unwilling to rest content with what he saw as the vague and superficial notions which had been used in the traditional paradigm, but also sceptical of the received wisdom of the Western textbooks.[35]

[35] See also Hua Yilun, p. 12b, which describes Xu's attempt to check the trajectories of shells by setting up targets. Xu Shou's colleague Li Shanlan wrote a text on ballistics, *Huo qi zhen jue* 火器真訣 [A true explanation of firearms] (1858) which included work on trajectories, and it may have been the formulae in

Xu Shou was a remarkably ingenious man, and could surely have become a high official: during the disastrous Taiping assault on Wuxi, for example, he is said to have led over hundred boats to help his townfolk escape across Lake Tai.[36] This act of courage, and his extraordinary knowledge of science, drew him to the attention of Zeng Guofan, who by the early 1860s had recognised that China had to master the foreign military technologies which – together with the Taiping rebellion – had brought the dynasty to the brink of extinction, and which had already all but destroyed the scholarly community which had flourished in the Lower Yangzi basin.

Xu Shou as a kaozheng *scholar*

The little we know about Xu Shou's early work has many tantalising suggestions that he was indeed working within the *kaozheng* tradition, a tradition which was more or less obliterated by the Taiping rebellion. One of the most striking of his recorded sayings is

Do not be two-faced, do not speak wildly, talk to people to establish the truth [of the matter] [...] Do not spread rumours, do not speak of things of which you have no experience, do not talk of horoscopes, nor of *fengshui* 風水 [siting; sometimes called "geomancy"]. Do not speak of sorcery and prophecy. Do not use *yin* 陰 and *yang* 陽 to select the day for marriages and funerals. In sacrifices for the Four Seasons, sacrifice to your own ancestors, not to external spirits.[37] In managing funerals do not use Buddhist monks and Daoists to perform rituals or musicians to beat [drums] and blow [shawms]. In siting dwellings, there is no need to consult *fengshui* practitioners, simply discuss it with other people. Never speak of the production and destruction of the *wuxing* 五行, nor talk of the superficial ideas of *li* 理 and *qi* 氣. Always ascertain the truth of the matter by reference to the actual facts (*yi shi shi zheng* 以事實證) [...][38]

The source of his thoroughgoing rationalism is not clear. Such a complete rejection of these traditional beliefs must, one suspects, have had some emotional source – perhaps, as a reaction to the early deaths of his father and first wife[39] – but there is no hint as to what drove Xu Shou to such a total abandonment.[40] Whatever the cause of his scepticism, it seems to have given his scientific researches a moral force and purpose, namely the goal of the restoration of an ancient, purer, stronger Chinese civilisation free of superstitious accretions.

this work which Xu Shou was investigating. See Wang Yusheng 王渝生, "Li Shanlan yanjiu" 李善蘭研究 [Research on Li Shanlan], in Mei Rongzhao 梅榮照 (ed,), *Ming-Qing shuxueshi lunwen ji* 明清數學史論文集 [A collection of essays on the history of mathematics in the Ming and Qing dynasties] (Nanjing, 1990), p. 403.

36 Hua Yilun, p. 12b.

37 Presumably this means tree- and other spirits as well as Buddhist deities. It is interesting to note that Xu Shou is not rejecting the entire corpus of traditional Chinese beliefs – ancestors still deserve our reverence – only those which he regards as irrational superstitions.

38 Cheng Peifang, p. 14b. This translation is based upon that in James Reardon-Anderson, *The Study of Change*, p. 21, with some minor changes, but also translates slightly more.

Xu Shou's hostile attitude to traditional science was also shown when Baron von Gumpach's books on the subject were offered to the Shanghai Polytechnic. Xu Shou said that they were "sooner burnt the better" (see *North China Herald* (6 April 1876), pp. 321–2).

39 See Lu Xun 鲁迅, *Nahan* 呐喊 [War-cry] (Beijing, 1973), p. 2, and the short story "Fuqin de bing" 父亲的病 [Father's illness], *ibid.*, pp. 99ff.

40 Xu Shou explicitly attacked traditional Chinese medicine in his article "Yixue lun" 醫學論 [On medicine], in *Gezhi huibian* 1, 3 (April 1876), pp. 8a–9a.

One of Xu Shou's interests was the making of replicas of the musical instruments used in antiquity, an activity which was also one of the concerns of certain other *kaozheng* scholars who were trying to discover the roots of the ancient theory of harmonies which had long been lost. Benjamin Elman mentions the case of Cheng Yaotian 程瑤田 (1725–1814), who attempted to cast ceremonial bronze bells based on the reconstructions of the famous mathematician Dai Zhen 戴震 (1724–77).[41] Xu Shou's own researches on acoustics could only have been carried out by a skilled instrument-maker, and thus the *kaozheng* emphasis on actual evidence and practical investigation may well have reinforced his growing interest in Western scientific methods.

The making of "instruments" – whether musical or scientific – was in fact central to his deep understanding of scientific ideas:

> The principles of science require instruments [*qi* 器] to be revealed and the making of instruments needs science as its guide.[42]

and it was this unusual combination of intellectual depth with practical skill which led Zeng Guofan to invite him to Anqing. The making of instruments not only allowed Xu Shou to repeat the experiments described in texts such as *Bowu xinbian* but also to gain sufficient physical insight into the processes involved as to be able to modify existing versions of steam engines and later to be confident enough of his own understanding to be able to correct a learned English professor on his knowledge of acoustics. Indeed, the article he published in *Gezhi huibian* on the topic was entitled "Kaozheng lülü shuo" 考證律呂説 [On an evidential investigation (*kaozheng*) into mathematical harmonics][43].

Xu Shou's education in the centre of the Jiangnan region gave him a heightened sensitivity to language. The *kaozheng* movement centred on philology, and the Qing philologists recognised that although many characters had used the right-hand part as purely phonetic symbols, there was also sometimes a connection between the original meaning of the phonetic component and the meaning of the whole character.[44] When Xu Shou came to choose characters for the chemical elements, he was obviously aware of the possibility of making a *huiyizi* 會意字 compound in which the meanings of the components of the character combine to make a new character. This is what Anatole Billequin did in *Huaxue zhinan* 化学指南 [A guide to chemistry],[45] so that the meaning of the whole character could be built of the meanings of the component graphs. (As for instance Billequin's term 𨰻 for calcium, built of the components "metal" 金, "stone" 石 and "ash" 灰 (because lime (calcium oxide) is made by heating limestone (*shihui* 石灰).)

Yet Xu Shou chose not to do this, but in almost every case either revived an ancient, obsolete character (probably from the *Kangxi* 康熙 *Dictionary*) with the "correct" phonetic or, where this was impossible, he created a new character with a right-hand side whose pronunciation imitated the Western name. This too seems to match *kaozheng*

[41] Elman, *From Philosophy to Philology*, p. 182. [42] Cheng Peifang, p. 14a. [43] See below.
[44] Elman, p. 218. [45] Published by the Beijing Tongwenguan in 1873.

scholarly preoccupations: ancient characters were being revived[46] and at the same time a precise relationship established between the Western sounds and the Chinese characters. This was even more evident in the transliterations used for the names of organic compounds, in which a highly systematic correspondence was developed so that at least in principle the Western name could be reconstructed from the Chinese transliteration (just as Sanskrit terms may be phonetically reconstructed from the Chinese Buddhist texts).[47]

John Fryer's description of Xu Shou's researches in Wuxi also indicates the collective and cumulative nature of their work, writing papers and circulating manuscripts, which was precisely how the *kaozheng* scholars worked with their "notation books" in accumulating and refining data.[48]

Thus his background in *kaozheng* studies prepared him for his pioneering work as the first modern Chinese scientist and engineer.

The building of steamships at Anqing and Nanjing[49]

In 1861 Xu Shou and Hua Hengfang were invited by Zeng Guofan to join his *mufu* 幕府 (private secretariat) at the newly-founded Arsenal at Anqing 安慶 in southern Anhui Province[50] where in 1862 they began working on the first Chinese-made steamship, with Hua attending to the calculations on the steam engine and Xu Shou supervising its actual construction.[51] This was an important opportunity for Xu Shou, as becoming a private secretary (usually known as *muyou* 幕友 "tent friend") was in the Qing dynasty an alternative career path for a gifted scholar who had not succeeded in the literary examinations: to be a *muyou* meant being paid by one's sponsor, rather than a member of the government bureaucracy,[52] and one might hold a position for many years and be financially relatively secure.[53] The disadvantage was being so closely identified with the sponsor that if he died or were disgraced another position might be hard to obtain. Xu Shou was to spend the rest of his life within the sphere of influence of first Zeng Guofan and later Zeng's protégé Li Hongzhang, and Xu Shou's son Xu Jianyin's untimely death

[46] Elman, pp. 45–6. John Fryer seems to have believed that there *was* an etymological connection between English and Chinese terms, although he was unable to give any convincing proof of this. See John Fryer, *A Contribution to Chinese Philology* in *Fryer Papers*: Carton 1.

[47] See Stanislaus Julien, *Méthode pour déchiffrer et transcrire les noms sanscrits qui se recontrent dans les livres chinois* (Paris, 1861).

[48] Elman, pp. 174–6.

[49] Accounts of Xu Shou's work in building steamships are to be found in *Zeng Wenzheng gong shoushu riji*; Gideon Chen, *Tseng Kuo-fan*, pp. 40ff; and Song Ziliang, "Zhongguo di yi sou zhengqichuan" (see no. 9).

[50] *Wuxi Jingui Xian zhi*, Vol. 21, p. 299; *Qingshi gao*, 13929; Zhang Zigao and Yang Gen, "Xu Shou fu-zi nianpu", p. 304; Xue Fucheng 薛福成, "Xu Zeng Wenzhenggong mufu binliao" 敘曾文正公幕府賓僚 [An account of the members of the private secretariat of Zeng Guofan], in Zuo Shunsheng 左舜生 (ed.), *Zhongguo jinbainianshi ziliao chubian* 中國近百年史資料初編 [A preliminary collection of materials on the past hundred years of Chinese history] (Taibei, 1966), p. 133.

[51] *Qingshi gao*, 13930.

[52] See Xue Fucheng 薛福成, "Xu Zeng Wenzhenggong mufu binliao" 敘曾文正公幕府賓僚 [An account of the members of Zeng Guofan's private secretariat] in Zuo Shunsheng 左舜生 (ed.), *Zhongguo jinbainianshi ziliao chubian* 中國近百年史资料初編 [Historical materials on the past hundred years of Chinese history, Volume 1] (Taibei, 1966), pp. 133–4; Kenneth E. Folsom, *Friends, Guests and Colleagues: The mu-fu System in the Late Ch'ing Period* (Berkeley, 1968); Tung-tsu Ch'u, *Local Government in China under the Ch'ing* (Stanford, 1962; paperback edition, 1969) ch. 6; and Jonathan Porter, *Tseng Kuo-fan's Private Bureaucracy* (Berkeley, 1972).

[53] Ch'u, p. 112.

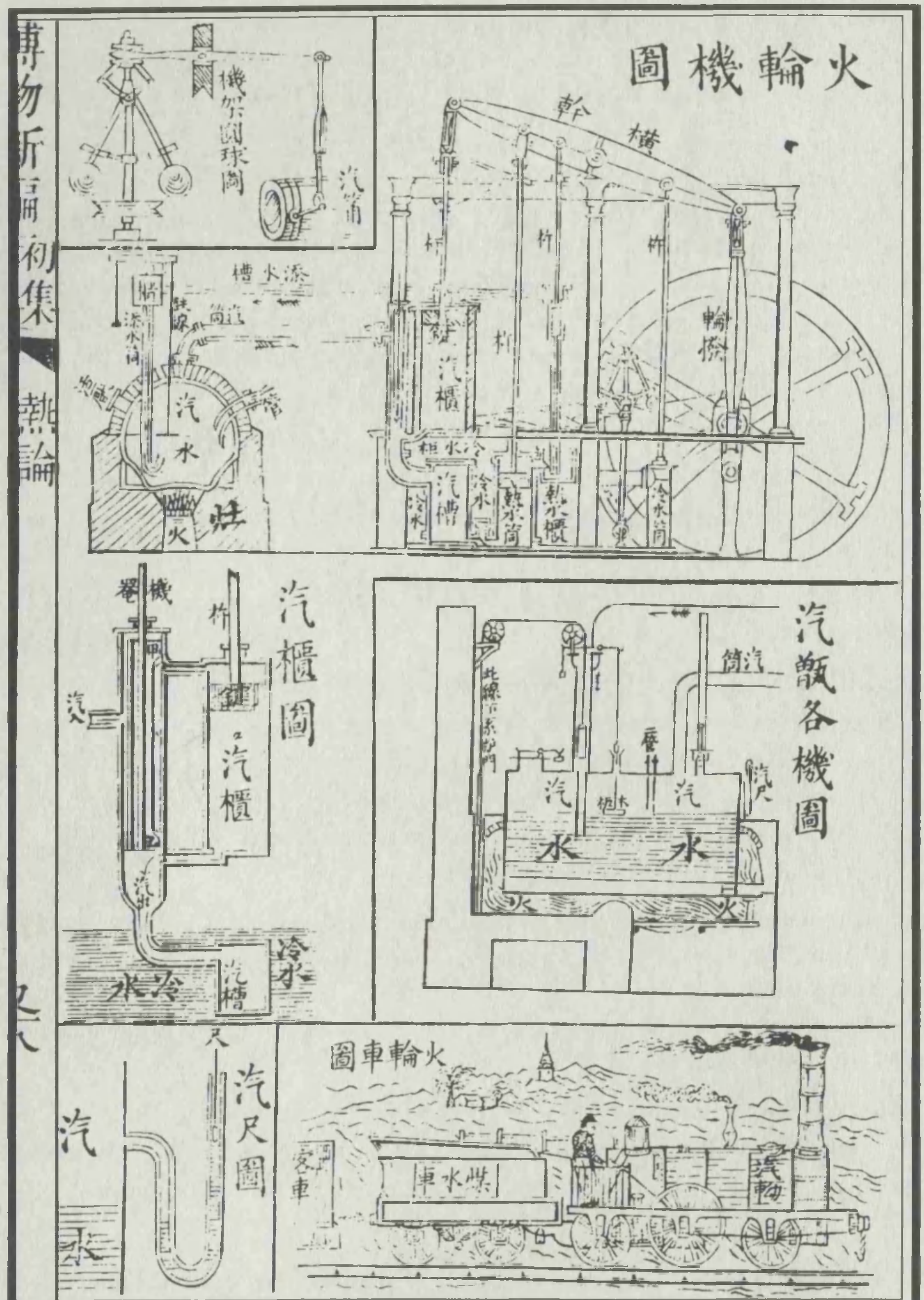


Fig. 4. Illustrations of steam engines from *Bowu xinbian* (reproduced by kind permission of the Wellcome Institute Library, London).

has even been attributed to intrigues connected with his estrangement from Li Hongzhang after the defeat of the Beiyang fleet in the Sino–Japanese War (1894–5).

Xu Shou and Hua Hengfang first built a steam engine, using *Bowu xinbian* (see Fig. 4) and probably other materials on steam technology together with a close inspection of a small foreign steamship moored at Anqing.[54] Within a remarkably short time they had mastered the principles: Zeng Guofan gave the following description of the first steam engine they made in his diary entry of 30 July 1862 (see Fig. 5):

After lunch Hua Hengfang and Xu Shou brought the engine of a steamship [they had made] to try it out. The way it worked was to use fire to make steam which enters a cylinder with three holes. Two of the three front holes are closed whilst steam enters through the third hole. The machine then moves backwards and describes an upward arc. The two back holes being closed, the steam enters [the third] back hole and the machine automatically moves forwards and describes a downward arc. The greater the fire the greater the abundance of steam. The machine moved to and fro and rotated as if it were flying. The demonstration lasted for about two hours (*yi shi* 一時). I was delighted that we Chinese can also [grasp] the wise and clever things of the foreigners, and that they will no longer take advantage of our ignorance.[55]

By late 1863 a small (3 *zhang* 丈 [about 10 m]) long vessel had been built, which could only cruise for one *li* 里 [0.33 miles].[56] According to Zeng Guofan, writing in a memorial five years later:

We used only Chinese workers and hired no foreigners at all, but although we built a small steamer and made it go, it was very slow and we had not yet really mastered [the technique].[57]

In September 1863 Yung Wing [Rong Hong 容閎] (1828–1912), the first Chinese person to graduate from an American university, met Zeng Guofan at Anqing[58] and after discussions with Xu Shou and Hua Hengfang (whom Yung Wing had already known several years before in Shanghai) Zeng agreed to send him abroad to buy machinery, a purchase which marked the beginnings of the Jiangnan Arsenal.

In 1864 a small pilot vessel had been built:

I went out of town and down to the river to see a small steamship built by Cai Guoxiang 蔡國祥,[59] two *zhang* 丈 and eight or nine *chi* 尺 long [about 10 m]. Since on reaching the middle of the river we had travelled [only] eight or nine *li* 里 [about 3 miles], I calculate that in two hours we would have travelled around 25 or 26 *li* [between 8 and 9 miles]. Larger versions of this will be built after this model, and more constructed.[60]

By 1865, Xu Shou's ship was ready, built of wood, over 50 *chi* (16.6 m] long and able to travel about 20 *li* [6.6 miles] per hour, about twice as long and half as fast again as the prototype, and now using a high-pressure steam-engine.[61] The mastery of the technology

[54] John Fryer, "An account...", p. 77.

[55] Zeng Guofan, *Zeng Wenzhenggong shoushu riji*, 14.15b. Translation based on Gideon Chen, *Tseng Kuo-fan*, pp. 40–1.

[56] See Zeng Guofan, *Zeng Wenzhenggong quanji*, viii, 27.6 (p. 4403), and Yang Gen, *Xu Shou*, p. 161.

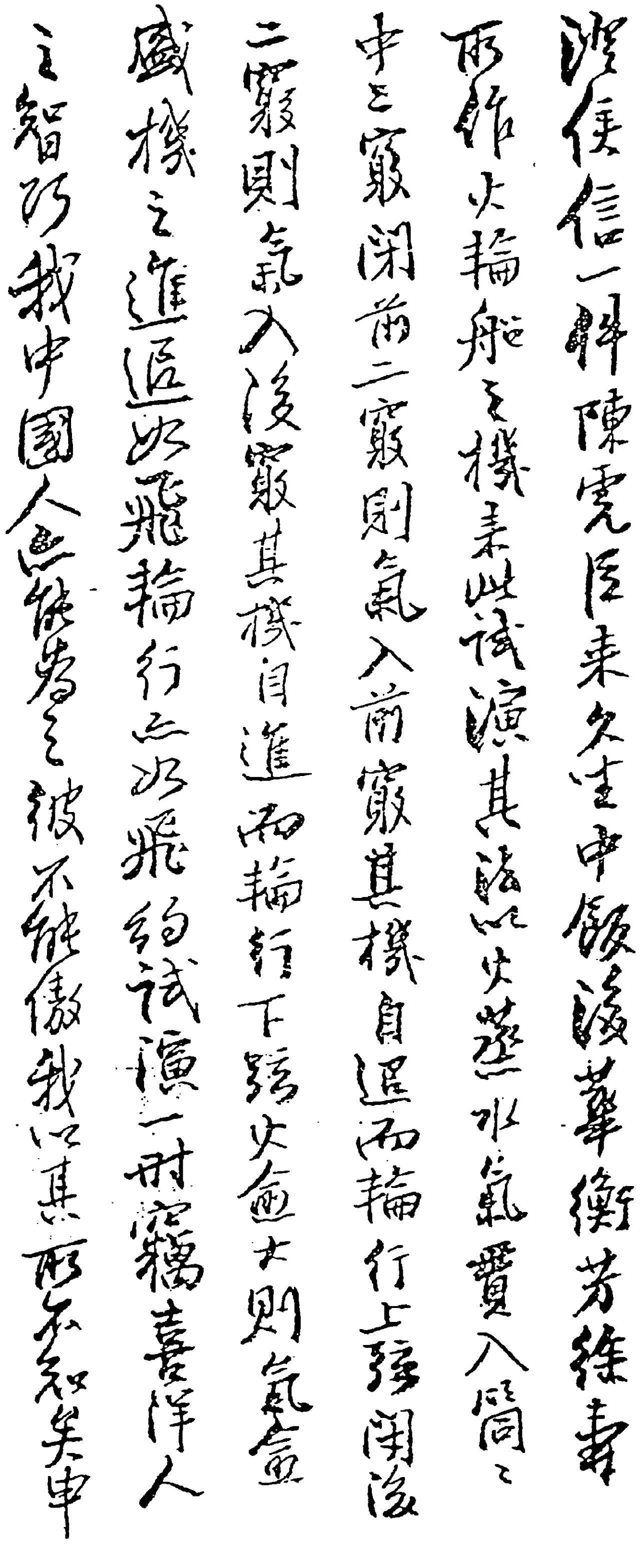
[57] Zeng Guofan, *ibid.*, 4403.

[58] Zeng Guofan, *Zeng Wenzhenggong shoushu riji*, 18.37a Tongzhi 2.10.23 = 3 Dec. 1863. Zeng had invited Yung Wing several months earlier, but the latter had refused, fearing that he was to be punished for his contacts with the Taiping leaders (see Yung Wing, *My Life in China and America* (New York, 1909; reprinted New York, 1978), p. 137. He landed at Anqing in September 1863, where he met Li Shanlan, Xu Shou and Hua Hengfang, whom he says he already knew in Shanghai (*ibid.*, p. 143).

[59] Cai Guoxiang was one of Zeng's military advisers. Presumably he was supervising the work of Xu Shou and Hua Hengfang.

[60] *Ibid.*, 28 Jan. 1864. Translation based on Gideon Chen, *Tseng Kuo-fan*, p. 41. Chen gives the date incorrectly as 28 Jan. 1863, and also takes *yi shi* 一時 as one hour rather than two hours, thus making the speed twice as great as Chen stated.

[61] *Qingshi gao*, 13930.



澄侯信一件陳虎臣來久坐中飯後華衡芳徐壽
所作火輪船之機來此試演其法以火蒸水氣貫入筒筒
中三竅閉前二竅則氣入前竅其機自退而輪行上弦閉後
二竅則氣入後竅其機自進而輪行下弦火愈大則氣愈
盛機之進退如飛輪行亦如飛約試演一時竊喜洋人
之智巧我中國人亦能為之彼不能傲我以其所不知矣申

Fig. 5. A page from Zeng Guofan's diary describing the steam engine built by Xu Shou and Hua Hengfang (reproduced by kind permission of the Library of the School of Oriental and African Studies, London University).

in just three years was a remarkable achievement by any standards, and indicates how much scientific understanding Xu Shou and his colleagues must already have had when they began the enterprise. The vessel was named the *Huanggu* 黃鵠 [Yellow Swan] by Zeng Jize 曾紀澤 (1839–90),[62] Zeng Guofan's eldest son, and his father was said to have been delighted by it; certainly he and his family used it for several voyages up and down the Yangzi River, and it was the vessel on which Xu Shou and Xu Jianyin finally travelled to their new posts at the Jiangnan Arsenal in 1867.[63]

His work at the Jiangnan Arsenal

At the Jiangnan Arsenal Xu Shou was for the first time in his life a government employee, although he and his colleagues became closely associated with Li Hongzhang, one of the two governors-general who had encouraged the formation of the Jiangnan Arsenal.

The tasks which Xu Shou was given at the Arsenal were: translating Western books; finding coal and refining iron; the manufacture of guns; and the training of ships' masters.[64] Here he also continued his practical investigations: building ships, guns, and making the explosives nitrocellulose and mercury fulminate,[65] and helping to set up factories for making acid[66] and gunpowder.

The work at the Jiangnan Arsenal was on a far larger scale than at Anqing, and it was obvious to the Chinese engineers that they could not solve all the problems without foreign help. In an interview with Dowager Empress Cixi 慈禧, Zeng stated that they were employing six or seven foreigners (French and English) as well as many Chinese.[67] In August 1868 the first ship, named the *Tianji* 恬吉 [Calm and Prosperous][68] had been completed,[69] able to travel at about 40 *li* [13.3 miles] per hour.[70] Xu Shou is credited with helping to build a series of vessels at Jiangnan from 1868 onwards[71] although it is difficult to discover how active and important a role he played in shipbuilding at the Arsenal after 1868.

[62] See *ibid.*, Qian Jibo, p. 16b; and John Fryer, "An account...", 77. [63] Yang Gen, *Xu Shou*, p. 163.

[64] Qian Jibo, p. 16b. [65] Qingshi gao, 13930.

[66] Xu Shou helped to set up the sulphuric acid plant at the Longhua 龍華 gunpowder factory in Shanghai (see *Gezhi huibian* 1, 2 (March 1876), 9a).

[67] Zeng Guofan, *Zeng Wenzhenggong shoushu riji*, 32.61b–62a, cited in Gideon Chen, *Tseng Kuo-fan*, pp. 49–59.

[68] See Zeng Guofan, *Zeng Wenzhenggong quanji*, viii, 27.6. (p. 4403). Its name was later changed to *Huiji* 惠吉 because of a taboo on the syllable *tian* 氵恬 in the Guangxu Emperor's personal name Zaitian 載氵恬. See Yang Gen, *Xu Shou*, p. 165 and Chen Yuan 陳垣, *Shihui juli* 史諱舉例 [Examples of historical taboo-words], p. 169. (Beijing, 1958).

[69] Zeng Guofan recorded in his diary of 28 Sept. 1868: "After breakfast I went to see the steamship built in Shanghai named *Tianji*. [...] We started at half past ten and went beyond Caishiji to Cuiluoshan, a distance of 90 *li* in 3 hours, and then returned from Cuiluoshan to Caishiji in one and a half hours. The speed going downstream is twice as fast as going upstream. It is wonderful to see the first steamship built in China so fast and so sure!" (Translation based on Gideon Chen, *Tseng Kuo-fan*, p. 47. I have altered two points of substance: Chen says that Zeng named the vessel: I think here he is simply reporting its name as *Tianji*. Secondly, the speed up-river is 90 *li* in 12 *ke* 刻 = 3 hours, not one and a half hours.)

[70] I calculate this given that Zeng in the above diary reference says that it went 90 *li* upstream in 12 *ke* and the same distance downstream in 6 *ke*, hence 180 *li* in 18 *ke* or an average of 40 *li* [13.3 miles] per hour.

[71] See Thomas L. Kennedy, *The Arms of Kiangnan: Modernization in the Chinese Ordnance Industry, 1860–1895* (Boulder, 1978).

In the same year he began working at a task perhaps more gruelling if not more difficult: the translation of a series of modern Western scientific texts into Chinese.

Xu Shou's scientific translations and other writings at the Jiangnan Arsenal (1867–1884)[72]

Whilst at the Jiangnan Arsenal, Xu Shou carried out a series of translations, many of them with the Englishman John Fryer, a partnership which produced some of the most important early translations of modern science texts, and which laid the basis for modern Chinese chemical nomenclature.[73]

Xu Shou was termed the *bishu* 筆述 or scribe: Fryer, the 口譯 [oral translator] would recite the general meaning of the English text in colloquial Mandarin Chinese, whilst Xu Shou had to render it in good literary Chinese. Here Xu's wide reading and practical knowledge must have made him an invaluable collaborator: few people – if any – in China at that time could have had his deep understanding of the principles of natural science, as he not only grasped them intellectually but also had practical experience of applying physical principles to the problems of building steamships, musical instruments and scientific apparatus.

In the early stages Xu Shou must have been heavily dependent on Fryer for the explanation of the English texts, as Xu seems not to have known any foreign language. Yet Xu Shou knew far more science from direct personal experience than Fryer, who had to read avidly to keep up with the subjects he was translating, and also seems to have had a much more inquiring mind than the Englishman. Thus although Fryer's help was essential in the early stages of the translation process, it was Xu Shou and his Chinese colleagues who produced the final version, and who checked it against the original text.[74] The choice of texts was also bound to be largely due to Fryer at first, but as time went on the Chinese officials influenced the direction of the work. Later, Fryer was to complain, rather disingenuously, of the unsystematic nature of the choices:

> Various high officials have asked to have books translated for them on special subjects. [...] In most cases each translator or Chinese writer seems to have selected such subjects as suited him best, without regard to the symmetry or harmony of the entire collection.[75]

Xu Shou's works include, in order of publication: *Qiji faren* 汽機發軔 [Manual of the steam engine][76] (1871); *Huaxue jianyuan* 化學鑑原 [The mirror of chemistry: a source-book] (1872);[77] *Shanghai Gezhi Shuyuan zhangcheng* 上海格致書院章程

[72] The information in this section comes from *Qingshi gao*, p. 13930; John Fryer, *An Account of the Department of the Translation of Foreign Books at the Kiangnan Arsenal, Shanghai* in the *Fryer Papers* [This, unlike the original article in the *North China Herald*, has an appendix listing both published and unpublished works.]; Du Shiran 杜石然, *Zhongguo kexue jishushi gao* 中國科學技術史 p. 262; Xu Zhenya 徐振亚 and Ruan Shenkang 阮慎康, "Xu Shou yizhu jianjie" 徐寿译著简介 in Yang Gen (ed.), *Xu Shou*; Xu Zhenya and Ruan Shenkang, "Xu Shou fu-zi zusun yizhu jianjie" 徐寿父子祖孙译著简介, in *Zhongguo keji shiliao* 中国科技史料 [China Historical Materials of Science and Technology] 7, 1 (1986), pp. 48–55; and A. A. Bennett, *John Fryer*, pp. 82ff.

[73] Yanagihara Zenkō 柳原前光 even came from Japan to buy his chemical translations. See *Shanghai Xian xuzhi* 上海縣續志 21.7a (p. 1123).

[74] See John Fryer, "Science in China", in *Nature* XXIV (19 May 1881), p. 55.

[75] *Ibid.*, p. 55.

[76] A translation of John Main, *Manual of the Steam Engine* [with Alexander Wylie].

[77] A translation of David Wells, *Principles and Applications of Chemistry* (New York, 1858) [with John Fryer].

[Regulations of the Shanghai Polytechnic] (1874); *Shanghai Gezhi Shuyuan jiang Xixue zhangcheng* 上海格致書院講西學章程 [Regulations for the teaching of Western studies at the Shanghai Polytechnic] (1874); *Huaxue jianyuan xubian* 化學鑑原續編 [A sequel to *The Mirror of Chemistry: a Source-book*] (1875);[78] *Cedi huitu* 測地繪圖 [Surveying charts] (1876);[79] *Gezhi huibian xu* 格致彙編序 [Introduction to *Gezhi huibian*] (1876);[80] *Yixue lun* 醫學論 [On medicine] (1876);[81] *Qiji mingming shuo* 汽機命名説 [On the nomenclature of steam engines] (1876);[82] *Lilan jilüe* 歷覽記略 [Record of a journey through iron-manufacturing districts] (1877);[83] *Jiang hui yu gui* 匠誨與規 [Lathes and turning] (1877);[84] *Huitehuode gangpao* 回特活德鋼礮 [Whitworth guns and steel] (1988);[85] *Zao guan zhi fa* 造管之法 [Methods of tube manufacture] (1877);[86] *Huirelu fa* 回熱爐法 [The regenerative furnace] (1877);[87] *Liuqiangshui fa* 硫强水法 [Manufacture of sulphuric acid] (1877);[88] *Sexiang liuzhen* 色相留真 [On photography] (1877);[89] *Zhoumu zhicai* 周幕知裁 [Knowing how to cut a circular cover] (1877); *Shanghai Gezhi Shuyuan ni she tie qian bolifang wei bowuyuan shuo* 上海格致書擬設鐵嵌玻璃房為博物院 [On the proposal to build an iron and glass building as a museum for the Shanghai Polytechnic] (1877); *Queshuiyi quanlun* 卻水衣全論 [A complete account of diving equipment]; *Xiyi zhixin* 西藝知新 [A new account of Western arts] (1878 and 1884);[90] *Huaxue jianyuan bubian* 化學鑑原補編 [A supplement to *The Mirror of Chemistry: a Source-book*] (1879);[91] *Kaozheng lülü shuo* 考證律呂説 [On an evidential investigation into mathematical harmonics] (1880); *Huoyao jiqi shuo* 火藥機器説 [Gunpowder manufacturing machinery] (1881);[92] *Huaxue kaozhi* 化學考質 [An investigation into chemical substances] (1883);[93] *Huaxue qiushu* 化學求數 [The seeking of numerical [patterns] within chemistry] (1883);[94] *Baocang xingyan* 寶藏興焉 [Precious resources and the utilisation thereof] (1884);[95] *Huaxue cailiao Zhong-Xi mingmu biao* 化學材料中西名目表 [A Chinese–English glossary of the names of chemical substances] (1885);[96] *Xiyao dacheng Zhong-Xi mingmu biao* 西藥大成中西名目表 [A Chinese–English glossary of

[78] A translation of the organic part of Charles Loudon Bloxam, *Chemistry, Inorganic and Organic, with Experiments and a Comparison of Equivalent and Molecular Formulae* (London, 1867) [with John Fryer].

[79] A translation of Edward C. Frome, *Outline of the Method of Conducting a Trigonometrical Survey*, 3rd ed. (London, 1862) [with John Fryer].

[80] In *Gezhi huibian* 1, 1 (Feb. 1876).

[81] In *Gezhi huibian* 1, 3 (April, 1876). In the same issue he replied to a query from a reader about the sulphurous smell produced when one's hands are rubbed together, saying that it was due to ozone (*ibid.*, 11b).

[82] In *Gezhi huibian* 1, 4 (June, 1876).

[83] A translation of John Fryer, *Notes of a Tour through Iron Manufacturing Districts*, an account of a tour he made in 1873.

[84] W. Henry Northcott, *A Treatise on Lathes and Turning* (London, 1876) [with John Fryer].

[85] Whitworth, *Whitworth Guns and Steel* [with John Fryer].

[86] A translation of *Manufacture of Metal Tubes and Files in Ure's Dictionary* [with John Fryer].

[87] A translation of Gorman (Geerman 格爾曼), *The Regenerative Furnace* [with John Fryer].

[88] Smith, *Manufacture of Sulphuric Acid* [with John Fryer].

[89] (author unknown, possibly John Fryer) *Photography: the Negative and the Print.*

[90] A compilation of various works on manufacturing [with John Fryer].

[91] A translation of the inorganic part of Charles Loudon Bloxam, *Chemistry* [with John Fryer].

[92] Of unknown source, this appeared as a series of articles in *Gezhi huibian* 4, 1–4 (1881) [with John Fryer].

[93] A translation of Carl R. Fresenius, *Manual of Qualitative Chemical Analysis*, ed. S. W. Johnson (New York, 1875) [with John Fryer].

[94] A translation of Carl R. Fresenius, *Quantitative Chemical Analysis*, 7th ed., trans from 6th German edition by A. Vacher (London, 1876) [with John Fryer].

[95] A translation of Crookes, *Metallurgy* [with John Fryer].

[96] This was prepared with John Fryer whilst translating *Huaxue jianyuan* and its sequels.

Western medicines] (1887); *Wuti yure gaiyi ji* 物體遇熱改易記 [A record of the changes undergone by substances when heated] (1899);[97] and *Falü yixue* 法律醫學 [Forensic medicine] (1899).[98]

Unpublished translations included: *Zaoshibiao shuo* 燥濕表說 [On hygrometrical tables];[99] *Tiechuan zhinanzhen fa* 鐵船指南針法 [Compass techniques in iron ships];[100] *Wuzhi yure gaiti* 物質遇熱改體 [Changes in volume of heated substances];[101] *Shiyan tie mei fa* 試驗鐵煤說 [On the assaying of iron and coal];[102] and *Zao xiangpi fa* 造象皮法 [Rubber manufacture];[103] and *Daishuxue* 代數學 [Algebra].[104]

The range of these works is astonishing, and reflects the fertility and scope of Xu Shou's understanding of these diverse subjects. They also, as Fryer hinted, reflected some of Xu Shou's own interests, such as assaying mineral ores, medicine and acoustics, in which latter field he was to make an original contribution to the scientific literature.

Xu Shou and the restoration of music[105]

Xu Shou's interest in replicating ancient musical instruments has already been noted, but it went beyond the mere reconstruction of the past. He had already discovered discrepancies between the traditional account of the relationship between the length of pitch pipes and the notes they produced. His interest was further stimulated when he read the account of the English physicist John Tyndall (1820–93) in the book *Sound*, translated by Fryer and Xu Shou's second son Xu Jianyin, which stated that the length ratio of an open pipe to another which sounded exactly one octave higher was 2:1. Xu Shou already knew from his own experiments that this was not the case, and had established a ratio of 9:4.

In 1880 John Fryer decided to write to John Tyndall to ask about this apparent anomaly, and sent a copy of the same letter to the journal *Nature*:

To Professor Tyndall
Dear Sir,

My friend Mr Hsü [Xu Shou] has brought some interesting facts relating to acoustics before my notice. As he is the father of the native official who translated with me your work "On Sound" and

[97] A translation of George Foster, "Changes of volume produced by heat" in Henry Watts, *A Dictionary of Chemistry and the Allied Branches of Other Sciences* (London, 1875) [with John Fryer].

[98] A translation of William A. Guy and David Ferrier, *Principles of Medical Jurisprudence*, 5th ed. (London, 1881) [with John Fryer].

[99] A translation of Glaisher, *Hygrometrical Tables* [with John Fryer].

[100] A translation of "Adjustment of compasses in iron ships", in *Journal of Science* [with John Fryer].

[101] A translation of an article in Watt's *Dictionary* [with John Fryer].

[102] A translation of Mitchell *et al.*, *Assaying of Coal and Iron* [with John Fryer].

[103] A translation of Hancock and Goodyear, *India Rubber Manufacture* [with John Fryer].

[104] This was the translation of an unknown Western text [with Xu Jianyin and John Fryer].

[105] The primary sources for this topic are the letter of John Fryer to John Tyndall, dated 1 June 1880 (*Fryer Papers*: Box 1, Folder 5); and the letter of John Fryer to the Editor of *Nature*, dated 25 November 1880 (*Nature* 10 March 1881), pp. 448–9); and Xu Shou's article "Kaozheng lülü shuo" 考證律呂說, in *Gezhi huibian* 3, 7 (1880).

The only reference to this correspondence in the secondary literature I can find is Dai Nianzu 戴念祖, "Zhongguo gudai zai guankou jiaozheng fangmian de shengxue chengjiu" 中國古代在管口校正方面的声学成就 [Ancient Chinese acoustical achievements in the calculation of the end correction for open pipes], in *Ziran keji shiliao* 自然科技史料 [China Historical Materials of Science and Technology] 13, 4 (1992), pp. 1–13.

as he refers particularly to that work I venture to forward you a translation of his remarks, in the hope that you will satisfy his mind on a subject in which he takes such a deep interest. He says: –

"In ancient Chinese works on music it is stated that strings or pipes produce an octave or twelve semitones higher or lower by halving or doubling their length.

In a work written in the Ming dynasty by Cheu-tsai-yoh [Zhu Zaiyu 朱載堉 (1536–1610)] it is stated that this rule will only hold good with strings but not with open pipes such as the flute or flageolet.

Some years ago I tried to investigate the cause of this difference and its exact amount. A round open brass tube, say nine inches long, gave a certain note by pressing the end of it against the upper lip and blowing through an embouchure made there. Cutting off half the tube, the remaining four and a half inches would not sound the octave; but by cutting off half an inch more, thus leaving four inches in length, the octave was sounded accurately. This experiment was tried on tubes of various lengths and diameters with a similar result. viz. that four-ninths of the length always sounded the octave more or less exactly. Looking at a foreign keyed flute, I noticed the same principle carried out in the arrangement for producing octaves. I could not however see the reason why open pipes should not follow the same rule as strings and closed pipes.

When I read the translation of Professor Tyndall's "On Sound" I was surprised to find the old Chinese idea strictly maintained. It says (p. 214): "In both stopped and open pipes the number of vibrations executed in a given time is inversely proportional to the length of the pipe," & c.[106] *According to this, as the octave of any note has to exactly double the number of vibrations in a given time, an open pipe ought to be exactly halved to make it sound an octave higher. This I have shown by my experiments to be erroneous.*

Fearing that I have misunderstood the English professor's meaning, I beg that he may be written to on this subject and my doubts may be thereby cleared up. What I want to know is the exact proportion in length that exists between any open pipe and a pipe of similar diameter sounding its octave higher. Also the exact proportions in length for each of the open pipes sounding the twelve semitones which form a scale of one octave. If the length forming the octave in open pipes does not agree with the length for strings or closed pipes, then the lengths of all the pipes giving intermediate notes must also differ. How are these lengths to be calculated? Can they be expressed by any mathematical curve or formula? Why does not the same rule hold good for open pipes as for strings or stopped pipes? I have a theory of my own but I do not feel sufficient confidence in myself to make it public until I have bestowed more thought and attention upon it. In the meantime I shall be glad if any foreign scientists can enable me to understand this interesting and important subject. The theory and practice of music in China has gradually become vitiated through errors in the construction of musical instruments, and I am therefore desirous of having a scientific basis upon which a reformation may be effected."[107]

There is no treatise on music or acoustics that I can find which throws any light on these interesting questions, and I shall deem it a great favour if you will direct me to any work that will enable me to satisfy the eager inquiries of my native friend.

I send by book-post a pamphlet for your kind acceptance, containing an account of the Department for the Translation of Scientific Books at the Kiangnan Arsenal. You will see that your "Notes on Light" are now published in Chinese. A copy will be forwarded to you shortly. Your "Heat a Mode of Motion" I hope to begin to translate at no very distant time. Your "Notes on Electricity" in Chinese will be published shortly.

I remain, dear Sir, yours faithfully

John Fryer

Shanghai, June 1, 1880

[106] This refers to the second edition of *Sound* (London, 1869). [107] I have italicised Xu Shou's words.

November 25th, 1880

P.S. I have sent a copy of this letter to the Editor of *Nature*, and shall feel greatly obliged if you will forward your reply, if any, to him for publication. J. F.

The Editor of *Nature* remarked, "It will be seen that a really scientific modern correction of an old law has most singularly turned up from China, and has been substantiated with the most primitive apparatus"[108], and the referee of the paper W. H. Stone commented, "It is not a little interesting that a confirmation of this little-known fact should have come from so far off, and have been obtained by such simple experimental means."[109]

The effect Xu Shou refers to had already been explained mathematically by Lord Rayleigh (John William Strutt) in his book *The Theory of Sound*, ii (London, 1878), pp. 187–90 and 291–5, but it was clearly not well-known at the time.

Zhu Zaiyu had obtained an end correction for an open pipe of 0.4719, whereas that of Xu Shou was 0.4444. The need for the correction arises because, whereas in the simplest acoustical theory of open pipes there is a node exactly at the mouth of the open pipe, and the sound is only produced by the column of air within the pipe, in practice the air some distance from the pipe is also excited by the vibration, and it is the contribution of this external vibration which results in the end correction.

It is not surprising that Tyndall made no reply to Fryer's letter, whose publication Tyndall (a notoriously sensitive man) must have found deeply humiliating, and Tyndall made no attempt to alter the erroneous passage in the 4th (1883) and 5th (1893) editions. This had not been Fryer's first contact with him. In the introduction to the third edition of *Sound* (1876), Tyndall quotes a letter he had received from Fryer:

One day soon after the first copy of your work on sound reached Shanghai, I was reading it in my study, when an intelligent official, named Hsü-chung-hu [Xu Jianyin] noticed some of the engravings and asked me to explain them to him. He became so deeply interested in the subject of Acoustics that nothing would satisfy him but to make a translation. [...][110]

After the publication of Fryer's letter in *Nature* all mention of this was removed in subsequent editions.[111]

Xu Shou and the Shanghai Polytechnic: a clash of cultural expectations[112]

Xu Shou's association with the Shanghai Polytechnic revealed a clash of ideals between Fryer's vision of "public science", with lectures and classes open to all, and the Chinese tradition of *kaozheng* scholarship as essentially the activity of a scholarly élite.

[108] *Ibid.*, p. 448. [109] *Ibid.*, p. 449. [110] John Tyndall, *Sound*, 3rd edition (New York, 1876), p. 6.

[111] John Tyndall was well-known in official circles in China: Guo Songtao 郭嵩濤 (1818–91) mentions seeing him lecture several times, on topics such as heat and acoustics, during Guo's stay as Chinese ambassador to Britain (1877–8). See Guo Songtao, *Lundun yu Bali riji* 倫敦與巴黎日記 [London and Paris Diary], in Zhong Shuhe 钟叔河 (ed.), *Zou xiang shijie congshu* 走向世界丛书 [The "Going out into the World" anthology] (Changsha, 1984), pp. 29, 464 and 507–8.

[112] The classic account of the Shanghai Polytechnic is still Knight Biggerstaff, "Shanghai Polytechnic Institution and Reading Room: an attempt to introduce Western science and technology to the Chinese", in *Pacific Historical Review* XXV 2 (May, 1956), pp. 127–49.

that the slime-glands were much less developed in the males than in the females.

The structure of the female organs in our Caracas species agrees pretty well with Prof. Hutton's drawings (*Ann. and Mag. of Nat. Hist.*, iv. ser., vol. 18, pl. xvii., fig. 8); but I am not prepared to accept his interpretation. The following sketch will give an idea of what I saw.

Moseley's Fig. 1 on pl. lxxiv. is very different from the shape of the ovary in our species; nor can I well understand the existence of ova on the *outside* of the ovary as they appear in his drawing. The ovary in *P. Edwardsii* is rather long, and abundantly covered by fine tracheal tubes, with the exception of a narrow zone close to the branching out of the oviducts. I could not satisfy myself as to its being divided by a septum, nor could I find any ova in it; most likely it is not now the right time. At a very short distance from the beginning of the oviducts there is a kind of obtuse *cæcum* on each of them, which is followed by a spherical body covered by tracheal tubes. These bodies are the organs described by Prof. Hutton as testes.

There is however in our species no trace of what he takes for *vasa deferentia*, the spherical body adhering directly to the oviduct. Its wall is of considerable resistance, and bursts only under great pressure, giving issue to an immense number of thin rod-like corpuscula, which soon after begin to move slowly in the surrounding water. They are of course spermatozoa which have lost their nuclei, and the spherical body can therefore be nothing else but a *receptaculum seminis*.

The oviducts of three specimens which I dissected contained very few embryos; in one there was only one in each oviduct, in the others there were two. They were fully developed, and occupied the part of the oviducts close to the vulva. It would appear from this that the time of reproduction is now almost over; further observations will show whether there is really such a periodicity in our species.

It is probable that the oviducts of *P. Edwardsii* never present the shape of strings of sausages, as seen by Mr. Moseley in *P. Capensis*, the embryos being so considerably larger.

Animals thrown alive into alcohol pour forth from their slime-glands first the viscid substance contained in these; then there comes out a slightly reddish matter, which dissolves in the alcohol, giving it the same colour.

With respect to all other points I can only confirm Mr. Moseley's statements. I keep alive a colony of *Peripatus* of both sexes in the hope to have once a chance to observe the copula.

I cannot conclude these remarks without confessing that I am not at all quite sure whether our *Peripatus* is really *P. Edwardsii*, as the figure of this species in Nicholson's "Manual of Zoology" (5th edit. p. 315), which is said to be after Grube, does not agree well with my living specimens. Grube's original paper I cannot consult here. It may be however that he made his drawing from a contracted alcoholic specimen. A. ERNST

The University, Carácas, January 16

ACOUSTICS IN CHINA

THE following letter to Prof. Tyndall has been sent to us for publication by the writer, Mr. Fryer. It will be seen that a really scientific modern correction of an old law has singularly turned up from China, and has been substantiated with the most primitive apparatus. Dr. W. H. Stone, to whom the letter has been submitted, has kindly appended a note.

TO PROF. TYNDALL, LL.D., F.R.S., &c.

DEAR SIR,—My friend Mr. Hsü has brought some interesting facts relating to acoustics before my notice. As he is the father of the native official who translated with me your work "On Sound," and as he refers particularly to that work, I venture to forward you a translation of his remarks, in the hope that you will satisfy his mind on a subject in which he takes such deep interest. He says:—

"In ancient Chinese works on music it is stated that strings or pipes produce an octave or twelve semitones higher or lower by halving or doubling their length.

"In a work written during the Ming dynasty by Chen-tsai-yoh it is stated that this rule will only hold good with strings, but not with open pipes such as the flute or flageolet.

"Some years ago I tried to investigate the cause of this difference and its exact amount. A round open brass tube, say nine inches long, gave a certain note by pressing the end of it against the upper lip and blowing through an *embouchure* made there. Cutting off half the tube, the remaining four and a half inches would not sound the octave; but by cutting off half an inch more, thus leaving four inches in length, the octave was sounded accurately. This experiment was tried on tubes of various lengths and diameters with a similar result, viz. that four-ninths of the length always sounded the octave more or less exactly. Looking at a foreign keyed flute I noticed the same principle carried out in the arrangements for producing octaves. I could not however see the reason why open pipes should not follow the same rule as strings and closed pipes.

"When I read the translation of Prof. Tyndall's treatise 'On Sound,' I was surprised to find the old Chinese idea strictly maintained. It says (p. 214): 'In both stopped and open pipes the number of vibrations executed in a given time is inversely proportional to the length of the pipe,' &c. According to this, as the octave of any note has to execute exactly double the number of vibrations in a given time, an open pipe ought to be exactly halved to make it sound an octave higher. This I have shown to be erroneous by my experiments.

"Fearing that I have misunderstood the English professor's meaning, I beg that he may be written to on this subject, and that my doubts may be thereby cleared up. What I want to know is the exact proportion in length that exists between any open pipe and a pipe of similar diameter sounding its octave higher. Also the exact proportions in length for each of the open pipes sounding the twelve semitones which form a scale of one octave. If the length forming the octave in open pipes does not agree with the length for strings or closed pipes, then the lengths of all the pipes giving intermediate notes must also differ. How are these lengths to be calculated? Can they be expressed by any mathematical curve or formula? Why does not the same rule hold good for open pipes as for strings or stopped pipes? I have a theory of my own, but I do not feel sufficient confidence in myself to make it public until I have bestowed more thought and attention upon it. In the meantime I shall be glad if any foreign scientists can enable me to understand this interesting and important subject. The theory and practice of music in China has gradually become vitiated through errors in the construction of musical instruments, and I am therefore desirous of having a scientific basis upon which a reformation may be effected."

There is no treatise on music or acoustics that I can find which throws any light on these interesting questions, and I shall therefore deem it a great favour if you will direct me to any work that will enable me to satisfy the eager inquiries of my native friend.

I send by book-post a pamphlet for your kind acceptance, containing an account of the Department for the Translation of Scientific Books at the Kinagnan Arsenal. You will see that your "Notes on Light" are now published in Chinese. A copy will be forwarded to you shortly. Your "Heat a Mode of Motion" I hope to begin to translate at no very distant time. Your "Notes on Electricity" in Chinese will be published shortly.

I remain, dear Sir, yours faithfully,

Shanghai, June 1, 1880 JOHN FRYER

November 25th, 1880

P.S.—I have sent a copy of this letter to the Editor of NATURE, and shall feel greatly obliged if you will forward your reply, if any, to him for publication.—J. F.

MR. FRYER is perfectly correct in his observations. You will find the explanation and formula needed at p. 167 of my little book on Sound, under the heading "Correction of Bernouilli's Law." "It has long been known," I there say, "that if an open pipe be stopped at one end its note is not exactly an octave below that given by it when open, but somewhat less, the interval being about a major seventh instead of an octave."

Then follows the mathematical statement, from which the corrections needed by Mr. Fryer could easily be obtained. M. Bosanquet's excellent experimental investigation of the subject is briefly described. His results give the correction for the open end of the pipe as ·635 of radius of pipe, and ·59 *r* for the mouth. Mr. Bosanquet remarks that in Bernouilli's theory the hypothesis is made that the change from the constraint of the pipe to a condition in which no remains of constraint are to be perceived takes place *suddenly* at the point where the wave system leaves the pipe. It is however evident that the divergence which takes place may be conceived of as sending back to the pipe *a series* of reflected impulses, instead of the single

Fig. 6. An article in *Nature* (10 March 1881, pp. 448–9), with John Fryer's letter to John Tyndall (reprinted with permission from *Nature* (10 March 1881, pp. 448–9), Copyright 1881 Macmillan Magazines Limited).

At first, Xu Shou's role was that of energetic organiser and treasurer, and he was remarkably successful in persuading high Chinese officials to give support and funds.[113] Although the grandiose scheme of a "Crystal Palace" described in *Gezhi huibian*[114] was not realised, the building was completed and the first lecture held in 1877.[115] Xu Shou used some of the money that had been raised to buy scientific apparatus.[116]

Although chemistry was obviously one of Xu Shou's greatest interests, there is no record of his having carried out experiments of any great originality in this field.

He had a deep knowledge of mineralogy and assembled at the Polytechnic what was probably the most extensive collection of rocks and minerals in China at the time, and also carried out chemical analysis of iron ore and other minerals sent in by readers of *Gezhi huibian*, many of whose samples turned out to be relatively worthless mica or iron pyrites.[117] This free assay service clearly excited some enthusiasm in the readers: such large quantities of rock specimens began to be submitted that eventually Fryer had to ask his readers to stop sending them in altogether.[118]

Following problems in finding suitable staff to look after the institution, Xu Shou and his family moved into the Polytechnic buildings and from this time until Xu Shou's death in 1884 the Polytechnic was to all intents and purposes their private residence. The Committee set up to manage the affairs of the Polytechnic found that quite often they did not even attend meetings, sometimes claiming the "bad weather" as an excuse,[119] and it became increasingly difficult to discuss the educational purposes of the institution.

Fryer wrote in 1885:

Finding the wishes of the Committee did not accord with his own, he step by step ignored them altogether. Meeting after meeting was held to try and adjust matters, but without effect. [...] As a consequence, the premises have gradually become too much like a private residence for the Hsü [Xu] family and their friends who assist in taking charge, while the original public and educational character of the Institution, whether from a Chinese or a foreign point of view, is almost, if not entirely lost. Little, if any, encouragement has been afforded for some time past by the curator or the Hsü [Xu] family to Chinese, who may have come to see the books and apparatus, or to make enquiries about the work that ought to be carried out in such an establishment. Month after month has passed without a visitor coming near the place. The costly books in the Chinese language have

113 John Fryer wrote: "The replies of the two Viceroys, to whom memorials were sent by Mr Hsü [Xu], are so highly satisfactory that they will be framed and suspended in the Hall of the main building" (John Fryer, *First Report of the Shanghai Polytechnic Institution and Reading Room* (Shanghai, 1875), p. 10).

114 This scheme was proposed in the February 1877 issue of *Gezhi huibian.*

115 The lecture, on electricity, was by the American missionary Calvin Mateer (Dikaowen 狄考文), the founder of Dengzhou College, and a noted science educator of this period.

116 "His Majesty the King of the Belgians has made the handsome donation of five hundred dollars to the Institution which the Committee have decided to spend on the purchase of philosophical [scientific] apparatus from Belgium as per annexed correspondence. This apparatus will shortly arrive in Shanghai and will be sufficient for a course of twelve elementary lectures which it is specially adapted to illustrate. Mr Hsü [Xu] proposes to expend the sum of two thousand taels which he has at his disposal, in the purchase of additional apparatus and specimens to be presented to the Institution, so as to complete the collection and make it the best of its kind in China" (John Fryer, *First Report*, p. 7).

117 John Fryer, "Third Report of the Chinese Polytechnic Institution and Reading Rooms, Shanghai", in *North China Herald* (18 April 1883), p. 433 and *Gezhi huibian*, 1, 11 (December, 1876), p. 11a.

118 *Gezhi huibian*, 2, 2 (March, 1877), p. 16a.

119 *North China Herald* (15 March 1877), p. 269.

Fig. 7. A portrait of Xu Jianyin from Zhong Shuhe, *Zou xiang shijie*.

lain unused on the shelves in the side room used as the library, which has generally been shut up and has seldom seen daylight. The valuable scientific apparatus has been spoiling in the glass cases made for its reception for want of use and attention. The glass windows and doors of the main building seem never to have been cleaned and seldom even opened since the day of commencement. The front entrance has often been closed to visitors. The Hon. Secretary [John Fryer] has on more than one occasion had to knock on the door for a long time in the middle of the day before he could obtain admission, and then only on shouting his name from the outside. In a word as far as the original plan of work is concerned the Institution has for one or two years been dead to the world.[120]

It is only fair to point out that Xu Shou had no opportunity to reply to these criticisms, but the decay of the place was remarked upon by other observers as early as 1877,[121] and it does seem that the expectations of the foreigners involved were very different from those of Xu Shou, for whom the Polytechnic was a place of refuge and quiet study, where he

[120] John Fryer, "Fourth Report of the Chinese Polytechnic Institution and Reading Rooms, Shanghai, from March 1883 to March 1885", in *North China Herald* (10 July 1885), p. 44.

[121] *North China Herald* (15 March 1877), p. 261. This editorial article contrasted the forlorn aspect of the Shanghai Polytechnic with the bustling Hongkong Museum. The bitter hostility of the piece towards such an apparently innocuous institution seems surprising but probably reflects the suspicion felt in the foreign community of Fryer and others who were felt to be too closely tied to Chinese government interests (in this case represented by Li Hongzhang), hence the unfavourable contrast with the colonial institution.

could assemble his remarkable collection of scientific apparatus and conduct experiments in his spare time.

John Fryer had intended the Polytechnic to be "public and educational", where earnest enquirers could peruse the books, examine specimens, and obtain advice and instruction on the useful arts, but such ideas proved to be hopelessly alien – and probably irrelevant to – what the Chinese committee members saw as China's need of a core élite of highly educated scientists and engineers who would develop science and technology within existing institutions. The lay public had no place in the latter scheme, and Xu Shou probably hoped that if he ignored Fryer's schemes, the whole idea of the place being in the public domain would quietly die, which is for a time exactly what happened. It was to be a further ten years after Xu Shou's death before the Shanghai Polytechnic opened its doors fully to become something resembling Fryer's original vision.[122]

Xu Jianyin 徐建寅 (1845–1901)[123]

The life of Xu Jianyin

As the second son of Xu Shou,[124] Xu Jianyin (Xu Zhonghu 仲虎) grew up in Wuxi in what was, in nineteenth century China, an extremely unusual household: one in which Western science was taken seriously. During his teens Xu Jianyin became directly involved with the first experiments which Xu Shou and Hua Hengfang carried out in Wuxi, following the diagrams and explanations of *Bowu xinbian* and other texts. Unlike his father, who never passed the literary examinations, wearing "cotton cloth" (*buyi* 布衣) all his life, Xu Jianyin was a successful candidate, and this perhaps is one explanation for the self-confidence with which he later undertook a succession of important posts in China and abroad.

Xu Jianyin moved to Anqing with his father in 1861 at the invitation of Zeng Guofan to join the latter's *mufu* to begin building the first Chinese steamship, and in 1867 Xu Jianyin, by then given the rank of district magistrate, followed his father to Shanghai to work at the Jiangnan Arsenal, where they carried out the translation of scientific books as well as being involved in the manufacture of ships.

122 It was not until 1896, twenty years after the opening, that regular science classes were held in the Shanghai Polytechnic.

123 The primary sources for Xu Jianyin's life are: Min Erchang 閔爾昌 (ed.), *Beizhuan jibu* 碑傳集補 [Supplementary collection of epitaphs] (Beiping, 1932), 43.13b; Zhao Ersun 趙爾巽 (ed.), *Qingshigao* 清史稿 [A draft history of the Qing dynasty], 505.13930; *Xi-Jin si zhe shishi huicun* 錫金四哲事實匯存 [A collection of facts about four philosophers of Jingui and Wuxi], quoted in Yang Gen (ed.), *Xu Shou*; Xu Jianyin, *Ouyou zalu* 歐游雜錄 [A record of a European journey], in *Xiaofanghu zhai yudi congchao* 小方壺齋 地叢抄 [A collection of geographical works from the Little Square Pot Studio], 57 *ce*. Secondary sources include: Zhang Zigao 張子高 and Yang Gen 楊根, "Xu Shou fu-zi nianpu 徐壽父子年譜", in *Xu Shou*, pp. 301–16; Ji Hongkun 季鴻崑, "Xu Jianyin yu Zhongguo wuyan huoyao de yanzhi" 徐建寅與中國無烟火藥的研制 [Xu Jianyin and the manufacture of Chinese smokeless gunpowder], in *Xu Shou*, pp. 317–34; Xu Zhenya 徐振亞 and Ruan Shenkang 阮慎康, "Xu Jianyin, Xu Huafeng, Xu Jiabao yizhu jianjie" 徐建寅徐華封徐家宝譯著簡介 [A simple introduction to the translations of Xu Jianyin, Xu Huafeng and Xu Jiabao], in *Xu Shou*, pp. 335–45; Zhong Shuhe 钟叔河 (ed.), *Zou xiang shijie* 走向世界 [Going out into the world] (Beijing, 1985), ch. 17.

124 Xu Shou's first wife was surnamed Sheng 盛 and she gave him one son, Dalü 大吕, of whom nothing is known. His second wife, surnamed Han 韓 gave him two sons, Xu Jianyin and Xu Huafeng.

In 1868 John Fryer [known in Chinese as Fulanya 傅蘭雅] was appointed as director of the Department for the Translation of Scientific Books in the Jiangnan Arsenal, but it seems that a year earlier, whilst still working at the Anglo-Chinese School in Shanghai, Fryer had already struck up a close friendship with Xu Jianyin, who was only six years younger than him, and they had already been collaborating on translations in 1867. Fryer wrote in one of his letters:

One young fellow who is a mandarin of the rank of district magistrate and wears a white button and flowered peacock's feather and has become like a brother to me. We work very much together and he often comes to my house and dines. His name is Hsü-chung-hu [Xu Zhonghu = Xu Jianyin] or in Chinese 徐仲虎. Perhaps I may be able to bring him to England when I return.[125]

A year later, by which time Fryer had been appointed officially at the Arsenal, he was writing to his cousin:

The Chinese who are working with me are some of them really clever. There are none lower in rank than district magistrates. We get on capitally together so far. One [Xu Jianyin] is younger than the rest and has made quite a strong friendship with me and tells me all his affairs as if I were his brother. He is the cleverest Chinaman I ever met and I am but a child compared to him in many respects. We sometimes argue different points of view up till midnight.[126]

This close relationship is reflected in the number of translations on which they worked in the 1870s and early 1880s, including several articles in *Gezhi huibian* written whilst Xu Jianyin was in Germany. After Xu Shou's death in 1884, with Fryer's reorganisation of the Shanghai Polytechnic, they became estranged, and the collaboration with Fryer seems to have ceased.

Xu Jianyin and the Shanghai Polytechnic

Xu Jianyin's name appears in several of the accounts of committee meetings in the early years of the Shanghai Polytechnic, when Xu Shou was heavily involved in fundraising and the building of the premises. Xu Jianyin himself left China in 1879, when little had been achieved in the way of educational activities, and he played little active role in the developments between 1879 and 1884. By this time Fryer had become increasingly exasperated at the lack of progress in developing science education at the Polytechnic, for which he publicly blamed Xu Shou, his friends and his family (that is to say, Hua Hengfang (the curator), Xu Shou himself, Xu's third son Xu Huafeng 徐華封, and probably Xu Jianyin's wife and children), who had more or less taken over the building. One telling incident occurred soon after Xu Shou's death, when Xu Jianyin returned to Shanghai after his European tour.

According to John Fryer's Fourth Report in 1885

[Xu Jianyin], the member of the Committee previously alluded to as one of the chief promoters of the Institution at its commencement, came and took the entire charge of the building and funds out of his brother's [Xu Huafeng's] hands as successor in office to his father for the time being. He

[125] John Fryer to George Fryer, 25 March 1867 (*Fryer Papers*, Box 1, Folder 1).
[126] John Fryer to Susy 11 July 1868 (*Fryer Papers*, Box 3, Folder 3).

established himself on the premises and began to expend some of the money in hand by the addition of a wall with iron gate and railings at the entrance, anticipating the sanction of the Committee to his proceedings at the next meeting.[127]

Fryer went on to make it clear that, in his view, as long as the Xu family were ensconced in the Polytechnic – protected from the general public by an iron fence – no further progress could be made towards its stated objectives, and it seems that from this time onwards their relationship, which had initially been so cordial, was irreparably damaged.

Transmitting science: the translations and other works of Xu Jianyin[128]

The translations carried out with John Fryer, included *Yungui yuezhi* 運規約指 [Practical geometry] (1870);[129] *Huaxue fenyuan* 化學分原 [Chemical analysis] (1872);[130] *Qiji xinzhi* 汽機新制 [New types of steam engines] (1872);[131] *Qixiang xianzhen* 器象顯真 [The engineer and machinist's drawing book] (1872);[132] *Shuishi caolian* 水師操練 [Naval exercises] (1872);[133] *Qiji biyi* 汽機必以 [Essentials of the steam engine] (1873);[134] *Lunchuan buzhen* 輪船布陣 [Manoeuvring streamships] (1874);[135] *Shengxue* 聲學 [Acoustics] (1874);[136] *Cao Gelinpao fa* 操格林礮法 Gatling gun drill][137] (1875); *Dianxue* 電學 [Electricity] (1880);[138] *Zao tie quan fa* 造鐵全法 [A complete account of iron manufacture] (1880);[139] *Lun xie nei tiezhi zhi gongyong* 論血内鐵質之功用 [On the role of iron in the blood] (1880);[140] *Lun zao huozhuan huoni fengguan* 論造火磚火泥風管 [On the manufacture of fire-bricks and fire-clay air-ducts] (1880);[141] *Lun zao boliping ji dengzhao* 論造玻璃瓶及燈罩 [On the manufacture of glass bottles and lamp-covers] (1880);[142] *Lian tong zhu tong ya tongban zhu tongguan chou tongguan han tongguan gefa* 煉銅鑄銅軋銅板鑄銅管抽銅管焊銅管各法 [Methods for smelting copper, casting copper, pressing copper plate, casting copper tubes, drawing copper tubes and soldering copper tubes] (1880);[143] *Yue Kelubu chang zao pao ji*

[127] John Fryer, "Fourth Report of the Chinese Polytechnic Institution and Reading Rooms", *North China Herald* (10 July 1885), p. 44.

[128] The information on the translations comes from the same sources as in n. 72.

[129] A translation of William Burchett, *Practical Geometry* (1855): this was the first translation which John Fryer did at the Jiangnan Arsenal, working from his home. See the letter from John Fryer to Broadhurst Tootal 28 April 1868 in *Fryer Papers*, Box 1, Folder 2.

[130] A translation of John E. Bowman, *An Introduction to Practical Chemistry, including Analysis*, edited by Charles Loudon Bloxam (Philadelphia, 1866).

[131] A translation of a work by an unidentified English author Baierge 白爾格.

[132] V. Leblanc (Bailigai 白力蓋) and Jacques E. Armengaud, *The Engineer and Machinist's Drawing Book* (Glasgow, 1855). [Bennett, p. 89, miswrites the second character as 家].

[133] A translation of *Instructions for the Exercise and Service of Great Guns on Board Her Majesty's Ships* (London, 1843).

[134] John A. Bourne (Buerna 蒲爾捺), *A Catechism of the Steam Engine, in its Various Applications* (London, 1865).

[135] A translation of Pownoll Pellew (Beilu 斐路), *Fleet Manoeuvring* (London, 1868).

[136] A translation of John Tyndall (Tiandali 田大理), *Sound* (London, 1869).

[137] A translation of Franklin (Fulankelin 弗蘭克林), *Gatling Gun Drill*.

[138] A translation of Henry M. Noad (Naoaide 瑙挨德), *The Student's Textbook of Electricity* (London, 1867).

[139] A translation of Sir William Fairbairn (Feierben 非爾奔), *Iron: its History, Properties and Processes of Manufacture* (Edinburgh, 1869) [Bennett, p. 90, gives the title incorrectly as 造鐵金法].

[140] Published in *Gezhi huibian* 3, 6 (July, 1880).

[141] Published in *Gezhi huibian* 3, 7 (August, 1880).

[142] Published in *Gezhi huibian* 3, 7 (August, 1880).

[143] Published in *Gezhi huibian* 3, 11 (December, 1880).

閲克鹿卜廠造礟記 [Record of a visit to the Krupp gun factory] (1881);[144] *Shuilei waike zao fa* 水雷外殼殼法 [Methods for manufacturing the outer shells of mines] (1881);[145] *Bian lun san ze* 辨論三則 [Three distinctions] (1881);[146] *Zao shihui fa* 造石灰法 [Methods for manufacturing lime] (1881);[147] *Yue bowuhui nei fangsha jiqi lüe* 閲博物會内紡紗機器略 [A brief report on an inspection of the weaving machines in the [Berlin] Exhibition] (1881);[148] *Fuerjian chang guangong zhangcheng* 伏耳鑑廠管工章程 [Regulations for the management of workers in the Vulcan Factory (Stettin)] (1881);[149] and *Yiqi jizhu* 藝器記珠 [Notes on machines] (1884).[150]

He also translated *Tantian* 談天 [On the heavens] with Alexander Wylie (Weilieyali 偉烈亞力) and Li Shanlan (1881).[151] The following works he translated on his own: *Cedi jiefa* 測地捷法 [Methods of surveying]; *Deguo hemeng jishi benmo* 德國合盟紀事本末 [A full account of the German Federation] (1897);[152] and *Deguo yiyuan zhangcheng* 德國議院章程 [The constitution of the German Parliament] (1882).[153]

He was the author of *Shuilei luyao* 水雷錄要 [A general account of mines] (1880–1) and *Ouyou zalu* 歐游雜錄 [Miscellaneous notes of a European journey] (1880–1) describing his technological reconnaissance of Western Europe. Whilst at the Fuzhou shipyard, he also wrote *Bingxue xinshu* 兵學新書 [A new account of military science] (1898), and he was the editor of a collection of reprints of articles on science called *Gezhi congshu* 格致叢書 published in the year of his death.

Unpublished translations (all with John Fryer) included *Qiji chicun* 汽機尺寸 [Dimensions of steam engines];[154] *Chuanzheng congshu* 船政叢書 [A compendium on shipbuilding]; *Meiguo hemeng benmo* 美國合盟本末 [A full account of the United States]; *Zao chuan quan fa* 造船全法 [A full account of shipbuilding methods]; *Nietieqi shuo* 攝鐵器說 [An account of electromagnets]; *Huitu chuanxian* 繪圖船線 [Shipping charts]; *Shiban yinfa* 石板印法 [Lithography]; *Zao liuqiangshui fa* 造硫強水法 [Manufacture of sulphuric acid]; *Yingcheng yaoshuo* 營城要說 [On fortifications]; *Pao yu tiejia lun* 礟與鐵甲論 [On guns and armour-plate]; *Niandai biao* 年代表 [Chronological chart]; and *Haijun zhangcheng* 海軍章程 [Naval regulations].

His European travels seemed to have awakened in him an interest in Western political systems, reflecting his deepening involvement with the practicalities and politics of industrial modernisation in China.

144 Published in *Gezhi huibian* 4, 4 (May, 1881). 145 Published in *Gezhi huibian* 4, 4 (May, 1881).
146 Published in *Gezhi huibian* 4, 8 (September, 1881).
147 Published in *Gezhi huibian* 4, 7 (August, 1881).
148 Published in *Gezhi huibian* 4, 11 (December, 1881).
149 Published in *Gezhi huibian* 4, 11 (December, 1881).
150 A translation of Sir Guildford L. Molesworth (Musihuode 慕司活德), *Pocket Book of Useful Formulae for Civil and Mechanical Engineers* (London, 1871).
151 William Herschel (Houshile 侯失勒), *The Outlines of Astronomy*.
152 The original author is unknown.
153 Translated from a German work by an author transliterated as Fenfugen 芬福根.
154 A translation of Bourne (Buerna 蒲爾捺), *Proportions of the Steam Engine*.

His work in Government Arsenals

From 1874, when he was just 29 years old, Xu Jianyin held a series of important posts in Government Arsenals, the first position being at the Tianjin Arsenal, where he helped Li Hongzhang to set up a gunpowder factory and a process for acid manufacture which made acid said to be "better and cheaper" than any that could be imported.[155] In 1875 he moved to the Shandong Arsenal 山東機器局 at Jinan 暨南, where he worked under Ding Baozhen 丁寶楨 (1820–1886) for four years. Ding was full of praise for his work and his character:

> [...] whenever I talked to him he was able to seek truth from facts and never indulged in exaggeration or boasting.[156]

Xu Jianyin recommended that the Shandong Arsenal should not make its own guns, as from his experience at the Jiangnan Arsenal he knew the great difficulties they had encountered. In 1875 he was sent on a mission to buy saltpetre, sulphur, coal and foreign machines for the Arsenal. It is significant that by this time Xu Jianyin had realised that it was not possible for China to be completely self-sufficient in the manufacture of certain machines and guns. His experience at the Jiangnan Arsenal had made him realise that it was more effective for the Chinese to make items which their own technology could handle and for which they had the raw materials (such as acid and gunpowder), whilst sophisticated hardware such as guns and ships were better bought from foreigners. Although he never says this himself, it was likely that the reasons for this policy were that Chinese industry was so undeveloped that it could not keep pace with the developing arms race (it could barely deliver the armaments of the 1870s in sufficient quantity and quality), and therefore it was better not to invest large sums in capital machinery which soon became obsolete.[157] Thus he had a direct influence on the direction of China's armaments industry at this critical time, although in practice it proved difficult for the Chinese Arsenals even to manufacture ammunition and explosives of adequate quality.[158]

Technological reconnaissance: Xu Jianyin's European travels

In 1879 Xu Jianyin was recommended by Li Hongzhang to be the Second Counsellor to the Chinese Legation in Berlin, whence he travelled with his former Jiangnan Arsenal colleague the translator Carl Kreyer (*Jinkaili* 金楷理).[159] At this time, Li Hongzhang

[155] See Qian Jibo, "Xu Shou zhuan", 43.17a; "Zhonghu Xu gong jiazhuan" 仲虎徐公家傳 [Biography of the family of Xu Jianyin], quoted in Yang Gen (ed.), *Xu Shou*, pp. 354–6; and *Gezhi huibian* 1, 2 (March 1876), p. 9a.

[156] Ding Baozhen, *Ding Wencheng gong yiji* 丁文誠公遺集 [A posthumous collection of the writings of Ding Baozhen), 12.16b (p. 1398).

[157] *Ibid.*, 12.16b.

[158] Li Hongzhang complained of this problem in 1873, and over 20 years later in 1894 Zhang Zhidong was reporting similar difficulties. See Quan Hansheng 全漢昇, "Qingji de Jiangnan zhizaoju" 清季的江南製造局 [The Qing dynasty Jiangnan Arsenal] in *Bulletin of the Institute of History and Philology, Academia Sinica*, XXIII (1951), pp. 145–59.

[159] Carl T. Kreyer was an American of German extraction. Originally a missionary, he moved to work at the Jiangnan Arsenal in 1869, leaving in 1878 to act as interpreter for Xu Jianyin (see John Fryer to George Fryer, 7 December 1869 in *Fryer Papers*, Box 1, Folder 4).

was developing the Beiyang Fleet (*Beiyang haijun* 北洋海軍), modelled on the German Navy. Xu was given two tasks: to inspect and purchase armour-plated warships, for which Li Hongzhang had set aside one million taels; and to investigate European factories of all kinds.[160] After the long sea voyage he travelled from Marseilles to Paris, where he was met at the station by Prosper Giquel (Riyige 日意格) (1835–86), who accompanied Xu Jianyin on a number of his visits.[161] Whilst in France, Xu Jianyin visited a mining institute where five Chinese students were studying,[162] a soap factory,[163] a glass factory,[164] the Louvre,[165] a steam hammer factory,[166] an iron foundry,[167] a firebrick factory,[168] a telescope factory,[169] and a lime plant.[170] In Britain he saw an armour-plated warship-building yard[171] and steel mills.[172] In Germany he visited amongst other places a porcelain factory,[173] an optical instrument factory,[174] a physics and chemical apparatus shop,[175] the Siemens (*Ximensi* 西門司) electric motor factory,[176] a glass instrument factory,[177] several gunpowder factories,[178] a borax works,[179] an iron galvanising factory,[180] an astronomical observatory,[181] a naval hospital,[182] the Vulcan (*Fuerjian* 伏耳鑑) shipyard at Stettin,[183] and a mining college at Hanover where five more Chinese students were studying,[184] a mine factory,[185] a copper mill,[186] a telegraphic machine factory,[187] a factory making lead type[188] and the Krupp (*Kelubu* 克鹿卜) gun factory.[189]

He was interested not only in the production methods but also in the management techniques these companies employed to ensure a high-quality product.[190] His mission was successful in the range and variety of factories visited, although sometimes his European hosts were cautious about allowing him access to their industrial secrets,[191] even though in the depressed economic conditions of the late 1870s they must have been eager to gain access to the potentially vast Chinese market.

[160] See Yang Gen (ed.), *Xu Shou*, p. 309. A complete itinerary is to be found in Xu Jianyin "Ouyou zalu" in Zhong Shuhe (ed.) *Zou xiang shijie congshu* [The "Going out into the world" collection](Changsha), pp. 632–7.

[161] *Ouyou zalu*, p. 7a. All page references to "Ouyou zalu" are to the Xiaofanghu Zhai edition, unless otherwise indicated. See Steven A. Leibo, *Transferring Technology to China: Prosper Giquel and the Self-Strengthening Movement* (Berkeley, 1985).

[162] *Ouyou zalu*, p. 7a. Giquel was supervising the Chinese students in France and Britain. See *Li Wenzhonggong. Zougao* 42. la. [163] *Ouyou zalu*, p. 8a. [164] *Ibid.*, p. 8a. [165] *Ibid.*, p. 8b.

[166] *Ibid.*, p. 9a. [167] *Ibid.*, p. 9b. [168] *Ibid.*, p. 9b. [169] *Ibid.*, p. 10b. [170] *Ibid.*, p. 12b.

[171] *Ibid.*, p. 28a.

[172] *Ibid.*, pp. 29a–29b. In London and Germany he had many conversations with Zeng Jize 曾紀澤, the eldest son of Zeng Guofan, whom he had known since the days of the Anqing Arsenal, and who was by then ambassador to Britain, France and Russia. See Zeng Jize, *Chushi Ying-Fa-Eguo riji* 出使英法俄国日记 [Diary of an embassy to Britain, France and Russia], ed. Zhong Shuhe 钟叔河 (Changsha, 1985).

[173] *Ouyou zalu*, p. 13a. [174] *Ibid.*, p. 13b. [175] *Ibid.*, p. 13b. [176] *Ibid.*, p. 13b. [177] *Ibid.*, p. 15a.

[178] *Ibid.*, pp. 15b–16a and 16b–17a. [179] *Ibid.*, p. 18a. [180] *Ibid.*, p. 25b. [181] *Ibid.*, p. 18b.

[182] *Ibid.*, p. 21a.

[183] *Ibid.*, pp. 26b and 34b. The Vulcan shipyard at Bredow near Stettin on the Baltic coast was one of the premier German shipyards in the late nineteenth century. See Marina Cattaruzza, *Arbeiter und Unternehmer auf den Werften des Kaiserreichs* (Stuttgart, 1988), pp. 11–19. [184] *Ouyou zalu*, p. 22b. [185] *Ibid.*, p. 30a.

[186] *Ibid.*, p. 30a. [187] *Ibid.*, p. 31b. [188] *Ibid.*, p. 31b.

[189] *Ibid.*, p. 32a. Krupp's took the Chinese market very seriously. Alfred Krupp had a portrait of Li Hongzhang hanging over his bed, and Krupp's had taken "huge orders" from China and Japan in the war scare of 1874–5. See Bernhard Menne, *Krupp, or Lords of Essen* (London, 1937), p. 108. By 1885, Li Hongzhang openly favoured the German arms industry over the British (*ibid.*, p. 131).

[190] 'Ouyou zalu', in Zhong Shuhe, *Zou xiang shijie congshu*, p. 643.

[191] *Ouyou zalu*, p. 33a. Krupp's were unwilling to tell him how their fire-clay was made, and would not let him see the process.

He ordered two ironclad steamships from the Vulcan factory in the Baltic port of Stettin, the *Zhenyuan* 镇遠 and *Dingyuan* 定遠, both for the Beiyang Fleet, at a cost of over 6 million taels each (although he claimed he received a large discount) and he also arranged for Chinese artisans to come to Germany for training.[192] These ships were more advanced than anything the Japanese navy had at the time, but this did not prevent them being sunk in the disastrous Sino-Japanese War of 1894–5.[193]

On his return to China he wrote *Ouyou zalu* 歐游雜錄 [Random records of a European journey], describing his travels. It is rather a dry work, with only occasional remarks of a more personal kind, but it provides some interesting insights, such as how impressed he was by German efficiency and especially by the Vulcan shipyard in Stettin.[194] In gunpowder manufacture he noted that the machinery used in Germany was not as advanced as that in Shanghai, Tianjin or Jinan, but that the quality of the product was higher, because the Germans were constantly improving the process.[195] His experience in Europe was to change his view of China's modernisation: it made him markedly more pessimistic than he had been before, and more aware of the enormous technological gulf which now lay between China and the industrialised states, the latter by now including not only the Western nations but also China's neighbour, Japan; by the end of his journey it seems he had also begun to take political reform seriously.

His return to China and involvement with the reform movement

Xu Jianyin apparently fell ill whilst in Germany, and applied for leave to return to China. (It may be that this was a diplomatic illness, as he seems to have had a poor relationship with his superior Li Fengbao 李鳳苞 (1834–87).[196] On his return journey in 1881 he passed through Paris, where he met Zeng Jize 曾紀澤, who was then negotiating the Treaty of St Petersburg.[197] Zeng entrusted him to carry the signed copy of the treaty back to Beijing. After having carried out this task, Xu returned to Shanghai to recuperate,[198] and to look after his dying father Xu Shou. Having observed the customary period of mourning, he went in 1886 to work at the Jinling 金陵 Arsenal in Nanjing, where he manufactured breech rifles and steel.[199] He also helped to set up a school

[192] *Ibid.*, pp. 35b–36a. Western Europe was at the end of a prolonged economic recession at this time, and so it is not surprising that the order from China was welcomed by the Vulcan shipyard, whose manager went to great lengths to entertain Xu Jianyin and his party. The two ships eventually reached China in 1885 (see *Li Wenzhonggong quanshu. Zougao*, 55.16a, memorial dated 14 November 1885).

[193] 'Ouyou zalu' in Zhong Shuhe (ed.), *Zou xiang shijie congshu*, pp. 631–2. [194] 'Ouyou zalu', p. 35a.

[195] *Ibid.*, p. 18b.

[196] See Zeng Jize, *Chushi Ying-Fa-Eguo riji*, p. 469. Li Fengbao was dismissed from his post in 1884, accused of accepting a bribe of 600,000 taels over the purchase of the warships.

[197] A. Hummel *Eminent Chinese of the Ching Period*, pp. 746–7.

[198] *Li Wenzhonggong quanshu. Zougao*, 42.48a–49a, dated 21 January 1882. There is no mention of Xu Jianyin in Zeng Jize's memorials in *Zeng Huimingong yiji* 曾惠敏公遺集 [A posthumous collection of the works of Zeng Jize] (1893; reprinted 1968) over this period, but this may be because, being based in Germany, Xu was not one of Zeng's direct subordinates. Sun Jingkang 孫景康, "Zhonghu Xu gong jiazhuan" 仲虎徐公家传 [A biography of Xu Jianyin] quoted in Yang Gen (ed.), *Xu Shou*, p. 355 says that he returned from Germany in the tenth year of the Guangxu reign-period, i.e. 1884/5, but I have taken Li Hongzhang's memorial as the more reliable source.

[199] Zeng Jize recounts meeting him at the fort at Wusongkou on Guangxu 12.10.28 (23 November 1886). See Zeng Jize, *Chushi Ying-Fa-Eguo riji*, p. 965.

at Zhenjiang 鎮江, and negotiated with the American and British consuls over anti-missionary disturbances in the region.[200]

In May 1890 we find him prospecting for coal for the Hubei Iron Manufacturing Bureau near Daye 大冶, presumably for Zhang Zhidong 張之洞 (1837–1909), who had become Governor-General of Hubei and Hunan in the previous year. The mines eventually opened in 1894, working in conjunction with the ironworks at Hanyang 漢陽.[201]

In 1895, after the defeat of the Beiyang Fleet in the Sino-Japanese War, Xu Jianyin was sent to investigate the Weihaiwei 威海衛 shipyard, on which he gave a report to Prince Gong 恭親王 (1833–98) which reflected badly on Li Hongzhang's management of the entire naval defence programme. This resulted in an irreparable rift with Li Hongzhang, with whom Xu Jianyin had been associated all his adult life.[202] It is likely that this incident was not the only reason for the cooling of the relationship: his foreign travels had made Xu Jianyin more radical in his attitude to the need for political reform in China, and he now gravitated towards the reformist group in Shanghai led by Liang Qichao, with whom Xu and other intellectuals associated with the Jiangnan Arsenal are said to have met regularly in 1896.[203]

In the same year he was sent to the Fuzhou shipyard, where Yulu 裕祿 (d. 1900), the Manchu official in charge of shipbuilding of the time, was told to keep an eye on him, to see whether he should be promoted to *titiao* 提調 [superintendent]. The cooler official attitude towards him was probably partly due to his past associations with the disgraced Li Fengbao and Li Hongzhang, and partly because the court was by now aware of his association with the reform clique, a connection which became public during the Hundred Days' Reform of 1898.[204]

[200] Zhang Zigao and Yang Gen, "Xu Shou fu-zi nianpu", p. 311.

[201] See the letter Xu Jianyin wrote to Xue Fucheng 薛福成 which Xue quoted in *Chu shi Ying-Fa-Yi-Bi siguo riji* 出使英法义比四国日记 [Diary of an embassy to Britain, France, Italy and Belgium], ed. Zhong Shuhe 钟叔河 (Changsha, 1985), p. 236 dated Guangxu 16.9.29 = 11 November 1890. The coal was three to four *chi* 尺 thick, and of a quality comparable with the best English coal, of low sulphur content and with few rocky impurities. See also Hummel, p. 29 for details of Zhang Zhidong's development of the ironworks at Hanyang, and Chen Zhen 陈真, *Zhongguo jindai gongyeshi ziliao* 中国近代工业史资料 [Materials on the history of modern Chinese industry] (Beijing, 1961), pp. 370–517. Zhang Zhidong is known to have sent out German and Belgian mineralogists with Chinese officials and mining students to prospect for minerals all over China during the early 1890s. See *Zhang Wenxianggong quanji* 張文襄公全集 [The collected works of Zhang Zhidong], 39.3a–3b (dated 8 October 1895), where the coalfield Xu discovered is also mentioned.

The Hanyang Ironworks had a sad history, recounted in Quan Hansheng 全漢昇, "Qingmo Hanyang tiechang" 清末漢陽鐵廠 [The late Qing Hanyang Ironworks], in *Shehui kexue luncong* 社會科學論叢 1 (1950), pp. 1–33.

[202] *Xu Shou*, pp. 313–4 and Ji Hongkun, "Xu Jianyin yu wuyan huoyao de yanzhi", in *Xu Shou*, p. 319.

[203] "Liang Qichao nianpu" 梁啓超年譜 [Biography of Liang Qichao], in Jian Bozan 翦伯贊 (ed.), *Wuxu bianfa* 戊戌變法 [Materials on the 1898 Reform Movement] (Shanghai, 1953), iv, p. 172.

[204] Ji Hongkun, p. 319. Yulu nevertheless wrote glowingly of Xu Jianyin's extraordinary prowess in technical matters. See Yulu's memorials dated Guangxu 22.9.13 (19 October 1896) in Li Yushu 李毓澍 ed. *Chuanzheng zouyi huibian* 船政奏議彙編 [A collection of memorials on shipbuilding] (1888; reprinted Taibei 1968), v, 47.6a (p. 2345) and 47.7a–7b (pp. 2347–8).

Xu Jianyin, like Liang Qichao saw translation as a priority in overcoming China's backwardness, and in 1897 he and the translator Yan Fu 嚴復 (1853–1921)[205] wrote to Liang's newspaper *Shiwubao* 時務報 [*The Chinese Progress*],[206] complaining of the urgent need to develop the translation programme which had until then only scratched the surface (*pimao* 皮毛, literally "skin and feathers") of Western studies. Within a year Xu was in the capital, at the vanguard of the reform movement.

During the hectic period of the Hundred Days' Reform, he was sent by Kang Youwei, Head of the Board of Works (*Gongbu* 工部), to the short-lived *Jingshi nong-gong-shang zongju* 京師農工商總局 [Central Bureau for Agricultural, Industrial and Commercial Affairs in Beijing].[207]

After the Reform Movement collapsed and the Dowager Empress resumed power, Xu Jianyin went back to Wuxi to sweep his parents' graves. Such were his rare gifts however that in 1900 he was once again invited by Li Hongzhang's rival Self-Strengthener, Zhang Zhidong, to take charge of the Hanyang Steel and Gunpowder Factory. This was during the time of the Boxer Rebellion, when the Western powers were refusing to sell munitions to the Chinese, and many foreign workers were withdrawn from China, so it was with a sense of urgency that Xu Jianyin set to work to make smokeless gunpowder to break the foreign embargo.

Making smokeless gunpowder[208]

There were three types of gunpowder being manufactured in China at the turn of the century: the traditional black variety (*hei huoyao* 黑火藥), which was of course a Chinese invention, with a saltpetre:sulphur:charcoal ratio of 75:10:15; brown or prismatic gunpowder (*lise huoyao* 栗色火藥) with a composition ratio of 80:4:6; and smokeless gunpowder (*wuyan huoyao* 無烟火藥) or nitrocellulose.[209]

The ingredients of smokeless gunpowder were: nitrocellulose (guncotton) 40 parts; ethanol 30 parts; diethyl ether 30 parts; ethanone (acetone) 3 parts; pine resin 5 parts; camphor 10 parts; castor oil 5 parts; and white wax 2 parts.

The cotton was first washed with sodium carbonate, water and steam, changing the water eight times, to remove grease. Then it was sent to the *simianshafang* 撕棉紗房 [cotton shredding chamber] and baked dry. Here a machine pulled it into

[205] Yan Fu was a graduate of the Fuzhou Navy Yard who studied in Europe and made a number of influential translations, including that of Thomas Huxley's *Evolution and Ethics*, which introduced Darwin's ideas to a Chinese readership. See A. Hummel, *Eminent Chinese of the Ch'ing Period*, pp. 643–4.

[206] See also Shen Wenzhuo 沈文倬, "Qingdai xuezhe de shujian" 清代学者的书简 [Correspondence of Qing scholars], in *Wenwu* 文物 (1961), issue 10, p. 65.

[207] See Kang Youwei's memorial dated Guangxu 24.7.5 (21 August 1898) in *Yuzhe huicun* 諭折彙存 [A collection of imperial edicts and memorials] (1898–1903; reprinted Taibei, 1967); the order from the Zongli Yanmen to Xu Jianyin to go to Beijing "without delay" dated Guangxu 24.7.7 (23 August 1898) in *Chuanzheng zouyi huicun*, v, 51.4a (p. 2573); *Da Qing lichao shilu* 大清歷朝實錄 423.3a–4a; and Zhang Zigao and Yang Gen, "Xu Shou fu-zi nianpu", pp. 314–5.

[208] See Xu Jianyin, *Ouyou zalu*, pp. 16b–17a, for an account of a German smokeless gunpowder factory, in which, ironically, he notes that the most hazardous stage in the process is the compression of the gunpowder. See *Gezhi huibian* 4, 1 (1881), pp. 11a–14a and 4, 2 (1881), pp. 10a–11b for articles on gunpowder manufacturing equipment and *Gezhi huibian*, 5, 3 (1890), p. 49b for a short article (perhaps by Xu Jianyin) on smokeless gunpowder. See also James Reardon-Anderson, *The Study of Change*, pp. 153–6 for an account of Xu Jianyin's work on smokeless gunpowder.

[209] Ji Hongkun, p. 323.

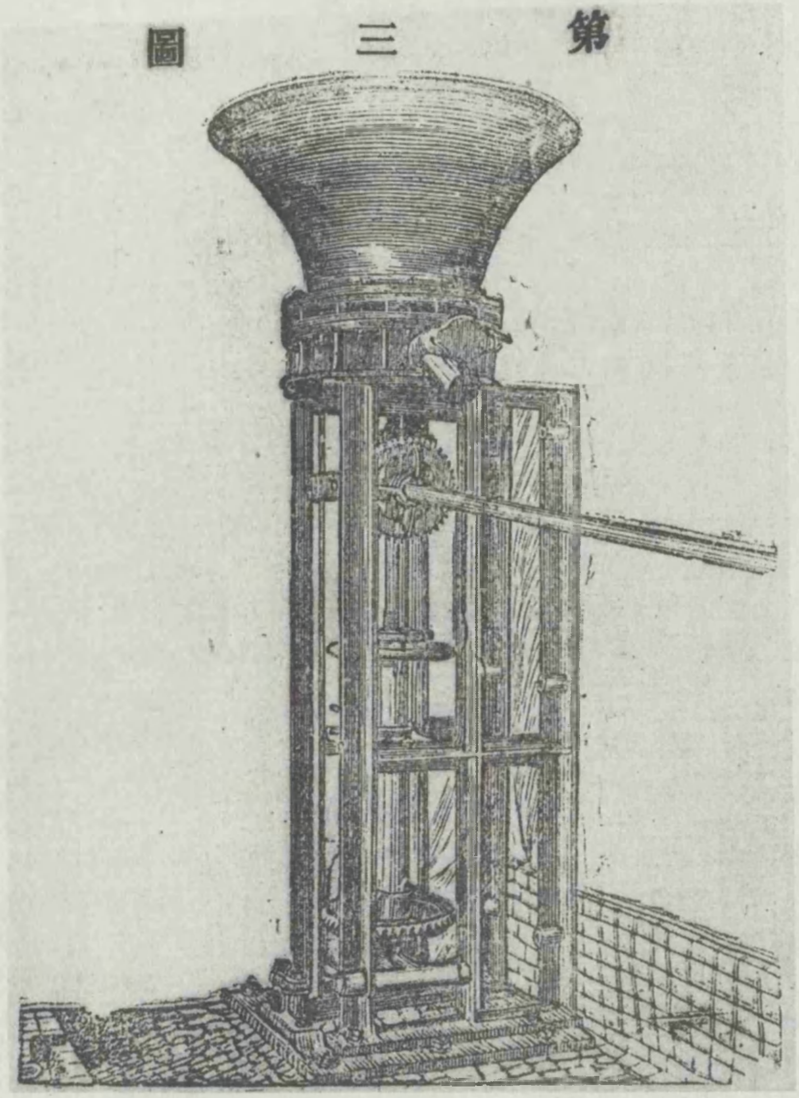


Fig. 8. Gunpowder manufacturing equipment illustrated in *Gezhi huibian* 4, 1 (February, 1881) (reproduced by kind permission of the British Library).

shreds twice (to increase its surface area) and it was then sent to the *hongmianliaofang* 烘棉料房 [cotton baking chamber] where again it was baked dry. From here it was sent to the *lanmianyaofang* 爛棉藥房 [nitrocellulose pulping chamber] where it was soaked in a mixture of concentrated nitric and sulphuric acids for 30 minutes (thus making the active ingredient of the explosive, nitrocellulose), removed, and the acid filtered off. The material was then soaked in clean water for 14 minutes, changing the water several times. It was then washed with steam and sodium carbonate for 24 minutes, changing the water 8 times. It was then filtered again, and sent to the *momianyaofang* 磨棉藥房 [grinding chamber]. Here it was mixed with water and ground to a uniform pulp for 20 minutes, and sent to the *piaoyaofang* 漂藥房 [washing chamber]. Here it was mixed with water, bleached and sprayed with clean water for 28 minutes, and then tested to make sure all the acid had gone. It was then filtered and sent to the *hongmianyaofang* 烘棉藥房 [nitrocellulose baking chamber] where it was baked dry for 94 minutes: it was now guncotton. The dry guncotton was sent to the *banyaofang* 拌藥房 [mixing chamber] where it was mixed (with the other ingredients mentioned above) for 3 minutes and put in casks. The only difference between the rifle and gun guncotton was in the size of the grains used: the method of mixing was identical. Finally it was sent to the *yayaofang* 軋藥房 [compression chamber] where it was moulded into lumps of various sizes, cut up, dried, coated with wax and wrapped.[210]

According to Zhang Zhidong,[211] the Hanyang plant had been built by foreign workers and was designed to minimise the risk of explosion.[212] The most dangerous phase of the process took place in the three southern chambers, where the nitrocellulose was cut, dried and packed, and that is why they were designed with passageways between them so that any explosion would be limited in extent. It was inside the westernmost chamber that Xu Jianyin was working, when workers outside the building made the machine he was using run too fast,[213] so that a spark flew and caused a terrible explosion, killing Xu Jianyin and 15 other people, the force of the explosion being so great that his boot was found 100 metres away, and nothing remained of his body.[214]

There is a claim by Ji Hongkun 季鴻崑 that Xu Jianyin's death was not accidental but a result of sabotage: the previous director, a man called Liu 劉, had been dismissed in favour of Xu Jianyin, and may have caused the explosion in revenge; there is even a suggestion that Xu Jianyin may have been the victim of murderous rivalry between Li Hongzhang and Zhang Zhidong.[215]

Zhang wrote with what seems to be genuine grief at Xu Jianyin's death, saying that he was an irreplaceable colleague, and that all China would mourn his loss.[216] Thoroughly conversant with the principles and practice of modern technology, men such as Xu Jianyin were extraordinarily rare at this time in China when, as one contemporary director of such factories observed, for most official superintendents of these factories

> arithmetic is a closed book; if you give them a mineral, they cannot identify it; if you ask them about some ingenious device, they cannot [even] name it. Nor do their efforts extend to making skimping work and filching materials unusual. And, as for whether the machines are any use, they [just] have to listen to the workmen's advice, as they have not the least idea themselves how to discriminate the good from the bad.[217]

[210] Ji Hongkun, p. 330.

[211] Zhang Zhidong, *Zhang Wenxianggong quanji* 張文襄公全集 (Beiping, 1937), 52.5b–8a.

[212] It was by no means the first smokeless powder plant in China. In 1894 a plant had been built at Longhua 龍華 in Shanghai, supplied by a subsidiary of Krupp's, and the reporter commented prophetically "It is a very open question [...] how dangerous [its] manufacture will be with inexperienced Chinese workmen" (see *North China Herald* (22 June 1894), p. 983).

[213] Zhang Zhidong, 52.6b. The machine was deliberately placed outside the building to avoid an explosion, with its axle piercing the wall.

[214] *Qingshigao*, 13929; *Beizhuan jibu*, 43.18a; Ji Hongkun, p. 334 and Zhang Zhidong, 52.6b.

[215] See Ji Hongkun, p. 334.

[216] Zhang Zhidong, 52.7b.

[217] The writer was Hu Yufen 胡燏棻 (d. 1906), writing in 1895. See Chen Zhen 陳真, *Zhongguo jindai gongyeshi ziliao* 中国近代工业史資料 [Materials on the history of modern Chinese industry] Third collection. Part 1 (Beijing, 1961), pp. 15–16.

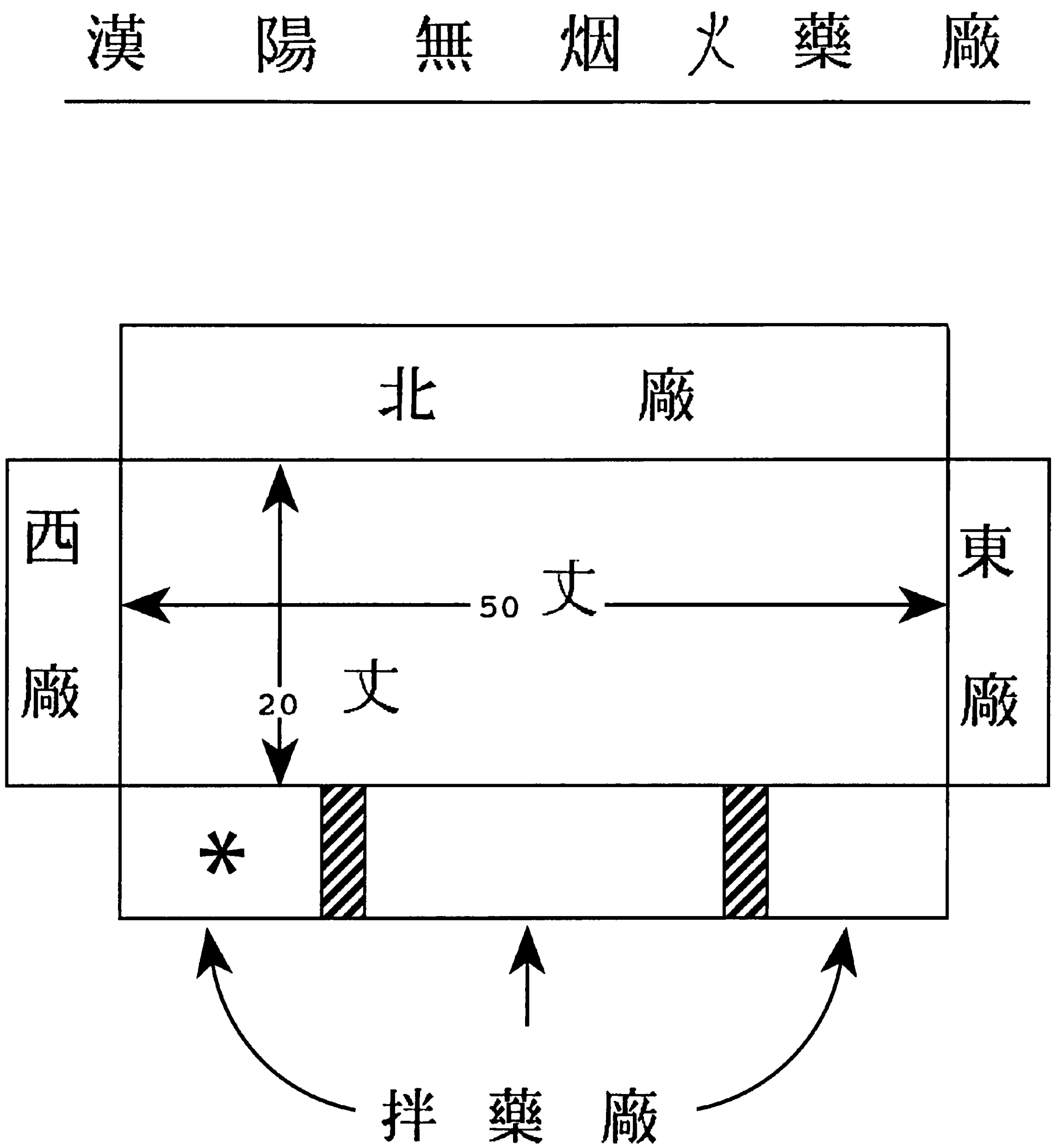


Fig. 9. The Hanyang Smokeless Gunpowder Factory around 1900 (based upon Zhang Zhidong's description in *Zhang Wenxianggong quanji* 52.5b–8a). * indicates where the explosion occurred.

Conclusion: Science as transmission and science as practice

The achievements and influence of this small group of active workers in the field of natural science are out of all proportion to their numbers. With only very limited help from Westerners in China (many of whom, like John Fryer, themselves had only a sketchy knowledge of science), they carried out researches on topics such as acoustics, optics, ballistics, and thermometry which were remarkable for their originality and depth. Their personal influence was rather small – there was no "Wuxi school" – but through their translations they helped to create a climate of opinion in which "science" came to be seen as an indispensable part of progress, even if what "science" meant was rather ill-defined. To understand the complex interplay between the quiet, scholarly world of the *gezhijia*

格致家 [scientists] and late Qing society we need first to examine the milieu in which they arose.

They all came from a wealthy area of the Lower Yangzi valley, long famous for producing talented and unorthodox scholars, a centre for book production noted for its fine libraries. Their education seems to have given them the determination and the intellectual self-confidence to turn to what more ambitious men would have seen as the alien and worthless field of Western studies. They allied themselves with the more progressive of the Self-Strengtheners, first Zeng Guofan and later Li Hongzhang and Zhang Zhidong, but also, more unconventionally, worked closely with the foreign missionaries (amongst whom I would include John Fryer)[218] who were beginning to translate scientific and mathematical works in Shanghai. Their proximity to the most Westernised city in China was a key factor in the development of the Wuxi science community. There they found Westerners who were relatively knowledgeable and enthusiastic about natural science, whose Chinese was good enough to communicate the ideas directly, and who happened to need Chinese collaborators for their own, evangelistic translation programme. Shanghai was also far enough from the capital for them to be able to consort with foreigners without arousing too much suspicion. The missionaries they met were apparently happy to have them as colleagues, even though none of the Chinese appears to have become a Christian.

The time at which they became active was just when the first modern government schools and arsenals were being opened, and they both found careers associated with these new institutions: the Arsenals in Anqing, Nanjing, Shanghai, Tianjin, Shandong and Hanyang; the translation bureaux; and of course the Shanghai Polytechnic.

Their attitude to Western science, although clearly positive, was not uncritical. Once they had access to Western books such as *Bowu xinbian*, they did not merely absorb their contents, but tried to repeat the experiments the books described, and, in doing so made new and unexpected discoveries. Indeed, they may well have felt that their understanding was deeper than that of their Western counterparts. As Li Shanlan is reported to have said about his discovery of a new method for calculating logarithms:

> Although *they* [the Westerners] can just calculate the numbers, yet they are ignorant of the principle.[219]

Whilst unusually open to Western ideas, they do not appear to have seen themselves as outside the mainstream of Chinese culture: on the contrary, as far as it can be discovered, their view of themselves was as reformers and revivers of a long and ancient native tradition of natural philosophy, working with the methods of their predecessors in the *kaozheng* movement.

It is perhaps remarkable how little attached they seem to have been to the traditional concepts of *li*, *qi*, *yin-yang* and *wuxing* and so on. I suggest that this is partly because they

[218] Fryer was a Church Missionary Society educational missionary for his first few years in China, working in schools in Hongkong, Beijing and Shanghai.

[219] Alexander Wylie, *Chinese Researches* (Shanghai, n.p., 1897), p. 193.

did not come from a background in which such concepts had any real meaning or function in everyday discourse, unlike their medical colleagues who were (and still are) in daily touch with a system which uses *qi* as an explanatory and diagnostic tool. Divorced from practice, the traditional concepts had long lost any emotional or even intellectual power, whereas the new concepts of force, energy, acceleration, element and compound, provided them with an explanatory framework which in its rational view of the universe was not at all incompatible with the ethos of traditional Chinese science. *Li*, *qi*, *yin-yang* and *wuxing* were not "refuted" by Western science: they were for the most part ignored as the new ideas poured into China. It is significant that only in the medical field was there any serious attempt, by writers such as Tang Zonghai 唐宗海 (1851–1908) and Zhang Xichun 張錫純 (1860–1933), to make any connection, let alone a compromise, between Western science and traditional Chinese views.[220]

I suggest that these two men did indeed form part of a *scientific community* in Wuxi for a short period (from about 1855 (or slightly earlier) to 1861),[221] after which they moved to Anqing and became involved in the process of shipbuilding, which probably left little time for pure research. The Wuxi period was of great importance, as it shows both the difficulties they were working under and also how well, in some respects, the methods of *kaozheng* scholarship had prepared them to receive Western science, both on a technical level, with its respect for the evidence and attention to detailed observation; and, more broadly, the central *kaozheng* myth of the restoration of lost knowledge gave a moral purpose to their studies which went beyond mere curiosity. The development of this scientific community, whilst apparently spontaneous, benefited from being so close to Shanghai where the new science was being promulgated through Li Shanlan and the learned Protestant missionaries of the Mohai Shuguan, and where not only books but also scientific equipment became available. The relatively peaceful and leisured existence in Wuxi before the arrival of the Taiping rebels allowed Xu Shou and his colleagues the time to experiment and to think, checking the hypotheses and explanations in their foreign textbooks against their own experience. The devastation of the Taiping Rebellion, and the external threats to China of the late nineteenth century, forced them to leave their homes but also indirectly compelled them to become involved in the applications of science in military technology. They thus became, in a pattern familiar in the modern world, scientists who owed their living to military research, which took as its primary aim improvements in the armaments and armoured vessels which China needed to defend itself.

[220] Tang Zonghai argued in *Zhong-Xi huitong yijing jingyi* 中西匯通醫經精義 [The essential meaning of the medical classics in the light of Chinese–Western eclecticism] (1892) that Western medicine was inferior to Chinese but that it could be used as a supplement, and thus help to purify and revive a lost tradition. Zhang Xichun believed that in fact the two traditions are identical. See Zhao Hongjun 赵洪钧, "Chinese versus Western medicine: a history of their relations in the twentieth century", tr. Nathan Sivin, *Chinese Science*, x (1991), pp. 21–37.

[221] See David C. Reynolds, "Redrawing China's intellectual map: images of science in nineteenth-century China', *Late Imperial China*, XII 1 (June 1991), pp. 26–61. Reynolds argues that the nineteenth-century Chinese distanced science from traditional categories of thought, and were impeded from developing institutions partly because of the kind of science they were presented with by Westerners – science as a given, which had to be absorbed, memorised and diffused – a form of secular gospel.

As they began working in Anqing, and even more at the Jiangnan Arsenal, the purely scientific aspect of their work seems to have faded away as they became increasingly involved in solving practical problems and in the exhausting and often uncreative process of translation. The faithful translations they generated must nevertheless have given them what was at that time in China an unrivalled understanding of the science of the day, yet they had little opportunity to transmit their knowledge directly. The universities where they could have trained the next generation of Chinese scientists had not been built, and the few institutions teaching science (such as the Tongwenguan) were staffed mainly by foreigners. Expertise in science became associated with foreign study: by the end of the century thousands of Chinese students were being sent abroad, mainly to Japan, to receive their science education. There was in short little encouragement in China itself for those Chinese who had already taught themselves science: they were soon to be overtaken in their career paths by *liuxuesheng* 留學生 [students studying abroad] who had learnt their science in Tokyo, Paris, Edinburgh or London rather than the Shanghai Polytechnic.

This had a serious effect on the future of China's science, as the scientific work they did in Wuxi was not only *real* science (that is, a cumulative growth of knowledge and understanding firmly based on interactive experience),[222] but in many ways was *more* real than the science called "useful knowledge" which John Fryer and missionary organisations such as the Society for the Diffusion of Useful Knowledge, were promoting. For the "diffusion of science" as they conceived it required its recipients to be passive onlookers. It is perhaps not entirely coincidental that this intellectual passivity was a reflection of the political passivity on which the Western powers were counting in their dealings with China.

The model of science which the foreigners brought to China was, as David C. Reynolds has hinted, that of a *secular gospel*,[223] as an accumulation of dead knowledge which has to be learned, assimilated, displayed and then diffused, rather than a lively, uncertain and participatory, practical process of learning and discovery. In this sense the work Xu Shou and his colleagues carried out in Wuxi was far in advance of the approach of their Western missionary colleagues, and it was tragic that their original scientific researches were cut short by the demand for new technology.

It may well be that the musty, rather authoritarian ethos surrounding the nineteenth-century transmission of Western science, was one of the reasons why it for so long lacked appeal to the Chinese, and it was only when it became possible for people to see experiments themselves – whether at the Shanghai Polytechnic evening classes in the 1890s, or as students in the Tongwenguan or Calvin Mateer's Dengzhou College – that science as an activity rather than a book-subject began to be attractive.

The intrinsic originality of the work of the Wuxi group should not conceal the fact that these early modern Chinese scientists were very few in number, and however brilliantly

[222] I mean by "interactive experience" that the act of doing an experiment or carrying out an observation leads the experimenter to ask more questions and to form more hypotheses, rather than simply to watch.

[223] See David C. Reynolds, "Redrawing China's intellectual map: images of science in nineteenth-century China", p. 32. Indeed, a contemporary newspaper called Fryer and his colleagues "secular missionaries" (see *North China Herald* (26 Dec. 1872), pp. 548–9.

they mastered the new technologies it was impossible for them to do more than slow the relative weakening of China's military capability in the face of increasingly insolent and well-armed Western aggression. If anything, in the short term the development of an interest in Western science actually undermined China's ability to resist Western advances, as China came to rely for several decades on Western teachers (or on Chinese students travelling abroad) and Western technology, and this made China more rather than less dependent on the West. Science as practised in China became involved with the solution of short-term problems such as acid and gunpowder manufacture, less concerned with the nature of the world than a means to an end.

The scientific community in Wuxi, which built on the earlier *kaozheng* scholarly networks, seems in retrospect a brilliant episode, a false dawn or intellectual stillbirth which was prevented by a variety of historical factors from leading to a full renaissance of the native tradition of science in China.[224] Sidetracked by the desperate military needs of the time, native scientific originality had no choice but to give way to the desperate need to develop indigenous versions of foreign technology. A China-based military-industrial technology was the pressing need: a permanent *scientific* community, which could afford the time to follow wherever intellectual curiosity would lead, was for China a luxury which would have to wait.

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[224] See Jonathan Porter, "The scientific community in early modern China", *ISIS*, LXXIII, 269 (1982), pp. 529–44.

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References and notes should be typed in the form of the following examples:

1. G. H. Luce, *Phases of pre-Pagán Burma: Languages and History* (Oxford, 1985), i, pp. 171–8.
2. *Ibid.*, p. 30.
3. C. E. Bosworth, "Ghaznevid military organisation", *Der Islam*, XXXVI (1960), pp. 40–50.
4. M. Sharon, "The Ayyubid walls of Jerusalem", in *Studies in Memory of Gaston Wiet*, ed. M. Rosen-Ayalon (Jerusalem, 1977), pp. 179–95.
5. B. Z. Kedar (ed.), *Jerusalem in the Middle Ages* (Jerusalem, 1979), p. 122.

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TAN SITONG AND THE ETHER RECONSIDERED

By David Wright
School of Oriental and African Studies, London

Preamble

The main subject of this paper is the influence of Western science on the philosophy of the young scholar Tan Sitong 譚嗣同 (1865–98) who was active in the reform movement of the late Qing dynasty. It seeks to show that his understanding of Western science was not as confused and superficial as some commentators have claimed,[1] and that in fact his conception of *yitai* 以太 drew on views of the ether and electricity which were held by some at least of the most eminent Western scientists of his time. It also demonstrates that *yitai* is the direct descendant of the *qi* 氣 of the Neo-Confucian philosopher Zhang Zai 張載 (1020–77), and shows how Tan developed the views of Kang Youwei 康有為 (1858–1927) on the relationship of *qi* to consciousness.

Introduction

The late nineteenth century was a period during which Western influence on China grew rapidly, especially in the coastal cities such as Shanghai and Guangzhou (Canton), as a result of contacts between Chinese people and foreign soldiers, traders, diplomats and missionaries. For most ambitious young scholars the traditional route via the 'examination hell' still remained the principal way to high office and worldly success, but some, especially those who had failed to achieve the highest grades, began to be attracted by the new field of 'Western studies', either for the opportunities of employment it might offer or as a source of inspiration for the solution of the problems which China was facing. Missionary translators, teachers and writers including W. A. P. Martin (1827–1916), John Fryer (1839–1928), Young J. Allen (1836–1907) and Calvin Mateer (1836–1908) with their Chinese colleagues such as Li Shanlan 李善蘭 (1811–82), Xu Shou 徐壽 (1818–84), Hua Hengfang 華蘅芳 (1833–1902) and Xu Jianyin 徐建寅 (1845–1901) produced a stream of texts in Chinese, both translations and compilations, and by the 1890s the ideas they contained on science, law, geography and religion were beginning to affect the thinking of a group of radical reformers which included Kang Youwei, Liang Qichao 梁啟超 (1873–1929) and Tan Sitong. Of these it was Tan Sitong who was most deeply influenced by the concepts of modern science, an influence which has sometimes been seen as based upon misunderstandings, but which this paper will seek to show reveals Tan as having a profound and highly perceptive insight into certain key concerns of late nineteenth-century Western science and their relation to the Chinese concepts of *ren* 仁 and *qi* 氣.

Tan's early life

Tan Sitong was one of the most brilliant young scholar-reformers of the late nineteenth century, an eclectic who hoped to create a new system out of Confucian, Buddhist and Western ideas. He was beheaded in the aftermath of

[1] Both Western and Chinese commentators have suggested that Tan had a distorted understanding of late nineteenth-century science, particularly in respect of his concept of the ether. See Nathan Talbott, 'T'an Ssu-t'ung and the ether', in Robert K. Sakai (ed.), *Studies on Asia* (Nebraska: University of Nebraska, 1960), 20–34 and Xu Yijun 徐義君, *Tan Sitong sixiang yanjiu* 譚嗣同 思想研究 (Researches on the thought of Tan Sitong), (Changsha: Hunan Renmin Chubanshe, 1981), ch. 4.

the abortive Hundred Days' Reform Movement of 1898, and for that reason is regarded as a heroic figure by both Nationalist and Communist historians.

The son of a high official, born in the Xuanwu 宣武 district of Beijing, he had a sickly childhood, narrowly escaping death from diphtheria.[2] His mother and two sisters died in the same epidemic, and he went to Liuyang 瀏陽 in Hunan Province, his father's family home, to escape the danger; thereafter he had a unhappy home life,[3] which may account for some of the vehemence of his attacks on traditional Chinese 'family values'.[4] He travelled with his father to Lanzhou in Gansu Province,[5] and spent several years plying between Gansu and Liuyang. He failed the official examinations five times, later going to Xinjiang to serve the governor there and travelling all over China looking at inscriptions, investigating local customs and talking to like-minded young people. He wrote many poems, essays, letters and biographies in this period, as well as becoming an accomplished swordsman.[6]

By 1895 he was, according to his contemporary Liang Qichao, a devoted follower of Jesus,[7] but in his masterpiece *Renxue* 仁學 (An exposition of benevolence)[8] he made it clear that he regarded Buddhism[9] and Confucianism as superior to Christianity;[10] nevertheless, his willingness even to consider Christianity worthy of study marks Tan as unusually liberal among Chinese scholars of his time.[11]

His mature philosophy developed in the 1890s, out of his reading of New Text Confucianism, Buddhist texts and Western books in translation. His greatest contemporary influence was perhaps the reformer Kang Youwei, but the ideas he absorbed from the Jiangnan Arsenal translations of Xu Shou, John Fryer and others led him to believe that Western science was quite compatible with (and did indeed corroborate) the Buddhist and Confucian aspects of his thinking. A key concept in the *Renxue* was *yitai* 以太 'ether' which seems to have been a development of the traditional Chinese concept of 氣 *qi*. Like *qi*, *yitai* is not ethically neutral; for Tan, *yitai* is the vector of ethical values as well as the primary physical substance, and it is this refusal to separate the physical and the spiritual realms which makes his system so interesting and significant in the history of the interaction of Chinese and

[2] See Yang Tingfu 楊廷福, *Tan Sitong nianpu* 譚嗣同年譜 (Biography of Tan Sitong), [hereafter *TSTNP*], (Beijing: Renmin Chubanshe, 1957), 31. His father gave him the style Fusheng 復生 'returned to life' because of his recovery.

[3] *TSTNP*, 31.

[4] See *Tan Sitong Quanji* 譚嗣同全集 (The collected works of Tan Sitong), (Beijing: Zhonghua Shuju, 1981) [hereafter *TSTQJ*], 348 in which Tan speaks of the inhumanity of much of family life, and specifically mentions the behaviour of stepmothers towards the children of their predecessors. See Chan Sin-wai, *An exposition of benevolence* [hereafter *AEOB*], (Hong Kong: Hong Kong University Press, 1984), 174. English translations of *Renxue* are from *AEOB* unless otherwise indicated.

[5] *TSTNP*, 35.

[6] See Oka Takashi 'The philosophy of T'an Ssu-t'ung' in *Papers on China*, 9 (August 1955), 3; *TSTNP*, 32; and Luke S. Kwong 'Reflections on an aspect of modern China in transition: T'an Ssu-t'ung (1865–1898) as a reformer', in Paul A. Cohen and John E. Schrecker (ed.), *Reform in nineteenth-century China* (Cambridge, MA: East Asian Research Center, 1976), 186.

[7] See Oka, 4.

[8] In *TSTQJ*, 289–375.

[9] See Chan Sin-wai, *Buddhism in Late Ch'ing political thought* (Hong Kong: Chinese University Press, 1985), especially ch. iii, for an excellent account of the Buddhist revival in the late nineteenth century and its influence on Tan.

[10] Oka, 19. In his introduction, Tan says 'Buddhism is greater than Confucianism and Christianity' *TSTQJ*, 289.

[11] Tan speculated on the possibility of a synthesis of all the world's religions, noting the spread of Buddhism to the West, and the interest missionaries such as Timothy Light and Alexander Williamson had shown in Buddhism. See *TSTQJ*, 464.

foreign ideas.[12] Up until the writings of Tan Sitong there is little evidence of Western science being taken seriously by Chinese intellectuals as having anything important to say about the way in which the world should be apprehended. The guns and steamships which so alarmed the Self-strengtheners carried no philosophical, let alone ethical, message, only pointing to the need for China to invest in an arms race before it was totally overwhelmed by Western technical superiority. Those Chinese scholars who had begun a serious study of Western science were on the whole absorbed in 'Western studies' for the sake of their practical applications, with little interest in reconciling the Chinese and Western philosophical viewpoints.[13] It is only with Tan that there begins to be a real appreciation of how these ideas might be integrated into a new world-view which did not require a complete break with the Chinese past.

This paper will discuss (1) what Tan's ideas were, (2) the Chinese and Western sources of his thinking, (3) the extent to which Tan was successful in his synthesis, and (4) the significance of Tan's ideas for later generations of thinkers, reformers and revolutionaries.

The ether of Tan Sitong

Tan introduced the concept of *yitai* both in a short article *Yitai shuo* 以太說 (On the ether)[14] published in 1898 and in his major work *Renxue* 仁學[15] which first appeared in 1897[16] and which is as remarkable for its borrowings from Buddhist cosmology as its incorporation of Western science. One can see three great traditions, Indian, Chinese and European in a somewhat uneasy confluence, and sense his intellectual excitement as he discovers their mutual resonances. He says:

> Throughout the realms of physical phenomena *fajie* 法界, empty space *xukongjie* 虛空界 and sentient beings *zhongshengjie* 眾生界,[17] there is something extremely great and supremely subtle which adheres to everything, penetrates everywhere and connects everything, so that everything is permeated by it. It has no visible form, no sound, no smell or taste. It has no name but we call it the ether (*yitai* 以太).[18] As a practical concept, Confucius variously referred to it as loving kindness *ren* 仁, as the origin *yuan* 元 or as the nature *xing* 性. Mo Zi referred to it as universal love *jian'ai* 兼愛. The Buddha referred to it as the Buddha-Nature *xinghai* 性海, and as compassion and mercy *cibei* 慈悲. Jesus referred to it as [the Holy] Spirit *linghun* 靈魂 and as loving others as oneself and regarding one's

[12] Tan's interest in the ether has been commented on in Fung Yu-lan (tr. Derk Bodde), *History of Chinese philosophy* (Princeton: Princeton University Press, 1953), 692–4, in Nathan Talbott's monograph 'T'an Ssu-t'ung and the ether' (see n. 1), in Richard H. Shek, 'Some Western influences on T'an Ssu-t'ung's thought', in Paul A. Cohen and John E. Schrecker (ed.), *Reform in nineteenth-century China* (Harvard: East Asian Research Center, 1976), Oka Takashi 'The philosophy of T'an Ssu-t'ung' (see n. 6), and Xu Yijun, *Tan Sitong sixiang yanjiu* (Changsha: Hunan Renmin Chubanshe, 1981).

[13] The translator Xu Shou for example apparently rejected the traditional Chinese conceptions of *wu xing* 五行 and *yin-yang* 陰陽 out of hand as superstitions. See Cheng Peifang 程培芳, '*Xu Xuecun xiansheng zhuan*' 徐雪村先生傳 (A biography of Mr. Xu Xuecun [=Xu Shou]) in Min Erchang 閔爾昌 ed. *Beizhuan jibu* 碑傳集補 (Supplementary collection of stele biographies), (Beiping: Yanjing University, 1932), 43. 15b–16a.

[14] See *TSTQJ*, 432–4.

[15] References to the Chinese text are all to the version in *Tan Sitong quanji* (see n. 8).

[16] See Xu Yijun, 171.

[17] These are Buddhist terms: the realm of physical phenomena is the *dharma-dhātu*; the realm of empty space the *ākāśa-dhātu*; and the realm of sentient beings the *sattva-dhātu*. (See Fung Yu-lan, vol. 2, 693).

[18] As Derk Bodde points out, this negative definition echoes the description of the Dao given in chapter 25 of the *Daodejing* 道德經 (The Way and its Power). See Fung Yu-lan, 693.

enemies as if they were friends. The scientists[19] refer to it as the power of [chemical] affinity *aili* 愛力[20] and gravitational attraction *xili* 吸力.[21] It is all these different things, and through it the realm of physical phenomena comes to be, that of empty space is established, and that of sentient beings issues forth.[22] There is nothing closer to us than our bodies, within which we have over two hundred bones, muscles, blood vessels and viscera; that which forms them, adheres to them and causes them not to fall asunder is *yitai*. On the one hand there are husbands and wives, fathers and sons, elder and younger brothers, princes, ministers, friends and acquaintances;[23] on the other hand there is the family, the nation, the world, and that which knits them all together is *yitai*. The body comprises the eye, ear, nose, tongue and the trunk and limbs. How is it possible for the eye to see, the ear to hear, the nose to smell, the tongue to taste, and the body to touch? It is the *yitai*. There is nothing closer to the body than the earth, and the earth is made of an agglomeration of atoms (*zhidian* 質點[24]). What is it that makes them able to adhere to one another? It is *yitai*. If atoms are further divided, until nothing remains, so as to observe from what substance they are congealed, it is *yitai*.[25]

This remarkable passage shows the astonishing audacity which Tan brings to his task: there is no evidence that Confucius, Mo Zi, the Buddha or Jesus ever thought or spoke of the subjects of their respective teachings as *substances* coursing through the cosmos. It is Tan himself who develops the idea of the ethical, ethereal fluid *yitai* in order to bring these very different concepts into a unified materialistic framework.[26]

He goes on to say that the ether is the 'origin of the elements'[27] that is, the primary substance of which all the chemical elements are built. The ether is thus the basis of all chemistry, as all the myriad forms of elements, compounds and mixtures are in fact merely different forms of the same ether.

The Buddhist doctrine of *śūnya* (Ch. *kong* 空 'emptiness')[28] seems to be echoed in Tan's belief that the perceived world is only apparently made of discrete, distinct entities (stones, plants, animals, human beings): in fact there are no differences, and everything interpenetrates everything else.[29] The appar-

[19] The term for 'scientist' which Tan used was *gezhijia* 格致家, now replaced by *kexuejia* 科學家.

[20] *AEOB*, 67. Chan Sin-wai translates *aili* as 'centripetal force' but it seems that it is chemical attraction being alluded to here. See John Fryer and Xu Shou 徐壽, transl. *Huaxue jianyuan* 化學鑒原 (Shanghai: *Jiangnan Arsenal*, 1872), 1.3b.4.

[21] *Xili* 吸力 is given by W. A. P. Martin in Justus Doolittle, *Vocabulary and handbook of the Chinese language* (Fuzhou: Rozario, Marcal & Co., 1872), 309, as meaning 'gravitational attraction'.

[22] Translated in Fung Yu-lan, vol. 2, 693.

[23] These are the people who comprise the Five Cardinal Relationships which Confucius said were the basis of society.

[24] The term *zhidian* 質點 is used by Fryer and Xu Shou in *Huaxue Jianyuan*.

[25] *TSTQJ*, 293–4. Translation based upon that in *AEOB*, 67.

[26] Although *yitai* has its origins in a materialistic view of the universe, Tan's materialism is of a somewhat eccentric type. He seems at times to be using the least substantial of all materials, the ether, as a means of subverting the crudely materialistic views of Western scientists.

[27] *TSTQJ*, 306 (*AEOB*, 89. Chan translates this phrase *yuanzhi zhi yuan* 原質之原 as 'element of elements', but there seems no reason to render the second *yuan* as 'element').

[28] See Richard Robinson, *Early Mādhyamika in India and China* (Madison, Milwaukee: University of Wisconsin Press, 1967), 55 and *passim*.

[29] This interpenetration is emphasized by the *Huayan-Sūtra*, cited by Tan as one of his sources. The Sogdian monk Fa Zang 法藏 (643–712) wrote the *Essay on the Golden Lion* expounding the ideas of the *Huayan-Sūtra* in which he uses the analogy of Indra's net. 'Each loop of this net is decorated with a jewel, in such a way that each jewel not only reflects the image of every other jewel, but also the multiple images reflected in each of the other jewels' (Fung Yu-lan, vol. 2, 353).

ent 'self' is actually no more than a temporary configuration of *yitai*, a snapshot of existence beneath which nothing is constant or unchanging as blood cells are born and die, and as gases are inhaled and exhaled, and sensations arise and decay.

Tan hints that ether, electricity and consciousness are closely related phenomena:

> The ether functions in its most spiritual and subtle aspect when it constitutes the brain in the human body ... it is the electricity in the atmosphere for there is no object it does not permeate ... it is the power of electricity that unites Heaven, Earth, the myriad creatures, the self and other men into a single organism.[30]

Tan regards *yitai* as the undifferentiated, primal stuff from which all things are made:

> Someone might object, saying 'Plants, trees, metals and stones are extremely lacking in intelligence and yet are different in their natures [in respect of] cold and heat; birds, beasts, fishes and turtles are extremely stupid yet differ in their natures [in respect of] water and land. You say that human beings lack an [innate] nature: can this really be so?'
>
> I say that, when I speak of the origin of things, they really do lack an [innate] nature: that is obvious. For, if one considers the differences between animals and plants, is it really true that they have their own natures? Or is it just that their constituent atoms differ in their[31] spatial arrangement and relative proportions?[32] For all the atoms derive from sixty-four elements, and the nature of the substance arises from the combination of one element with another. If a compound is analysed and one element is combined with another one, or if the [proportion] of one atom is increased or decreased then a substance with a new nature is produced. Even if equal numbers of two elements are combined, depending on the extent to which one element dominates the other, substances of different natures are generated. Such changes are so complex that it is impossible to record them all here. Even if you gathered together tens of millions of graduates to devote themselves to the study of chemistry they would not be able to unravel its threads and explain its mysteries, and that is why there has never been an increase or decrease in the elements. It would appear that fragrant and rank [substances] each have their own natures, but if the reason for the fragrance or rankness is investigated it is found that it also is to do with slight differences in the arrangements of atoms, so that when they impinge upon the nerves of the nose they [produce] differences in the ebb and flow [of the nervous impulses], and of the resistance and conductivity of the nerves, so that they are thus perceived as fragrant or rank. If by some means the aggregation of the atoms is changed, the fragrant may actually change places with the rank. This is the shallowest of the chemist's arts: far more difficult [operations] can be performed. ... The remaining differences between the sixty-four elements relate to the origin of the elements, which is none other than the ether. It is unborn, so cannot be said to exist; it is undestroyed, so

[30] Translation from Fung Yu-lan, vol. 2, 693–4.

[31] The character *wu* 無 'not' should be emended to *qi* 其 'its'.

[32] Tan uses the term *fenji* 分劑 meaning 'chemical equivalents', employed in *Huaxue jianyuan*. See n. 20.

cannot be said not to exist. It may be said that ether has a nature; it may also be said that it has no nature.[33]

The non-existence of separate 'things' is also for Tan part of his argument for reform. The interconnectedness of sentient beings for him implies a compassionate political system which will allow *ren* to operate without hindrance:

> When rulers are deposed there will then be equality between the higher and the lower; when universal principles are followed, there will then be equality between the rich and the poor. For thousands and thousands of miles, the entire world will be like one family, one man.[34]

Having given a rather materialistic account of *yitai* in the early chapters of *Renxue*, in Section 26 he states unequivocally that *yitai* is part of consciousness, and that it may even be said that ether does not exist at all.[35]

Yitai is thus a manifestation of the consciousness of the entire universe, connecting the physical, mental and spiritual realms in and through *ren*.

The philosophy of Tan Sitong

The main concepts employed in *Renxue* are: (1) *yitai* 以太 'ether', (2) *tong* 通 'mutuality' or 'perfect intercommunication',[36] (3) *ren* 仁 'benevolence', and (4) *xinli* 心力 'mental power'.

Of these, 'ether' and 'benevolence' seem often to be interchangeable, for despite his enthusiasm for Western science it was not its materialism which appealed to him. For Tan, it was the ether with its mysterious qualities and omnipresence which was of real importance, as it allowed him to posit the universality of benevolence despite all appearances to the contrary.

Tong 通 'mutuality' was according to Tan the key property[37] of the phenomenon of benevolence, spreading out like a ripple across the surface of a lake.[38] The 'something' which was transmitted was 'benevolence': Tan saw benevolence as flowing between sentient beings, whilst 'mutuality' was the means by which it was transmitted. The source and receiver were both in a relationship of communication; it was not a matter of an active source and a passive receiver. The ether was the both the receptacle of the process, and an active participant in it, and could therefore be said to be positively good rather than (like an electric wire transmitting a telegram) indifferent to the ethical quality of the messages it carried. Just as two waves on the water surface can pass through one another without hindrance, the non-obstruction or complete interconnectedness of all things was ensured as their mutual *ren* or benevolent attraction was transmitted by the all-pervading ether. This total interconnectedness is described in the *Avataṃsaka Sūtra* (which Tan cites as one of his sources) *as shi shi wu ai* 事事無礙 'no obstruction between things'.[39] It is also *tong* which is manifested as equality.[40] It is this equality which, conversely, is mutuality, and mutuality is *ren*.[41]

Ren 仁 'benevolence' was one of the key concepts in Confucius's thought,

[33] *TSTQJ* 306. My translation, based on *AEOB*. This passage is partially translated in Fung Yu-lan, vol. 2, 695, and fully in *AEOB*, 88–9.
[34] *AEOB*, 215–16, from *TSTQJ*, 367.
[35] *TSTQJ*, 331; *AEOB*, 136.
[36] Chan Sin-wai translates *tong* as 'interconnectedness' but I prefer 'mutuality' as it seems to imply a more active relationship than mere connexion.
[37] *TSTQJ*, 291.
[38] ibid., 434. Tan explicitly says here that *yitai* is manifested as waves.
[39] See Francis H. Cook, *Hua-yen Buddhism* (University Park: Pennsylvania University Press, 1977) ch. i.
[40] *TSTQJ*, 291.
[41] ibid., 293.

and continued to preoccupy his followers until the beginning of the present century. The title of Tan's book, *Renxue* 仁學 (literally, 'The study of *ren*') shows that it was also central to Tan's philosophy. It is important to realize that in Chinese *ren* can mean both the noun 'love' or 'benevolence' and the act of loving, and is thus both the loving relationship and the activity which characterizes that relationship.

Xinli 心力 'mental power': according to Tan, all brains are connected via ether, and 'good thoughts have to have a response, like sending a telegram, with no obstruction for 10,000 *li*.'[42] It is this ability of minds to influence one another for good which Tan regards as a manifestation of *ren*, the means by which the power of *ren* can be employed to solve China's intractable moral and political problems, but he is far from being a nationalist in a narrow sense. He was aware that mental power could be abused, and that power in itself would not lead to true success. He argued that it was just as well that China in its current state did not have a powerful army, as it would do more harm than good. China should regard those who have invaded it as friends[43] as they encouraged the Chinese to 'put together all our power to concentrate on the task of self-strengthening.'[44] In the end, the salvation of the world depended on seeing things correctly.

> ... whether or not the world and all sentient beings can be saved depends on how things are perceived by sentient beings.[45]

This characteristically Buddhist emphasis on Right Understanding through the operation of mental power makes Tan's revolutionary programme very different from that of the next generation of political radicals, for whom the problem *was* one of power rather than of thought.

These four concepts are thus for Tan intimately connected, so closely in fact that it serves no purpose to differentiate them too precisely. Each of them is to some extent both a manifestation of, and a medium through which the others can operate, although it is clear that Tan sees *ren* as sovereign, *tong* as its principal property, and *yitai* and *xinli* as the means through which *ren* is made manifest.

Tan's vision was thus apparently materialistic but in the end it took its stand on mental formations: it was consciousness and not the material world which had to be reformed.

Chemical change: the uncreated and the undestroyed

Tan saw *yitai* as the unchanging essence behind all the various external, phenomenal forms of chemical elements and compounds, and relates this to the conservation of mass and indestructibility of chemical atoms in the course of chemical change. He considered the example of water:

> ... if water is heated it gradually dries up; it is not destroyed but transformed into hydrogen and oxygen. If the hydrogen and oxygen gases are collected, their weight is the same as that of the original water. If the heat is removed they will convert back to water, with no diminution or destruction.[46]

[42] Letter to Ouyang Zhonggu, *TSTQJ*, 462.
[43] *TSTQJ*, 344; *AEOB*, 166: 'The invasion of China by the countries in the East and West was actually engendered by heaven, which applied its benevolence in the most subtle manner.'
[44] ibid., 361; *AEOB*, 202.
[45] ibid., 372; *AEOB*, 225.
[46] ibid., 307; *AEOB*, 90. Here Tan's understanding of chemistry is faulty. Water is not decomposed into hydrogen and oxygen by heating under normal conditions, and nor do hydrogen and oxygen combine back into water spontaneously as heat is withdrawn. Tan seems to assume that all such changes are reversible, perhaps because he has no practical experience of doing science himself.

Later in the same passage, he compared the conservation of mass during combustion of a candle with the unborn and the undestroyed.[47] In biochemistry too, the apparent flux of chemical change pointed to a metaphysical unity behind the material, an entity which was uncreated and undestroyed, which was of course *yitai*:

> When blood and breath are functioning, they pass away in no time, not even as long as seconds and instants. It is impossible to point definitely to a certain stream of breath or a certain cycle of blood as the self. The moment we regard the self as being destroyed it is nevertheless born. It can be said that the self is being born and also being destroyed. Thus it is said: the unborn and the undestroyed are simply the same as the born and the destroyed.[48]

This is reminiscent of a passage in Wang Fuzhi's commentary on Zhang Zai's *Zhengmeng* in which Wang says:

> Before birth this *li* 理 [Principle] is in the Great Void, and is the body and nature of Heaven; after born, this *li* is congealed within forms (*xing* 形), and is the nature of human beings; after death, the *qi* of this *li* again returns to the Great Void. Forms may be congealed or dispersed, [but] *qi* [is] neither diminished nor increased, [and] *li* also is not compounded. This is the so-called generality attaching to the *Dao*.[49]

Biology: the richness and complexity of the living world

The richness and teeming complexity of the living world clearly impressed Tan, and one suspects that he had actually looked through a microscope himself when he says:

> Take any object from the natural world, whether a leaf, a speck of dust, the tip of a hair, or a drop of water, and you will see things yet smaller, and these are [in turn] formed by the cohesion of weightless atoms. If a microscope is used to observe them, the markings on the leaf are like mountains and rivers; the rotation of dust particles is like that of little globes; the tip of a hair and a drop of water have myriads of microscopic plants and animals, some rooted, some free-floating, some creeping, flying or wriggling, crawling and sucking. None of these microscopic plants and animals lacks ... yet smaller plants and animals which are parasitic upon them.[50]

It was indeed in his reading of Western science that Tan found exciting corroboration of his views on interconnectedness of all things, and above all in the mysterious substance called ether.

The conception of the ether in Western science

The concept of the subtle fluid called *ether*[51] can be traced back to the Ionian philosophers of the sixth century B.C., who said that 'betweeen the earth and sky was a layer called *aer* αερ, misty air, whilst above this layer is

[47] Letter to Ouyang Zhonggu, *TSTQJ*, 462 and in *Renxue* in *TSTQJ*, 307.
[48] ibid., 315; *AEOB*, 103.
[49] See Wang Fuzhi, *Zhang Zi Zhengmeng zhu* 張子正蒙注 (Notes on Zhang Zai's *Correcting youthful ignorance*), (Beijing: Zhonghua shuju, 1975), 100.
[50] From *Yitai shuo* in *TSTQJ*, 433.
[51] The classic history of ether theories is Sir Edmund Whitttaker, *A history of the theories of aether and electricity* (London: Thomas Newton and Sons, 1951). C. C. Gillispie, *The edge of objectivity: an essay in the history of scientific ideas* (London: Oxford University Press, 1960) also gives an interesting account of the modern history of the ether.

aither αἰθήρ which is shining and fiery, akin to men's souls',[52] and Heraclitus (fl.500 B.C.), too, may have equated fire with *aither*.[53] For Aristotle (384–22 B.C.) *aither* was the fifth element, only capable of change of place, not of quality and quantity like Earth, Air, Fire and Water.[54] Lucretius (99–55 B.C.) said that the heavier atoms eject the lighter, which rise up as fiery *ether*.[55]

In the philosophy of the Stoics, the 'cosmos is filled with an all-pervading substratum called *pneuma*, a term often used synonymously with *air*. A basic function of the *pneuma* is the generation of the coherence of matter and generally the contact between all parts of the cosmos.'[56] Unlike the later 'scientific' versions of the ether, the Stoic *pneuma* had an ethical dimension. Sextus Empiricus said that Empedocles and the Pythagoreans based their belief in the fellowship of men on the all-pervasiveness of the *pneuma*.

> For there is one spirit (*pneuma*) which pervades, like a soul the whole universe, and which also makes us one with them.[57]

The physical state of a highly organized physical body, such as a piece of stone, wood or metal, which exhibits a cohesive wholeness was termed *hexis*. 'The elements of *hexis* are not mere localized units, but physical properties which interpenetrate and create a totality where each of them shares in the existence of the rest.'[58] '... all the qualities which define the physical state of a certain body ... have their origin in common roots and are therefore interdependent and not additive. Every one of them are affected if all or some others change.'[59] *Hexis* thus represents 'the highest type of all possible [inorganic] structures i.e. an entity which exhibits 'communication' between the individual members and the whole.[60]

René Descartes (1596–1650) postulated a plenum in which there were three types of matter, the third type of which formed 'the air, or ether',[61] the planets existing in swirling vortices of the plenum. The ether particles were large and ill-suited to movement, being large and of 'very irregular and branching shapes'.[62] He argued that a vacuum was self-contradictory as it was impossible 'for that which is nothing to possess extension'.[63] The ether itself he seemed to take for granted but assigned it no special role, and it was completely denuded of any spiritual aspect.[64]

Isaac Newton (1642–1727) employed the concept of ether to explain the action of gravity, believing that 'it may suffice to impel bodies from the denser parts of the medium towards the rarer with all that power we call gravity.'[65] This view of ether consisting of mutually repulsive particles, producing effects such as gravity by the 'effect of forces, not of attraction but of repulsion, exerted by the particles of a rarefied medium dispersed unevenly throughout the vacuities in the gravitating bodies themselves and throughout the space

52 G. N. Cantor and M. J. S. Hodge, *Conceptions of ether: studies in the history of ether theories 1740–1900* (Cambridge: Cambridge University Press, 1981), 3.
53 ibid., 3.
54 ibid., 5.
55 ibid., 7.
56 Shmuel Sambursky, *Physics of the Stoics* (London: Hutchinson, 1971), 1.
57 ibid., 2.
58 ibid., 9.
59 ibid., 9.
60 ibid., 81.
61 René Descartes, *Principles of philosophy*, 1644, translated by Valentine Rodger Miller and Reese P. Miller (Dordrecht, Holland: D. Reidel Publishing Company, 1983), 181.
62 ibid., 138.
63 ibid., 47.
64 See Sir Edmund Whittaker, *A history of the theories of aether and electricity*, I, 5.
65 Arnold Thackray, *Atoms and powers* (London: Oxford University Press, 1970), 28, quoting Newton's *Opticks*.

that separates them.'[66] continued to be influential until the early twentieth century, but particularly in the nineteenth century the advent of the wave theory of light and the discovery of the electromagnetic field and the propagation of electromagnetic waves led to theories of the ether being at the centre of the theoretical problems in physics.[67]

The luminiferous ether postulated by Fresnel (1788–1827)[68] and the electrical ether of Faraday (1791–1867)[69] were unified by James Clerk Maxwell (1831–79) as the electromagnetic ether[70] through which the waves of fluctuating electrical and magnetic fields constituting light were transmitted.

By the nineteenth century the physical *ether* was, according to Cantor and Hodge, regarded as having the following properties: (1) spatial and temporal extension, (2) presence in spaces empty of ordinary solids fluids and gases, (3) not perceived as ordinary materials are, (4) able to transmit actions or effects including or like those of magnetism, electricity, heat and nervous impulses, (5) able to penetrate and pass through ordinary solid, fluid and gaseous materials, and (6) able to cause observable changes in ordinary bodies through changes in its distribution.[71] Thomas Young (1773–1829) and Fresnel regarded the ether as an elastic solid, but it was clearly a solid of an extraordinary type, both tenuous and yet able to withstand the enormous forces involved in propagation of light waves; resistant to the rapid motion of light yet allowing the passage of the planets in their orbits. G. G. Stokes (1819–1903) likened it to pitch, brittle when struck with a hammer yet plastic when gentle pressure is applied.[72] The penetrative nature of the scientific ether was correctly perceived by Tan as analogous to his concept of *tong* 通, although *tong* involves ether in the mutual relationship between entities as well as porosity to its flux.

In addition to the above physical properties, there were several attempts to incorporate the ether into chemical theories. Newton himself had regarded the ultimate units of chemistry as undifferentiated atoms. According to Arnold Thackray, in Newtonian atomism 'change of any sort was possible only by the separation, association and motion of the ultimate permanent particles of matter. These ultimate particles of different sizes and shapes were themselves immutable.'[73] These 'ultimate' atoms were not the same as the ether, but the undifferentiated nature of the ether and its all-pervasiveness were clearly hints that there might be some connexion between the two.[74] In the eighteenth century the Scottish chemist and physiologist William Cullen (1710–90) said, 'In all nature there seems to be an elastic repellent fluid which is the cause of the phenomena we observe in nature; more particularly, of the various states of aggregation in different bodies ... The attractive and repellent powers are

[66] G. N. Cantor and M. J. S. Hodge, *Conceptions of ether*, 1.

[67] See Whittaker, *History*, 19 for a concise summary of the role of the Newtonian ether: 'All space is permeated by an elastic medium or *aether*, which is capable of propagating vibrations in the same way as the air propagates the vibrations of sound, but with far greater velocity. This *aether* pervades the pores of all material bodies, and *is the cause of their cohesion*. Its density varies from one place to another, being greatest in the free interplanetary spaces.'

[68] P. M. Harman, *Energy, force and matter: the conceptual development of nineteenth-century physics* (Cambridge: Cambridge University Press, 1982), 21–4. Fresnel proposed an elastic solid ether capable of transmitting the transverse vibrations of light waves.

[69] ibid., 33. Faraday suggested that a 'wave of electricity' passed from the primary to the secondary circuit when the loop was closed, producing a transient electric current.

[70] ibid., 84–98. Maxwell tried to develop a theory of contiguous ether particles which would transmit action in an electromagnetic field. His failed attempts to construct a mechanical model of the ether did not prevent him from deducing his famous set of equations which, amongst other things, predicted the existence of electromagnetic waves which would travel at the speed of light.

[71] Cantor and Hodge, *Conceptions of ether*, 2.

[72] See Whitttaker, *History*, 128.

[73] Thackray, *Atoms and powers*, 25.

[74] ibid., 25.

constantly acting in opposition to each other and yet perhaps depend on the very same aether acting by different circumstances.'[75]

One of the questions which puzzled the nineteenth-century theorists was whether the ether was a perfect, structureless continuum[76] or constructed of minute particles of 'ether atoms'.[77] There were attempts such as that of William Thomson, Lord Kelvin (1824–1907), to treat chemical atoms as discontinuities, such as vortices, in the ether. In 1867 he published the influential paper 'On vortex atoms', in which he envisaged atoms as vortices in a plenum-filling ether.[78] James Clerk Maxwell treated the magnetic field as rotating vortex tubes in the ether, with idle-wheel particles ensuring that the vortices all rotated in the same sense, identifying the idle-wheel particles with electricity.[79] In 1883 Joseph John Thomson (1856–1940) published his 'Treatise on the motion of vortex rings', in which the postulated atoms consisting of interconnected vortex rings in stable structures in an ethereal continuum, a theory which he hoped would lead to a mathematically based, deductive chemistry.[80] James Jeans (1877–1946), the eminent physicist, attempted to explain radioactivity in terms of a 'rearrangement of an ether structure', a process which would 'consist in an increase of material energy at the expense of the destruction of a certain amount of matter'.[81] Even the great Dmitri Mendeleev (1834–1907) himself proposed that the ether was a real gas and placed it in the newly discovered noble gas group of the Periodic Table.[82]

It is no coincidence that several of the physicists most active in developing the theories of the ether were also involved in psychical research (such as J. J. Thomson, Oliver Lodge (1851–1940) and William Crookes (1832–1919)[83]), and the existence of the scientific ether encouraged them in their belief in the essential unity of material and spiritual phenomena.[84]

In *The ether of space*, Lodge stated:

> I am now able to advocate a view of the Ether which makes it uniformly present and all-pervading, but also massive and substantial beyond conception. It is turning out to be by far the most substantial thing—*perhaps the only substantial thing*—in the material universe. [My italics][85]

The hint he gives in the italicized phrase above was made explicit in his

[75] J. R. R. Christie, 'Ether and the science of chemistry 1740–1790', in Cantor and Hodge, 93.

[76] This was the view of Joseph Larmor (1857–1942) who between 1893 and 1897 published a series of papers entitled collectively *Dynamical theory of the electrical and luminiferous medium.* See Harman, 101.

[77] Carl von Nägeli proposed in 1884 a detailed particulate theory of the ether. He speculated that chemical atoms consisted of billions of tiny ether particles or *amers*, of which there were two types, A and B, and three forces, electrical, gravitational and ethereal, the latter being either repulsive or attractive. See Helge Kragh, 'The aether in late nineteenth-century chemistry', in *Ambix*, 36/2 (July 1988), 52–3.

[78] Harman, 83.

[79] ibid., 89–93.

[80] J. J. Thomson was unable in fact to make any substantial predictions with his theory, which was later abandoned. See Harman, 98.

[81] James H. Jeans, 'A suggested explanation of radio-activity', *Nature*, 70, 1905 (2 June 1904), 101. Jeans's comment on the destruction of matter to produce energy is a remarkably prescient one, coming some time before the full implications of the relationship between energy and mass predicted by Special Relativity were appreciated.

[82] Helge Kragh, 'The ether in late nineteenth-century chemistry', 55–8.

[83] See William Crookes, *Researches in Spiritualism* (London: J. Burns, 1874).

[84] Kragh, 57. Sir William Crookes, discoverer of thallium, was for many years the President of the Society for Psychical Research and a leading promoter of spiritualism. See Trevor H. Hall, *The Spiritualists* (London: Gerald Duckworth, 1962) for a fascinating account of the alleged liaison between Crookes and the medium Florence Cook.

[85] Sir Oliver Lodge, *The ether of space* (London: Harper and Barnes, 1909), p. xiv.

moving tribute to his son Raymond who was killed in the First World War, in which he makes clear his belief in an ethereal after-life:

> Death is not a word to fear, any more than birth is. We change our state at birth, and come into the world of air and sense and myriad existence; we change our state at death and enter a region of—what? Of ether, I think, and still more myriad existence, a region where communion is more akin to what we call telepathy, and where intercourse is not conducted by the accustomed indirect physical process; but a region in which beauty and knowledge are as vivid as here: a region in which progress is possible and in which 'admiration, hope and love' are even more real and dominant. It is in this sense we can truly say, the dead are not dead, but alive.[86]

Here Lodge seems to envisage the ether as a heavenly realm, with communication between the ethereal entities which seems echoed in Tan's concept of *tong*.

There was thus in the late nineteenth century a current of Idealist thought which tried to modify the apparently godless purposeless and mechanistic physics of the atomists and to rescue spirituality from the march of atheistic materialism by means of the ether. The ether, with its 'subtlety', imponderability and general elusiveness was the substance on which the hopes of religiously inclined scientists were placed, and also through which those non-scientists who were hostile to science sought to reintroduce God, as rational grounds for faith had begun to shrink in the face of physical and biological determinism.[87]

The ether was seen by many as one of the key concepts of nineteenth century physics, as in *This wonderful century* by the evolutionary biologist Alfred Russel Wallace in 1898:

> Heat, therefore, seems to be the source of all change in matter, and the essential condition of all life; while the other vibrations of the ether, which we know as light and electricity, may also be essential. Ether, therefore, seems to be the active, matter the passive agent in the constitution of the universe; and the recognition of the existence of the ether, together with the considerable amount of knowledge we have acquired of its modes of action, must be held to constitute one of the most important intellectual triumphs of the nineteenth century.[88]

The idea of a search for an underlying unity of all phenomena cannot be dismissed as unscientific, and for many in the late nineteenth century the discovery of phenomena such as X-rays, the allotropy of certain elements,[89] the isomerism of organic compounds,[90] and the Periodic Table itself, all con-

[86] Sir Oliver Lodge, *Raymond, or Life and Death* (London: Methuen, 1916), 298.

[87] See John Theodore Merz, *A history of European thought in the nineteenth century*, II (Edinburgh: William Blackwood, 1903), 36ff. on 'Problems as to the nature of the ether', and ch. xi, 'On the psycho-physical view of Nature'.

[88] Alfred Russel Wallace, *This wonderful century: its successes and failures* (London: Swan Sonnenschein, 1898), 57. His book is less triumphalist than its short title might suggest: as well as portraying the successes of materialistic science he has several chapters on the neglect of psychical research, phrenology and hypnotism. He dismissed vaccination as an illusion, and was disturbed by the rising tide of materialism and selfishness he saw around him.

[89] Allotropy is the phenomenon of one element existing in several different structural forms. Carbon is well-known to exist both as graphite and diamond, and recently a new form C_{60} has been discovered. Phosphorus possesses yellow, red and black allotropes, whilst oxygen exists both in the normal diatomic form O_2 and the triatomic allotrope ozone O_3.

[90] Organic compounds with the same molecular formulae can exist in several different forms depending on the way in which the carbon atoms are linked. Propanol C_3H_8OH, for example, exists as two different forms or isomers.

firmed the existence of a single 'primal' form of matter of which all other forms were constructed. There was even a short-lived revival of alchemy in France, stimulated by the transformations of matter offered by these discoveries.[91]

This is precisely the current in which Tan Sitong saw a connexion with traditional Chinese thought. It was not, as is sometimes said, that Tan simply did not properly understand what he had read.[92] On the contrary, his views and those of the more spiritually-minded Western scientists of the day were closer than has sometimes been realized.

The Chinese origins of Tan's views on the ether

Tan began *Renxue* with an etymological derivation of the term *ren* 仁 which he said meant 'the association of two people',[93] and stated that *yuan* 元 'origin' had the same etymology, thus implying that *ren* has a fundamental significance as the origin of all relations. Tan further claimed that *wu* 無 'nothing' was also cognate with *yuan* 元. This was not mere philological pedantry: it was a central part of his system, as he had demonstrated that the Confucian concept of *ren* 'loving kindness', *yuan* 元 'origin', that is, natural or physical origin, and *wu* 無 'non-existence', the Buddhist concept of non-existence, were in ancient times one word, and hence by implication one idea.

Tan stated in his introduction that his ideas were based on his reading of Buddhist texts[94] such as the *Huayan* 華嚴 [*Avataṃsaka* or *Garland*] *Sūtra*, the *xinzong* 心宗 'Mind school' (that is the Chan (Zen) Buddhists) and *xiangzong* 相宗 'Mere Ideation school' [the *Faxiang* 法相 school]; of Western books, the New Testament, and books on mathematics, science, and social sciences; and the *Yijing* 易經 (Book of Changes), the *Chunqiu Gongyang zhuan* 春秋公㨾傳 (Gongyang Commentary on the *Spring and Autumn Annals*), *Lunyu* 論語 (*Analects* of Confucius), *Liji* 禮記 (Records of Rites), *Meng Zi* 孟子 [Mencius], *Zhuang Zi* 莊子 [Chuang Tzu], *Mo Zi* 墨子[95] and *Shiji* 史記 (Records of the Historian), as well as writings of Tao Yuanming 陶淵明 (372–427),[96] Zhou Maoshu 周茂叔 [Zhou Dunyi 周敦頤] (1017–73),[97] Zhang Hengqu 張衡渠 [Zhang Zai 張載] (1020–77),[98] Lu Zijing 陸子靜 [Lu Xiangshan 陸象山] (1139–93),[99] Wang Yangming 王陽明 [Wang Shouren 王守仁] (1472–1528),[100]

[91] See H. Carrington Bolton 'The revival of alchemy in France', *Chemical News*, 11 February 1898. For the alchemical background see Allen G. Debus, *Chemistry, alchemy and the New Philosophy 1550–1700* (London: Variorum Reprints, 1987).

[92] For instance, Talbott, 'T'an Ssu-t'ung and the ether', 27.

[93] *TSTQJ*, 289.

[94] Tan studied under the Buddhist teacher Yang Wenhui 楊文會 (1837–1911), who himself had lived in England from 1878–1881, where he took an interest in astronomy, geography and optics. See Holmes Welch, *The Buddhist revival in China* (Cambridge, MA: Harvard University Press, 1968), 2–6.

[95] Mo Zi was regarded as heretical by the Confucians. His writings include some of the most remarkable examples of the fertility and originality of ancient Chinese scientific thought. Tan was convinced that the teachings of Mo Zi were the origin of Western science. See '*Xing suanxue yi*' 興算學議 (Proposal for the revival of mathematics), *TSTQJ*, 171.

[96] A poet of Daoist leanings. See Fung Yu-lan, vol. 2, 692.

[97] A Song Neo-Confucianist who wrote on the *Taijitu* 太極圖 'The Diagram of the Supreme Ultimate' relating *yin* and *yang* to *qi*. See Fung Yu-lan, vol. 2, 444.

[98] Zhang Zai wrote extensively on *qi* and its meaning. See Ira E. Kasoff, *The thought of Chang Tsai (1020–1077)*, (Cambridge: Cambridge University Press, 1984).

[99] A contemporary of Zhu Xi who wrote: 'The Way (Dao) fills the Universe, nowhere being concealed. It is, in Heaven, called the *yin* and *yang*; in Earth it is called love (*ren* 仁) and righteousness (*yi* 義). Thus, then, love and righteousness are man's original mind.' (See Fung Yu-lan, vol. 2, 575).

[100] Wang Yangming also speaks of the nature of *ren*: 'The reason that the great man is able to be one with Heaven, Earth and all things, is not that he is thus for some purpose but because

Wang Chuanshan 王船山 [Wang Fuzhi 王夫之] (1619–92),[101] and Huang Lizhou 黃梨洲 [Huang Zongxi 黃宗羲] (1610–95).[102]

The influence of the Neo-Confucian concept of qi *on Tan*

Tan's *yitai* is the descendant of the *qi* of the Neo-Confucians: *yitai* and *qi* are both a type of material substance and a spiritual essence from which material objects have congealed, and in which a moral quality also inheres. A major influence on Tan was Zhang Zai, the Northern Song Neo-Confucian, whose theories of *qi* were to be woven into Zhu Xi's synthesis of Confucian and Buddhist thought.[103]

Zhang Zai wrote:

From the Great Void (*Taixu* 太虛) comes that which is denoted by 'Heaven'; from the transformation of *qi* comes that which is denoted by 'Dao'; from the combination of Void and *qi* comes that which is denoted by 'nature' (*xing* 性); from the combination of nature with intellectual knowledge (*zhi* 智) and sensory perception (*jue* 覺) comes what is denoted by 'mind' (*xin* 心).[104]

This is one of the connexions which was central to Tan's philosophy: the Universe and the human mind were one, and were connected by the transformations of *qi*.

The communication between things was also stressed by Zhang Zai:

Since the Great Void is clear, there is no obstruction in its clarity. Since it is clear it is therefore spiritual (*shen* 神). If on the contrary there is turbidity rather than clarity, then in the turbidity there is obstruction (*ai* 礙), and if there is obstruction there is form (*xing* 形). All *qi* that is clear [is subject to] penetration (*tong* 通), whereas that which is dull (*hun* 昏) is obstructive [to communication], and the ultimate in clarity is spirit (*shen*). Thus if in the congealing [of the *qi* 氣] the wind there is a gap, and the wind blows, then a sound can be transmitted: this is proof of clarity! If [the wind] does not blow and yet [the sound] is still transmitted, this is the ultimate in communication.[105]

The concept of *tong* 'communication' which Tan regards as one of the key properties of *yitai* would thus seem to have one of its precursors in the omnipresent *qi*, the transparency of which is a measure of its place in the hierarchy of spirit. It is also interesting that it Zhang Zai uses transparency as

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the love (*ren* 仁) of his mind is naturally so and thus makes possible this union.' (Fung Yu-lan, vol. 2, 599).

[101] Wang Fuzhi wrote: 'Within the Universe there only Principle (*li* 理) and Ether (*qi* 氣). The Ether is the vehicle of Principle, through which it derives its orderliness.' (Fung Yu-lan, vol. 2, 641)

[102] Huang Zongxi wrote: 'In the great process of evolutionary change there is only the single Ether (*qi* 氣), which circulates everywhere without interruption.' (Fung Yu-lan, vol. 2, 640)

[103] Tan took a particular interest in Zhang Zai's philosophy, writing an unpublished article entitled '*Zhang Zi Zhengmeng: Canliangpian buzhu*' 張子正蒙 參兩篇 補注 (Additional notes on the 'Two in Three Essay' in *Correcting youthful ignorance*). See *TSTQJ*, 56. Tan also regarded Zhang Zai's views on *qi* as prefiguring modern astronomical concepts. See '*Lun jinri Xixue yu Zhongguo guxue*' (On modern Western studies and ancient Chinese thought), 1898, in *TSTQJ*, 399–400, and '*Shijuying lu bizhi. Sipian*' 石菊影 廬筆識 思篇 (Notes from the Calcareous Slate Shadows Studio: Thoughts) in *TSTQJ*, 123–4. See also A. C. Graham, *Two Chinese philosophers* (London: Lund Humphries, 1958), 31 for an account of Neo-Confucian views of *qi*.

[104] See *Zhang Zai ji: Zheng Meng* 張載集:正蒙 (Collected works of Zhang Zai: *Correcting youthful ignorance*) (Beijing: Zhonghua shuju, 1978), 9. The translation is based on that in Fung Yu-lan, vol. 2, 488.

[105] *Zhang Zai ji: Zheng Meng*, 8–9. See Wang Fuzhi, *Zhang Zi Zhengmeng zhu*, 16 (see n. 49).

a metaphor for the degree of spiritual perfection: Tan also would make a connexion between the transmission of light waves in the ether and communication through *qi*.

It is this version of *qi*, both spiritual and yet intimately connected with the material world, immanent and transcendent, on which Tan built his theory of *yitai*.

Kang Youwei and the ether

Kang Youwei was the intellectual leader of the reformers who attempted in 1898 to achieve a constitutional monarchical solution to China's problems. Kang's great work *Datongshu* 大同書 (Book of Great Unity),[106] itself shows the influence of his reading of Western science, and it is likely that his ideas in turn would have affected Tan's views,[107] and perhaps that Tan may have influenced him.

Kang speaks of our feelings for the sufferings of others in the first section of *Datongshu*, which is entitled *Seeing the many sufferings entailed in entering the world.* He says:

> I have my own body; if someone else is suffering, what has it to do with me? And yet I feel sad and deeply affected by it, troubled when I am walking and pondering it when I am sitting. Why is this? Why does it affect me in this way? ... When Bismarck burned the city of Sedan in France,[108] I was only ten *sui* or so old, and had no feeling of grief, yet when I saw pictures[109] of it, I was deeply distressed. Seeing corpses strewn out in the forest, burning buildings, I was deeply moved ... What is the reason behind this? Is it what the Europeans call *yitai*? Is it what was called in ancient times the 'heart which cannot bear the sufferings [of others]?' Is it the case that everyone has this 'compassionate heart'?[110]

Kang also referred to electricity as an all-pervading, conscious energy:

> Vast in the Primal *qi*, creator of Heaven and Earth. Although the size of the whole spiritual substance (*hunzhi* 魂質) of Heaven and Earth are different, they are both produced by division of the vast *qi* in the Great Origin (*tai yuan* 太元), as if scooping up the drops of the vast ocean. Confucius said: 'Earth contains spiritual *qi*, and this [produces] the wind and the thunder, and these carry along the forms (*xing* 形), so that the multitude of things manifest life.' This spiritual thing is electricity: lightning (*guangdian* 光電) is able to be transmitted everywhere, and spiritual *qi* can make all things sentient (*gan* 感). It spiritualizes ghosts and gods, it gives birth to Heaven and Earth. In its entirety it is the Origin; divided it is human beings. Subtle and marvellous, is contact with its spirituality! There is

[106] Kang Youwei, *Datongshu* 大同書, Zhang Xichen 章錫琛 and Zhou Zhenfu 周振甫 (ed.), (Beijing: Guji chubanshe, 1956).

[107] The book was itself not written down in its present form until 1901–2, but it was conceived in 1884. (See Fung Yu-lan, vol. 2, 685). Kang in fact attempted to keep its ideas secret, but he allowed Liang Qichao to read it, and he discussed its ideas with other students, so it is likely that Tan too would have been familiar with its contents. (See Liang Qichao, *Intellectual trends in the Ch'ing period*, Immanuel Hsu (tr.), (Cambridge, MA: Harvard University Press, 1959), 97–8). The exact relationship of Tan and Kang is rather uncertain, and the evidence that they met before Tan wrote *Renxue* is rather dubious (see Chan Sin-wai, *An exposition of benevolence*, 15–16). This does not rule out the influence of Kang Youwei on Tan, nor that of Tan on Kang.

[108] Emperor Napoleon III of France suffered a severe defeat at the hands of the Prussian army at Sedan on 1st September 1870.

[109] Kang uses the expression *yingxi* 影戲 [shadow play], the contemporary term for magic lantern slides.

[110] *Datongshu*, 2.

> nothing devoid of electricity; there is nothing devoid of spirituality. This spirituality is conscious *qi* (*zhiqi* 知氣), spiritual consciousness (*hunzhi* 魂智), essential vigour (*jingshuang* 精爽), spiritual intelligence (*lingming* 靈明), and brilliant virtue (*mingde* 明德). Although these names are different they are the same in substance. If it has consciousness, it has attraction (*xinie* 吸攝), like that of a lodestone, how much more [is this the case] for human beings. This is the compassionate force of attraction. Thus for benevolence (*ren*), when stored together [in the mind], wisdom has primacy; when benevolence and wisdom are both being exercised, benevolence has primacy.[111]

These two passages reveal that, for Kang as for Tan, *yitai* was a concept which he felt relevant, although peripheral, to his thinking about compassion. They also show that *qi* was seen by Kang as a spiritual substance which brought life and consciousness to otherwise inert matter, that it was somehow related to electricity, and that magnetic attraction was related to compassion.[112] These ideas, present in embryonic form in *Datongshu*, are developed much further by Tan.

Kang also writes of *ren* as a universal property of all creatures, being displayed by animals as well as human beings. In his essay *Kang Zi nei-wai pian* (The esoteric and exoteric essays of Master Kang) he cites the regurgitation of food by young birds for older birds and the kneeling of the lamb when suckling, and the fact that cows and horses do not bite, as examples of *ren*,[113] and the calling of deer to one another and the orderly marching of ants as examples of politeness (*li* 禮), and the way the dog guards its master as a manifestation of righteousness (*yi* 義).[114] Later in the same essay he says:

> I am unable to know of the beginning of Heaven. If the accumulation of *qi* produces Heaven, then after much friction, the power of excessive heat is generated, and [from this] lightning (*guangdian* 光電) is produced. The elements (*yuanzhi* 原質) are transformed and make it, thereupon producing the Sun, the Sun produces the Earth, the Earth produces [material] things. It is the nature of [material] things to reproduce, and in human beings this is called *ren* 仁, the ultimate fulfilment of the potentiality of its power; restricted and controlled, it is called righteousness (*yi* 義).[115]

Despite these similarities in their thinking, Kang Youwei had much less interest than Tan in science, and his examples tend to be superficial and conventional by comparison. Although Tan was perhaps encouraged by Kang to take Western science seriously, Tan's detailed knowledge came not from Chinese sources but from translations of Western science textbooks and the Chinese writings of Western missionaires.

Influences from Western translations

In this paper I am mainly concerned with the sources of Tan's scientific ideas. According to *Tan Sitong nianpu*, Tan probably met John Fryer, the translator of many science textbooks at the Jiangnan Arsenal, in 1893 in

[111] *Datongshu*, 2–3. This translation is based on Fung Yu-lan, vol. 2, 685.

[112] As Joseph Needham has pointed out, the terms for 'magnet' and 'compassion' are homophones. See *Science and civilisation in China*, vol. IV, part 1 (Cambridge: Cambridge University Press, 1962), 232.

[113] See Jiang Guilin 蔣貴麟 ed. *Wanmucaotang yigao waibian* 萬木草堂 遺稿 外編, (Posthumous drafts from the Hall of Myriad Trees and Grasses), vol. 1 (Taibei: Chengwen chubanshe, 1978), p. 24. The first two examples are conventional allegories of filial piety.

[114] ibid., 24.

[115] ibid., 29.

Shanghai,[116] and bought many of his translations and also the publications of the Society for the Diffusion of Useful Knowledge (*Guangxuehui* 廣學會) which had been founded by the missionaries Alexander Williamson (1829–90), Joseph Edkins (1823–1905) and W. A. P. Martin (1827–1916) in 1887. It is also likely that he read articles on science in the journal *Wanguo gongbao* 萬國公報 (*The Globe Magazine*) edited by Young J. Allen (1836–1907).[117]

Tan met Fryer again in 1896 also in Shanghai,[118] when he had a long discussion with him about fossils and X-rays, and Fryer told him about a machine which could tell what you were thinking or even what you were dreaming.[119] It is likely that he read many of the Jiangnan Arsenal scientific translations of Fryer, Xu Shou and other colleagues, as he often uses terms employed in texts such as *Huaxue jianyuan* 化學鑑原 (A mirror of chemical science)[120] such as 'atom' *zhidian* 質點, and 'element' *yuanzhi* 原質. He also read Western anatomy books, which confirmed the importance of the brain in consciousness.[121]

Two of the Jiangnan translations which Tan is also likely to have read are *Guangxue* 光學 (Optics), a translation of John Tyndall's *Lectures on light* by the Prussian Carl T. Kreyer and his Chinese assistant Zhao Yuanyi 趙元益, and published in 1875;[122] and the more elementary *Guangxue xuzhi* 光學須知 (Essentials of Optics), published in 1890.[123]

In the section on light waves, the Chinese text of *Guangxue* says:

> In my book on sound I have already explained that the greater the elastic modulus of matter the greater the speed at which sound travels through it; and the more loosely-packed the atoms are in the material, the greater the speed is. The principles of light are also the same. The compressibility force of the medium for the transmission of light is very large. [The medium] is loose and thin, and may be called 'light-transmitting *qi*' (*chuanguangqi* 傳光氣).
>
> Light-transmitting *qi* is dispersed through space, and reaches all the subtlest [parts]. It is even present in a vacuum. All atoms are contained within it. The transparent parts of the human eye all contain it, and it is connected with the light-transmitting *qi* outside the eye. When the atoms of a luminous body vibrate, the light-transmitting *qi* also vibrates, thus producing waves which move and stimulate the retina and thus the eye senses that there is light.[124]

[116] See *TSTNP*, 63 and Adrian Arthur Bennett, *John Fryer: the introduction of Western science and technology in the nineteenth century* (Cambridge, MA: Harvard University Press, 1967), 44.

[117] See Adrian Arthur Bennett and Kwang-ching Liu, 'Christianity in the Chinese idiom: Young J. Allen and the early *Chiao-hui hsin-pao* 1868–1870', in John K. Fairbank (ed.), *The missionary enterprise in China and America* (Cambridge, MA: Harvard University Press, 1974), 159–96, and Richard H. Shek, 'Some Western influences on T'an Ssu-t'ung's thought' (cited n. 12 above).

[118] Chan Sin-wai, *AEOB*, 10 says that the 1896 meeting with Fryer took place in Tianjin, but this seems not to be the case. See Tan's letter to Ouyang Zhonggu in *TSTQJ*, 458 and 461.

[119] *TSTQJ*, 458. X-rays had only been discovered by Röntgen a year earlier. Fryer later translated a book on X-rays entitled *Tongwu dianguang* 通物電光 (Electric light which pierces things) which was published in 1899. See Bennett, *John Fryer*, 95.

[120] This was probably the most widely available chemistry text in China at this time, and included an influential system of chemical nomenclature.

[121] See '*Lun quantixue*' 論全體學 (On anatomy), in *TSTQJ*, 403–5.

[122] John Tyndall, *Six lectures on light, delivered in America 1872–1873* (London: Longmans, Green and Co., 1873).

[123] *Guangxue xuzhi* 光學須知 (Shanghai: Jiangnan zhizaoju, 1890) was translated and condensed from William Lees, *Handbook to diagrams in light and heat* (London: W. and A. K. Johnston, 1881), see A. A. Bennett, *John Fryer*, 83).

[124] Carl T. Kreyer and Zhao Yuanyi (tr.), *Guangxue* (Shanghai: Jiangnan Arsenal, 1879), 2.4a. See Adrian Arthur Bennett, *John Fryer*, 105. The book on sound referred to is John Tyndall,

Guangxue xuzhi discusses the particulate and wave theories of light, saying that the latter is generally preferred. In explaining light waves, it says:

> In space there is a type of very rarefied and very light gas (*qizhi* 氣質) called ether (*yituoqi* 以脱氣), which is the most capable [of all substances] of conducting [*yin*] light. Any luminous body frequently vibrates, and thus [causes] the surrounding *yituoqi* to vibrate, these movements leading to waves called light waves, and these light waves are transmitted to people's eyes, and the brain perceives them as light. All this is caused by *yituoqi*.[125]

An interesting translated text from which we can be *certain* some of Tan's ideas stem is one on mental healing *Ideal suggestion through mental photography*, by Henry Wood (1834–1909), translated as *Zhixin mianbing fa* 治心免病法 (A method for healing the mind and avoiding sickness), which Wood wrote in 1893 and was translated by Fryer in 1896, the very year in which Tan made his first draft of *Renxue*.[126] Fryer's translation states:

> There is a strictly hierarchical relationship between the mind and body. The former, which is real and permanent, has absolute dominion over the latter, which is ephemeral and transient ... the mind is the link between one person and other persons, between mankind and myriad things, and between one planet or galaxy and the other planets and galaxies in the universe.[127]

He goes on:

> Lately in the West it has been learned that inside the myriad things there is a fluid called ether. The space [between us and] the most distant items is not a vacuum but is filled by this ether. This ether is present even within the fine molecules of the air on Earth ... nowhere is it absent and in no way can we get rid of it. Without this ether the light of the sun and other stars cannot be transmitted to the Earth ... Irrespective of the distance or the sensitivity of the five senses, as soon as one person conceives a thought, he activates the ether and conveys it to the mind of others, making them think the same thought.[128]

Sound (London: Longmans, Green and Co., 1869), translated by John Fryer and Xu Jianyin 徐建寅 as *Shengxue* in 1874. See A. A. Bennett, *John Fryer*, 82.

[125] John Fryer, *Guangxue xuzhi* (Shanghai: Jiangnan zhizaoju, 1890), 9a.

[126] Mentioned in Richard H. Shek, 'Some Western influences on T'an Ssu-t'ung's thought', 200.

[127] Shek, 200. There seems to be some confusion (*AEOB*, 10, 196, 197) about the date and English title of *Zhi xin mian bing fa* which Tan says had a profound influence on him. The correct English title is *Ideal suggestion through mental photography*.

[128] Shek, 'Some Western influences on T'an Ssu-t'ung's thought', 201.

Wood's original book mentions the ether only once: We find this great force called thought has scientific relations, correlations and transmutations, that its vibrations project themselves in waves through the ether, regardless of distance and other sensory limitation, that thus strike unisons in other minds and make them vibrant; that they relate themselves to like and are repelled by the unlike; that their silent though forceful impact make a distinct impression; in fact, that they are substantial entities, in comparison with which gold, silver and iron are as evanescent as the morning dew.

See Henry Wood *Ideal suggestion through mental photography: a restorative system for home and private use. Preceded by a study of the laws of mental healing* (Boston, MA: Lee and Shephard, 1893), 52.

It is interesting to speculate as to why Fryer expanded on the notion of ether quite so extensively, giving it far more prominence than Wood did in his original work. (This was recognized by Shek. See Richard Shek 'Some Western influences on T'an ssu-t'ung's thought', 201). It is possible that, seeing the connexion between ether and *qi*, Fryer sought to emphasize the ether in the hope that it would appeal to Chinese intellectuals such as Tan Sitong. As Fryer and Tan met twice, in 1893 and 1896, it is also possible that Fryer actually knew of Tan's interest in Zhang Zai.

From this passage, the all-pervasiveness of the scientific ether and its key role in communication between sentient beings is clearly expressed, and may well have been one of the sources which encouraged Tan's emphasis on the quality of *tong*.

Henry Wood described love as 'a great universal spiritual law of attraction'[129] and stated that: 'As love inheres in universal matter, so love permeates universal Spirit.'[130] ... 'Life is a continuous divine communication ... The divine exuberance fills every space not closed against it.'[131] ... 'There are invisible theads which connect us with every part of our environment. Vibrations are ever passing over these connections, backward and forward, and it is for us to control their purpose and quality. Every star, sun, person, circumstance and principle is exchanging messages with us.'[132]

We have clear evidence of Tan's fascination with Wood's book (or Fryer's version of it) in a letter he wrote to his teacher Ouyang Zhonggu 歐陽中鵠 on 31 August 1896:

> I again went to Shanghai to visit John Fryer, as I wanted to clarify these principles [of how the world is changed by the power of the mind], but he had just returned to his country, so I obtained his translation *Zhixin mianbing fa*. On reading it I could not help feeling great joy.[133]

Tan's identification of the Westerners' ether with *qi* seems to be confirmed in Section 9 of his article '*Shijuying lu bishi*' 石菊影廬 筆識 (Notes from the Calcareous Slate Shadows Studio), written in 1895, in which he says:

> When Westerners write of *qi*, [there are those who say] it extends above the Earth for 200 *li* and then stops, and those who say it does not stop there. Those who say it stops at 200 *li* [argue that] there are no living things [i.e. animals] on high mountains, and only plants grow there. If you go higher there are not even any plants continuing to grow; this is due to the density of the *qi*. The higher [you go] the thinner it gets, until it becomes non-existent. Thus if you go up in a balloon, you have to take the *qi* in bottle so that [you] can breathe, as there is no *qi*. Those who say that the *qi* does not cease at 200 *li*, [argue that] the warmth of the Sun is transmitted [*da* 達] to the Earth [through it]. These two theories have both been tested, and the latter has been vindicated, so [we can say] that *qi* has no end. The *qi* [which extends up to] 200 *li* is the *qi* of living things, whereas the *qi* in which [there is] intercourse between Heaven and Earth certainly has no end. The [light of the] Sun is transmitted through this *qi* to the Earth, and the [light of the] Moon and the stars is all transmitted through this *qi* to the Earth. The light of the Moon and stars which shines, causing the Earth to be bright, is transmitted through this *qi* of the Moon and stars. When people raise their eyes to look at the Moon and stars, it is the Earthly *qi* which transmits [their gaze] to the Moon and stars. The Sun and Moon attract the seas on the Earth to cause the tides, with the high tides at the full and new Moon. How could it be [possible for] Principle (*li* 理) to reach that far and yet for it to be unattained by *qi*?[134]

The *qi* described here is clearly very closely related to the Western ether, essentially physical, and not explicitly endowed with ethical characteristics

[129] Henry Wood, *Ideal suggestion through mental photography*, 94.
[130] ibid., 112.
[131] ibid., 114.
[132] ibid., 144.
[133] See *TSTQJ*, 461. In fact, Fryer was returning to the USA, not to his native England.
[134] *TSTQJ*, 127–8.

such as *ren*. In *Renxue* he developed this materialistic view of *qi* into the much grander and more idealistic conception of *yitai* as a cosmic fluid, the vector of *ren*,[135] and in doing so decisively brought Chinese and Western science and metaphysics into their first conscious contact: the *qi* of which Zhang Zai had written was the very same *chuanguangqi* or *yituoqi* or *yitai* which to Western scientists was an indispensable part of the edifice of modern physics.

Tan's synthesis of Chinese and Western ideas

From ancient Chinese thought, Tan took the idea of *qi* as the fundamental substance which was also an agent in its own evolutions. From Zhang Zai he learned that all things are made of *qi*, and that it acted as a medium for transmission and communication between selves, and their moral quality of the selves depends on the transparency of the *qi*. Wang Yangming taught him that *ren* filled the universe, linking all human beings and other entities. His fellow-reformer Kang Youwei identified the spiritual energy of *ren* with electricity.

Tan's readings of Western natural science textbooks enabled him to realize the relationship of electricity to light, and the metaphor of transparency which Zhang Zai had used allowed Tan to connect light, electricity and *ren*, the luminiferous and electromagnetic ether with *qi*.

Tan's *yitai* would thus seem to possess the following properties: (1) permeating everything,[136] (2) connecting everything, including the members of all human relationships, (3) adhesive, causing atoms to agglomerate,[137] (4) not susceptible to the senses,[138] (5) the cause of gravitational attraction,[139] (6) the cause of chemical attraction,[140] (7) manifest in electricity,[141] (8) manifest in brain activity,[142] (9) manifest in 'mental power' *xinli*,[143] (10) manifest in atoms,[144] (11) the origin of the [chemical] elements,[145] (12) the medium for the transmission of *ren*,[146] (13) the origin of Heaven and Earth and the Ten Thousand Things, (14) equivalent to *ren* 'benevolence',[147] (15) equivalent to nature (*xing* 性),[148] (16) equivalent to compassion (*cibei* 慈悲),[149] (17) equivalent to impartial love (*jian'ai* 兼愛),[150] (18) equivalent to soul (*linghun* 靈魂),[151] (19) equivalent to unselfish love (*ai ren ru ji* 愛人如己),[152] (20) equivalent to *qi*,[153] (21) undifferentiated[154] (so that phenomena such as electricity and brain

[135] The way in which Tan's view of ether developed between *Shijuying lu bishi* and *Renxue* is discussed in Xu Yijun, chs. 3 and 4.
[136] *TSTQJ*, 293.
[137] ibid., 294.
[138] ibid., 293.
[139] ibid., 294.
[140] ibid., 294.
[141] ibid., 291.
[142] ibid., 295.
[143] ibid., 291.
[144] ibid., 434.
[145] ibid., 309.
[146] ibid., 291.
[147] ibid., 293.
[148] ibid., 293.
[149] ibid.
[150] ibid.
[151] ibid., 294.
[152] ibid.
[153] Tan does not say explicitly that *yitai* is *qi*, but it is clear from his attention to Zhang Zai that he regards *yitai* as a form of *qi*.
[154] ibid., 295.

activity are actually identical), (22) a 'perceived division' (*xiangfen* 相分) of consciousness,[155] (23) eternal,[156] (24) infinite.[157]

This list is by no means complete, but serves to indicate the complexity of the notion. Tan often does not separate clearly what *yitai* actually *is* from how it is *made manifest*, a distinction which is also often unclear (or not felt necessary) with traditional accounts of *qi*.[158]

The purpose of Tan's conception of ether

Tan needed the ether to provide a philosophical foundation for his political programme of reform. By arguing that *yitai* was changeless in essence although existing in many forms, he was implying that the outward *political* forms could change without undermining their essence, just as the steam, water and ice are really all forms of the same substance.

By emphasizing the essential oneness of all things, Tan could argue that the monarchical system, with its hierachical organization of society and insistence on nation-states, ran counter to the true nature of things, which is that 'there is no barrier between others and the self'.[159] By seeing the true nature of the world, the *ren* 'benevolence' which binds us together through the medium of the *yitai* will be able to be the basis of a new society of individuals not divided according to false categories of names 'used by rulers to control their subjects, by officials to control their people, by fathers to repress sons, and by husbands to oppress wives; and brothers and friends each seize upon a name with which to resist each other.'[160]

By the same token, he looked with horror on the sexually repressive practices in China, which, he said, led to an inflammation of men's lust,[161] and on the way in which women were denigrated,[162] including footbinding,[163] and on the practice of killing animals for food.[164]

All these undesirable forms of behaviour derived from incorrect understanding of the underlying unity of all things: an epistemological error which was, for Tan, the root of all evil.

Tan was led by his conception of the ether to a radical egalitarianism, foreseeing the dissolution of all states.[165] His compassion did not extend to the Manchus, whose overthrow he clearly advocated,[166] and whom he regarded

[155] *TSTQJ*, 331. The term *xiangfen* is a technical term used by the Mere Ideation (*weishi* 唯識) School of Chinese Buddhism, meaning that part of consciousness which appears to be the object of perception. In the Mere Ideation School, there are no external 'real' objects outside consciousness. See Fung Yu-lan, vol. 2, 302.

[156] *TSTQJ*, 331.

[157] ibid., 293.

[158] See Nathan Sivin, *Traditional medicine in contemporary China* (Ann Arbor: Center for Chinese Studies, University of Michigan, 1987), 47.

[159] *TSTQJ*, 295; *AEOB*, 72.

[160] *TSTQJ*, 299; *AEOB*, 78.

[161] *TSTQJ*, 303; *AEOB*, 84–5: 'The way society proscribes lust is far too stringent, and has the opposite effect of giving rise to more lust.'

[162] *TSTQJ*, 304; *AEOB*, 85: 'There is nothing to suggest that men are superior to women. If we understand that both men and women are the basic components of heaven and earth, then they both have countless virtues, and have great things to do, that they are both equal ... '.

[163] *TSTQJ*, 303; *AEOB*, 84: 'If we Chinese do not examine the causes leading to the fall of our country, and in fear hasten to rid ourselves of the great evil of footbinding, there would be more lust and killing ...'.

[164] *TSTQJ*, 305; *AEOB*, 88: '... what can we say of ourselves when we ..., having chosen rice as our main diet, still kill animals to stuff our bellies ...?'

[165] *TSTQJ*, 367; *AEOB*, 215–16.

[166] *TSTQJ*, 342; *AEOB*, 161: 'That is why it was reported in a Russian newspaper that "Since no less than several million Chinese suffer the utmost bitterness, we should overthrow their dynasty and rescue their people." European and American countries speak in the same vein, all trying to gain spoils for themselves, under the lofty pretext of "doing their duty". If the Chinese people do not do it themselves, the disaster will be beyond words.' That is to say, China faced a full-scale foreign invasion if reform were not instituted.

as little better than savages.[167] This is not the only occasion when there is some contradiction between his specific, passionate concern for contemporary China and its fate, and a sweeping, metaphysical view of a universe filled with boundless *ren* and perfect mutuality.

Tan here went far beyond the monarchist position of his fellow reformers Kang Youwei and Liang Qichao towards a view more reminiscent of the 'withering away of the state' of the Communists,[168] although this resemblance is probably fortuitous, as there is no evidence that Tan had read any Marxist works, which did not begin to appear in Chinese translation in Japan until the early years of the twentieth century.[169] In any case, Tan's programme was essentially spiritual in content, far removed from the class struggle of the *Communist Manifesto*.[170]

Was Tan's synthesis in Renxue *successful?*

Before considering this question we have first to consider the criteria of success: did Tan achieve a self-consistent system? Did it provide a metaphysical basis for the action which Tan believed was necessary? Was it more than a brilliant syncretic structure with no roots or room for creative development?

As a self-consistent system it has to be judged only a partial success. *Yitai* is so vague that nothing is excluded. If the teachings of Confucius, Buddha and Jesus with their very different doctrines are transmitted by the *yitai*, why not those of Lao Zi, Muḥammad, Darwin, Marx or Nietzsche? This flexibility is of course also a strength, since it allowed Tan to insinuate Western scientific and political ideas garbed in a form which both the more conservative Chinese scholars might find palatable,[171] and which the younger, more Western-influenced thinkers would consider advanced and scientific in outlook.

The shocking nature of some of his proposals should not be underestimated. Whilst the overthrow of the Manchus might have been a popular cause, his anti-monarchism, feminism, attacks on sexual taboos, let alone the almost anarchist vision of a world without states, mark him as the most uncompromisingly radical and daring of the late Qing reformers.

As a metaphysical structure it was powerful if extremely abstract. Its intellectual brillance stands with few parallels in China or anywhere else.

As a programme for action it was inspirational rather than practical. The passion of Tan's denunciation of the Manchus, of footbinding, of cruelty and injustice in all their forms, could in the hands of a politician have become the sacred text of a political party but the historical process of the next decade did not allow his ideas to reach a wider audience. His major influence was, ironically, his extinction at the hands of the Manchus, through which he

[167] *TSTQJ*, 341; *AEOB*, 160–61 'Barren were their lands, inferior their race, bestial their minds, and savage their customs ...'.

[168] Friedrich Engels, 'Socialism: utopian and scientific', in Lewis S. Feuer (ed.), *Marx and Engels: basic writings on politics and philosophy* (London: Fontana/Collins, 1984; originally published by Foreign Languages Press, Moscow), 146–7.

[169] Jacques Guillermaz, *A history of the Chinese Communist Party 1921–1949* (London: Methuen, 1972; the French edition appeared in Paris: Payot, 1968), 21–2.

[170] Robert Darnton in *Mesmerism and the end of the Enlightenment in France* (Cambridge, MA: Harvard University Press, 1968) shows that Nicolas Bergasse, the follower of Franz Anton Mesmer and founder of the Society of Universal Harmony, suggested in 1783 that the conscience is a physical organ 'that is united to all points in the universe ... It is by this organ that we put ourselves in harmony with nature.' [... and that] the peaceful flow of the [mesmeric] fluid would produce a blissfully healthy, happy and justly organized France (p. 114).

Darnton suggests that mesmerism helps to explain the 'genesis of a revolutionary mood' in the France of the 1780s, as literate French turned away from the cold rationalism of the Enlightenment and looked for a more emotionally rewarding creed (pp. 161f.).

[171] This point was suggested in discussion with Bridie Andrews.

became a symbol of the struggle of idealistic Chinese youth against tyrannical rulers.

The physical status of Tan's ether

The physical status of *yitai* is much more problematic. If *yitai* were really to be material it could have been subject to scientific inquiry, whereas Tan's *yitai* is in practice (if not in its Chinese and Western origins) for Tan almost wholly metaphysical, a linguistic entity which allowed him to incorporate many disparate philosophical ideas and also to give his work a scientific flavour which if it were not so transparently sincere might make him suspect of dabbling.[172]

This openness is in itself of great significance. No other Chinese thinker of his generation had recourse to such an (albeit ambiguously) *material*[173] model to justify his philosophical ideas, and the fact that Tan chose to do this indicates that he was one of the few people in China who appreciated the great prestige which the concepts of natural science had achieved in the West by the late nineteenth century. The methods, logic and nomenclature of science permeate the *Renxue*, which, far from having 'no formal organisation'[174] is clearly intended to be read as a deductive system, beginning with twenty-seven definitions of *ren* and other terms.[175]

Yet *yitai* the medium for the transmission of *ren* was as a concept as insipid as the material it supposedly represented. Despite its profundity, it has a blandness which was unlikely to excite interest let alone action amongst other intellectuals of his generation. The underlying unity of all phenomena, and a salvation which depends on true perception and mental power, are after all essentially conservative ideas, and hardly constitute a call to arms.

Tan left no followers to develop his system further partly because by the time his ideas became widely known the scientific *ether* on which *yitai* depended for its pedigree was already under assault from the ether-free relativity theories of Einstein (1879–1955)[176] and the experiments of Michelson and Morley. The *yitai* followed the ether into (near) oblivion.[177]

Nevertheless, his concept of *yitai was* a truly brilliant synthesis, and cannot be dismissed as a misunderstanding or as shallow syncretism. Its weakness was not intellectual—the connexions he made are real and fruitful—but political and scientific. Its political weakness was its caution and abstract quality, providing no clear route by which the immense changes he advocated could

[172] The late nineteenth century was a period in which other writers also tried to claim the prestige of science to support their religious or political ideas. Mary Baker Eddy's *Science and health with key to the Scriptures* (Boston, MA, 1875) had earlier also tried to annex the prestige of 'science' to a 'mind-only' philosophy of disease, in which, as in Henry Wood's *Ideal suggestion through mental photography*, the right-thinking mind would overcome disease by the correct perception of error. See Danny Kwok, *Scientism in Chinese thought* (New Haven, 1965) for the way the role of science later became an issue in the debates of the May 4th Movement.

[173] This may seem to contradict the earlier statement that Tan's *yitai* was 'almost wholly metaphysical'. Tan's use of the ether/*qi*/*yitai* in *Renxue* indeed *is* almost entirely metaphysical, but he makes use of the fact that it has a respectably materialist pedigree, both in Zhang Zai's *qi* and in the Western scientists' luminiferous and electromagnetic ethers. Tan makes play of the ambiguity of the concept itself to create his synthesis.

[174] Talbott, 'T'an Ssu-t'ung and the ether', 22.

[175] This is reminiscent of the definitions of the Mohist *Canons*, which Tan cites as one of his sources. See A. C. Graham, *Later Mohist ethics and science* (Hong Kong: The Chinese University Press, 1978), 261ff.

[176] Einstein's Special Theory of Relativity (1905) and his General Theory of Relativity (1915) did not require the existence of an ether. See Albert Einstein, *Relativity* (London: Methuen, 1920; reprinted University Paperbacks, 1960), 146 et seq.

[177] The ether died as an object of study by theoretical physicists but its use continued for many decades in texts on radio and even in poetry, as in T. S. Eliot's 'The love song of J. Alfred Prufrock' (1917).

be achieved, although he was clear that the traditional monarchical system required reform, and that modern science needed to be taken seriously as an object of study.[178]

Yitai was not intended as a scientific model, to be tested against experiment, but rather as a philosophical basis for reform, designed to alter his countrymen's perception of themselves as individuals and as a nation. Tan saw China as a country with no cohesion, in which everyone seemed to care only for his or her own family. He hoped to make people see that they were all interdependent and interconnected by *yitai*, and had to work together for a better society in which *ren* was the guiding principle. However, it was in the end not his philosophy but his actions, and especially his death as a martyr in the aftermath of the Hundred Days Reform of 1898,[179] which influenced the next generation, especially the students of Changsha, where he had helped to produce several newspapers. Tan's revolutionary sacrifice helped to stir one young Hunanese student at least to attempt to change the world.[180]

Tan's *Renxue* was an opening of the mind to ideas from other cultures. This is rare in any society, and took particular courage in the milieu to which Tan belonged. Although there were by this time many Chinese who immersed themselves in 'Western studies' few if any attempted to reconcile what they read of Western science with orthodox Chinese thinking in such a creative way. Tan was convinced that the ancient Chinese philosophers had understood many scientific concepts long before the Westerners,[181] but pointed out that Confucius learned from the barbarians rather than despising them,[182] and this is the attitude which Tan himself adopted, rather than being content with the complacent claims of some Chinese intellectuals of his time[183] that Chinese thinkers had long ago propounded the same theories or discovered the same phenomena: *gu yi you zhi* 古已有之 'This was known of [in China] in ancient times'.[184]

Tan discovered that there were many common elements connecting Western science with Buddhist and neo-Confucian philosophy, and he believed that he had arrived at a deeper understanding of the true meaning of *ren* through the insights of the Western scientists, Buddhists and Christians, which would lead to a revival of a truly Chinese Dao, a Reformation of Confucianism analogous to Martin Luther's 'revival' of Christianity,[185] incorporating the best features

[178] Tan proposed to his teacher Ouyang Zhonggu the setting up of a Science and Mathematics Academy in Hunan in 1896. See '*Liuyang xingsuan ji*', *TSTQJ*, 174.

[179] Tan was executed in the Caishikou 菜市口 area of Beijing after the collapse of the Hundred Days Reform. His fellow reformers such as Kang Youwei managed to escape to Japan. See *TSTNP*, 118.

[180] Mao Zedong was influenced by Tan, according to his biographer Li Rui (*Comrade Mao's early revolutionary activities*, Beijing, 1957, cited in Jacques Guillermaz, *A history of the Chinese Communist Party*, 20).

[181] See '*Lun jinri Xixue yu Zhongguo guxue*' (On modern Western studies and ancient Chinese philosophy), *TSTQJ*, 398–400.

[182] ibid., 399.

[183] Such as Zeng Jize 曾紀澤 (1839–90), writing after his first visit to Europe, in Yu Yueheng 喻岳衡 ed. *Zeng Jize yiji* 曾紀澤遺集 (Posthumous collection of the writings of Zeng Jize) (Changsha: Yuelu shushe, 1983), 363.

[184] Although even Tan uses this expression, with some justice, when writing of ancient Chinese astronomy in '*Shijuying lu bishi*'. See *TSTQJ*, 123, and also in '*Lun jinri Xixue yu Zhongguo guxue*' 論今日西學與 中國古學 (On present-day Western studies and ancient Chinese thought), ibid., 398–400. The point is that Chinese scholars had often been far in advance of their Western counterparts, but Tan, unlike many of his contemporaries, did not use this as an excuse to dismiss Western science as the mere regurgitation of ancient Chinese theories.

[185] *TSTQJ*, 338; *AEOB*, 152: 'The loss of the teaching of Confucius was caused by rulers and by the erroneous teaching which advocated monarchical rule. To this day, no one has come forward to revitalize Confucianism. I earnestly cherish the hope that there will be a Martin Luther for the teaching of Confucius.'

of all these ideas and hence to a moral, cultural, intellectual and political renaissance of China.

Conclusion

Tan Sitong was a remarkably creative and perceptive thinker, who realised that there was in late nineteenth century Western science much that seemed to corroborate Neo-Confucian and Buddhist ideas about reality. He was able to channel his indignation at the injustices of Manchu rule into writing his masterpiece *Renxue*, a fertile synthesis of Western and Chinese ideas, which had he lived might have generated a fascinating debate. He had already carried out enough work to show that beneath the surface there were many common themes in Western science and Chinese thought, some of which are only now being clearly understood and given their true value. As his colleague Liang Qichao wrote of him:

> Tan met his end at the age of only thirty-three. Had he been given more years, his accomplishment would have soared to unpredictable heights. Though he left behind only one book, he shed infinite light, and although he passed away in the twinkling of an eye, he had no equal as a sweeping and cleansing force. It is for this reason I compare him with a meteor.[186]

[186] Liang Qichao, *Intellectual trends in the Ch'ing period*, 110.

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