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MAPPING MEANINGS

The Field of New Learning in Late Qing China

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CONTENTS

BENJAMIN A. ELMAN

FROM PRE-MODERN CHINESE NATURAL STUDIES 格致學 TO MODERN SCIENCE 科學 IN CHINA[1]

INTRODUCTION

This paper is about the contested nature of the interaction since 1550 between Chinese and Europeans over the meaning and significance of natural studies. Unlike the colonial environment in India, where British imperial power after 1700 could dictate the terms of social, cultural, and political interaction between natives and Westerners, natural studies in late imperial China were until 1900 part of a native imperial project to master and control Western views on what constituted legitimate natural knowledge.[2] Each side made a virtue out of the mutually contested accommodation project, and each converted the other's forms of natural studies into acceptable local conventions of knowledge. Arguably, Europe was already ahead by 1600 in producing basic machines such as clocks, screws, levers, and pulleys that would be applied increasingly to the mechanization of production. But Europeans still sought the technological secrets for silk, textile weaving, porcelain, and tea production from the Chinese.[3] Chinese literati in turn borrowed from Europe new algebraic notations (of Hindu-Arabic origins), geometry, trigonometry, and logarithms from the West. Indeed, the epistemological premises of modern Western science were not triumphant in China until the early twentieth century. Until 1900, then, the Chinese interpreted the transition in early

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[1] Earlier versions of this paper were presented at UC, Berkeley (Center for Chinese Studies), Stanford (World History Conference), UCLA (Center for the Cultural Study of Science, Medicine, and Technology), and at the Institute for Advanced Study (Chinese Studies Program) in Princeton.

[2] On India, see Bernard Cohn. 1996. *Colonialism and Its Form of Knowledge: The British in India.* Chicago: University of Chicago Press, pp. 5–56. See also Gyan Prakash. 1999. *Another Reason: Science and the Imagination of Modern India.* Princeton: Princeton University Press, pp. 3–14, who notes that the British civilizing mission in India initiated the cultural authority of modern science in South Asia. Prakash adds that Indians also identified a body of indigenous South Asian traditions consistent with Western science.

[3] Cf. Donald F. Lach. 1977. *Asia in the Making of Europe. Volume II. A Century of Wonder, Book 3: The Scholarly Disciplines.* Chicago: University of Chicago Press, pp. 397–400.

modern Europe—from new forms of scientific knowledge to new modes of industrial power—on their own terms.[4]

Consequently, we should not underestimate Chinese efforts to master on their own terms the Western learning (known as *xixue* 西學 or *gezhi* 格致) of the Jesuits in the sixteenth, seventeenth, and eighteenth centuries.[5] Literati scholars and imperial calendrical specialists in the government interpreted early modern Western achievements in natural studies in light of native traditions of scholarship, which they used to evaluate and apply specific Jesuit techniques. This local research agenda represented neither an indigenous modernization process nor the beginnings of a modest scientific revolution, at least by Western standards.[6] And in not searching for a Western form of modernity until the late nineteenth century, late imperial Chinese and Manchus were not acting out a purely anti-Western ideological agenda either. At times, however, court politics in Beijing interceded, and the Jesuits as bearers of Western tidings were faced with the political animosities such new (*xin* 新) learning produced among those in power who were satisfied with the old (*gu* 古) learning.

To paraphrase the views of Peter Winch, we must first acknowledge that as yet we do not have appropriate categories of learning that resemble the pre-modern Chinese frames for what we call natural studies or natural history.[7] Moreover, as Donald F. Lach has pointed out, an analytical ordering of early modern European scholarship within the framework of modern learning is equally problematic.[8] To understand the pre-modern Chinese frames for their knowledge systems of the natural world, as for early modern Europe, we should first try to extend our own understanding and make room for them. That will be attempted below. We will place natural studies in China within its own internal and external contexts by reconstructing in outline form its communities of interpretation.[9]

Unfortunately, one of the most common generalizations scholars make today concerning the role of science (= natural studies) in late imperial China is that after about 1300 studies of astronomy and mathematics were in steady decline there until the arrival of Jesuit missionaries in the sixteenth century.[10] When Matteo Ricci (1552–1610) described the scientific prowess of Chinese during the late Ming dynasty (1368–1644), he noted that they

> have not only made considerable progress in moral philosophy but in astronomy and in many branches of mathematics as well. At one time they were quite proficient in arithmetic and geometry, but in the study and teaching of these branches of learning they labored with more or less confusion.

Ricci concluded:

> The study of mathematics and that of medicine are held in low esteem, because they are not fostered by honors as is the study of philosophy, to which students are attracted by the hope of the glory and the rewards attached to it.[11]

Chinese mathematics and astronomy, according to this view, had reached their pinnacle during the Song (960–1280) and Yuan (1280–1368) dynasties but had declined precipitously during the Ming.[12] This longstanding perspective has been tested by recent studies that

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[4] See Donald Mungello. 1985. *Curious Land: Jesuit Accommodation and the Origins of Sinology*. Honolulu: University of Hawaii Press, pp. 23–43; and Lionel Jensen. 1977. *Manufacturing Confucianism: Chinese Traditions and Universal Civilization*. Durham: Duke University Press, pp. 34–75. The accommodation project carried over to natural anomalies, supernatural events, and religious faith. See Qiong Zhang. 1999. "About God, Demons, and Miracles: The Jesuit Discourse on the Supernatural in Late Ming China", *Early Science and Medicine* 4.1 (February 1999), pp. 1–36.

[5] See Xu Guangtai 徐光台 . 1996a. "Ruxue yu kexue: yige kexueshi guandian de tantao" 儒學與科學 ：一個科學史觀點的探討 (Literati studies and science: analysis from the angle of the history of science), *Qinghua xuebao*, New Series, 26.4 (December 1996), pp. 369–92.

[6] But see Nathan Sivin. 1995a. "Why the Scientific Revolution did not take place in China—or didn't it?". Reprinted in id. *Science in Ancient China: Researches and Reflections*. Aldershot/Brookfield: Variorum, pp. 45–66.

[7] Cf. Peter Winch. 1970. "Understanding a Primitive Society", in: Bryon Wilson (ed.). *Rationality*. Oxford: Basil Blackwell, pp. 93–102.

[8] Cf. Lach 1977, p. 395.

[9] Cf. Stanley J. Tambiah. 1990. *Magic, Science, Religion, and the Scope of Rationality*. Cambridge: Cambridge University Press, p. 154.

[10] Cf. Keizō Hashimoto. 1988. *Hsu Kuang-ch'i and Astronomical Reform*. Osaka: Kansai University Press, p. 17.

[11] *China in the Sixteenth Century: The Journals of Matteo Ricci: 1583–1610*. 1953. Translated into Latin by Father Nichola Trigault and into English by Louis J. Gallagher, S. J. New York: Random House, pp. 31–3.

[12] For the conventional perspective, see Joseph Needham. 1959. *Science and Civilisation in China*. Cambridge: Cambridge University Press, vol. 3, pp. 173, 209; and Ho Peng Yoke. 1985. *Li, Qi, and Shu: An Introduction to Science and Civilization in China*. Hong Kong: Hong Kong University Press, p. 169.

indicate that mathematics and calendar reform remained important concerns among Ming literati before the arrival of the Jesuits in China.[13] Others have demonstrated that the Jesuits misrepresented their knowledge of contemporary European astronomy to suit their religious objectives during the late Ming and early Qing (1644–1911) dynasty. Such self-serving tactics, which produced contradictory information about new trends in European astronomy, lessened their success in transmitting the European sciences to late Ming literati.[14] From this perspective, late Ming scholars were not lifted out of their scientific 'decline' by contact via the Jesuits with European astronomy. Rather, they themselves reevaluated their astronomical legacy and its current inadequacies, successfully taking into account pertinent features of the European sciences introduced by the Jesuits.[15]

Views that late imperial literati, unlike their Song and Yuan predecessors, were participants in a strictly humanist civilization, whose elite participants were trapped in a literary ideal that eschewed interest in the natural world, have been common since the Jesuits.[16] Historians have typically appealed for corroboration to the civil examination system. Matteo Ricci wrote:

> The judges and the proctors of all examinations, whether they be in military science, in mathematics, or in medicine, and particularly so with examinations in philosophy, are always chosen from the senate of philosophy, nor is ever a military expert, a mathematician, or a medical doctor added to their number.[17]

In addition, we have assumed that the classical curriculum for Ming civil examinations had refocused elite attention on a 'Dao Learning' (*Daoxue* 道學, i.e., 'Neo-Confucian') orthodoxy stressing moral philosophy and literary values and away from earlier more specialized or technical studies. Conventional scholarship still contends that technical fields such as law, medicine, and mathematics, common in Tang and Song examinations, were not replicated in late imperial examinations.[18]

When faced with foreign rule (first under the Mongols, 1240–1368, and later under the Manchus, 1644–1911) significant numbers of literati, in addition to the usual number of candidates who failed, turned to occupations outside the civil service such as medicine. In the eighteenth and nineteenth centuries, when demographic pressure meant that even provincial and metropolitan examination graduates were not likely to receive official appointments, many literati turned to teaching, medicine, and scholarship as alternative careers.[19] Moreover, examiners used policy questions on natural events and anomalies to gainsay the widespread penetration of popular religion and the mantic

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[13] See Roger Hart. 1996. *Proof, Propaganda, and Patronage: A Cultural History of the Dissemination of Western Studies in Seventeenth-Century China*. Ph.D. diss., University of California (Los Angeles), *passim*. See also Willard Peterson. 1986. "Calendar Reform Prior to the Arrival of Missionaries at the Ming Court", *Ming Studies* 21, pp. 45–61; and Thatcher E. Deane. 1989. *The Chinese Imperial Astronomical Bureau: Form and Function of the Ming Dynasty 'Qintianjian' From 1365 to 1627*. Ph.D. diss., University of Washington (Seattle), which documents the voluminous record of calendrical reform in China from the early empire to the late Ming.

[14] Cf. Nathan Sivin. 1973. "Copernicus in China", in: *Colloquia Copernica II: Études sur l'audience de la théorie héliocentrique*. Warsaw: Union Internationale d'Historie et Philosophie des Sciences, pp. 63–114.

[15] Cf. Jacques Gernet. 1982. *China and the Christian Impact*. Cambridge: Cambridge University Press, pp. 15–24. See also Sivin's biography of Wang Hsi-shan, Nathan Sivin. 1970–78. "Wang Hsi-shan (1628–1682)", in: *Dictionary of Scientific Biography*. New York: Scribner's Sons, vol. 14, pp. 159–68; and Deane 1989, pp. 401–41.

[16] See Michael Adas. 1989. *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance*. Ithaca: Cornell University Press, pp. 41–68, 79–95.

[17] *China in the Sixteenth Century: The Journals of Matteo Ricci: 1583–1610*, p. 41. See also George H. Dunne, S.J. 1962. *Generation of Giants: The Story of the Jesuits in China in the Last Decades of the Ming Dynasty*. Notre Dame: University of Notre Dame Press, pp. 129–30; Kiyosi Yabuuti. 1973. "Chinese Astronomy: Development and Limiting Factors", in: Shigeru Nakayama and Nathan Sivin (eds.). *Chinese Science: Explorations of an Ancient Tradition*. Cambridge, Mass.: MIT Press, pp. 98–9.

[18] See, however, Zhang Hongsheng 張鴻聲. 1995. "Qingdai yiguan kaoshi ji tili" 清代醫官考試及題例 (Qing dynasty examinations for medical officials with examples), *Zhonghua yishi zazhi* 25.2 (April 1995), pp. 95–6, on Qing examinations to choose a limited number of medical officials, which were based on Ming precedents. See also Liang Jun 梁峻. 1995. *Zhongguo gudai yizheng shilüe* 中國古代醫政史略 (Historical summary of medicine and government in ancient China). Huhehot: Nei Menggu renmin chubanshe. Calendrical and cosmological questions were required in Ming examinations administered for candidates applying for positions in the Astronomical Bureau. See Deane 1989, pp. 197–200.

[19] Cf. Robert Hymes. 1986. "Not Quite Gentlemen? Doctors in Song and Yuan", *Chinese Science* 7, pp. 11–85; and Joseph Levenson. 1957. "The Amateur Ideal in Ming and Early Qing Society: Evidence from Painting", in: John K. Fairbank (ed.). *Chinese Thought and Institutions*. Chicago: University of Chicago Press, pp. 320–41.

arts among examination candidates and to keep such beliefs out of politics.[20]

1. Interest in natural studies during the Ming dynasty

Natural studies in China had at times since the Yuan dynasty been classified under the phrase *gezhi* 格致 (lit., 'inquiring into and extending knowledge', *gewu zhizhi* 格物致知). At other times, particularly in the medieval period, and often simultaneously after the Yuan, such interests were expressed in terms of *bowu* 博物 (lit., 'broad learning concerning the nature of things'). The full mapping out of the asymmetrical conceptual categories associated with these two potential candidates in Song and Ming times for natural studies and natural history respectively remains incomplete. Moreover we are still unsure how the two terms usually were deployed vis-à-vis each other.

In addition, in ancient and medieval bibliographic classifications other terms such as *shuji* 術技 (skills and techniques) were used to demarcate what we today refer to as science and technology. In the late eighteenth century *Siku quanshu* 四庫全書 (Complete collection in the Imperial Four Treasuries) scheme of disciplines, medicine and calendrical studies were included as subcategories under the Philosophy (*zibu* 子部, lit., 'masters') category (see Table 1).

Table 1: Forty-four subdivisions of the Siku quanshu 四庫全書 *(Complete collection in the Imperial Four Treasuries)*

Classics (*jingbu* 經部)	History (*shibu* 史部)	Masters (*zibu* 子部)	Literature (*jibu* 集部)
Change(s)	Dynastic Histories	Literati	Elegies of Chu
Documents	Annals	Military Strategists	Individual Collections
Poetry	Topical Records	Legalists	General Anthologies
Rituals	Unofficial Histories	Agriculturalists	Literary Criticism
Spring and Autumn Annals	Miscellaneous Histories	Medicine	Songs and Drama
Filial Piety	Official Documents	Astronomy and Mathematics	

[20] See Benjamin A. Elman. 2000. *A Cultural History of Civil Examinations in Late Imperial China*. Berkeley: University of California Press, pp. 346–60.

Table 1: Forty-four subdivisions of the Siku quanshu 四庫全書 *(Complete collection in the Imperial Four Treasuries) (cont.)*

Classics (*jingbu* 經部)	History (*shibu* 史部)	Masters (*zibu* 子部)	Literature (*jibu* 集部)
General Works	Biographies	Calculating Arts	
Four Books	Historical Records	Arts	
Music	Contemporary Records	Repertories of Science	
Philology	Chronography	Miscellaneous Writers	
	Geography	Encyclopedias	
	Official Registers	Novels	
	Institutions	Buddhism	
	Bibliographies and Epigraphy	Daoism	
	Historical Criticism		

Similarly the mathematical aspects of music were subsumed under the Classics, while chronography and geography were listed under History. Hence, we cannot assume that there was a single and unified traditional field of natural studies in China before the Jesuit arrival known as *gezhixue*.[21] Nonetheless, it appears to me, tentatively, that among Song and post-Song literati elites *gezhi* was the most common epistemological frame for the accumulation of knowledge per se. *Bowu* on the other hand carried with it a more common and popular notion of curiosities.[22] For example, the *Taiping yulan* 太平御覽 (Encyclopedia of the Taiping era, 976–83), compiled under imperial auspices by Li Fang 李昉 (925–96) during the early years of the

[21] Cf. Xu Guangtai 徐光台. 1996b. "Mingmo Qingchu xifang gezhixue de chongji yu fanying: yi Xiong Mingyu Gezhi cao wei li" 明末清初西方格致學的衝擊與反應：以熊明遇格致草為例 (Impact and response in late Ming and early Qing Western *scientiae*; using Gao Mingyu's draft of *Scientiae* as an example) in: Taiwan University History Department (ed.). *Shibian, qunti yu geren* 世變，群體與個人 (Epochal change, groups and history). Taibei: Taiwan National University, pp. 236–58

[22] See Robert F. Campany. 1996. *Strange Writing: Anomaly Accounts in Early Medieval China*. Albany: SUNY Press, pp. 49–52. See also Qiong Zhang. 1998. "Nature, Supernature, and Natural Studies in Sixteenth- and Seventeenth-Century China". Paper presented at the Colloquium sponsored by the Center for the Cultural Studies of Science, Medicine, and Technology, UCLA History Department, Los Angeles, November 16, 1998.

Northern Song dynasty (960–1126), included earlier texts dealing exclusively with unusual events, strange objects/things/birds/spirits, and anomalies to provide a contemporary lexicon of textual usages in antiquity and medieval times that denoted the scope of *bowu* within classical writings.[23]

On the other hand, the Southern Song (1127–1280) philosopher Zhu Xi 朱熹 (1130–1200), who became the core interpreter of the late imperial classical canon, argued that "inquiring into and extending knowledge" presupposed that all things had their principle (*wan wu zhi li* 萬物之理). Zhu therefore concluded: "one should in three or four cases out of ten seek principles in the outside realm" (*san si fen qu waimian li hui fang ke* 三四分去外面理會方可). In most cases, six to seven out of ten, however, moral principles should be sought within. Thereafter, the investigation of things became the key to opening the door of knowledge for literati versed in the Classics and Histories."[24]

Due to Zhu Xi's later scholarly eminence, *gezhi* became a popular 'Dao Learning' term borrowed from the Great Learning (*Daxue* 大學 ; one of the Four Books) in the Record of Rites (*Liji* 禮記 ; one of the Five Classics) by literati to discuss the form and content of knowledge. In fact, however, there was much classical debate surrounding Zhu Xi's single-minded prioritizing of the *gewu* 格物 passage in the Great Learning to establish the epistemological boundaries for literati learning.[25] Yü Ying-shih's 余英時 longstanding claim that the seventeenth century turn among literati elites toward precise philology in classical studies can be traced back to sixteenth century debates surrounding the Old Text version of the Great Learning (*Daxue guben* 大學古本) deserves mention here.[26]

Wang Yangming 王陽明 (1472–1528), for instance, preferred the Old Text version of the Great Learning to gainsay Zhu Xi's 'externalist' views of the 'investigation of things' in the Four Books. Subsequently, the delicate issue of the late Ming appearance of an even more ancient "stone inscribed version of the Great Learning" (*Daxue shiben* 大學石本), which was later determined a forgery, reopened for many sixteenth and seventeenth century literati Wang Yangming's famous claim that Zhu Xi had manipulated the original text of this key passage to validate and make canonical his personal interpretation of the 'investigation of things'. In particular, Wang Yangming gainsaid Zhu Xi's emphasis on *gezhi* ahead of morality (*chengyi* 誠意 , lit. 'making one's intentions sincere'). For Wang the investigation of things and the extension of knowledge took a backseat to making one's will sincere.[27]

During the late Yuan, *gezhi* as a *Daoxue* term was already used by the medical writer Zhu Zhenheng 朱震亨 (1282–1358) to denote technical learning. In Zhu's most famous work entitled *Gezhi yulun* 格致餘論 (Views on extending medical knowledge), which was included in the *Siku quanshu* in the late eighteenth century,[28] Zhu opposed Song medical prescriptions, but he made a strong appeal to Yuan literati that they should include medical learning in their 'Learning of the Way'. In his view, medical learning was one of the key fields of study that not only complemented the moral and theoretical teachings of *Daoxue*, but it was also a key to the practical uses (*shixue* 實學) of the latter. The *Siku quanshu* editors cited Zhu's preface as arguing that medicine was one of the concrete fields that informed the "inquiry into and extension of knowledge" (*gewu zhizhi zhi yishi* 格物致知之一事).[29]

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[23] Cf. *Taiping yulan* 太平御覽 (Encyclopedia of the Taiping era). 1960. Reprint Taibei: Zhonghua Bookstore, vol. 612, *juan* 4a–10a (Reprint of *Sibu congkan* 四部叢刊 edition).

[24] See *Zhuzi yulei* 朱子語類 (Conversations with Master Zhu [Xi] classified topically). 1979 [1473]. Reprint Taibei: Chengwen, vol. 18, pp. 14b–15a. See also Yamada Keiji 山田慶兒 . 1978. *Shushi no shizengaku* 朱子の自然学 (Zhu Xi's natural studies). Tokyo: Iwanami, pp. 413–72.

[25] Cf. Daniel Gardner. 1986. *Zhu Xi and the Daxue: Neo-Confucian Reflection on the Confucian Canon*. Cambridge: Harvard University Council on East Asian Studies, pp. 27–59.

[26] See Yü Ying-shih. 1975. "Some Preliminary Observations on the Rise of Qing Confucian Intellectualism", *Qinghua Journal of Chinese Studies*, New Series 11.1 (*cont.*) and 11.2 (December 1975), p. 125, for discussion of Wang Yangming's crifique of Zhu Xi's elucidation of the *Great Learning*, which created a textual crisis in the sixteenth century.

[27] See Wang Fan-shen. 1995. "The 'Daring Fool' Feng Fang (1500–1570) and His Ink Rubbing of the Stone-inscribed Great Learning", *Ming Studies* 35 (August 1995), pp. 74–91. See also Wang Yangming 王陽明 . 1973. "Chuanxi lu" 傳習錄 (Instructions for practical living), in: *Wang Yangming quanji* 王陽明全集 (Complete works of Wang Yangming). Taibei: Kaozheng Press, p. 129.

[28] See Zhu Zhenheng 朱震亨 . 1983–86. *Gezhi yulun*格致餘論 (Views on extending medical knowledge). Reprint Taibei: Commercial Press (in the *Siku quanshu* 四庫全書 edition), vol. 746, p. 638.

[29] See the synopsis ("Tiyao" 提要) of Zhu Zhenheng's study prepared by the editors of the *Siku quanshu zongmu* 四庫全書總目 (Catalogue of the complete collection

In addition to its central epistemological place in literati classical learning since 1200, the notion of *gewu* was also applied to the collection, study, and classification of antiquities, as in Cao Zhao's 曹昭 (fl. 1387–99) *Gegu yaolun* 格古要論 ('Essential Criteria of Antiquities', lit. 'Key issues in the investigation of antiquities'), which was published in the early Ming and enlarged several times thereafter. The work originally appeared in 1387/88 with important accounts of ceramics and lacquer, as well as traditional subjects such as calligraphy, painting, zithers, stones, bronzes, and ink-slabs. The 1462 edition prepared by Wang Zuo 王佐 (*jinshi* 進士 of 1427) was enlarged considerably and included findings from the official Ming dynasty naval expeditions led by Zheng He 鄭和 (1371–1433) to Southeast Asia and the Indian Ocean from 1405 to 1433. Wang also added the subjects of imperial seals, iron tallies, official costumes, and palace architecture. In his "Preface," Wang added:

> 凡見一物，必遍閱圖譜，究其來歷，格其優劣，別其是否而後已
> Whenever one sees an object, you must look it all over, trace its appearance, and examine its history and origins. You should investigate its strengths and weaknesses, and distinguish its accuracy.[30]

He was particularly interested in ancient bronzes, calligraphic specimens, and curiosities.[31]

The term *gezhi* was also chosen by Ming literati in the seventeenth century as one of the native categories of specialized learning (*xuewen* 學問), with the latter equivalent to early modern European *scientia*. In the late Qing, reformist Chinese officials and scholars reworked *gezhixue* to designate modern Western science between 1865 and 1900. Subsequently *gezhixue* was replaced in the early twentieth century by *kexue* as the Chinese equivalent for science, which suggests that native terms for Western science were contested at different times and in different ways.[32] Early Jesuit translations of Aristotle's theory of the four elements (*Kongji gezhi* 空際格致, lit., 'investigation of space', 1633) and Agricola's *De Re Metallica* (*Kunyu gezhi* 崑崳格致, lit., 'investigation of the earth', 1640) into classical Chinese, for example, had used the term *gezhi* in light of the Latin *scientia* (= 'organized or specialized knowledge', or *xuewen*, as *scientia* was translated in Chinese in the sixteenth century) in their titles.[33] 'Dao Learning' doctrine and natural studies, particularly medical and calendrical learning, were not mutually exclusive.[34]

Willard Peterson in his valuable study of Fang Yizhi 方以智 (1611–71) has noted how late-Ming views of the *Daoxue* doctrine of the 'investigation of things' (*gewu* 格物, lit., 'approaches to phenomena') had changed from a type of moral endeavor, purely, to an additional stress on external things. Fang Yizhi's opus magnum entitled *Wuli xiaozhi* 物理小識 (Notes on the principles of things) stressed material investigations to comprehend the seminal forces underlying patterns of natural change. Fang generally accepted Western explanations of natural phenomena, such as a spherical earth, limited heliocentrism, and human physiology, brought by the Jesuits, but he was critical of them for leaving behind material investigations and ending in unverified religious positions. Fang Yizhi favored, instead, descriptive knowledge of the natural world, and he inscribed the 'Dao Learning' interpretation of the 'investigation of things' with a new view of

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[29] (*cont.*) of the Four Treasuries). 1973. Ji Yun 記昀 et al. (comp.). Reprint Taibei: Yiwen Press, vol. 746, p. 637.

[30] See the abridged version of the *Gegu yaolun*格古要論 (Essential criteria of antiquities).1573–1619. In: Hu Wenhuan 胡文煥 (comp.). *Gezhi congshu* 格致叢書 (Collectanea of works inquiring into and extending knowledge). Microfilm: Taibei: National Central Library, Rare Books Collection (film of Ming Wanli edition) ca. 1596, vol. 25. See the preface "Xu" 序 by Wang Zuo 王佐, pp. 1a–b. See also Sir David Percival (tr.). 1971. *Chinese Connoisseurship, the Ko Ku Yao Lun: The Essential Criteria of Antiquity*. London: Faber. The new information from other parts of Asia, however, did not challenge the existing frameworks of knowledge in Ming China, which differs from the wider impact of sixteenth century oceanic discoveries in early modern Europe. See Lach 1977, pp. 446–89.

[31] These literati practices of collecting and classifying antiquities merged into the academic discipline of archeology in the early twentieth century. On this development see Su Rongyu's contribution in this volume.

[32] For discussion, see Lydia Liu. 1995. *Translingual Practice: Literature, National Culture, and Translated Modernity—China 1900–1937*. Stanford: Stanford University Press, pp. 20–42.

[33] See Pan Jixing. 1991. "The Spread of Georgius Agricola's *De Re Metallica* in Late Ming China", *T'oung Pao* 57, pp. 108–18; and James Reardon-Anderson. 1991. *The Study of Change: Chemistry in China, 1840–1949*. Cambridge: Cambridge University Press, pp. 30–6; 82–8.

[34] See Roger Hart. 1997. "Local Knowledges, Local Contexts: Mathematics in Yuan and Ming China". Paper presented at the Song-Yuan-Ming Transitions Conference, Lake Arrowhead, Cal., June 5–11, 1997. The conference volume unfortunately will not include this important paper for publication.

the accumulation of knowledge, which gainsaid both the introspective focus of Wang Yangming and the moralist focus of Zhu Xi.[35]

Similarly, the Ming scholar and Hangzhou bookseller Hu Wenhuan 胡文煥 (fl. ca. 1596) compiled and published the *Gezhi congshu* 格致叢書 (Collectanea of works inquiring into and extending knowledge) as a late-Ming repository of classical, historical, institutional, and technical works from antiquity to the present in China that presented a cumulative account of all areas of textual knowledge important to a literati audience in the seventeenth century. Although no two editions of this collectanea were the same, Hu apparently printed a total of 346 works for this and other collectanea in his print shops in Nanjing and Hangzhou, which by some accounts were divided into 37 categories (*lei* 類), such as classical instruction, philology, phonology, historical studies, rituals and regulations, legal precedents, geography, mountains and streams, medicine, Taoism, Buddhism, agriculture, stars, physiognomy, poetry and literature, painting, and epigraphy, among others. Only 181 works were apparently available to the compilers of the *Siku quanshu*, and the version of the *Gezhi congshu* that focused strictly on the 'investigation of things' contained 46 works that stressed classical philology and etymology, beginning with the *Erya* 爾雅 (Progress toward correctness) dictionary annotated by Guo Pu 郭璞 (276–324) of the Jin dynasty.[36]

The *Gegu yaolun* account of early Ming antiquities, for instance, was also included in the collection, but it was abridged by Hu Wenhuan to include only the key parts and titled *Gegu lunyao* 格古論要 (On the most important items in the investigation of antiquities). Hu noted:

> 謂古之不可不格也，古格而未有不通於今。物格而未有不通於人。格之時義大矣哉
> Antiquity must be investigated. When antiquity is investigated it always penetrates to the present. When things are investigtated it always penetrates to humanity. Timely investigations are very meaningful.[37]

[35] Cf. Willard Peterson. 1975. "Fang I-chih: Western Learning and the 'Investigation of Things'", in: Wm. Theodore de Bary et al. (eds.). *The Unfolding of Neo-Confucianism*. New York: Columbia University Press, pp. 369–411.

[36] See Hu Wenhuan 1573–1619, which contains 46 works.

[37] See Hu Wenhuan's preface ("Xu" 序) to the *Gezhi congshu* edition of the *Gegu lunyao*, in *Gegu yaolun*1573–1619, 25, pp. 1a–2a.

Overall, the *Gezhi congshu* collectanea emphasized a broad learning of phenomena (*bowu* 博物), one of the 37 categories, that encompassed natural and textual studies within a humanist and institutional agenda. Within the collection, Zhang Hua's 張華 (232–300) *Bowuzhi* 博物志 (A treatise on curiosities), and Li Shi's 李石 Song dynasty continuation, titled *Xu bowuzhi* 續博物志 (Continuation to a treatise on curiosities) were subsumed under the general category of *gezhi* here. Other works included in the *Gezhi congshu* were the *Shiwu jiyuan* 事物紀原 (Record of the origins of things and affairs) compiled by Gao Cheng 高承 (ca. 1078–85), and the *Gujin shiwu kao* 古今事物考 (Examination of ancient and contemporary things and affairs) prepared by Wang Sanpin 王三聘 in the Ming dynasty.[38]

In addition to Hu Wenhuan's Ming "*Gezhi* studies," Dong Sizhang 董斯張 completed the *Guang bowuzhi* 廣博物志 (Expansion of a treatise on curiosities), which paid more attention to 'natural history'. Such works on *bowu* 博物 as 'natural history' suggest that as a term *bowu* needs to be conceptually mapped asymmetrically with *gezhi*. Sometimes the former was included under the latter, sometimes not. In both *gezhi*-oriented and *bowu*-framed late-Ming works, the transformation of objects into artifacts, antiquities, and art objects was attempted. From heaven and earth to birds, animals, insects, fish, grasses, foodstuffs, architecture, and tools, the inventory of 'organized knowledge' from a Chinese frame of reference represented a systematic collection of data from a wide variety of native sources about China's natural resources, the arts, and manufactures. In the interaction with Western *scientia*, Chinese literati were drawn into a moderate transformation of their own traditions of natural studies.[39]

2. Natural studies in Ming civil examinations

Careful scrutiny of Ming dynasty examination records reveals that civil examinations also tested the candidates' knowledge of astrology (*tianwen* 天文), calendrics (*lifa* 歷法), and other aspects of the natural

[38] Ibid., and Campany 1996, pp. 51–2. A preface for the version of 156 works in the Library of Congress edition of the *Gezhi congshu* is entitled *Baijia mingshu xu* 百家名書序 (Preface to the *Renowned works of the Hundred schools*).

[39] Cf. *Gezhi congshu*, *passim*. See also Ssu-yü Teng and Knight Biggerstaff. 1971. *An Annotated Bibliography of Selected Chinese Reference Works*. Cambridge: Harvard University Press, p. 105.

world, which were referred to as 'natural studies' (*ziran zhi xue* 自然之學).[40] Ming candidates for both the provincial and metropolitan examinations, unlike their Song counterparts, were expected to grasp many of the technicalities in calendrics, astrology, anomalies (*zaiyi* 災異) and the musical pitch series (*yuelü* 樂律). The latter was the basis for official weights and measures. In the early Ming, for example, the Yongle 永樂 emperor (r. 1402–24) put calendrical and practical studies near the top of what counted for official, literati scholarship. More importantly, the emperor had legitimated 'natural studies', Thereafter such questions regularly appeared on Ming civil examinations.[41]

*Table 2: Ming Dynasty Policy Questions Classified by Topic: Yingtian Prefecture, 1474–1600, 230 questions, top 15 ranks only**

Rank	*Topic*	*Pct. of Total*	*Selection Probability*
1	Learning/Selection (*yangcai* 養才, *yongren* 用人)	9.6%	43.4%
2	Daoxue (*daoxue* 道學)	8.3%	37.5%
3	Ming rulers (*taizu* 太祖, *chengzu* 成祖)	7.4%	33.5%
4	World ordering (*zhiguo* 治國)	7.0%	31.6%
5	Economy/Statecraft (*licai* 理財)	5.7%	25.8%
6	Ruler-official (*junchen* 君臣)	5.2%	23.5%
7	National defense (*guofang* 國防)	4.3%	19.4%
7	Classical studies (*jingxue* 經學)	4.3%	19.4%
9	Law (*faxing* 法刑)	3.5%	15.8%
9	Military matters (*bingshi* 兵事)	3.5%	15.8%
11	Literature/Poetry (*wenshi* 文詩)	3.0%	13.6%
11	Natural studies (*ziran* 自然)	3.0%	13.6%
13	History (*shixue* 史學)	2.6%	11.8%
13	Agriculture (*nongzheng* 農政)	2.6%	11.8%
13	Customs/Values (*fengsu* 風俗)	2.6%	11.8%

*) Source: Nanguo xianshu 南國賢書 (Record of civil examination success in the Southern Capital Region). Compiled by Zhang Chaorui 張朝瑞 (ca. 1600 edition). The probability for each policy question is calculated based on the assumption that each of the five selections is mutually independent. If the selection of five questions were mutally dependent, then the probability for each type would be slightly higher. Most topics above and below are based on actual Chinese categories. I have added a few, such as natural studies, which are based on combining categories, such as astrology, calendrical studies, and musical harmonics.

Table 2, for instance, reveals that 50 to over 75 thousand candidates empire-wide for the provincial examinations during the Ming dynasty could reasonably expect a required policy question on astrology or calendrics. In the Qing, curiously, the likelihood of such policy questions was negligible.[42] Instead, candidates increasingly had to answer questions dealing with textual issues growing out of the evidential research studies that peaked in the late eighteenth century.

We should quickly add, however, that the ability to deal with astrological, medical, mathematical calculations for calendrics, and other technical questions was an essential tool of the new classical studies emerging in the late Ming and early Qing. It just was not tested within the precincts of the Qing civil service before 1860.[43] For example, Xiong Mingyu's 熊明遇 (b. 1579) Jesuit-inspired work entitled *Gezhi cao* 格致草 (Draft for investigating things and extending knowledge) revealed how far the classical ideal of *gewu* could be extended using European criteria for determining the fundamental ground of all things in the world (*suo yi ran zhi li* 所以然之理). Published in 1648, after the fall of the Ming and in the midst of the Manchu takeover of south China, the *Gezhi cao* represented an accommodation between Jesuit natural philosophy cum theology and the classical repertoire of literati learning based on *gewu*.[44]

[40] See Elman 2000, pp. 461–81.

[41] See *Huang Ming sanyuan kao* 皇明三元考 (Study of the provincial, metropolitan, and palace civil examination *optimi* during the Ming dynasty). Zhang Hongdao 張弘道 and Zhang Ningdao 張凝道 (comps.). Late Ming edition, after 1618, vol. 2, p. 3b; and *Zhuangyuan ce* 狀元策 (Policy essays of *optimi*). 1997 [1733]. Jiao Hong 焦竑 and Wu Daonan 吳道南 et al. (comps.). n.p. Huaidetang edition, chapter "Zongkao" 總考, p. 15a.

[42] See Elman 2000, pp. 720–2.

[43] See Yuan-ling Chao. 1995. *Medicine and Society in Late Imperial China: A Study of Physicians in Suzhou*. Ph.D. diss., University of California (Los Angeles); and Chu Pingyi. 1994. *Technical Knowledge, Cultural Practices and Social Boundaries: Wan-nan Scholars and the Recasting of Jesuit Astronomy, 1600–1800*. Ph.D. diss., University of California (Los Angeles). Cf. Benjamin A. Elman. 1984. *From Philosophy to Philology*. Cambridge, Mass.: Council on East Asian Studies, Harvard University, pp. 61–4, 79–85, 180–4.

[44] See Xiong's preface ("Zixu" 自敍) in Xiong Mingyu 熊明遇. 1648. *Gezhi cao* 格致草 (Draft for investigating things and extending knowledge). n.p. (1648 edition in the Library of Congress Asian Library). For discussion see Xu Guangtai 1996b, pp. 236–58.

3. The Elimination of Natural Studies in Early Qing Examinations

The previous discussion demonstrates that it is a mistake to read back into the Ming dynasty the view that 'Dao Learning' moral philosophy and natural studies were opposed to technical learning. Specialized knowledge about astronomy, the calendar, and musical harmonics required in the civil examinations made some difference in the cultural prestige and social status of literati-officials vis-à-vis experts employed in the Astronomy Bureau or the Office of Music. As moral generalists versed in the classical orthodoxy that granted them the highest social, political, and cultural prestige, Ming civil officials were required to know how astronomy, mathematics, calendrical studies, and musical harmonics were part of the orthodox apparatus of ritual. They were not licensed to become 'scientists', but neither were they hostile to understanding the role of natural phenomena in governance.

Moreover, the longstanding political *raison d'être* for the literatus had been his official status as a moral paragon who made his classical degree, earned by examination, relevant to his bureaucratic position. Classical statecraft had always been premised on the linkage between classical learning and political competence. That competence was not measured by the literatus' status as an expert in natural studies. Part of it, however, involved using his knowledge of the Classics to understand the role of the calendar or music in governance. In the policy questions, technical learning was not the ultimate object of the question. Rather, the examiners expected candidates to place technical learning within the classical narrative of world-ordering bequeathed by the sage-kings.

Accordingly, the policy questions on natural studies were restricted to fields relevant to bureaucratic governance and discussed in the basic Classics, or at least read into them by the early commentaries. Other fields such as medicine and alchemy were not deemed appropriate for the examination curriculum. It was important that astronomy and mathematics were discussed in the early Classics, while medicine and alchemy were not. The 'wrong' answer to such policy questions would indicate that the candidate had failed to grasp the heterodox implications of any effort to observe phenomena in the heavens or on earth in ways that challenged the dynasty in power. As a

public event, the policy question and answer delivered in the precincts of an examination compound made natural studies part of the orthodox system by placing them, during the Ming, within the civil service examination curriculum. By promoting technical knowledge, the examiners successfully domesticated astrology, musical pitch, and calendrics. Literati were chosen for officialdom in this way because they knew that the moral terms of their success presupposed the subordination of expert knowledge to 'Dao Learning'.

Natural studies was justified as the proper concern of the moral generalist because it could be brought within the orthodox system. Experts, as long as they were subordinate to dynastic orthodoxy and its legal representatives, were necessary parts of the cultural, political, and social hierarchies. The literatus-official coexisted with the calendrical expert in the bureaucratic apparatus but at higher levels of political status, cultural prominence, and social prestige.[45] The Ming civil examinations, therefore, were not remarkable because they included policy questions on natural studies. They were remarkable because they successfully encapsulated natural studies within a system of political, social, and cultural reproduction that guaranteed the long-term dominance of the dynasty, its literati, and the 'Dao Learning' orthodoxy.

We have some clues, however, about why in the Qing period such policy questions on natural studies were so rare and uninformed when compared to the Ming dynasty.[46] Geography and astrological studies had been overlapping fields in earlier dynasties, but during the early Qing this linkage was broken when, as shown below, the court banned policy questions on the calendar and celestial studies. Thereafter, geography, particularly local geography, flourished as a source for provincial and metropolitan policy questions.[47] The Manchu throne sought to monopolize this potentially volatile area of expertise within the confines of the court. Contemporary calendrical debates between Jesuits and literati-officials, which challenged the Yuan-Ming calendrical system during the Ming-Qing transition gave the imperial court

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[45] Cf. Deane 1989, pp. 353–90.

[46] See Xu Ke 徐珂 . 1920. *Qingbai leichao* 清稗類鈔 (Classified jottings on Qing dynasty unofficial history). Shanghai: Commercial Press, vol. 21, p. 65.

[47] See Shen Xinzhou 沈新周 . 1910. "Xu" 序 (Preface), in: *Dixue* 地學 (Geographical studies). Shanghai: Saoye shanfang lithograph.

pause about allowing possibly divisive questions on the calendar to appear in civil examinations.[48]

The collapse of the Ming dynasty and its Qing successor under non-Han rule created opportunities until 1685 for experts in astronomy-astrology and music to break out of their subordinate positions and to challenge a discredited Ming elite for political power under a new Manchu ruling elite. The increased cultural importance of astronomical expertise, when the new dynasty had to reformulate in expert terms its calendrical and musical *raison d'être* as quickly as possible, challenged for a time the cultural distinction accumulated by literati via mastery of classical studies. Court scholars such as Li Guangdi 李光地 (1642–1718) actively patronized specialists in calendrical calculations (see below) and made the musical pitch series a high priority in their officially financed research.[49]

Not until the 1680s, when the Manchu dynasty had mastered its political and military enemies, did the intellectual fluidity of the early decades of the Qing begin to disappear, leaving Han literati and Manchu elites in a precarious balance at the top (and calendar specialists again in the middle) of the political and social hierarchies, which lasted into the nineteenth century. In the process, policy questions on the third session of the provincial and metropolitan examinations virtually ceased to include natural studies. By 1715, the Kangxi emperor (r. 1662–1722) successfully banned focus in the civil examinations on study of astronomical portents and the calendar because they pertained to Qing dynastic legitimacy.

The emperor could not restrict such interest among the literati community outside the civil examination bureaucracy, however. The emperor, for example, decreed in 1713 that thereafter all examiners assigned to serve in provincial and metropolitan civil examinations were forbidden to prepare policy questions on astronomical portents, musical harmonics, or calculation methods. The latest works in Qing natural studies, court projects on which the Kangxi emperor had employed Jesuit experts, were put off limits to examiners and examination candidates.[50]

This evolving Qing ban on examination candidates studying astronomy, astrology, and music for the civil examinations was noted at the time in Shen Xinzhou's 沈新周 1712 preface to his study entitled *Dixue* 地學 (Studies of geography). Shen indicated that all discussions of astronomical portents (*yan tianwen* 言天文) were forbidden late in the Kangxi reign. In this public acknowledgement of Qing imperial policy, we see by way of contrast how important the Yongle emperor's early Ming decree had been in encouraging natural studies. The Yongzheng emperor 雍正 (b.1678–1735), however, changed the Kangxi emperor's policy a bit by admitting imperial students with specializations in astrology (*tianwensheng* 天文生) into the dynastic schools.[51]

4. Evidential studies and Gezhixue 格致學

Such bans on natural studies, however effective in the civil examinations, did not carry over to literati learning, where a decisive sea change in classical learning was occurring. Clearly there were limits to imperial power outside the government. In contrast to their *Daoxue* predecessors, Qing 'evidential research' (*kaozheng* 考證) scholars stressed exacting research, rigorous analysis, and the collection of impartial evidence drawn from ancient artifacts and historical documents and texts. Evidential scholars made verification a central concern for the emerging empirical theory of knowledge they advocated, namely "to search truth from facts" (*shishi qiushi* 實事求是). This program involved the placing of proof and verification at the center of the organization and analysis of the classical tradition in its complete, multidimensional proportions, which now included aspects of natural studies and mathematics.

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[48] See Jonathan D. Spence. 1974. *Emperor of China: Self-portrait of K'ang-hsi.* New York: Vintage Books, pp. xvii–xix, 15–6, 74–5. On the Yang Guangxian 楊光先 (1597–1669) anti-Jesuit affair in Kangxi court life in the 1660s, see Chu Pingyi. 1997. "Scientific Dispute in the Imperial Court: The 1664 Calendar Case", *Chinese Science* 14, pp. 7–34.

[49] Cf. Arthur Hummel (ed.). 1972. *Eminent Chinese of the Qing Period.* Reprint Taibei: Chengwen, pp. 473–5.

[50] See *Huangchao zhengdian leizuan* 黃朝政典類纂 (Classified materials on Qing dynasty government regulations). 1969. Xi Yufu 席裕福 (comp.). Reprint Taibei: Shenwu Press, vol. 191, pp. 7b–8a. For discussion of these court compilations, see Elman 1984, pp. 79–80.

[51] See Shen Xinzhou 1910. See also "Qingchao tongdian" 清朝通典 (Encyclopaedic history of institutions of the Qing dynasty). 1936. In: *Shitong* 十通 (The ten *Tong*). Shanghai: Commercial Press, vol. 18, p. 2131.

Philological studies developed and evolved during the eighteenth and nineteenth centuries because published works on the Classics were part of a dynamic classical research enterprise whose goals were not scientific or objective per se but instead were tied to a new literati commitment to use the language of the ancient Classics as an impartial means to recapture the ideas and intentions of the sage-kings of antiquity. Even if they were scholarly iconoclasts in their own time, they still were firmly conservative in their social beliefs and commitments.[52]

By the late eighteenth century, reflecting the scholarly trends of the Qianlong era (1736–95), the policy questions for civil examinations began to exhibit a common five-way division of topics, usually in the following order: 1) Classics; 2) Histories; 3) Literature; 4) Statecraft; and 5) Local geography. The primacy of classical learning in the policy questions was due to the impact of Han Learning and evidential research among literati scholars, first in the Yangzi delta, and then empire-wide via examiners from the delta provinces of Jiangsu, Zhejiang, and Anhui. What was fueling the popularity of the revival of first a poetry question on session one and then philology in the policy questions in session three of the civil examinations was the close tie between the rules for rhyming in regulated verse and the field of phonology, which became the queen of philology during the Qianlong reign. The role of phonology in evidential research studies was paying dividends by improving literati knowledge of classical sounds and rhymes.[53]

Qing dynasty evidential scholars such as Dai Zhen 戴震 (1724–77) had in mind a systematic research agenda that built on paleography and phonology to reconstruct the meaning (*yi yin qiu yi* 以音求義) of Chinese words. Later Wang Niansun 王念孫 (1744–1832), and his son Wang Yinzhi 王引之 (1766–1834), extended Dai's approach and attempted to use the meanings of Chinese words as a method to reconstruct the intentions of the sages, the farsighted authors of those words. Moreover, technical phonology when applied to the study of the history of the classical language reached unprecedented precision and exactness. To achieve this end, evidential scholars chose philological means, principally the application of phonology, paleography, and etymology, to study the Classics.[54]

One byproduct of these philological trends was the full realization of how important poetry, particularly regulated verse, was for the reconstruction of antiquity via phonology, paleography, and etymology. For example, Liang Zhangju 梁章鉅 (1775–1849), who assembled one of the first cultural studies of the examination regime entitled *Collected Comments on the Crafting of 8-legged Civil Examination Essays* (*Zhiyi conghua* 制藝叢話) in the early nineteenth century, compiled another collection in which he outlined the study of poetry and the rules of regulated verse. In the conclusion, Liang traced how Qing classical scholars had finally unraveled the rhyme system of the *Poetry Classic*. They had thereby illuminated the technical rules in regulated verse and made major advances in the study of phonology.[55]

A full-blown scientific revolution as in Europe did not ensue,[56] but *kaozheng* scholars made astronomy, mathematics, and geography high priorities in their research programs, another by-product of the changes in classical studies then underway. Animated by a concern to restore native traditions in the precise sciences to their proper place of eminence, after less overt attention during the Ming dynasty, evidential scholars such as Dai Zhen, Qian Daxin 錢大昕 (1728–1804), and Ruan Yuan 阮元 (1764–1849) successfully incorporated technical aspects of Western astronomy and mathematics into the literati framework for classical learning. Qian Daxin, in particular, acknowledged this broadening of the literati tradition, which he saw as the reversal of centuries of focus on moral and philosophic problems:

> In ancient times, no one could be a literatus (*Ru* 儒) who did not know mathematical calculation. Chinese methods [now] lag behind Europe's because *Ru* do not know mathematics.[57]

The impact of evidential research made itself felt in the attention *kaozheng* scholars gave to the Western fields of mathematics and astronomy first introduced by the Jesuits in the seventeenth century.

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[52] See Elman 1984, *passim*.

[53] See Elman 2000, pp. 546–62.

[54] Cf. Hamaguchi Fujio 濱口富士雄 . 1994. *Shindai kokyogaku no shisō shi teki kenkyū* 清代考據學の思想史的研究(Research on the intellectual history of Qing dynasty evidential studies). Tokyo: Kokusho kankōkai.

[55] Elman 2000, pp. 562.

[56] See Sivin 1995a, pp. 45–66.

[57] Qian Daxin 錢大昕 . 1968. *Qianyantang wenji* 潛研堂文集 (Collected essays of the Hall of Subtle Research). Taibei: Shangwu yinshuguan, vol. 3, p. 335.

Such interest had built upon the early and mid-Qing findings of Mei Wending 梅文鼎 (1633–1721), who was sponsored by Li Guangdi and the Manchu court once his expertise in mathematical calculation (*li-suan* 歷算) and calendrical studies was recognized. Mei had contended that study of physical nature gave scholars access to the principles (*li* 理) undergirding reality. In essence, Mei saw Jesuit learning as a way to boost the numerical aspects of the *Daoxue* notion of moral and metaphysical principle.[58] At the same time, however, the imperial court and Mei Wending prepared preliminary accounts stressing the native Chinese origins (*zhongyuan* 中源) of Western natural studies. Mei (and his highly placed follower in the early Qing court Li Guangdi) sought to restore and rehabilitate the native traditions in the mathematical sciences to their former glory. Under the Kangxi emperor's imperial patronage mathematical studies were upgraded from an insignificant skill to an important domain of knowledge for literati that complemented classical studies.[59]

For example, Chen Yuanlong's 陳元龍 (1652–1736) *Gezhi jingyuan* 格致鏡原 (Mirror origins of investigating things and extending knowledge), was published in 1735, and in the 1780s it was included in the Imperial Library. A repository of detailed information divided into thirty categories culled from a wide variety of sources, the *Gezhi jingyuan* represented a post-Jesuit collection of practical knowledge by a well-placed scholar in the Kangxi and Yongzheng courts that narrowed the focus of Hu Wenhuan's late-Ming *Gezhi congshu*, much of which had already been lost, to cover almost exclusively the arts and natural studies. Special attention was given to the origins and evolution of printing and stone rubbings, in addition to topics dealing with geography, anatomy, flora and fauna, tools, vehicles, weapons and tools for writing, as well as clothing and architecture.[60]

The seventeenth century impact of Jesuit knowledge in China was not always so easily domesticated in the eighteenth, however. Literati scholars took a range of positions concerning natural studies. A private scholar, Jiang Yong 江永 (1681–1762), for instance, combined a classical loyalty to Zhu Xi's *Daoxue* teachings with knowledge of Western Jesuit studies obtained through evidential studies. Conservative as a classical scholar, Jiang was quite radical in his critique of both Han Learning and Mei Wending in natural studies for exalting native ancient studies in all cases. Jiang Yong recognized the advantages Western astronomy had over native traditions, while at the same time he continued to uphold the cultural superiority of the *Daoxue* view of morality. Although Jiang preferred Western learning for understanding the principles of nature because they were more precise and consistent than native traditions, he maintained a clear distinction between astronomical methods and cultural values.[61]

Overall, Ruan Yuan's compilation of the *Chouren zhuan* 疇人傳 (Biographies of astronomers and mathematicians) while serving as governor of Zhejiang province in Hangzhou from 1797 to 1799, reprinted in 1849 and later enlarged, marked the climax of the celebration of natural studies within the Yangzi delta literati world of the eighteenth century, which had been increasing since the late seventeenth century. Containing biographies and summaries of the works of 280 *chouren*, including thirty-seven Europeans, this work was followed by four supplements in the nineteenth century. Limin Bai has noted how the mathematical sciences had begun to grow in importance among literati beyond the reach of the imperial court in the late eighteenth century. They were now linked to classical studies via evidential research. Because Ruan Yuan was a well-placed literati patron of natural studies in the provincial and court bureaucracy, his influential *Chouren zhuan* represented the integration of the mathematical

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[58] See John Henderson. 1980. "The Assimilation of the Exact Sciences into the Qing Confucian Tradition", *Journal of Asian Affairs* 5.1 (Spring 1980), pp. 15–31.

[59] See Limin Bai. 1995. "Mathematical Study and Intellectual Transition in the Early and Mid-Qing", *Late Imperial China* 16.2 (December 1995), pp. 23–61; and Catherine Jami. 1994. "Learning Mathematical Sciences During the Early and Mid-Qing", in: Benjamin A. Elman and Alexander Woodside (eds.). *Education and Society in Late Imperial China, 1600–1900.* Berkeley: University of California Press, pp. 223–56. On the Chinese origins theory, see Quan Hansheng 全漢昇 . 1935. "Qingmo de 'xixue yuan chu Zhongguo' shuo" 清末的西學源出中國說 (Late Qing theory of the Chinese origin of Western learning), *Lingnan xuebao* 4.2 (June 1935), pp. 57–102.

[60] See Chen Yuanlong 陳元龍 . 1735. *Gezhi jingyuan* 格致鏡原 (Mirror origins of investigating things and extending knowledge), in: *Siku quanshu* (Complete collection (*cont.*) in the Imperial Four Treasuries), vols. 1031–2. I have also used the 1735 edition of this work available in the Library of Congress.

[61] Cf. Chu Pingyi. 1995. "Cheng-Zhu Orthodoxy, Evidential Studies and Correlative Cosmology: Chiang Yung and Western Astronomy", *Philosophy and the History of Science: A Taiwanese Journal* 4.2 (October 1995), pp. 71–108.

sciences with evidential studies. Mathematical study was no longer independent of classical studies.[62]

Literati scholars had by the late eighteenth century incorporated mathematical study into evidential research and made natural studies a part of classical studies. Their efforts provide us with another piece to the puzzle concerning the fate of natural studies and technology in late imperial China since the Jesuits first made their presence felt in the seventeenth century.

5. *Gezhixue* as modern science in the nineteenth century

Philology and natural studies were wedded together when Qing literati scholars such as Mei Wending and his grandson Mei Juecheng 梅穀成 (d. 1763) evaluated early modern European findings in calendrical astronomy and searched through the classical canon for evidence that this new knowledge was likely based on ancient Chinese knowledge, which had been transmitted to the Western regions in antiquity. Mei Juecheng contended, for instance, that the Song-Yuan *Tianyuan* 天元 (heavenly origins) method for graphically representing algebraic equations was the equivalent of the algebraic formulas later introduced by the Jesuits. This more sophisticated 'Chinese origins' argument, when compared to that of the Kangxi emperor, legitimated renewed Qing literati interest in the sciences, and philology became one of the key tools later evidential research scholars employed.[63]

The mathematical studies (*shuxue* 數學) associated with evidential research in the eighteenth century was algorithmic, i.e., focusing on getting the right results, and thus was less concerned to justify methods and formulas. Wang Lai 汪萊 (1768–1813) and Jiao Xun 焦循 (1763–1820), for example, each tried to build on traditional Chinese algebraic equations, known as *Tianyuan*, rather than just automatically accept the Indic-Arabic forms of algebra that the Jesuits and later the Protestants taught when they came to China. Wang in particular derived more than one positive root for a *Tianyuan* equation, which by following Western views of positive and negative roots contributed something new to the traditional focus on a single, positive solution for any algebraic equation.[64]

Wang Lai, who was appointed to the dynastic observatory in Beijing, employed Western methods accepted in the calendrical office since the Kangxi reign, in his calculations of *Tianyuan*. As a result of his professional ties to the French Jesuit 'new studies' harbored in the observatory, Wang was criticized by more conservative *kaozheng* scholars interested in traditional mathematics for going too far in emulating Western methods. Because he was a literatus outside the court and thus tied to the Yangzi delta academic community, Li Rui 李銳 (1773–1817), who devised a theory of *Tianyuan* equations strictly in terms of Song *Tianyuan* mathematics, received more support from literati, many of whom still revered Yang Guangxian 楊光先 (1597–1669) for his prosecutions of the Jesuits in the Kangxi court in the 1660s. Before 1850, then, classical learning still took precedence over Western learning, and the antiquarian interests of evidential scholars stimulated them to study the textual history of native mathematics rather than build on the findings of Western mathematics, as Wang Lai had.

In the aftermath of the bloody defeat of the Taipings, however, a weakened Qing dynasty and its literati-officials began to face up to the new educational requirements the civil service would have to fulfill to survive in a world increasingly filled with menacing industrializing nations. The Opium War (1839–42) provoked very few important calls for introduction of Western learning into the civil service curriculum, but the situation after the fall of the Taipings in 1865 was remarkably different. Literati such as Xu Shou 徐壽 (1818–82) and Li Shanlan 李善蘭 (1810–82), who were involved in translating the Western natural sciences into Chinese at the Jiangnan Arsenal in Shanghai beginning in the 1860s, built conceptual bridges between post-industrial revolution Western learning and the traditional Chinese sciences in the middle of the nineteenth century. *Xixue* now often equalled *gezhixue*. One of the volumes that paralleled the translation project for a Science Outline Series at the Jiangnan Arsenal in Shanghai, for example, focused on British scientific knowledge compiled by

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[62] Cf. Hummel 1972, pp. 402. See also Limin Bai 1995, pp. 23–30.

[63] Cf. John Henderson. 1986. "Qing Scholars' Views of Western Astronomy", *Harvard Journal of Asiatic Studies* 46.1, pp. 121–48.

[64] Cf. Horng Wann-sheng. 1993. "Chinese Mathematics at the Turn of the 19th Century", in: Lin Zheng-hung and Fu Daiwie (eds.). *Philosophy and Conceptual History of Science in Taiwan*. Dordrecht: Kluwer Academic Publishers, pp. 167–208.

Henry Roscoe (Luo Sigu 羅斯古, 1833–1915) and others, which was entitled *Gezhi qimeng sizhong* 格致啟蒙四種 (Science Primer Series in four parts).[65] In the process, post-industrial revolution Western science, now called modern science, was initially introduced in the mid-nineteenth century as compatible with but no longer subordinate to native classical learning.

Both Feng Guifen 馮桂芬 (1809–74), a Hanlin academician, and Xue Fucheng 薛福成 (1838–94), who was prevented by the Taiping wars from taking civil examinations, became administrative experts and advisors to many of the chief ministers of the late Qing, including Zeng Guofan 曾國藩 (1811–72) and Li Hongzhang 李鴻章 (1823–1901), the leaders of the post-Taiping turn toward foreign studies (*yangwu yundong* 洋務運動). The classical curriculum needed to adapt more Western learning and science subjects to be viable, they claimed. Western models became a legitimate object of concern and debate to reform the civil examinations. Li Hongzhang, for example, followed Feng Guifen's recommendation and in 1863 established the *Tongwenguan* 同文館 school of Western languages and science in Shanghai, which was added to the Jiangnan Arsenal in 1869. Li also proposed establishing eight categories for civil examinations (*bake qushi* 八科取士) in 1867, which included mathematical science (*suanshu gezhi* 算數格致) and technical science (*jiqi zhizuo* 機器制作) as a single category. *Jishu* 技術, a term often used as a bibliographic term in earlier dynastic bibliographies, became the technical term for technology.[66]

Qing literati and officials became obsessed with the goal of wealth and power (*fuqiang* 富強), which in the last decades of the dynasty became the technical term for political economy, as in Joseph Edkins' (Ai Yuese 艾約瑟, 1823–1905) translation of *Political Economy* by William Stanley Jevons (Zhe Fensi 哲分斯, 1835–1882), entitled *Fuguo yangmin ce* 富國養民策 (Policies for enriching the dynasty and nourishing the people), which was included as a volume in another series also named *Gezhi qimeng* 格致啟蒙 (Science Primer), supported by Sir Robert Hart (He De 赫德, 1835–1911) and edited by Joseph Edkins.[67] While living in the treaty port of Shanghai to avoid the Taipings, Feng Guifen prepared an essay around 1861 entitled *Gai keju yi* 改科舉議 (Proposal for reforming the civil examinations) in which he attempted to balance the strengths of the selection process with the needs of the future.[68] Feng was aware that he had to sell his recommended changes to opponents who would oppose any blatant effort to introduce Western learning into the examination curriculum. Accordingly, he altered the content of native traditional fields. What Feng meant by classical studies, for instance, included evidential research (*kaoju* 考據) and philology (*xiaoxue* 小學), subjects of learning already included in provincial and metropolitan policy questions. In addition, he added mathematics to the field of classical studies and quietly relegated the literary essay and poetry question to the last session.[69]

Feng also called for widening the selection process for officials to include recommendation and the promotion of clerks who demonstrated their administrative abilities to their superiors. One way to do this, according to Feng, was to divide the civil examination system in two, with one group required to master machinery and physics (*zhiqi shangxiang* 制器尚象). Based on such reforms, "our China [*Zhonghua* 中華] can begin to arise in the world." Otherwise, Feng presciently predicted, she will be a victim of native militarists hiding behind the slogan of 'self-strengthening' (*ziqiang* 自強).[70] One of the strengths of Western learning Feng noted was its mastery of mathematics, which Feng wished to incorporate into the civil examinations.

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[65] The Series contained four parts, see *Gezhi qimeng si zhong* 格致啟蒙四種 (Science Primer Series in four parts). 1875. Young J. Allen and Zheng Changyan 鄭昌炎 (trsl.). Shanghai: Jiangnan zhizaoju. Henry Roscoe prepared the section for chemistry (*huaxue* 化學), Archibald Geikie (Qi Gou 祁覯, 1835–1924) for physical geography (*dilixue* 地理學), Balfour Stewart (Si Duhuo 司都藿, 1828–87) for physics (*gewuxue* 格物學), and Norman J. Lockyer (Luo Keyou 駱克優, not known) for astronomy (*tianwenxue* 天文學).

[66] See "Yangwu yundong dashiji" 洋務運動大事記 (Record of major events during the Foreign Affairs Movement). n.d. In: Xu Tailai 徐泰來 (ed.). *Yangwu yundong xinlun* 洋務運動新論 (New views of the Foreign Affairs Movement). Changsha: Hunan renmin chubanshe, pp. 349–448; and Hummel 1972, pp. 240–3, 331–3.

[67] Cf. Joseph Edkins (tr.). 1886. "Fuguo yangmin ce" 富國養民策 (Policies for enriching the dynasty and nourishing the people), in: Joseph Edkins (ed.). *Gezhi Qimeng* 格致啟蒙 (Science Primer). Beijing: Zong shuiwusi, vol. 12 [Translation of William S. Jevons, *Political Economy*, 1871].

[68] Cf. Feng Guifen 馮桂芬. 1897. *Jiaobinlu kangyi* 校邠廬抗議 (Protests from the cottage of Feng Guifen). Reprint Taibei: Wenhai Press, pt. 2, pp. 55a–56b.

[69] Cf. Feng Guifen 1897, pt. 2, pp. 56b–57a. Zheng Guanying 鄭觀應 (1842–1923) also was an early advocate of including Western topics in the examination framework.

[70] Cf. ibid., pp. 57a–64a; 72b–74b.

Geography and calendrical studies, the latter banned in dynastic schools and civil examinations since the Kangxi reign, were also essential fields for literati, Feng contended. Not until 1887, however, were candidates specializing in mathematics allowed to pass the provincial examinations under a special quota, although they also had to fulfill the same classical requirements.[71]

By building on eighteenth century classicism, which had incorporated a revised version of traditional numerical studies as a part of evidential studies, literati associated with Han Learning after the Taiping Rebellion created the intellectual space needed to legitimate literati study of natural studies and mathematics. For instance, Li Shanlan first went to Shanghai in 1852 and for eight years there worked for the London Missionary Society to translate Western science works into classical Chinese. Later, Li was recommended to the newly established Beijing *Tongwenguan* translators' bureau in 1864, but he took up the appointment in 1866 only after the *Tongwenguan* was upgraded to a college and a department of mathematics and astronomy was added. There, Li Shanlan worked with W. A. P. Martin (Ding Weiliang 丁韙良, 1827–1916), who served as president of the college from 1869 to 1882, to teach mathematics and prepare scientific translations.[72]

Xu Shou initially collaborated with John Fryer (Fu Lanya 傅蘭雅, 1839–1928) at the Jiangnan Arsenal in Shanghai to translate Western scientific literature into classical Chinese, an enterprise that combined a narrow, textually based vision of science, brought by Protestant missionaries to attract Chinese converts, with the skewed *kaozheng* view of the sciences as a domain of classical studies appropriate only for literati. Xu, like Fryer, in effect remained for the most part a cultivator not a researcher of science. Together they founded the *Gezhi shuyuan* 格致書院 in Shanghai in 1874, which was curiously translated into English as the "Shanghai Polytechnic Institute."[73] From different sides, Chinese literati and Western modernizers saw in *gezhi* what they wanted to see, a native trope or Western science.

[71] Cf. ibid., pp. 66a–70a. See also *Guangxu zhengyao* 光緒政要 (Important issues of governance in the Guangxu reign). 1909. Shen Tongsheng 沈桐生 (comp.). Shanghai: Chongyitang, vol. 10, section 13, pp. 18a–20a.

[72] See Hummel 1972, pp. 480.

[73] This somewhat surprising translation was chosen because the model for this institution was the Polytechnical Institute on London's Regent Street.

The Institute had a reading room and library of scientific works. Xu and Fryer also created the first science journal in China entitled *Gezhi huibian* 格致彙編, known in English as "The Chinese Scientific Magazine," which ran first monthly issues from 1876 to 1882 in Shanghai and then quarterly from 1890 to 1892. At its peak it reached some 2000 readers in the treaty ports. Such conceptual compromises were based on maintaining the post-Jesuit term for natural studies, i.e., *gezhi*, but this time using *gezhi* to refer to modern Western, not early modern, science. In this way, mathematics and the other more industrial sciences such as chemistry became acceptable, if still less popular than the civil service, activities for literati.[74]

6. The Denigration of Traditional Chinese Natural Studies

Despite the relative success of traditional Chinese natural studies and Western science in developing together from the seventeenth to the late nineteenth century among literati elites in China under the rubric of *gezhixue*, until 1850 there was little attention by those same elites to European science as a form of practice requiring laboratories to replicate experiments and for such experiments to confirm or reject past scientific findings. For Catholic or Protestant missionaries and literati mathematicians, natural studies was little more than a textual exercise requiring translation of technical knowledge, mastery of those technical texts, and the reproduction via memory of technical learning. Moreover, those who were drawn after the Taiping Rebellion to scholarly work in the new arsenals in Fuzhou, Shanghai, and elsewhere, or translation positions in the *Tongwenguan*, tended to be literati such as Xu Shou and Li Shanlan, men who had failed the more prestigious civil examinations several times and saw Western learning and the sciences as an alternative route to fame and fortune. Yan Fu 嚴復 (1853–1921) and Lu Xun 魯迅 (1881–1936) were also famous examples of this group of outcasts from the civil examinations that

[74] Cf. David Reynolds. 1991. "Re-Drawing China's Intellectual Map: 19th Century Chinese Images of Science", *Late Imperial China* 12.1 (June 1991), pp. 27–61. See also David Wright. 1996. "John Fryer and the Shanghai Polytechnic: Making Space for Science in Nineteenth-Century China", *British Journal of the History of Science* 29, pp. 1–16; and id. 1995. "Careers in Western Science in Nineteenth-Century China: Xu Shou and Xu Jianyin", *Journal of the Royal Asiatic Society*, third series, no. 5, pp. 49–90. Cf. Reardon-Anderson 1991, pp. 17–28, 45–8.

initially served as the pool of highly educated men who filled the world of late-Qing institutions oriented toward *gezhixue*.[75]

Recent research indicates, however, that the various arsenals, shipyards, and factories in the treaty ports were important technological venues for experimental practice where, in addition to the production of weapons, ammunition, and navies, a union of scientific knowledge and experimental practice among literati and artisans was first forged in Shanghai, Nanjing, Tianjin, Wuhan, and elsewhere. Indeed, it is likely the case that the 'techno-science'[76] of late-Qing China was an important building block for the rise of both dynastic and private industry in the late nineteenth century treaty ports where most of the arsenals were established. The Jiangnan Arsenal in Shanghai and the Fuzhou Shipyard, for instance, were generally acknowledged by Europeans and Japanese to be more advanced than their competitor in Meiji Japan, the Yokosuka Dockyard, until the 1880s. David Wright has noted that the two ironclad steamships ordered by Xu Jianyin 徐建寅 (1845–1901), Xu Shou's son, in 1879 from the Vulcan factory in the Baltic port of Stettin for the Beiyang Fleet were more advanced than anything the Japanese navy had at the time, although both were sunk in the Sino-Japanese War of 1894–95. In gunpowder manufacture, the machinery used in Germany was not as advanced as that in Shanghai. Accordingly, outside the civil examination regime and its precincts of licentiates, provincial graduates, and *jinshi* (literatus presented to the emperor for appointment), where millions competed for few places in the bureaucracy, a notable group of doctors, nurses and medical assistants were trained in missionary schools, and an even larger group of engineers, military technicians, and technical specialists were instructed in the arsenals and shipyards.[77]

[75] Cf. David Wright. 1997. "The Great Desideratum: Chinese Chemical Nomenclature and the Transmission of Western Chemical Concepts", *Chinese Science* 14, pp. 35–70.

[76] Bruno Latour denotes the difficulty in dividing science from technology after the industrial revolution. Bruno Latour. 1987. *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge, Mass.: Harvard University Press.

[77] See Meng Yue. 1999. "Hybrid Science versus Modernity: The Practice of the Jiangnan Arsenal", *East Asian Science, Technology, and Medicine* 16, pp. 13–52. See also Takehiko Hashimoto. 1999. "Introducing a French Technological System: The Origin and Early History of the Yokosuka Dockyard", *East Asian Science* 16, pp. 53–72; and David Wright 1995, p. 81.

It was not until the Sino-Japanese War, when the Japanese navy, which was tied to Yokosuka technology, decisively defeated the Qing navy, which was tied to Fuzhou and Shanghai technology, that the alleged superiority of Japan in military technology, or so it was reinterpreted, became common knowledge to Chinese and Japanese patriots. Although the Jiangnan Arsenal had appeared superior in science and technology to Yokosuka until the 1880s, after 1895 each side then read their different fates in 1895 teleologically back to the early Meiji period (later even back further to *Rangaku* 蘭學, 'Dutch Learning'), in the case of triumphant Japan, or back to the failures of the self-strengthening movement after 1865 (later back to all classical learning), in the case of the defeated Qing.

Another sea change in elite and popular opinion in late-Qing China now determined how the Manchu-Chinese refraction of Western science and technology through the lens of *gezhixue* would be interpreted after 1895. Literati radicals such as Yan Fu declared that accommodation between Chinese ways and Western institutions had failed. The Sino-Japanese War thus altered the frame of reference for the 1860–1895 period for both Chinese and Japanese. The beginnings of the 'failure narrative' for Chinese science, i.e., why China had not produced science, paralleled the story of political decline (why no democracy) and economic deterioration (why no capitalism) during the late empire.[78]

Yan Fu, whose poor prospects in the civil examinations led him to enter the School of Navigation of the Fuzhou Shipyard in 1866, expressed long pent up bitterness toward the civil examinations, when he became a publicist and prepared articles for the reformist press that emerged after 1895. Since 1885, Yan had failed the provincial examinations four times.[79] Many like Yan Fu began in the 1890s to link the weakness of the Qing dynasty to the classical education required in civil examinations, which allegedly had wasted the minds of genera-

[78] Cf. Reardon-Anderson 1991, pp. 76–78. See also Nathan Sivin. 1985. "Max Weber, Joseph Needham, Benjamin Nelson: The Question of Chinese Science", in: E. Victor Walter (ed.). *Civilizations East and West: A Memorial Volume for Benjamin Nelson*. Atlantic Highlands: Humanities Press.

[79] See Yan Fu 嚴復 . 1953. "Jiuwang juelun" 救亡決論 (On what determines rescue or perishing), in: *Wuxu bianfa ziliao* 戊戌變法資料 (Sources on the 1898 reforms). Beijing: Shenzhou guoguangshe, pp. 360–71. See also Benjamin Schwartz. 1969. *In Search of Wealth and Power: Yan Fu and the West*. New York: Harper Torchbooks, pp. 22–41.

tions. Moreover, Yan and other reformist voices associated the power of the West with modern schools where students were trained in modern subjects requiring practical training in the sciences and technology.[80]

For Yan Fu and the reformers, Western schools and Westernized Japanese education were examples that the Qing dynasty should emulate. The extension of mass schooling within a standardized classroom system stressing science courses and homogeneous or equalized groupings of students seemed to promise a way out of the quagmire of the imperial education and civil examination regime, whose educational efficiency was now, in the 1890s, suspect. Uncritical presentations of Western schools and Japanese education as science-building success stories were widely accepted. Those involved with the 1898 Reform Movement contended that political reform required fundamental educational change, and educational change was possible only if the civil examinations were reformed.[81]

One of the products of the iconoclasm of the 1898 reforms that survived the Empress Dowager's coup was the Imperial University of Beijing, which was established to be at the pinnacle of an empire-wide network of schools that would expand on the Tongwenguan. The new university was designed like the Translation College to train civil degree-holders, i.e., literati, in Western subjects suitable for government service. W. A. P. Martin, who had earlier worked with Li Shanlan, was chosen as the dean of the Western faculty. Science courses at the Imperial University, interestingly, were still referred to as *gezhi*, and the facilities included modern laboratories equipped with the latest instruments for physics, geometry, and chemistry. This promising development was short-lived, however, because rebels associated with what was called the Boxer Rebellion smashed everything in sight at the university in the summer of 1900.[82]

The delegitimation of classical learning, once complete, eventually had consequences that went beyond what the court and literati expected.[83] The race to establish new institutions of higher learning that would stress modern science accelerated after the occupation of the capital by Western and Japanese troops in 1900. The Boxer popular rebellion and the response of the Western powers and Japan to it unbalanced the power structure in the capital so much that foreigners were able to put considerable pressure on provincial and national leaders. Foreign support of reform and Western education thus strengthened the political fortunes of provincial reformers such as Yuan Shikai 袁世凱 (1859–1916) and Zhang Zhidong 張之洞 (1837–1909), who had opposed the Boxers.[84]

The story of the demise of traditional natural studies and the rise of modern science in China was more complicated than just the demise of classical learning and the rise of modern education, which would subordinate the classics to science. A social, political, and cultural nexus of classical literati values (within which natural studies were embedded), dynastic imperial power, and elite gentry status was unraveling.[85] The Qing dynasty became a party to the delegitimation of classical studies and the accompanying rethinking of the nature and scope of *gezhixue* vis-à-vis modern science. By first decanonizing the classical canon, late nineteenth century literati hoped to free them-

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[80] Cf. Marianne Bastid. 1988. *Educational Reform in Early Twentieth-Century China*. Translated by Paul J. Bailey. Ann Arbor: University of Michigan China Center, pp. 12–3; and Y. C. Wang. 1966. *Chinese Intellectuals and the West, 1872–1949*. Chapel Hill: University of North Carolina Press, pp. 52–9. Curiously, Yan Fu's own translations were criticised for their incomprehensibility because they were written in classical style. On Yan Fu's translations see Timothy Wong's contribution in this volume.

[81] See Elman 2000, pp. 585–94; and Paula Harrell. 1992. *Sowing the Seeds of Change: Chinese Students, Japanese Teachers, 1895–1905*. Stanford: Stanford University Press, pp. 11–60.

[82] See Renville Lund. 1956. *The Imperial University of Beijing*. Ph.D. diss., University of Washington (Washington), pp. 118–22; and Reardon-Anderson 1991, p. 109.

[83] Cf. Elman 2000, pp. 608–18. See also Paul Bailey. 1990. *Reform the People: Changing Attitudes Towards Popular Education in Early Twentieth Century China*. Edinburgh: Edinburgh University Press, pp. 26–7, who stresses the Boxer Rebellion as the "turning point in the court's attitude towards reform."

[84] See Stephen R. MacKinnon. 1980. *Power and Politics in Late Imperial China: Yuan Shi-kai in Beijing and Tianjin, 1901–1908*. Berkeley: University of California Press, pp. 3–4, 216–7. On the impact on the urban elite in Hunan and Hubei, see Joseph W. Esherick. 1976. *Reform and Revolution in China: The 1911 Revolution in Hunan and Hubei*. Berkeley: University of California Press, pp. 40–52. For Zhejiang province, see Mary B. Rankin. 1986. *Elite Activism and Political Transformation in China: Zhejiang Province, 1865–1911*. Stanford: Stanford University Press, pp. 172–88.

[85] For the concept of "cultural nexus", see Prasenjit Duara. 1988. *Culture, Power, and the State: Rural North China, 1900–1942*. Stanford: Stanford University Press, pp. 5–6, 38–41, 247–8.

selves from the moral and classical imperatives of the past, but they also began to distance themselves from traditional views of and approaches to natural studies, medicine, and technology.[86]

The delegitimation of classical learning after 1900 initially did not challenge the use of *gezhi* as a term from the Four Books to translate modern science into classical Chinese, however. Session one of the reformed, post-1901 civil examinations, for example, expected candidates to answer five questions dealing with Chinese institutions and politics (*Zhongguo zhengzhishi shilun* 中國政治史事論). Session two included five policy questions on Western institutions and politics (*Geguo zhengzhi yixue ce* 各國政治藝學策). The last session required three classical essays, two on quotations from the Four Books and one from the Five Classics (*Sishu yi, wujing yi* 四書義·五經義). In theory, all three sessions were expected to count equally for the final rankings, but how this would work out in practice remained unknown. Would examiners really relegate classical essays and give priority to contemporary issues? And what role would the sciences play in this reform?

In 1902 the first civil examinations since the post-Boxer reforms took place in Kaifeng, the capital of Henan province. Because the provincial examination halls in Shuntian, where the metropolitan examinations in Beijing had also been held, had been burned down by the foreign troops sent in to relieve the Boxer siege of the international legations, the metropolitan examination could not be held in Beijing. The 1902 examination reforms failed in the short run to accomplish their goals because of the classical tenacity of the conservative examiners. Nevertheless the overall scope of the examinations became decidedly more institutional, international, and science-oriented in focus. A catalog of policy questions used in the examinations after the reforms, which was compiled in 1903, identified the thirty-two categories that were used:

[86] Cf. Chuzo Ichiko. 1968. "The Role of the Gentry: An Hypothesis", in: Mary Wright (ed.). *China In Revolution: The First Phase, 1900–13*. New Haven: Yale University Press, p. 299; Ernest P. Young. 1977. *The Presidency of Yuan Shih-k'ai: Liberalism and Dictatorship in Early Republican China*. Ann Arbor: University of Michigan Press, pp. 7–8; and Helen R. Chauncey. 1992. *Schoolhouse Politicians: Locality and State During the Chinese Republic*. Honolulu: University of Hawaii, pp. 10–1.

*Table 3: Categories of policy questions**

1. Way of ordering (zhidao 治道)	9. Assemblies (yiyuan 議院)
2. Scholarship (*xueshu* 學術)	10. State organizations (*zhengti* 政體)
3. Domestic government (*neizheng* 內政)	11. Public laws (*gongzhi* 公治)
4. Foreign relations (*waijiao* 外交)	12. Penal laws (*xinglü* 刑律)
5. Current affairs (*shishi* 時事)	13. Education Affairs (*jiaowu* 教務)
6. Civil examinations (*keju* 科舉)	14. Astronomy (*tianxue* 天學)
7. Schools (*xuexiao* 學校)	15. Geography (*dixue* 地學)
8. Official institutions (*guanzhi* 官制)	16. Calendrical studies (*lixue* 曆學)
17. Mathematics (*suanxue* 算學)	25. Agriculture system (I) (*nongzheng* (*shang*) 農政 (上))
18. Sciences (I) (*gezhi* (*shang*) 格致 (上))	26. Agriculture system (II) (*nongzheng* (*xia*) 農政 (下))
19. Sciences (II) (*gezhi* (*xia*) 格致 (下))	27. Public works (*gongzheng* 工政)
20. State finance (*caizheng* 財政)	28. Commercial system (*shangzheng* 商政)
21. Monetary system (*bizhi* 幣制)	29. Roads and mines (*lukuang* 路礦)
22. Military system (I) (*junzheng* (shang) 軍政 (上))	30. Topography (*yudi* 輿地)
23. Military system (II) (*junzheng* (*xia*) 軍政 (下))	31. History (*shixue* 史學)
24. Defense matters (*fangwu* 防務)	32. Foreign history (*waishi* 外史)

*) Source: "Mulu" 目錄 , in: *Zhongwai shiwu cewen leibian dacheng* 中外時務策問類編大成 (Compendium of classified examination questions on current affairs in China and abroad). 1903. n.p., pp. 1a–28b.

Although the examiners' biases toward Chinese learning pervaded many of these fields, the impact of the Western sciences on the civil service curriculum was quite noticeable. For example, five of the eight questions on the natural sciences, which was still called *gezhi*, were phrased as follows:

> 1. Much of European science originates from China (*zhongguo* 中國); we need to stress what became a lost learning as the basis for wealth and power.

2. In the sciences, China and the West (*tai xi* 泰西) are different; use Chinese learning (*zhongxue* 中學) to critique Western learning (*xixue* 西學).

3. Substantiate in detail the theory that Western methods all originate from China.

6. Prove in detail that Western science studies mainly were based on the theories of China's pre-Han masters.

7. Itemize and demonstrate using scholia that theories from the Mohist Canon preceded Western theories of calendrical studies, light, and pressure.[87]

Such views revealed that in official terms, the wedding between the traditional Chinese sciences and Western science, worked out beginning in the eighteenth century, was still in effect. Publicly at least, the officials of the late-Qing dynasty maintained the fiction that

> 西人格致之學多來於中國諸子之說
> the Western sciences for the most part derived from the teachings of the pre-Han masters.[88]

After 1905, however, when the civil examinations had been abolished, the ever increasing number of overseas Chinese students in Japan, Europe, and the United States perceived that outside of China the proper language for science included a new set of concepts and terms that superseded traditionalist literati notions of natural studies associated with *gezhi*. For example, Japanese scholars during the early Meiji period had already in the 1860s demarcated the new sciences by referring to *Wissenschaft* as *kagaku* (*kexue* 科學, lit. 'classified learning based on technical training')[89] and natural studies as *kyūri* (*qiongli* 窮理, lit. 'exhaustively study the principles of things'). The latter term, long associated with 'Dao Learning' in China since the Song dynasty, was reinterpreted in Japan based on the Dutch Learning tradition of the late eighteenth century, when Japanese scholars interested in Western science still used terms from Chinese learning (*kangaku* 漢學) to assimilate European natural studies and medicine.[90]

Chinese students and scholars initially adopted the Japanese bifurcation between technical learning and natural studies. Yan Fu, for instance, rendered the terms 'science' or 'sciences' as *kexue* in his 1900–1902 translation of John Stuart Mill's (1806–1873) *System of Logic*, while translating natural philosophy as *gewu* 格物, or the 'investigation of things'.[91] Similarly, when regulations for modern schools were promulgated in 1903, the term *gezhi* was used to refer collectively to the sciences in general, while the sciences as individual, technical disciplines were designated as *kexue*. This two-track terminology for science lasted through the end of the Qing dynasty and was continued during the early years of the Republic of China, but Chinese students who returned from abroad increasingly saw the need to develop a single Chinese term for the Western sciences that would leave behind the earlier assimilation of traditional Chinese natural studies into modern science.[92]

Many overseas students were as radical in their political and cultural views, which carried over to their scientific iconoclasm. Traditional natural studies became part of the 'failed' history of traditional China to become 'modern', and this view now included the claim that the Chinese had never had any science. The earlier claim for the 'Chinese origins' of Western science, so prominent before 1900, was now deemed superstition (*mixin* 迷信, lit. 'confused beliefs'). What had come before modern *kexue* was magic and the supernatural, not science. How pre-modern Chinese demarcated the natural and supernatural was lost, when both 'modernists' and 'socialists' in China accepted the West as source of all science as *kexue*, which was diametrically opposed to *gezhi*.

Linkage between political revolution and the perception by many radicals that a scientific revolution was also required influenced the

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[87] See *Zhongwai shiwu cewen leibian dacheng*, "mulu", pp. 13a–13b.

[88] Ibid., p. 13a.

[89] Cf. Liu 1995, pp. 33; 336, presents *kexue/kagaku* as a second-hand *kanji* borrowing from classical Chinese that the Japanese used to translate science into Japanese. Her source is the Song dynasty literatus Chen Liang 陳亮 (1143–94), who uses *kexue* as a shorthand reference to mean 'civil examination studies' (*keju zhi xue* 科舉之學 equals *kexue*). This twelfth-century usage is unique to the Song dynasty, which the Japanese borrowed.

[90] Cf. Albert Craig. 1965. "Science and Confucianism in Tokugawa Japan", in: Marius Jansen (ed.). *Changing Japanese Attitudes Toward Modernization*. Princeton: Princeton University Press, pp. 139–42.

[91] Cf. Yan Fu嚴復 (tr.). 1902. *Mule mingxue* 穆勒名學 (Miller's *Logic*). n. p.: Jisuzhai [Translation of John Stuart Mill. 1843. *A System of Logic. Ratiocinative and Inductive*, 2 vols.]. In the nineteenth cenutry, *gewu* was also used to delimitate the new field of physics. On the establishment of this new discipline and its various designations see Iwo Amelung's contribution in this volume.

[92] Cf. Reardon-Anderson 1991, pp. 82–7.

changes that occurred after 1911. Those Chinese who thought a revolution in knowledge based on Western learning was required not only challenged what they called 'Confucianism' (*Kongjiao* 孔教), but they also unstitched the interwoven patterns of traditional Chinese science, medicine, and classical learning long accepted as components of an ideological tapestry buttressing imperial orthodoxy.[93] Those educated abroad at Western universities such as Cornell University or sponsored by the Rockefeller Foundation after 1914 for medical study in the United States, as well as those trained locally at higher-level missionary schools, regarded modern science as *kexue*, not *gezhixue*, because they believed the latter term was derived from the language of the discredited past and inappropriate for modern science. The belief that Western science represented a revolutionary application of scientific methods and objective learning to all modern problems was increasingly articulated in the journals associated with the New Culture Movement. The journal *Kexue* 科學 (Science), which was published by the newly founded Science Society of China (*Zhongguo kexueshe* 中國科學社) and first issued in 1915, assumed that an educational system based on *kexue* was the panacea for all of China's ills because its knowledge system was superior. By 1920, the Science Society, which had been founded by overseas Chinese students at Cornell in 1914, had some 500 members in China and grew to 1000 in 1930.[94]

Such scientism on the part of Chinese scientists trained abroad, many from Cornell, was iconoclastic in its implications for traditional natural studies in China and influenced post-imperial literati such as Chen Duxiu 陳獨秀 (1879–1942), who argued in the issues of the journal *Xin qingnian* 新青年 (New Youth), which he helped found in 1915, that science and democracy were the twin pillars of a modern China that must dethrone the imperial past. In the process, post-imperial scholars and novelists such as Ba Jin 巴金 (1904–2000), in his novel *Family*, for example, initiated an assault on pre-modern natural studies and medicine as a haven of superstition and backwardness. During the early Republic, the elite view of popular customs (*fengsu* 風俗) was also reconfigured in modernist terms, a trend that included Xu Ke's 徐珂 (1869–1929) *Qingbai leichao* 清稗類鈔 (Classified jottings on Qing dynasty unofficial history). In Xu's collection, popular lore was divided up and reclassified into the categories of 'magicians and shamans' (*fangji* 方伎) and 'confused beliefs', for example. Xu Ke intended his collection of lore, published in 1917, as a sequel to the Northern Song dynasty *Taiping kuangji* 太平廣記 (Expanded records of the Taiping reign, 976–83) and the later *Songbai leichao* 宋稗類鈔 (Classified jottings on Song dynasty unofficial history). However, the new cultural context ensured that such lore was publicly acceptable among modernist literati only if it could be pigeonholed as superstition.[95]

Traditional Chinese medicine, which was the strongest field of the Chinese sciences during the transition from the late Qing to the Republican era, was also subjected to such derision, although it was more successful in retaining its prestige than Chinese astrology, geomancy, and alchemy, which were dismissed by modern scholars as purely superstitious forms of knowledge.[96] When the Guomindang-sponsored Health Commission proposed to abolish Chinese medicine (*Zhongyi* 中醫) in February 1929, for example, traditional Chinese doctors responded by calling for a national convention in Shanghai on March 17, 1929, which was supported by a strike of pharmacies and surgeries nationwide. The protest succeeded in having the proposed abolition withdrawn, and the Institute for National Medicine (*Guoyiguan* 國醫館) was subsequently established. One objective, however, was to reform Chinese medicine along Western lines.[97]

Bridie Andrews has documented the remarkable odyssey of Western medicine in early Republican China. She notes that the practice of Western medicine in China was assimilated by individual Chinese doctors in a number of different ways. Some defended traditional Chi-

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[93] See Benjamin A. Elman. 1997. "The Formation of 'Dao Learning' as Imperial Ideology During the Early Ming Dynasty", in: T. Huters, R. Bin Wong, and P. Yu (eds.). *Culture and the State in Chinese History*. Stanford: Stanford University Press, pp. 58–82.

[94] See Peter Buck. 1980. *American Science and Modern China*. Cambridge: Cambridge University Press, pp. 171–85; and D. W. Y. Kwok. 1971. *Scientism in Chinese Thought, 1900–1950*. New York: Biblo and Tannen, *passim*.

[95] Xu Ke 1920, vol. 74, p. 11, and *passim*.

[96] Cf. Eugenia Lean. 1996. "The Modern Elixer: Medicine as a Consumer Item in the Early Twentieth-Century Press". M.A. thesis paper, University of California (Los Angeles), November 1996.

[97] See Bridie Andrews. 1997a. "Tuberculosis and the Assimilation of Germ Theory in China, 1895–1937", *Journal of the History of Medicine and Allied Sciences* 52.1, 114–57; pp. 142–3.

nese medicine, but they sought to update it with Western findings. Others tried to equate Chinese practices with Western knowledge and equalized their statuses as medical learning. The sinicization of Western pharmacy by Zhang Xiqun 張錫純 (1860–1933), for example, was based on the pharmacopia in the Chinese medical tradition. Another influential group associated with the Chinese Medical Association, which stressed Western medicine, criticized traditional Chinese medical theories as erroneous because they were not scientifically based.[98]

Andrews also documents how in this cultural encounter, techniques such as acupuncture were modernized by Chinese practitioners such as Cheng Dan'an 承澹盦 (1899–1957), whose research on acupuncture enabled him to follow Japanese reforms by using Western anatomy to redefine the location of the acupuncture points. Cheng's redefinitions of acupuncture thus revived what had become from his perspective a moribund field that was rarely practiced in China and, when used, mainly served as a procedure for blood-letting. This reform of acupuncture, which included replacing traditional coarse needles with the filiform metal needles in use today, ensured that the points for inserting needles were no longer placed near major blood vessels. Instead, Cheng mapped the points according to the Western nervous system. According to Andrews, a new scientific acupuncture sponsored by Chinese research societies thus emerged.[99]

During the transition from the Qing dynasty to the Republic of China, then, new political, institutional, and cultural forms emerged that challenged the creedal system of the late empire and refracted the latter's cultural forms of knowledge, such as traditional Chinese medicine. Just as the emperor, his bureaucracy, and literati cultural forms quickly became symbols of political and intellectual backwardness, so too traditional forms of knowledge about the natural world, were uncritically labeled as superstition, while modern science in its European and American forms was championed by new intellectuals as the proper path to objective knowledge, enlightenment, and national power. Even those who sought to maintain Chinese traditional medicine by modernizing it according to Western standards of rigor, however, also played a part in the denigration of past medical practices.[100]

Conclusion

The dismantling of the traditions of *gezhixue* and *bowuxue*, among many other categories, that had linked natural studies, natural history, and medicine to classical learning from 1370 to 1905 climaxed during the cultural and intellectual changes of the New Culture Movement.[101] When their iconoclasm against classical learning and its traditions of natural studies climaxed after 1915, New Culture advocates helped replace the imperial tradition of *gezhixue* with modern science and medicine. The fall of *gezhixue* concluded a millennium of elite belief in literati values and five hundred years of an empire-wide classical orthodoxy that had encompassed the Chinese natural studies and local technologies. The legacy of destroying that cultural cum creedal system and the centering frames for human experience that it enforced should not be underestimated. What fell between 1905 and 1915 was an educational regime based on classical learning. Socially, classical credentials no longer confirmed gentry status or technical expertise, so sons of literati, and now daughters, turned to other avenues of learning and careers outside officialdom, particularly the sciences, modern medicine, and engineering. Literati increasingly travelled to Shanghai, Fuzhou, and other treaty ports to seek their fortunes in arsenals and shipyards as members of a new gentry-based post-imperial Chinese intelligentsia that would become the seeds for modern Chinese intellectuals.

As elites turned to Western studies and modern science between 1905 and 1915, fewer remained to continue the traditions of classical learning (Han Learning), moral philosophy (Song Learning), or *gezhixue* that had been the intellectual core of imperial orthodoxy and

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[98] Cf. Andrews 1997a, pp. 114–57; and Bridie Andrews. 1997b. "Medical Lives and the Odyssey of Western Medicine in Early Twentieth-Century China". Paper presented at the History of Science Society Annual Meeting, San Diego, Cal., November 8, 1997.

[99] Cf. Andrews 1997b, pp. 24–8. For other fields, see Laurence Schneider. 1988. "Genetics in Republican China", in: J. Bowers, J. Hess, and N. Sivin (eds.). *Science and Medicine in Twentieth-Century China: Research and Education.* Ann Arbor: Center for Chinese Studies, University of Michigan, pp. 3–29; and Yang Ts'ui-hua. 1993. "The Development of Geology in Republican China, 1912–1937", in: Lin Cheng-hung and Fu Daiwei (eds.). *Philosophy and Conceptual History of Science in Taiwan.* Dordrecht: Kluwer Academic Publishers, pp. 221–44.

[100] See Buck 1980, pp. 91–121.

[101] See Min-zhi Maynard Chou. 1974. *Science and Value in May Fourth China: The Case of Hu Shih.* Ph.D. diss., University of Michigan (Ann Arbor), pp. 23–35.

literati statuses before 1900. Thereafter, the traditional Chinese sciences, classical studies, 'Confucianism' and 'Neo-Confucianism' survived as vestigial learning in the public schools established by the Ministry of Education after 1905 and have endured as contested scholarly fields taught in the vernacular in universities since 1911. The millennial hierarchy of literati learning, based on the Four Books and Five Classics, study of the Dynastic Histories, mastery of poetry, and traditional natural studies was demolished in favor of modern science and its impact via Darwinism on social and historical studies.[102]

What then ensued after 1911 was a remarkable intellectual consensus among Chinese and Western scholars that imperial China had failed to develop science before the Western impact. Even the Chinese protagonists involved in the 1923 "Debate on Science and Philosophy of Life" accepted the West as the repository of all scientific knowledge and only sought to complement such knowledge with moral and philosophical purpose.[103] The consensus drew on heroic accounts of the rise of Western science to demonstrate that imperial China had no science worthy of the name. Both Western scholars and Westernized Chinese scholars and scientists had essentialized European natural studies into a universalist ideal. When Chinese studies of the natural world, her rich medieval traditions of alchemy, or pre-Jesuit mathematical and astronomical achievements in China were discussed, they were usually treated dismissively and tagged with such epithets as superstitious, prescientific, or irrational to contrast them with the triumphant objectivity and rationality of the modern sciences.

Many scholars were so convinced that because China had had no industrial revolution and had never produced capitalism, therefore the Chinese could never have produced science. With the exception of a reformed version of traditional Chinese medicine that has survived and is now thriving as one version of 'holistic' medicine, the traditional fields of *gezhixue* in imperial China were destroyed by the impact of modern science.[104]

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[102] See James R. Pusey. 1983. *China and Charles Darwin*. Cambridge: Harvard University Press, *passim*.

[103] See Wang Hui. 1998. "From Debates on Culture to Debates on Knowledge: Zhang Junmai and the Differentiations of Cultural Modernity in 1920's China". Paper presented at the Workshop "Reinventions of Confucianism in the Twentieth Century", sponsored by the UCLA Center for Chinese Studies under the auspices of the University of California Pacific Rim Research Program, Los Angeles, January 31, 1998. See also Charlotte Furth. 1970. *Ting Wen-chiang: Science and China's New Culture*. Cambridge, Mass.: Harvard University Press.

[104] Besides Needham's *Science and Civilisation in China* series, see also the articles collected in Sivin 1995a, and Nathan Sivin. 1995b. *Medicine, Philosophy, and Religion in Ancient China: Researches and Reflections*. Aldershot, Brookfield: Variorum, and also Nathan Sivin. 1987. *Traditional Medicine in Contemporary China*. Ann Arbor: Center for Chinese Studies, University of Michigan.

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