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

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. 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. 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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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 xixie 西學 or gerbi 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 which 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. 

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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indicate that mathematics and calendar reform remained important concerns among Ming literati before the arrival of the Jesuits in China. 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. 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. 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. Historians have typically appealed for corroborative evidence 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{19} Moreover, examiners used policy questions on natural events and anomalies to gain the widespread penetration of popular religion and the mantic


\textsuperscript{18} See, however, Zhang Hongsheng 张衡盛. 1995. “Qingde yiyuan kuohui ji tili” 清代醫官考核及制度 (Qing dynasty examinations for medical officials with examples). Zhonghu yishi zhiyi 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 Li Lan 莉兰. 1999. Zhongguo yiyuan shi 聲音 (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.

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 務致 (lit., ‘inquiring into and extending knowledge’, gezu shizhi 務物致知). At other times, particularly in the medieval period, and often simultaneously after the Yuan, such interests were expressed in terms of bowa 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 shujü 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 (zhju 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)

<table>
<thead>
<tr>
<th>Classics (jingju 儒術)</th>
<th>History (shuju 史部)</th>
<th>Masters (zhju 子部)</th>
<th>Literature (juben 集部)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change(s)</td>
<td>Dynastic Histories</td>
<td>Literati</td>
<td>Elegies of Chu</td>
</tr>
<tr>
<td>Documents</td>
<td>Annals</td>
<td>Military Strategists</td>
<td>Individual Collections</td>
</tr>
<tr>
<td>Poetry</td>
<td>Topical Records</td>
<td>Legalists</td>
<td>General Anthologies</td>
</tr>
<tr>
<td>Rituals</td>
<td>Unofficial Histories</td>
<td>Agriculturalists</td>
<td>Literary Criticism</td>
</tr>
<tr>
<td>Spring and Autumn</td>
<td>Miscellaneous Histories</td>
<td>Medicine</td>
<td>Songs and Drama</td>
</tr>
<tr>
<td>Annals</td>
<td>Official Documents</td>
<td>Astronomy and</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mathematics</td>
<td></td>
</tr>
</tbody>
</table>

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 gezhi. 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. Bowa on the other hand carried with it a more common and popular notion of curiosities. 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

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21 Cf. Xu Guangtai 徐光台, 1906b, “Mingmou Qingchu xifang gezhi xue de chongyi ya fangyi: yi Xiong Mingyu Gezhi cao wei li” 喜情考西方哲學的衝擊與反應：以熊明遇著書為例 (Impact and response in late Ming and early Qing Western science; using Gao Mingyu's draft of Scientia as an example) in: Taiwan University History Department (ed.), Shiban, qiyu yu geren 世變，奇遇與個人 (Epochal change, groups and history). Taipei: Taiwan National University, pp. 236–58.

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 buowu within classical writings. 23

On the other hand, the Southern Song (1127–1280) philosopher Zhu Xi (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 wu 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 xi jen qu watran om lii hyang ke 三人四分之體外求). In most cases, six to seven out of ten, however, moral principles should be sought within. Therefore, 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 (Daoxue 大學; one of the Four Books) in the Record of Rites (Li Ji 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 Yu Ying-shih’s 余英時 longstanding claim that the seventeenth century turn among literati elites toward precise philosophy in classical studies can be traced back to sixteenth-century debates surrounding the Old Text version of the Great Learning (Daoxue gaben 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 gain say Zhu Xi’s ‘extremal’ 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” (Daoxue shihun 大學石本), which was later determined a forgery, rekindled 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 程意, 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 yulan 格致欽論 (Views on extending medical knowledge), which was included in the Siku quanshu in the late eighteenth century, 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 zhi zhi zhi yi 格物致知之義). 28


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 *Shu ping* (fl. 1387–99) *Gegu yaolun* 創古要論 (‘Essential Criteria of Antiquities’), lit. ‘Key elements in the investigation of the old history and 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:

凡古一物，必有闡聞譜，究其來歷，格其優劣，別其是否而後可
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 (*xaewen 學問*), with the latter equivalent to early modern European *scientia*. In the late Qing, reformist Chinese officials and scholars reworked *gezhi* to designate modern Western science between 1865 and 1900. Subsequently *gezhi* was replaced in the early twentieth century by *kehua* 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 gezhì 空際格致*, lit., ‘investigation of space’, 1633) and Agnolo’s *De Re Metallica* (*Kungyi gezhì 昆侖格致*, 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 *xaewen*, 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 *Daxue* doctrine of the ‘investigation of things’ (*gewu* 俗物, 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 expressed the ‘Dao Learning’ interpretation of the ‘investigation of things’ with a new view of...

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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 Rongyao’s contribution in this volume.
the accumulation of knowledge, which gainsaid both the introspective focus of Wang Yangming and the moralist focus of Zhu Xi. 38

Similarly, the Ming scholar and Hangzhou bookseller Hu Wen-huan 胡文焕 (fl. ca. 1596) compiled and published the Gezi congshu 格致叢書 (Collection 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 collection were the same, Hu apparently printed a total of 346 works for this and other collections in his print shops in Nanjing and Hangzhou, which by some accounts were divided into 37 categories (類類), such as classical instruction, philology, phonology, historical studies, rituals and regulations, legal precedents, geography, mountains and streams, medicine, Taoism, Buddhism, agriculture, stars, physiology, 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 Gezi congshu that focused strictly on the “investigation of things” contained 46 works that stressed classical philology and etymology, beginning with the Er ya 厘雅 (Progress toward correct form) dictionary annotated by Gao Pu 高步 (276–324) of the Jin dynasty. 39

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

古之不可不備也，古格而未有不備於今。今格而未有不備於人。格之時義大矣哉。

Antiquity must be investigated. When antiquity is investigated it always penetrates to the present. When things are investigated it always penetrates to humanity. Timely investigations are very meaningful.

Overall, the Gezi congshu collection 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 Hui’s 張華 (232–300) Bowschi 博物志 (A treatise on curiosities), and Li Shi’s 李時 李時的 Song dynasty continuation, titled Xiu bowschi 讃博物志 (Continuation to a treatise on curiosities) were subsumed under the general category of gezi here. Other works included in the Gezi congshu were the Shiwu jiyan 物記原 (Record of the origins of things and affairs) compiled by Gao Cheng 高承 (ca. 1078–85), and the Gejun 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 Wen-huan’s Ming “Gezi studies,” Dong Sizhang 董斯張 completed the Guang bowschi 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 gezi. Sometimes the former was included under the latter, sometimes not. In both gezi-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 ‘organizational 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 (tiānwén 天文), calendars (lìfèn 历法), and other aspects of the natural


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

<table>
<thead>
<tr>
<th>Rank</th>
<th>Topic</th>
<th>Pct of Total Selection Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Learning/Selection (yongren 用人才)</td>
<td>9.6%</td>
</tr>
<tr>
<td>2</td>
<td>Daoxue (Daoxue 孔子学)</td>
<td>8.3%</td>
</tr>
<tr>
<td>3</td>
<td>Ming rulers (zhengzhi 政治)</td>
<td>7.4%</td>
</tr>
<tr>
<td>4</td>
<td>World order (zhihe 治和)</td>
<td>7.0%</td>
</tr>
<tr>
<td>5</td>
<td>Economy/Statecraft (licai 理財)</td>
<td>5.7%</td>
</tr>
<tr>
<td>6</td>
<td>Ruler-official (junzhen 君臣)</td>
<td>5.2%</td>
</tr>
<tr>
<td>7</td>
<td>National defense (jiefang 国防)</td>
<td>4.3%</td>
</tr>
<tr>
<td>8</td>
<td>Classical studies (fengxue 風學)</td>
<td>4.3%</td>
</tr>
<tr>
<td>9</td>
<td>Law (fuxing 法刑)</td>
<td>3.5%</td>
</tr>
<tr>
<td>10</td>
<td>Military matters (jinshi 兵事)</td>
<td>3.5%</td>
</tr>
<tr>
<td>11</td>
<td>Literature/Poetry (wenshi 文詩)</td>
<td>3.0%</td>
</tr>
<tr>
<td>12</td>
<td>Natural studies (ziran 自然)</td>
<td>3.0%</td>
</tr>
<tr>
<td>13</td>
<td>History (shiju 史學)</td>
<td>2.6%</td>
</tr>
<tr>
<td>14</td>
<td>Agriculture (zongcheng 田政)</td>
<td>2.6%</td>
</tr>
<tr>
<td>15</td>
<td>Customs/Values (fenggu 風俗)</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

* Source: Nanguoxian shu 南國賢書 (Record of civil examination success in the Southern Capital Region). Compiled by Zhang Chaoji 張朝基 (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 mutually 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 overall 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. Instead, candidates increasingly had to answer questions dealing with textual issues growing out of the evidentiary 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. For example, Xiong Mingyu’s 星明議 (b. 1579) Jesuit-inspired work entitled Gezhi cao 耕致草 (Draft for investigating things and extending knowledge) revealed how far the classical ideal of ganwu could be extended using European criteria for determining the fundamental ground of all things in the work (xiao yi ran zhi li 所然之理). 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 ganwu.44

public event, the policy question and answer delivered in the precincts
of an examination compound made natural studies part of the ortho-
dox 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
calendar. Literati were chosen for officidom in this way because
they knew that the moral terms of their success presupposed the sub-
ordination 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 calen-
drical expert in the bureaucratic apparatus but at higher levels of poli-
tical status, cultural prominence, and social prestige.\footnote{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.\footnote{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.\footnote{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 calend-
rical system during the Ming-Qing transition gave the imperial court

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 cul-
tural prestige and social status of literati-officials vis-a-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 stud-
ies, 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 gov-
ernance.

Moreover, the longstanding political raison d'être for the literatus
had been its 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 under-
stand the role of the calendar or music in governance. In the policy
questions, technical learning was not the ultimate object of the ques-
tions. 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 commentators.
Other fields such as medicine and alchemy were not deemed appro-
priate for the examination curriculum. It was important that astron-
omy 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 het-
erodox implications of any effort to observe phenomena in the heav-
eans or on earth in ways that challenged the dynasty in power. As a
pause about allowing possibly divisive questions on the calendar to appear in civil examinations.  

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 otherwise financed research.  

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.  

This evolving Qing ban on examination candidates studying astronomy, astrology, and music for the civil examinations was noted at the time in Shên Xīnzhōu’s 沈昕周 1712 preface to his study entitled Dīxù 地歴 (Studies of geography). Shen indicated that all discussions of astronomical portents (yān tiānwén 証天文) 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 應正 (b. 1678–1735), however, changed the Kangxi emperor’s policy a bit by admitting imperial students with specializations in astrology (tiān wēn shēng 天文生) into the dynamic schools.  

4. EVIDENTIAL STUDIES AND GEZIHUXUE 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 Dīxù predecessors, Qing ‘evidential research’ (kǎozhēng 察證) 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” (shíshí qíshí 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.  

50 See Shên Xīnzhōu 1712.  
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 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 philology, which became the queen of philology during the Qianlong reign. The role of philology 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 philology to reconstruct the meaning (yi yin qie yi 一字一句) of Chinese words. Later Wang Niansun 吴念孙 (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 philology, paleography, and etymology. For example, Liang Zhanji 梁章矩 (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 philology.55

A full-blown scientific revolution as in Europe did not ensue,56 but kaizheng 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 袁元 (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 學) who did not know mathematical calculation. Chinese methods [now] lag behind Europe’s because Ru does not know mathematics.57

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

52 See Elman 1984, passim.
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-suàn 精算) 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 中原) 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 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. Conservatively 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 zhuai 嘗人賦 (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 zhuai represented the integration of the mathematical

⁶⁰ On the Chinese origin theory, see Quan Hansheng 金漢森. 1935. “Qingguo de xi xue jingyuan 中國的西學鏡原” (Late Qing theory of the Chinese origin of Western learning), Lingnan xuebao 4.2 (June 1935), pp. 57–102.
⁶¹ See Chen Yuanlong 陳元龍. 1735. Gezhi jingyuan 格致鏡原 (Mirror origins of investigating things and extending knowledge), in: Sikuo quanzha (Complete collection

⁶⁰ (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.
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. GEZHI XUE AS MODERN SCIENCE IN THE NINETEENTH CENTURY

Philology and natural studies were wedded together when Qing literati scholars such as Mei Wenjing and his grandson Mei Juecheng 梅敬承 (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 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, legitimized renewed Qing literati interest in the sciences, and philology became one of the key tools later evidential research scholars employed.63

The mathematical studies (shuìxué 從學) 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 Xiao Xun 小園 (1763–1820), for example, each tried to build on traditional Chinese algebraic equations, known as Tianyuan, rather than just automatically accept the Arabic-Far Eastern 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 observatory 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 kaochêng 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 李锐 (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 protestations 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 mathematicians, 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 gezhi xue. 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

William Stanley Jevons (Zhe Fensi 惰分斯, 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 黄德, 1835–1911) and edited by Joseph Edkins.66 While living in the treaty port of Shanghai to avoid the Taipings, Feng Guiren 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.67 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 (kaojing 考據) and philology (xiaojuexue 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.68

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, one group required to master machinery and physics (zhiqi shangxue 聲器尚象). 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’ (zhiqiang 自強).69 One of the strengths of Western learning Feng noted was its mastery of mathematics, which Feng wished to incorporate into the civil examinations.

65 The Series contained four parts, see Gezhi qimeng yi zong 格致啟蒙綜論 (Sci- ence Primer Series in four parts). 1875. Young J. Allen and Zheng Changyuan 翟時炎 (trs.). Shanghai: Jiangnan Zhiyouji. Henry Roscoe prepared the section for chemistry (liuxue 化學), Archibald Geikie (Q Gou 郭氏, 1883–1924) for physical geography (dixue 地學), Balfour Stewart (Shi Duhu 史都華, 1828–87) for physics (geowu 學物) and Norman J. Lockyer (Luo Kenyou 錯克優, not known for astronomy) (fanyenuxue 天文學).


69 Cf. Feng Guiren 1897, pt. 2, pp. 56a–57a. Zheng Guanying 俎啟穎 (1842–1923) was an early advocate of including Western topics in the examination framework.
The Institute had a reading room and library of scientific works. Xu and Fryer also created the first science journal in China entitled *Gezhi huiben* 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 DERIVATION 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 *gezhi*, 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 *Tongvenguan*, tended to be literati such as Xu Shou and Li Shulan, 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 儒學 (1853–1921) and Lu Xun 魯迅 (1881–1936) were also famous examples of this group of outcasts from the civil examinations that


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.

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 naves, 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 competitors in Meiji Japan, the Yokosuka Dockyard, until the 1880s. David Wright has noted that the two ironclad steamships ordered by Xu Jiangyan 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 licentiate, provincial graduates, and jinshi (literati 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

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 延學, "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-

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 Tongwuguan. 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 gezhì, 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 (1859–1916) and Zhang Zhidong 张之洞 (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 gezhì vis-à-vis modern science. By first decanonizing the classical canons, late nineteenth century literati hoped to free them-


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 common examinations, for example, expected candidates to answer five questions dealing with Chinese institutions and polities (Zhongguo zhengzhishi shilun 中國政治史論 ). Session two included five policy questions on Western institutions and polities (Geggao zhengzhishi yixue ce 各國政治醫學策 ). The last session required three classical essays, two on quotations from the Four Books and one from the Five Classics (Shihua yi, wuying yi 五禽義・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:


Table 3: Categories of policy questions

| 1. Way of ordering (zhidao 治道) | 9. Assemblies (yiynan 議院) |
| 2. Scholarship (xueshu 學術) | 10. State organizations (zhengzi 政體) |
| 3. Domestic government (neizheng 內政) | 11. Public laws (gongshi 公治) |
| 4. Foreign relations (waijiao 外交) | 12. Penal laws (xingli 行律) |
| 5. Current affairs (shishi 時事) | 13. Education Affairs (jiaowu 教務) |
| 6. Civil examinations (keya 科學) | 14. Astronomy (tiexue 天學) |
| 7. Schools (xuesheng 學校) | 15. Geography (daxue 地學) |
| 8. Official institutions (guzheng 官制) | 16. Calendrical studies (xiexue 曆學) |
| 17. Mathematics (xueshu 算學) | 22. Agriculture system (l) (nongzheng (i) 勞政 (上)) |
| 18. Sciences (I) (nongzheng (ii) 勞政 (下)) | 23. Agriculture system (ii) (nongzheng (ii) 勞政 (下)) |
| 19. Sciences (II) (gexia 格致 (上)) | 24. Public works (gongzheng 工政) |
| 21. Monetary system (shizi 币制) | 26. Roads and mines (luduang 路礦) |
| 22. Military system (I) (junzheng (i) 勢政 (上)) | 30. Topography (yuli 地理) |
| 23. Military system (II) (junzheng (ii) 勢政 (下)) | 31. History (shixue 史學) |
| 24. Defense matters (junwu 防務) | 32. Foreign history (waiishi 外史) |

* Source: “Mak” 目錄，i.e. Zhongguo shihua ceyuan lishi dacheng 中外時務體 製條案大成 (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) are different; use Chinese learning (zhongxue 中學) to critique Western learning (xue 西學).

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

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

5. Itemize and demonstrate using scholia that theories from the Mohist Canon preceded Western theories of calendrical studies, light, and pressure.77

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

the Western sciences for the most part derived from the teachings of the pre-Han masters.86

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 traditional 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') and natural studies as kyöri (qvongli 哲理, 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.80

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 gezwu 格物, or the 'investigation of things'.81 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 individuals, 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.82

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 (mixun 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

85 See Zhongwai shiwu cewen leibian dacheng, "mula", pp. 13a–13b.

86 Ibid., p. 13a.

87 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' (keïn chieh xue 會試之學 equals kexue). This twelfth-century usage is unique to the Song dynasty, which the Japanese borrowed.


89 Cf. Yan Fu (譚鈞), 1902. Mune mingxue 視瞑學 (Miller's Logic), p. 1; Jiaozhi (Translation of John Stuart Mill), 1843. A System of Logic, Ratiocinative and Inductive, 2 vols., 1843. In the nineteenth century, gezwu was also used to define the new field of physics. On the establishment of this new discipline and its various designations see Iwo Anelung's contribution in this volume.

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’ (Kongtiao 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 gezhi kexue, 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 學 (Science), which was published by the newly founded Science Society of China (Zhongguo kexue shè 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 the 1920s, 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 science on the part of Chinese scientists trained abroad, many from Cornell, was iconoclastic in its implications for traditional 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’ (fangzhi 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 the influence of pharmacies and surgeries nationwide. The protest succeeded in having the proposed abolition withdrawn, and the Institute for National Medicine (Guoyi guan 国醫館) 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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95 Xu Ke 1929, vol. 74, p. 11, and passim.


Chinese 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 Xiquan 张锡纯 (1860–1933), for example, was based on the pharmacopsia 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 承丹庵 (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 refinements 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 sacred 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


100 See Bock 1980, pp. 91–121.

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 astronomic 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.


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Quan Hongzhong 乾宏中. 1935. "Qinggmo de "xixue yuan chu Zhongguo shao" 清末的西學源出中國說" (Late Qing theory of the Chinese origin of Western learning). Journal of Nationalism U2 (June 1935), pp. 57-102.


