SCIENCE (*GEWU*) IN LATE IMPERIAL CHINA

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There was no such thing as Science in Late Imperial China, and this is an article about it. Unlike Steven Shapin's opening statement in his synthetic account of the Scientific Revolution, our task in this essay is not to de-stabilize a dominant historiographical category, but rather to reconstitute a subject matter that has been repeatedly bent and stretched out of shape.[1] To be sure, plenty of ink has been spilled in and beyond professional history of science on specific topics ranging from the invention of gunpowder to calendrical sciences, either affirming or contesting an essentially "Chinese" tradition of science from ancient to modern times. While we find it useful to retrace some of the historiographical debate in this essay, our main aim is to sketch out a new, integrated narrative about science/knowledge in late imperial China by following the classically rooted Confucian notion of *gewu* (often translated as "Investigation of Things").

Both comparative and global approaches to the history of science that seek to engage late imperial China have to grapple with the difficulties of translating modern, European notions of science. It is our contention in this essay that the historiographical decision on whether to invoke "science" as a useful category of analysis for late imperial China can be better informed by reckoning with the long-standing debate in Confucian thought about the relationship between knowledge and moral action. As a central category for many Chinese historical actors during this period, *gewu* is useful to think with in order to move beyond simplistic questions about how or why China did not develop science in parallel to European society. By clearly delineating the term's parochial origins and uneven career across a heterogenous terrain of epistemic practice, we can better grasp the overall character of epistemic politics in late imperial China.

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[1] Shapin, *The Scientific Revolution*, 1.

In what follows, we will first review the historiographical trajectory of science in late imperial China (broadly construed to cover the period 1100-1900 CE). We will then provide a brief account of *gewu*, breaking it down into three major time periods: before and after the Ming-Qing transition in the seventeenth century, as well as during the late Qing reforms of the nineteenth century. Lastly, we reflect on how our revisionist account of science in late imperial China and its contemporary legacy may clarify China's role in the early modern global historiography of science/knowledge and open new questions for scholarly inquiry.

FROM CIVILIZATIONAL DECLINE TO EARLY MODERNITY

The Needham Question and Its Critics

The whole scholarly project of documenting pre-modern Chinese science has often been associated with the so-called "Needham question": why did modern science first emerge from Western Europe – and why did it fail to happen in late imperial China. Starting from the 1950s, Joseph Needham (1900-1995), whose title at Cambridge University remained Reader in Biochemistry through his long career, built an international research team dedicated to the history of Chinese science. The resultant *Science and Civilisation in China* (SCC) series, begun in 1954 and now having exceeded its seventh decade in existence (while still incomplete according to Needham's original scheme), has played a definitive role in sustaining and energizing this scholarship.[2]

The Needham question and its various iterations have generally framed the late imperial period in an unflattering light: What went wrong with China when European scientific achievements overtook Chinese civilization that had been more advanced during the first millennium in the Common Era? When did China start to fall behind in what Needham has memorably called "the Grand Titration" of civilizations?[3] The answer depends on the specific area of science under consideration. In the "General Conclusions and Reflections" volume of the SCC project, Kenneth Robinson and Mark Elvin quote a graph made by Needham and his collaborators in a 1970 collection, *Clerks and Craftsmen in China and the West* (Figure 1):

[2] For the latest complete list of publications in this series, see the publisher's website at https://www.cambridge.org/us/universitypress/subjects/history/history-science-general-interest/series/science-and-civilisation-china.

[3] Needham, *The Grand Titration*.

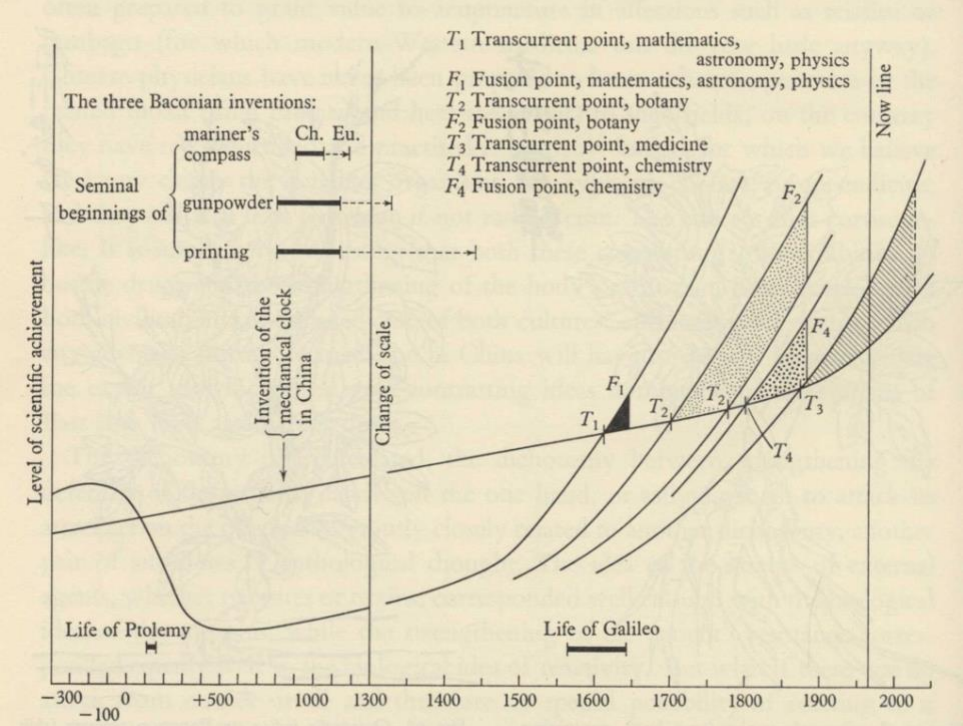

Fig. 99. Schematic diagram to show the roles of Europe and China in the development of oecumenical science.

Figure 1: Joseph Needham's diagram showing the "Grand Titration" in various fields. Needham, *Clerks and Craftsmen*, 414; reproduced in Needham, Robinson, Huang, and Elvin, *Science and Civilisation in China*, Vol. 7, Part 2, 28.

The graph succinctly summarizes Needham's thinking on various "transcurrent points" (when Western science surpassed the heretofore more advanced Chinese science) and "fusion points" (when Chinese science again caught up with Western science) for subfields such as mathematics, astronomy, physics, botany, medicine, and chemistry (all defined on modern scientific terms). The main characteristic of the time period between 1500 and 1900, which roughly corresponds to the second half of the Ming (1368-1644) and much of the Qing (1636-1911), is the recurrent drama of China "falling behind" in various fields of science, only "catching up" in the twentieth century under Western influence.

More nuanced messages can be deciphered from this dense graph about the state of the SCC project and its entangled relationship with the historiography of Western science in the 1960s. For example, technological innovations, such as the three "Baconian inventions – magnetic compass, gunpowder, and printing," were rendered as horizontal segments instead of curves, indicating that technology (and inventions) was thought to have a more fixed impact on civilizations (China had woodblock printing and moveable types earlier, but post-Gutenberg Europe has printing too, and that's the end of the story). Needham et al. saw medicine as the last area in which China lost out on the Grand Titration only around 1900

CE, and predicted a "fusion point" in the then-distant 2000s. This prophecy may, interestingly enough, have been partially fulfilled by the explosive growth of China-based biomedical research in the twenty-first century.

Even within the Needham group's publications, the scholarly project of documenting pre-modern Chinese science *predated* the so-called Needham question by nearly two decades. In the early SCC volumes completed in the 1950s (Vol. 1 "Introductory Orientations" (1956), Vol. 2 "History of Scientific Thought" (1956), and Vol. 3 Mathematics and the "Sciences of the Heavens and the Earth" (1959)), the *comparative* framework on a civilizational scale did not yet loom as large as it would in the late 1960s. At its very beginning, the SCC project began as a Marxist enterprise that saw human civilization as universal in its *telos* toward progress. Putting China on the map of the historiography of science was, for Needham at least, a crucial move to stay true to the Marxist vision for ecumenical human progress, not to reveal some essential *difference* in culture that divides the Chinese from the West. By the late 1960s, however, Needham and his collaborators themselves initiated the move from this positivistic approach to a culturalist, comparative approach.

Much of what we know today about late imperial Chinese science thus bears the clear signature of the 1970s and 1980s, during which time the search for "inhibiting factors" that prevented China from having its own Scientific Revolution loomed large, and the "fusion points" represented by intensifying Sino-Western exchange came under repeated scrutiny. In *The Pattern of the Chinese Past* (1973), Mark Elvin argues that China reached a "high-level equilibrium" early on and could not break through this blessing in disguise throughout the Ming and Qing times.[4] Similarly, the American Historian Nathan Sivin, who had participated in a series of SCC volumes on chemistry and alchemy published in the 1970s became a formidable critic of the search for "transcurrent points" and "fusion points." Sivin opted instead to look for the earliest discerning traits of Chinese and Western civilizations in their distinct approaches to arrive at reliable knowledge. This approach sees Chinese science as an ever-evolving "cultural manifold" whose most fundamental features were defined in the Classical era and have remained ever since.[5] The Needham project's internal shift thus can be seen as an integral part of Western academia's larger shift away from the modernization paradigm, ushering in the beginning of the "cultural turn" that would soon erase the universalist premises of its own history.

The Needham project's turn from a universalist to a culturalist framework of analysis does not, in any case, capture the whole picture for the field of history of Chinese science, which itself had acquired a transnational and multi-faceted scope by the 1980s. Many SCC volumes that came out in the 1980s and 1990s did not bear a similar critical thrust toward the Needham question. Especially worth noting is the anthropological approach that cast a wider

[4] Elvin, *The Pattern of the Chinese Past*.

[5] Sivin, "A Multi-Dimensional Approach."

net in the subject matter of "science" beyond transmitted classical texts, taking into consideration archaeological and other material evidence as important sources. Across the 1980s, contributors to SCC volumes emphasized combining a close study of primary sources with the study of material culture, technical expertise, and contemporary practices.[6]

After Joseph Needham passed away in 1995, the comparative framework with a focus on ancient sources resulted in Nathan Sivin and G.E.R. Lloyd's *The Way and the Word* (2002), only a few years apart from the publication of Shigehisa Kuriyama's stunning comparative work on classical medicine, *The Expressiveness of the Body and the Divergence of Greek and Chinese Medicine* (1999).[7] The 1999 *Osiris* volume, edited by Morris F. Low (a historian of modern Japan teaching in Queensland, Australia) with a diverse range of contributions with a heavy representation on transnational and modern topics, similar projected a new phase of the field "beyond Joseph Needham" and the core civilizational evaluations of China's past.[8] The comparative approach remained fruitful, even among those critical of the "question" framing.

From the Needham Question to Global History of Science

If many European and American historians had moved away from the modernization paradigm, it remained very much alive in the minds of overseas Chinese scholars who already played a key role in the early phase of SCC. Almost all of Needham's close Chinese collaborators, such as Lu Gwei-djen (1904-1991), Ho Peng-Yoke (1926-2014) and H.T. (Hsing-Tsung) Huang (1923-2012), had background in one or another field of modern science and some remained active in cutting-edge scientific research.[9] Their interest in premodern Chinese science could not be separated from their commitment to Science as a universal regime for the advancement of knowledge in the twentieth century.

After the Cultural Revolution ended in 1976, the People's Republic of China entered the 1980s swept up by a "culture fever" with a palpable hunger for non-Marxist interpretations of the Chinese past, which continued unabated across the 1989 Tiananmen Square protests and

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[6] E.g., Needham and Bray, *Science and Civilisation in China*, Vol. 6, Part 2. Most recently see Bray et al. *Moving Crops*; and Needham and Kuhn, *Science and Civilisation in China*, vol. 5, Part 9; Schäfer and Kuhn, *Weaving an Economic Pattern*. Unschuld used pharmaceuticals (*bencao*) and medical ethics as primary points of entry in the 1970s through a lens of historical anthropology. He has subsequently published numerous translations and concordances on important texts in traditional Chinese medicine. For a conceptual introduction to his work, see Unschuld, *What Is Medicine*; and Unschuld, *Medicine in China: A History of Ideas*.

[7] Lloyd and Sivin, *The Way and the Word*; Kuriyama, *The Expressiveness of the Body*.

[8] Low, ed., *Beyond Joseph Needham*. The only three papers on premodern China by Francesca Bray, Mark Elvin, and TJ Hinrichs, all of which have had a lasting influence, were included among a total of more than 20 in the volume. The shift to a regional, "East Asian" scope of inquiry has many contributing factors beyond the study of science in late imperial China and cannot be addressed in full here.

[9] For a reflective account of Lu's life and career, see Li, "Escaping Immortality."

its suppression.[10] History of Science (*kexue shi*), as a branch discipline of natural sciences in China, proved fertile ground for new research on earlier moments of "Sino-Western cultural exchange" (*zhongxi wenhua jiaoliu*) just as China of the 1980s underwent another phase of "reform and opening up" to the Western world.[11] The Needham question, along with the culturalist critique of it, also pre-occupied overseas Chinese scholars such as Yu Ying-shih (1930-2021), who conducted detailed studies of key Ming and Qing figures who confronted the challenge of Western learning. Chen Fangzheng, a longtime friend of Yu and a Western-educated physicist-turned-educator and historian of science, was among the leading intellectuals who cast their interest on understanding "why modern science first took place in the West".[12] Wu Yi-yi, the first Chinese PhD student in History of Science at Princeton University, graduated in 1990 with a thesis on Song records of anomalies but devoted his later works on popularizing Western scholarship on history of modern science.[13] In other words, the universalist framework of the Needham Question persisted among Chinese academic discourses and incorporated culturalist interpretations in the 1990s.

Much of this new research on Sino-Western cultural exchanges in the 1980s inspired a brief reprisal of the late imperial period in Nathan Sivin's influential 1986 essay on whether "scientific revolution" ever took place in China. Part of Sivin's essay had played with the idea that perhaps a scientific revolution did take place in China – not earlier than the West, as Elvin and others had implied with their focus on a twelfth-century Renaissance in the Song dynasty – but with the arrival of the Jesuits in the early seventeenth century. Matteo Ricci and others' geometry, world maps, and other learned writings deeply challenged the sense of superiority on the part of Chinese scholars and forever changed their approaches to mathematics, astronomy, and calendrical sciences. Yet the impact of this mini "scientific revolution" was limited in Sivin's view, for the Chinese "cultural manifold" remained formidable and would have to wait until Chinese imperial authority faced deeper, irrevocable challenges in the late nineteenth century.

Sivin's 1986 essay unwittingly anticipated a new focus on the late imperial period after 2000. In *On their own terms* (2005), Benjamin A. Elman presents an eloquent revisionist narrative of Chinese science between 1500 and 1900, seeing science as a central matter of concern for

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[10] Among other works, see Wang, *High Culture Fever*, and Hua, *Scientism and Humanism*.

[11] Yet at no point was the intense interest on culture ever disassociated from questions of nationalism and modernization – to wit, a planned SCC volume on zoology authored by Chinese historians of science was eventually abandoned by Needham and never published in English (Guo, Needham, and Cheng, *Zhongguo gudai dongwuxue shi*). Judged by its content, the completed Chinese version might have gone too far by pushing a patriotic nationalist agenda to count every single mention of animals in ancient and newer sources as evidence for the advancement of Chinese "zoology." We thank Chenchen Yan for bringing this book to our attention.

[12] Chen, *Jicheng yu panni*.

[13] Wu, *Shenme shi kexueshi*.

literati society and the imperial state.[14] Building on his own earlier works on changing scholarly paradigms in classical learning, Elman forcefully argued for seeing the period in Chinese history as "early modern," dynamic in itself and connected with other early modern civilizations of the world. By analyzing Jesuit bias and dogmatic agenda against Protestantism in the late sixteenth century, Elman argued that what the Jesuits knew but never conveyed to the Chinese (the Copernican cosmos and Newtonian physics and calculus) mattered as much as what they did demonstrate. By highlighting disparate agency and conflict of interest across the early modern global stage, Elman's narrative departs from Sivin's framework of Chinese science as a (uniquely Chinese) cultural manifold.

Energized by the increasing visibility of Chinese science in both Sinology and history of science in general, some of the most dynamic works published the 2000s and 2010s sought to shed light on the characteristics of knowledge culture in late imperial China.[15] This new literature has in turn made significant contributions to the global historiography of early modern science, with much new work done on key moments of Sino-Western exchange, or what Needham might have dubbed "fusion points".[16] In 2019, *Isis* published a Focus issue that calls for "a second look at Joseph Needham." With the "second" look referring explicitly to the critical verdict reached by Sivin and Low in the late 1990s, Florence Hsia and Dagmar Schaefer's introduction credited the early ideals of the SCC project for unapologetically placing China (and other non-Western cultures) at the center of history of science.[17] If the earlier Universalist/Internationalist ideals held by Marxist historians of science have mostly disappeared, at least some of them have been redeemed in connection to the emergent agenda of global history and anti-colonial redress in the early twenty-first century. The late imperial period is therefore at the center of this recent recasting of Chinese science as a crucial piece within a global history of early modern science.

GEWU AS CHINESE SCIENCE

Despite this flourishing of research since the 1950s on Chinese science, historians have not settled on how to interpret the very category of "science" in Chinese contexts. Elman, for example, approached the question of defining science through his own background in Ming-Qing intellectual and cultural history, rather than what might be thought of as traditional

[14] Elman, *On Their Own Terms*, introduction and passim.

[15] Nappi, *The Monkey and the Inkpot*; Schäfer, *The Crafting of the 10,000 Things*; Bray, *Technology and Gender*; Hanson, *Speaking of Epidemics*, among others.

[16] Hsia, *Sojourners in a Strange Land*; Barnes, *Needle, Herbs, Gods, and Ghosts*; Fan, *British Naturalists in Qing China*; Jami, *The Emperor's New Mathematics*; Huang Yi-nong, *Liangtou she*; Han Qi, *Tongtian zhi xue*; Cams, *Companions in Geography*; Söderblom Saarela, *The Early Modern Travels of Manchu*; Zhang, "The Plurality of Reception"; among other works.

[17] Hsia and Schäfer, "History of Science, Technology, and Medicine," and other contributions to the Focus issue.

history of science. Elman drew heavily from Chinese and Japanese scholars' works in history of ideas/intellectual history (*sixiang shi / shisōshi*), institutional history (*zhidu shi*), and other aspects of literati culture. It is with this preparation that Elman discussed what he called a "literati theory of knowledge" when he set up the stage for Sino-Western encounters, in which the idea of *Gewu* (the Investigation of Things) featured prominently.[18]

One of the primary drawbacks of this approach is arguably the almost singular focus on Classically-educated, examination-savvy scholars who self-identified as *ru* (Confucians), thereby marginalizing other agents of knowledge in the narrative. Even within the broad swaths of Confucian erudition, Elman's account also leaves open the question of how to approach the gap between what he calls "high-brow" versus "low-brow" learning. For example, Elman paid close attention to Hu Wenhuan (fl. late sixteenth century), whose versatile publishing enterprise adopted the soaring rhetoric of *gewu* to market his playful miscellany of "minor arts," but whose works were eventually shunned and criticized by "high-brow" scholars later on in the seventeenth and eighteenth centuries. Perhaps there was no unified "literati theory of knowledge" after all, and it is still necessary to heed Nathan Sivin's warning that there existed no unity around "science" in late imperial China.

Some new works in the 2010s and 2020s have tried to respond to this question of the unity of science by paying closer attention to the debates between different actors, including state and non-state interests.[19] Others used insights derived from the history and sociology of science to seek new interpretations of canonic figures in Chinese intellectual history.[20] A third direction used history of science away to critically re-evaluate the role of elite Confucian scholars vis-à-vis other forms of expertise such as craft, manufacturing, and commerce under the rubrics of the Qing state.[21] The pressing question that remains is how a new, composite history of knowledge might emerge from disparate results of research – and how that might yield a clearer, more persuasive narrative of how modern science came about in China as an integral aspect of the long and complex transition from empire to nation.[22] Despite the lack of unity around contingents of learned persons and technical experts, the pursuit for the coherence (*li*) of knowledge has nevertheless remained important as a throughline for historians. This historiographical debate plays out most directly and concretely for historians in the risks and implications of using *gewu* as an umbrella term for Chinese science.

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[18] Elman, *On Their Own Terms,* 4.

[19] Bian, *Know Your Remedies*; Vedal, *The Culture of Language in Ming China*.

[20] Hu, *China's Transition to Modernity*; Sela, *China's Philological Turn*; He, "Well-Ordered Textures."

[21] Ko, *The Social Life of Inkstones*; Chen, *Porcelain for the Emperor*.

[22] Wang, *The Rise of Modern Thought*; Yu, "The Search for a Chinese Way."

Gewu and Way Learning in Song-Yuan-Ming China, 1100-1600 CE

In *On their own terms,* Elman noted that both Jesuit missionaries in the late sixteenth and seventeenth century and Protestant missionaries in the nineteenth centuries used some variants of the term *gewu* to translate *scientia/science.*[23] The *locus classicus* of the phrase came from one chapter titled "Great Learning" (*Daxue*) in the ancient Confucian classic *The Book of Rites* (*Liji*). The lofty intention of "making bright virtues manifest" (*ming ming de*) in the world, the text argues, necessitates a long sequence of preparatory actions that ultimately point inward to a person's "sincerity of intention" (*chengyi*), which in turn requires the "attainment of knowledge" (*zhizhi*) through the "investigation of things" (*gewu*).[24] *Gewu* thus functions as the innermost node of moral action and the beginning of knowledge, the initiation of action-oriented learning that would eventually result in the proper ordering of one's family, state, and the whole world "under Heaven" (*tianxia*).[25]

During the twelfth century, the "Great Learning" chapter, together with other excerpts of the ancient classical tradition, took up a prominent role in the teachings of what came to be known as the "Way Learning" (*daoxue*) or "neo-Confucian" revival.[26] One of the most influential readings of the *gewu* passage is attributed to the scholar Zhu Xi (1130-1200):

> Now every person's intellect is possessed of the capacity for knowing; at the same time everything in the world is possessed of coherence (*li*). To the extent that *li* is not thoroughly probed a person's knowledge is not fully realized. For this reason the first step of instruction in the *Great Learning* teaches students that, encountering anything at all in the world, they must build on what they already know of and probe still deeper, until they reach its limit. Exerting themselves in this manner for a long time, they will one day suddenly become all penetrating; this being the case, the manifest and the hidden, the subtle and the obvious qualities of all things will all be known, and the mind, in its whole substance and vast operations, will be completely illuminated.[27]

Lifting *The Great Learning* out of the *Book of Rites* together with *Zhongyong*, another chapter from the same text, Zhu Xi famously paired them with *Analects* and *Mencius* to form the so-called "Four Books" (*sishu*) as a new foundational curriculum of Confucian education. Together with Zhu Xi's extensive commentaries, the Four Books would later become

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[23] Elman, *On Their Own Terms*, 4, 297.

[24] Andrew Plaks translates *Zhizhi* as "maximizing one's range of comprehension," and *gewu* as "extending to all things in the world the correct conceptual grid." See Elman, *On Their Own Terms*, 4n3.

[25] Johnston and Wang, Daxue *and* Zhongyong, 134-35.

[26] Bol, *Neo-Confucianism in History*, 100-108.

[27] Allen, *Vanishing into Things*, 168.

mandatory textbooks for entry-level civil service examinations all across the Chinese empire. Although examinations as a mechanism for selecting scholar-officials already became a regular occurrence as early as in the Tang dynasty (618-907 CE), it was under the Northern Song (960-1127 CE) and Southern Song (1127-1279 CE) that intense debates about the curriculum took central stage in national politics.[28] Advocates of Way Learning such as Zhu Xi at first promoted their reformed curriculum on the local level and passed their books and commentaries on to generations of gentry and students at local private academies during the Mongol Yuan dynasty. It wasn't until the early fifteenth century when the Ming emperor Yongle (r. 1402-1424 CE) mandated the *Four Books* and Zhu Xi's commentary as the required curriculum across all thirteen provinces of the Great Ming empire, with provincial examinations held every three years.[29] The *gewu*-based sequence of moral learning became a central tenant for neo-Confucian learning in the twelfth century, but only starting in the fifteenth century did every pupil recite the above-quoted passages from Nanjing, the first Ming capital, to Yunnan, a newly incorporated southwest frontier – a routine practice that persisted all the way until the abolition of the civil service examination by the Qing court in 1905.

What, then, marks Zhu Xi's curriculum and its emphasis on *gewu* as important for Chinese "science" during the Ming dynasty (1368-1644 CE)? Note that Zhu Xi's *gewu* scheme did not end with the investigation of individual things, but promised an "enlightening jump" from piecemeal knowledge to an all-penetrating understanding. This methodology was rooted deeply in his metaphysical view, according to which each *wu* (thing, event, phenomenon) was endowed with a complete set of *li*, the unitary heavenly "coherence."[30] On a broader scale, this metaphysical view also aligned with the prevailing intellectual trend of the Song dynasty, preferring the building of total-view systems to a case-specific empirical approach.[31] The myriad "things" investigated can and did encompass anything between Heaven and Earth, from the innermost corners of one's mind to the farthest shores of the universe, all of which are held to adhere to the ultimate Coherence that in some interpretations existed prior to all existence.

Unable to agree upon what constituted the "enlightening jump" between knowing individual things and attaining an understanding of coherent *li,* Ming scholars diverged into two major camps, with positions solidified by the mid-sixteenth century. One group, loosely identified with the teachings of Wang Yangming (1472-1529), pursued the ultimate promise of a thoroughgoing understanding by insisting that the *li* resides within each person's inner moral capacity, or conscience (*liangzhi*), rather than the fragmented and frivolous knowledge of

[28] De Weerdt, *Competition over Content*.

[29] Bol, *Neo-Confucianism in History*; Elman, *A Cultural History of Civil Examinations*.

[30] Peterson, "Another Look at Li," 17-18; Allen, *Vanishing into Things*, 175.

[31] Zuo, *Shen Gua's Empiricism*, 5-11.

individual things. A telling example of this view came from the young Wang Yangming (1472-1529), who once spent seven days looking at a grove of bamboo to fathom its *li*, acquiring nothing but an illness from excessive concentration.[32] This frustrating experience was only overcome later in his exile, when he suddenly realized that one's own nature was already sufficient, and it was unnecessary to seek from the outside.[33] This led to a phenomenological turn among this first group of scholars, reinterpreting *wu* as wherever one's intention is directed, and *gewu* as an extension of one's innate knowledge to these newly defined *wu*.[34]

Another group of Ming scholars moved in the opposite way, insisting that valid practices of *gewu* must begin with the meticulous investigation of individual things, through the accumulation of books and first-hand experience in the world.[35] Epitomized by Yang Shen (1488-1559) and Hu Yinglin (1551-1602), erudite Ming scholars rode the soaring tide of the booming print culture that accelerated after the mid-sixteenth century. Many enthusiastic scholar-officials were responsible for the retrieval and restoration of marginal knowledge, the compilation of encyclopedias (*leishu*) and collectnaea (*congshu*), and the avid documentation of their own life events for future historians. Benjamin Elman has shown how Hu Wenhuan's (fl. 1590s) *Collectanea of Works Inquiring into and Extending Knowledge* (*Gezhi congshu*) effectively collected "all areas of native textual knowledge" under the name of *gewu*, including "classical, historical, institutional, folkloric, medical, and technical works from the antiquity to the present." Critics of Hu Wenhuan, however, pointed out that such encyclopedic collecting strayed far afield from the action-oriented knowledge of Zhu Xi's *gewu* scheme.[36]

These debates retrace a broader understanding of intellectual history in Song-Yuan-Ming China, one centered on canonized works and doctrinal disagreements among Ming Confucian scholars. Historians of science have built on this work to assess how the idea of *gewu* may or may not have made an impact on pre-existing fields of technical expertise during this period, focusing particularly on expertise in medicine, astronomy, and musicology, among other fields.[37] In the subject of pharmacology, the late Ming physician-scholar Li Shizhen's *Compendium of Materia Medica* (*Bencao gangmu*) has often been hailed as one of the finest examples of the synthesis between (the erudite variety of) Neo-Confucian pursuit of systematic knowledge and the much older tradition of Classical medicine and its

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[32] Elman, *On Their Own Terms*, 7.

[33] Tu, *Neo-Confucian Thought in Action*, 120.

[34] Wang, *Wang Yangming quanji*, 1.6, 2.51.

[35] Bol, "Looking to Wang Shizhen," 121-27.

[36] Elman, "Collecting and Classifying," 140-41.

[37] Sivin, *Granting the Seasons*; Furth, "The Physician as Philosopher of the Way;" Vedal, *The Culture of Language in Ming China*, chapter 1.

clinical application. As Carla Nappi pointed out more recently, Li Shizhen's meticulous documentation of over 1,800 simples consists of more than an encyclopedic collection of pharmaceutical entries, but rather aims at capturing the transformative process of the cosmos through each unique creature.[38] As Zhu Xi's *gewu* teachings gained an officially-recognized status as orthodoxy, the study of technical subjects gained more recognition and respect.

At the same time, however, rising literacy and the availability of books also meant that technical know-how became more widespread in Ming society. While most educated men in Ming China would agree about the importance of knowledge within the framework of *gewu,* they disagreed fiercely as to its most qualified approach and practitioners. The late Ming, especially after the large-scale infusion of New World silver as a circulating currency after the 1570s, experienced unprecedented economic and cultural upheaval. In this sense, the plurality of interpretations of *gewu* resulted in –and was inseparable from--competing voices that threatened pre-established hierarchies in cultural and political lives.[39] Zhu Xi's vision of *gewu* no longer seemed to be functioning the way Ming Chinese had known it since the late fourteenth century.

Gewu and Evidential Learning: 1600-1820 CE

Writing in the 1620s and 1630s, a provincial scholar Song Yingxing (1587-ca.1666 CE) made the forceful case that craft was a surrogate for Heavenly work on earth that resulted in the "inception of things" (*kaiwu*). As Dagmar Schäfer has shown, Song Yingxing's well-known treatise must be grasped as an integral enterprise with his enthusiasm for the ultimate coherence that underlay the materiality of all things.[40] Song was speaking in full Neo-Confucian mode and would come out in full-throated defense for the validity of empirically informed, cosmologically grounded *gewu.* Yet, his approach would not be long lived in the political and social upheavals of the seventeenth century, as the Ming dynasty fell first to internal rebels and then to the invasion of Manchu Qing (founded in 1636 CE) from the Northeast.

Other scholars began to question one of the foundational premises of *gewu* in Zhu Xi's scheme – namely that knowledge must address the all-encompassing, systematic *li* in accordance to cosmological frameworks. Debates between "systems builders" and proponents of what Ya Zuo has called "empiricism" were not new—some contemporaries of Zhu Xi maintained that "things" (*wu*) as objects of knowledge can entail both "a distinctive

[38] Nappi, *The Monkey and the Inkpot*, chapters 3-6. See also Needham and Lu, *Science and Civilisation in China*, Vol. 6, Part 1, 308-21; and Paul U. Unschuld's complete translation.

[39] See, e.g., Shang, "The Making of the Everyday World," 63-92; He, *Home and the World*, chapters 1-2; Zhang, *Confucian Image Politics*, chapters 1-2.

[40] Schäfer, *The Crafting of the 10,000 Things*, 230-36.

object/ process with its own properties," and "a reification of a place in a larger order."[41] While Ming scholars began to emphasize the former aspect of *wu* through encyclopedic erudition, Qing scholars tilted the balance to a much greater degree. For the leading eighteenth-century scholar Dai Zhen (1724-1777), the pursuit of knowledge no longer aims at the all-encompassing cosmic coherence of the world, but a localized "texture/pattern" (*li*), the "subtle and minute characteristics" for each and every idiosyncratic thing.[42] With the accumulation of local facts pertaining to the Classics, argued Dai, the scholar approximates true knowledge "like ascending to a hall or platform… One has to follow the steps rather than skip them over."[43] There was to be no sudden enlightenment, no shortcuts to take other than a painstaking study of local details.

Debates over *gewu* were not surprising in an era when the existence and validity of a higher cosmic order was widely questioned following the Manchu conquest of China in mid-seventeenth century. Fang Yizhi (1611-1671), for example, at first emphasized the method of "concrete survey" (*zhice*) to exhaustively inquire after the "ultimate Coherence" (*zhili*) but then shifted to observations and recording of local facts during his exile to the South and conversion to Buddhism.[44] Many so-called forebears of the "Evidential Learning" (*kaozheng*) movement shared a similar experience of dislocation and epistemic transition. Under a weakened cosmological underpinning, the "things" (*wu*) under evidential inquiry opens new horizons through phonological reasoning or astronomical calculations. For example, scholars started treating language and in particular the pronunciation of characters as an evolving entity, instead of a timeless orchestra of cosmic sounds.[45] The growth of paleography and antiquarian research into excavated vessels and epigraphic documents, at the same time, led scholars to question received historical records as potentially falsifiable. The result is that *gewu* as an enterprise by the end of the seventeenth century took on a pronounced *historicist* cast, supported by rigorous investigation into evidence. This is what John Henderson called the "decline of Chinese cosmology," and what Benjamin Elman identified as the transition "from philosophy to philology."[46]

While intellectual histories of Qing China celebrated the achievements of Evidential Learning as the beginning of modern scholarship, it is also important to point out that the Manchu Qing court played a major role in shaping intellectual developments of the day. That is to

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[41] Zuo, *Shen Gua's Empiricism*, 40-41, 77.

[42] Dai, *Dai Zhen quanshu*, 6: 149; He, "Well-Ordered Textures," 426.

[43] Dai, *Dai Zhen quanshu*, 6: 376; Elman, *From Philosophy to Philology*, 29.

[44] Sun & Wang, "Fang Yizhi *Wuli xiaozhi*,'" 191-96.

[45] Vedal, *The Culture of Language in Ming China*, 217-23.

[46] See Henderson, *The Development and Decline of Chinese Cosmology*, chapter 9; Elman, *From Philosophy to Philology*, chapter 2.

say, the Qing state not only launched literary inquisitions against Ming loyalists and persecuted scholars who dared to question Manchu legitimacy to occupy the Ming throne, but also harnessed Evidential Learning for its own use. The Kangxi emperor (r. 1662-1722) famously patronized Jesuit astronomers and mathematicians, but also supported Chinese scholars such as Mei Wending (1633-1721) who sought to reconcile traditional Chinese mathematics with Jesuit teachings, going so far as to argue for a Chinese origin of Western learning.[47]

The study of language and its historical dimensions also received imperial patronage in the latter's effort to standardize and propagate Manchu learning amongst the Conquest elite, reviving and elevating the study of non-Chinese scripts and languages to a much more sophisticated level.[48] All the prized new tools of Qing Evidential Learning, such as paleography, historical etymology, and most notably the reconstruction of ancient phonology, resonated among private scholars and imperially-commissioned projects at court. By the mid- to late eighteenth century, the Manchu rulers have successfully appropriated elite Chinese scholars, who made peace with minority rule by embracing a sense of "modern" advancement of knowledge that also allowed for a more truthful interpretation of ancient classics. After all, conceptions of knowledge and empire were inseparable. Qing imperial expansion into Tibet, Mongolia, and the settlement of Xinjiang (lit. "new territories"), allowing for a much wider horizon for knowledge, greatly expanded the spatial and temporal dimensions of evidential research.[49]

Despite this prevailing intellectual shift, it is noteworthy that Zhu Xi's interpretation of the Four Book perpetuated as the imperial orthodoxy for Qing Civil Service Examinations. Even in the writings of most canonical figures of Evidential Learning, the specter of *gewu* as the first step toward knowledge-based action was sometimes shunned but never completely purged. In Ori Sela's words, for all their philological prowess, Evidential Scholars of the High Qing period were still uncertain of what and how their knowledge should be put into good use, which often got bracketed into a question of "meanings and principles" (*yili*).[50] By the early nineteenth century, it was clear that Dai Zhen's proposal of accumulative knowledge "like ascending to a hall or a platform" might not necessarily lead to consensus or reliable knowledge. For example, there was no institutional or social mechanism to compare observations made by the philologist Cheng Yaotian (1725-1814), whose interest in plants largely derived from botanical references in classical exegesis, with the growing

[47] Jami, *The Emperor's New Mathematics*, chapters 4, 11; Han, *Tongtian zhi xue*, chapter 5.

[48] Söderblom Saarela, *The Early Modern Travels of Manchu*, 153-62.

[49] Already stated in Guy, *The Emperor's Four Treasuries* and Elman, *Classicism, Politics, and Kinship*. For more recent studies see He, "Well-Ordered Textures," chapter 5; Zhang, "Qing China's Discovery of Central Eurasia"; Bian and Söderblom Saarela, *The Manchu Mirrors*, chapters 4-5.

[50] Sela, *China's Philological Turn*, 104-106, 131.

pharmacopeia compiled privately by the contemporary urbanite Zhao Xuemin (fl. 1750s-1803), who learned much about herbalist lore from itinerant physicians and exotic goods related by hunters and traders.[51] In terms of geography, Matthew Mosca suggests that Qing scholars before the 1800s were unable to agree on a consolidated notion of India largely due to the Qing empire's penchant to archive frontier governors' reports and the inconsistencies among textual and cartographical sources that were available to Chinese scholars. This led to a quagmire of "geographical agnosticism" that went largely unacknowledged in public but would come back to haunt the Qing self-image of enlightened rule.[52]

In sum, much remains to be properly understood for the continued importance and transformations of *gewu* in Qing China, before exogenic events again abruptly caused public culture to change course in the early nineteenth century. By the civilizational clash between the Qing empire and Western imperialism embodied by the First Opium War (1838-42), the Qing state and its scholars had largely moved past the late Ming crisis over *gewu* through cumulative evidence-based research.[53] The tenor of Evidential Learning was triumphalist in that it had managed to engage and appropriate Jesuit science while reaffirming the sanctity of ancient Chinese learning.[54] There is, of course, an analogous tension in the twentieth-century debate between the universal, "ecumenical" ideals of science espoused by the early phase of the Needham project and the subsequent culturalist interpretation of Chinese science. The concept of *gewu* turned out to be flexible enough to not just incorporate new ideas from other parts of the world, but also survive a fundamental intellectual transition accompanied by political change.

From Gewu to Kexue: Late Qing Transformations, 1820-1910 CE

Given the importance of calculus and mechanics for the story of European science, the year of 1859 was a pivotal one for China's engagement with Western knowledge. The year saw the publication of two influential textbooks, both co-translated by Alexander Wylie (1815-1887) and Li Shanlan (1811-1882): *Step by Step in Algebra, the Differential and Integral Calculus* (*Dai weiji sheji*) and *Speaking of the Heaven* (*Tantian*).[55] Bridging a temporal gap of nearly two centuries, these works provided Chinese readers with their first systematic introduction to fields of calculus and Newtonian mechanics, respectively, marking a new era that gradually shifted way from the ideal of *gewu*.

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[51] Métailié, "The Botany of Cheng Yaotian," 260.

[52] Mosca, *From Frontier Policy to Foreign Policy*, chapters 1, 3.

[53] Feng, *Qianhua wanpai*; He, "Well-Ordered Textures."

[54] Hu, *China's Transition to Modernity*, 126-30; Sela, *China's Philological Turn*, 154-58.

[55] The two works were translated from Elias Loomis's (1811-1889) *Elements of Analytical Geometry and of the Differential and Integral Calculus* (1851) and John Herschel's (1792-1871) *Outlines of Astronomy* (1849), respectively.

Wylie came to China in 1846 as a member of the London Missionary Society. He belonged to a new wave of Protestant missionaries that began to take the lead of Sino-European interactions, missionaries who had by then disseminated Chinese translations of the Bible and opened hospitals for the urban poor in southern China.[56] Li Shanlan was a successor to the high-Qing mathematical astronomers. Well-versed in the textual-classical tradition of Chinese mathematics, he was one of the many unsuccessful examinees struggling for elite status, who saw a decline of evidential studies due to the devastation of the scholarly society in the Taiping Rebellion.[57] Both missionaries and Qing mathematicians recognized the urgent need to introduce Western knowledge as a means of alleviating China's crises facing domestic upheavals and foreign threats. With the establishment of new institutes such as the Jiangnan Arsenal and the Beijing School of Foreign Languages, this collaboration received official sponsorship in the Self-Strengthening Movement from the 1860s onward. The result was the creation of a new society of scientifically minded translators, technicians, and engineers, who called their field *gezhi*, which combined the investigation of things (*gewu*) and attainment of knowledge (*zhizhi*). As keenly observed by Elman, this nomenclature indicated a major semantic change in the concept of *gewu*, from a fundamental and universal method in classical learning to a specific domain of knowledge in natural sciences.[58]

Behind this semantic shift was the clash of two knowledge systems. On the one hand, the introduction of Western knowledge was accompanied by an expansion of imperialist power in both practical and symbolic aspects of scientific learning. For instance, the collection of plant and animal specimens from China and various parts of the world led by Western naturalists, rewriting the indigenous tradition of *materia medica* by a a universal system of binomial nomenclature, became a typical form of scientific imperialism.[59] On the other hand, both the Chinese translators and their Protestant collaborators managed to adapt Western science to the native knowledge system. Li Shanlan developed a Chinese notation for calculus that resembled the multivariable equations found in Song-Yuan mathematical works, which had been well studied by philologist-mathematicians in the first half of the nineteenth century.[60] John Fryer (1839-1928), the most prolific Protestant translator among his fellows, also made significant efforts to give his Chinese translations of scientific terms a familiar appearance. Manuscripts of Chinese-Western glossaries preserved at University of California, Berkeley reveal multiple rounds of revisions in which Fryer moved away from

[56] Elman, *On Their Own Terms*, 283-86.

[57] Elman, *From Philosophy to Philology*, chapter 6.

[58] Elman, *On Their Own Terms*, 297.

[59] See, e.g., Fan, *British Naturalists in Qing China*; Mueggler, *The Paper Road*.

[60] Elman, *On Their Own Terms*, 305.

direct phonetization of Western terms, instead adding prefixes or suffixes to traditional names and inventing new Chinese characters.[61]

This knowledge negotiation entered a new phase after Qing China's stunning defeat in the Sino-Japanese War (1894-95). With its geographical proximity and cultural similarities, the rapidly modernizing Meiji Japan replaced Europe in the 1900s as the primary source of scientific knowledge and preferred destination for studying abroad.[62] Correspondingly, the term *kexue* (Ja. *kagaku*, "disciplinary learning"), as one of the many introduced Japanese neologisms, began to take the position of *gezhi* as the standard translation for "science." If the term *gezhi* still preserved the trace of traditional scholarship in its incorporation of *gewu*, the term *kexue* marked a more decisive departure from evidential learning, just like the new generation of overseas Chinese students who promoted the supposedly universal language of modern science.[63] Scientific knowledge, introduced from the East and the West, no longer worked as evidence for a common Chinese origin. Demarcated from the classical tradition and carefully curated in distinct disciplines, what Needham would come to call "ecumenical" modern science now took the lead, making possible the question of why China had not "discovered" modern science.

CONCLUSION

With the rapid ascent of *kexue*, *gewu* faded rapidly from the public discourse in twentieth-century China. The rest, so to speak, is modern history - a perennial struggle between Westernization and native resistance in all aspects of cultural arena, from hospital delivery rooms to funerary homes, from the nomenclature of minute life forms to the massive exploitation of early riches deposited underground.[64] In her 2010 article, Marwa Elshakry highlighted the making of "Western science" and what Needham would come to call "ecumenical" modern science in Egypt and China and the simultaneous distortion and forgetting of systematic forms of knowledge in the past. Scholars looking for a new global history of science, Elshakry argues, would do well to look beneath the piles of wreckage and rescue native terms of science such as the Arabic term *'ilm* and the Chinese term *gewu*.[65] Suffice it to say that her advice has been well heeded in the case of late imperial China, as reflected in the robust recent growth of scholarship we have reviewed in this essay. We hope

[61] Tola, *John Fryer and* The Translator's Vade-mecum, chapters 4-6.

[62] Reynolds, *China, 1898–1912*, Part Two.

[63] Elman, *On Their Own Terms*, 396-98; Jin & Liu, "Cong 'gewu zhizhi' dao 'kexue,'" 124-27.

[64] Rogaski, *Knowing Manchuria*; Meng, *Shanghai and the Edges of Empires*, 54-60.

[65] Elshakry, "When Science Became Western."

that the brief history of *gewu* here will further facilitate its use as a capacious and useful category of knowledge with its own dynamic history.

Still, there are more reasons to call for a new history of *gewu* beyond its usefulness in breaking free from the terminological constraints of modern science. Even after *gewu* gave way to *kexue,* the neo-Confucian pursuit of knowledge for a larger good continued to inspire new generations of followers and detractors in contemporary China. Exemplars of Way Learning and Evidential Studies also survived in various forms in public life, in and outside the professional confines of "Science" today. Episodes of China's response to the COVID-19 pandemic call to mind how the imperial state co-opted technical expertise and older cosmological symbolisms to buttress its legitimacy, and how individuals contested official rhetoric and "expert" knowledge by speaking from their moral conscience derived from experience, much as Wang Yangming had taught five hundred years ago.[66] The politics of *gewu* therefore continues within the body politic of what we call China today.

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[66] Bretelle-Establet, "Science, Demons, and Gods."

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