Benjamin Elman, *On Their Own Terms: Science in China, 1550-1900*, Cambridge: Harvard University Press, 2005, 606 pp.

Toby Huff

[Toby Huff is a Research Associate in the Department of Astronomy at Harvard University and Chancellor Professor Emeritus at University of Massachusetts Dartmouth. He is the author of The Rise of Early Modern Science: Islam, China and the West *(Second ed. Cambridge 2003), and* Intellectual Curiosity and the Scientific Revolution: A Global Perspective *(Cambridge University Press, 2011). He has lectured in Europe, given talks across the Muslim world and lived in Malaysia. Contact: thuff@fas.harvard.edu]*

The heart of this book is about the development of native Chinese sciences from the sixteenth to the early twentieth century under the influence of the Jesuits and then the Protestant missionaries in the nineteenth century. It has unusually long sections of prolegomena (sixteen pages of Preface and twenty-three of Prologue). In these sections the author takes up a wide set of smaller agendas that include the question of the appropriate theory of knowledge for the literati, elements of commercialization in the Ming dynasty, and the nature of print technology and publishing. "Chapter 1" is then devoted to Ming classification on the eve of the Jesuit mission to China. Nevertheless, Benjamin Elman thinks that the broad narrative about the place of science in Qing China that he offers is needed to understand how modern science eventually emerged in China.

Despite this ungainly opening, when the book first appeared, now more than half a decade ago, it was an exciting addition to our knowledge of what happened to science in seventeenth-century China under the influence of the extraordinary mission established by Matteo Ricci. The two big questions were just how successful or not the Jesuits were, how comprehensive their efforts had been, and secondly, whether Chinese science really did get reformed enough so that Needham's claims about the emergence of ecumenical science with Chinese science converging with western, global science in the eighteenth and nineteenth centuries is true. The title of this book broadcasts the null result with regard to the potential seventeenth century reform of Chinese science. Likewise, that aborted reform process prevented serious merging of Chinese and ecumenical science. Yet Elman persists in believing that somehow the Chinese story is a "remarkable achievement" (p. 420), despite its failure on almost all accounts.

Elman's elucidation of the seventeenth-century Chinese-Jesuit encounter, surely the best part of the book, is very richly detailed. His command of Chinese sources is broad and impressive while his efforts to understand the development of science in Europe are also exceptional among those who attempt comparisons. In the first four chapters Elman does a splendid job of explaining the background to the Jesuits' arrival and identifying the dozen or so books especially written by the Jesuit scientist-missionaries to explain virtually all aspects of the state-of-the-art astronomy as then practiced in Europe. Beyond Matteo Ricci's efforts to translate both Euclid's indispensable *Elements* (the first five books) and Sacroboso's standard work on the spherical nature of our world, scholars such as Emanuel Diaz, Adam Schall von Bell, Johann Schreck (also known as Terrentius), Nicholas Trigault, James Rho and a number of others, along with Chinese collaborators, went to extra lengths to explain European astronomy, its models, assumptions, and instrumentation to the Chinese. This included bringing the telescope, writing books about how it was made and used, and most surprising of all, explaining Kepler's cutting edge theory of optics that enabled astronomers to correct errors in observations that occurred under specific angular observational conditions. That the Jesuits were compelled not to discuss Copernicus' *hypothesis* in this context has been greatly exaggerated by Sinologists, but not Joseph Needham. He understood that from a strictly observational point of view, it was impossible to determine which system, Ptolemaic, Tychonic, or Copernican best fit the facts. Furthermore, the geo-heliocentric system of Tycho Brahe, though flawed, nevertheless had embedded within it, a heliocentric orientation around which the five planets revolve.

On the other hand, writers on the Jesuit influence on Chinese science have insufficiently emphasized the fact that the Jesuits made a special trip back to Europe in order to procure the most important books in science, mathematics and natural philosophy that could be translated into Chinese and thus give those aspiring scientists the ability to understand all the fundamental technical and metaphysical assumptions of western science. But the big bonus of the trip was the recruiting of twenty-two top notch scientists, and in particular Adam Schall von Bell and Johann Schreck, the latter being the seventh inductee after Galileo into the famous Academy of the Lincei. Upon their return to China with a telescope the translation project (of 7,000 books) was begun in earnest with the vast resources of the imperial throne. The project to reform Chinese astronomy was under the direction of the brilliant Xu Guangqi ("Dr Paul", d. 1632), who was a Christian convert and many times a successful candidate on the civil service examinations.

It is difficult to fault Elman's account of this episode which will be a major point of reference for future scholars looking into the Jesuit guided reforms. Nevertheless, he stopped short of explaining to the reader how deeply the reform movement penetrated the thinking of all those attached to the Chinese Bureau of Mathematics and Astronomy, and that Xu Guangqi in fact engineered one of the most impressive cases of empirical astronomical testing ever undertaken up to that point.

In the first instance, Xu impressed upon the Emperor that the translation project had to be comprehensively carried out because the Chinese mathematical astronomy system was indeed going to be replaced, and if some day, as had happened to the Chinese system, the "new" or "western" system met with failure, then the only way to correct it would be to go back to the fundamentals. Second, since the Chinese system had earlier (in 1612 and 1629) met with failure in solar eclipse tests against the European system, Xu set about systematically testing new astronomical observations against the Chinese, Ptolemaic, and Tychonic systems. All of this was made possible by the arrival of the telescope which was correctly understood to be capable of making more accurate observations than ever before. Even without cross-hairs (a micrometer) this was possible, above all using Kepler's technique of projecting light through a pinhole (or telescope) onto a sheet of paper with calibrated lines. In short, the Chinese astronomers of Xu Guangqi's generation were very sophisticated and wisely used the cutting edge ideas brought to them above all by Schall, Terrentius, and James Rho. In a word, those Chinese scholars knew a great deal about astronomical systems, the nature and limits of observations with a telescope, and the difficulties of establishing one system over another. Yet in a short few years, they moved from the Chinese to the Ptolemaic, and then to the geo-heliocentric system of Tycho Brahe. That was no small feat.

In this context it is downright churlish to blame the Jesuits for the subsequent failure of modern science to take hold in China. Elman, following Nathan Sivin, suggests that "European cosmology had been discredited by its own unexpected lack of internal coherence" (p. xxvi), when in point of fact (a) Europeans were still trying to determine which world system was correct, and (b) Xu Guangqi and his team (European and Chinese) of astronomers were themselves empirically trying to determine which system was best and were not especially muddled by the task. Evidence in favor of the Copernican system was building up, especially thanks to the observations of Galileo (confirmed by many others), and Kepler's *New Astronomy* of 1609. It would be a stretch to claim that all or most European astronomers were committed Copernicans in, say 1610 or 1618 when the Jesuits were gathering their new materials for transmission back to China. In short, Elman like others sells short the Jesuit efforts, flawed as they were, often wishing for the Chinese that the Europeans should just give them "all the rights answers." This is not to say that Elman is especially hard on the Jesuits; his account is probing and well balanced and does not actually attempt to apportion blame.

Yet as Elman points out in *On Their Own Terms,* nativist Chinese rebelled against the "new system" (and not for the first time) during the so-called "Rites Controversy" of the 1660s, approximately four decades after the telescope arrived. At that time Adam Schall von Bell, who had been a student in Rome and heard Galileo speak at the Roman College in 1611, was now at the helm of the Chinese Bureau of Astronomy and Mathematics. Because of the clear predictive superiority of European astronomy, still based on the geo-heliocentric models of Tycho Brahe, the Chinese had been persuaded to adopt the new Western system. But being in charge of that Bureau meant that Schall had to make divinatory decisions within the traditional Chinese astrological system. In this case he had to choose an auspicious date and site for an Imperial burial. When Chinese scholars hostile to Schall and the new system repeatedly attacked Schall regarding this decision, he and his European and Chinese associates ended up under house arrest and were sentenced to death. Schall died of a stroke within a year while the Chinese convert-assistants were executed. The Jesuit mission (and the new astronomy) was finally rescued by the extraordinary and dangerous efforts of Ferdinand Verbiest who dared to make astronomical predictions that were to be tested in public right in front of the Emperor and his court. Verbiest's success (in 1669) with his daring tests put him (and the Jesuits) back in charge of the Bureau of Mathematics and Astronomy, but the affair tainted Chinese-Jesuit relations ever after. According to Elman, those anti-Jesuit and anti-western sentiments peaked in the late eighteenth century, following the disbanding and later restoration of the Jesuit order. Of course there was internal bickering among the various Catholic Christian orders that did not help the situation.

Consequently, even the presumed champion of western science, the Kangxi Emperor (d. 1722), began to put further restrictions on even the limited presence of "natural studies" in the Civil Service Examinations after 1713. As with several of his earlier works, Elman keeps his eye on "natural studies," which he admits, is a problematic set of inquiries encompassing "things" broadly conceived, not particular disciplines, or general explanations, sometimes including "rational explanations" but also things "ineffable, fantastical and magical" (p. xxx). In other words, these investigations do not correspond to Aristotle's natural philosophy and the subjects of his "natural books."

This brings us to another surprising omission in such a fulsome work: there is no extended discussion of Chinese educational practices that Elman knows so much about. Since no major reform or change in the system is discussed, the reader is left to believe that the ancient emphasis on moral, ethical, poetic, and historical studies championed by neo-Confucianism, not natural science, remained the focus of study until the system's abolition in 1905.

The issue of the need to reform Chinese educational practices was pointedly suggested to the Kangxi Emperor by Verbiest in the 1680s. He had grasped the fact that Chinese "natural studies" were a far cry from Aristotle's natural philosophy, and though many of Aristotle's works in natural philosophy had been translated into Chinese, a new curriculum with a systematic focus on them was required to reform Chinese education. Elman discusses this episode and Verbiest's collection of the materials that he had studied at the University in Coimbra. Verbiest developed a proposal of 1683 that would entail a new curriculum but this was a bridge too far. The Emperor and scholars of the Hanlin Academy refused to allow the printing of the material under royal auspices (p. 146). Consequently, it is not surprising that no major reforms of Chinese education and examinations were instituted, making it nearly impossible for Chinese scholars to develop the scientific habits of mind necessary to advance modern science. Instead, Elman offers various allusions to the Jesuits withholding one or another small piece of western scientific knowledge instead of acknowledging that the Chinese simply were not trained (outside the astronomical bureau) to *do* modern science after the Rites Controversy.

For example, Elman suggests that the Jesuits or others did not explain calculus or did not provide a full account of Newton's *Principia* (1687) when it was mentioned in 1742; or that only the first five books of Euclid's *Elements* were translated by the Jesuits. Yet Elman knows that Newton's grand synthesis of terrestrial and celestial mechanics had nothing to do with calculus, it was all geometry. Understanding the geometric figures in Newton's *Principia* does not require the complete mastery of Euclid; and if it did, surely *Chinese scholars* after 1605 could have translated the rest of it themselves if they had so desired.

The problem is not the incomplete edition of Euclid or the withholding of knowledge of calculus, but the absence of an adequate science of motion in Chinese thought. This was what Joseph Needham pointed to when he wrote that Chinese science had no science of motion, neither dynamics nor kinematics. It was missing the work of Burdian, Bradwadine, Oremes and their successors. Elman is probably right in suggesting that European science, technology, and industry in the late eighteenth century benefitted from knowledge of calculus and this gave Europeans various industrial advantages. But the Chinese had not mastered the pre-industrial fundamentals of the science of motion.

Elman dwells a lot on Chinese mathematics, especially the work, influence and accomplishments of Mei Wending 梅文鼎 (d. 1721), who also did a great disservice to Chinese progress by claiming that Western science, and especially mathematics was really of Chinese origin. However, given the fact that the great Western pioneers in astronomy, i.e., Copernicus, Tycho Brahe, Galileo, Kepler, and Newton achieved their accomplishments using only geometry, not algebra or calculus, Elman's focus on various aspects of Chinese mathematics seems misplaced.

Surely the Jesuit attempt to suggest that somehow, deep down, ancient Chinese thought was compatible with western thinking was a misstep. But it was far more the nativist Chinese reaction that claimed all scientific knowledge originated with the Chinese which was the culprit. In the end, according to Elman's account, those who finally saw through this canard were led to abandon Chinese science altogether in the late nineteenth century in favor of what they could learn from the Japanese. At the same time, Elman comes close to special pleading when he tries to suggest that China in the late nineteenth century was not as far behind Japan with regard to industrial development and related fields as many scholars have thought and which led to their defeat by the Japanese in the Sino-Japan war of 1894-95.

Beyond all this, Elman does not sufficiently consider that Chinese science was deficient in a great number of areas. He does signal that Chinese study of anatomy was retarded but there is no mention of deficits regarding the use of microscopy in a broad range of human, animal and plant lifeforms. Likewise there were large deficits in hydraulics and pneumatics, and, not least of all, electric studies. Nor does he mention that despite their mastery of telescopes and their use, the Chinese made no modifications or improvements of it in the seventeenth or eighteenth centuries. All of this suggests that Elman's claim that China's assimilation of the rudiments of modern science from the sixteenth century to 1900 was a "remarkable" success rings hollow. In the realm of science, the Chinese neither kept up with the Arabs and Muslims in the 750-1350 period, nor with their Asian competitors in Japan who went on in the twentieth century to win far more Nobel prizes than the many-times-larger Chinese population.

At the same time, it is surprising that Elman offers no analysis of the bringing of modern chemistry to China in the nineteenth century by the Protestants and other Westerners. Some have argued that, of all the sciences in the nineteenth century, chemistry had the greatest impact, on life, industrial development and the other sciences. Among the Chinese it seems that by the end of the nineteenth century there were more chemists, chemistry teachers, industrial chemists, publications, and so on than in any other scientific field.[1] Of course, this was not a case of an indigenous science maturing; it was rather the result of a radically new import, which, one would think, was central to the story of the eventual transformation of China's scientific establishment.

Despite these problems with the book's arguments, all scholars working on Chinese science should have this book on their reference shelf.

---

[1] James Reardon-Anderson, *The Study of Change, Chemistry in China, 1840-1949* (New York: Cambridge University Press 1991), p. 4.