



## Review Essay

# Needham's Heavenly Volumes and Earthly Tomes

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*Science and Civilisation in China*, vol. V, *Chemistry and Chemical Technology*, Part 12, *Ceramic Technology*. By Rose Kerr and Nigel Wood, with additional contributions by Ts'ai Mei-fen and Zhang Fukang (Cambridge: Cambridge University Press, 2004), pp. 918, £120 (hardback), ISBN 0 521 83833 9.

*Science and Civilisation in China*, vol. VI, *Biology and Biological Technology*, Part 5, *Fermentations and Food Science*. By H.T. Huang (Cambridge: Cambridge University Press, 2000), pp. 741, £75 (hardback), ISBN 521 65270 7.

*Science and Civilisation in China*, vol. VI, *Biology and Biological Technology*, Part 6, *Medicine*. By Joseph Needham, with the collaboration of Lu Gwei-djen, edited and with an introduction by Nathan Sivin (Cambridge: Cambridge University Press, 2000), pp. 261, £65 (hardback), ISBN 0 521 63262 5.

*Science and Civilisation in China*, vol. VII, *Science and Chinese Society*, Part 2, *General Conclusions and Reflections*. By Joseph Needham, with the collaboration of Kenneth Girdwood Robinson and Ray Huang, and including contributions by them, with an introduction by Mark Elvin (Cambridge: Cambridge University Press, 2004), pp. 283, £65 (hardback), ISBN 0 521 08732 5.

Hsu, Elisabeth, ed. *Innovation in Chinese Medicine* (Needham Research Institute Studies 3) (Cambridge: Cambridge University Press, 2001), pp. 426, £65 (hardback), ISBN 0 521 80068 4.

Lo, Vivienne and Christopher Cullen, eds. *Medieval Chinese Medicine: The Dunhuang Medical Manuscripts* (Needham Research Institute Studies [unnumbered]) (London: RoutledgeCurzon, 2005), pp. 450, £95 (hardback), ISBN 0415342953.

Since the passing of Joseph Needham in the spring of 1995, seven more volumes of the *Science and Civilization in China* (SCC) series and six monographs and two edited volumes in the new Needham

Research Institute (NRI) Studies series have come out of 8 Sylvester Road, Cambridge, England.<sup>1</sup> This production shows Needham to be as prolific in “spirit” and prodigious in inspiration as he was in his 94 years of life as a scientist and historian of science. Needham reflected upon the legacy of the research institute that bears his name in the last sentence of his final published essay: “It will, I trust, be a green island of quietness in the City of Cambridge for many years to come.”<sup>2</sup> Judging from the 15 publications that have already appeared and the two that are forthcoming, in the past 11 years since he passed away, Needham’s own “green island of quietness” has become a veritable beehive of productivity.

Suffice to say that I will not review all of these new publications because of limits of both space and time. Two appendices summarize the titles, authors, and dates of the *SCC* and NRI studies series for easy reference. The five monographs published since 1996, and the 2002 reprint of Lu and Needham’s *Celestial Lancets*, make the new NRI studies series worth a brief introduction. The three science monographs present new approaches that situate *Astronomy and Mathematics in Ancient China* (Cullen), explicate *Chinese Mathematical Astrology* (Ho), and deconstruct *Aristotle in China* (Wardy). The two medical monographs offer excellent examples of a gender analysis of the first sixteenth-century collection of a single physician’s case records in *A Chinese Physician-Wang Ji and the ‘Stone Mountain Medical Case Histories’* (Grant)<sup>3</sup> and a critical assessment of the politics of *Chinese Medicine in Early Communist China* (Taylor). Although all of these NRI monographs published since 1996 are worth being seriously reviewed, my focus, however, will be on the four most recently published volumes of *SCC* and the only two

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<sup>1</sup> One more in each series are in press: *SCC* vol. V, pt 11. *Ferrous Metallurgy*, by Don Wagner and Ho Peng Yoke, *Explorations in Daoism: Science in Literature* (London, 2007 [forthcoming]).

<sup>2</sup> *SCC*, vol. 7, pt 2, (2004), li.

<sup>3</sup> See my first review in *Medical History*, 48 (2004), 397-399. For a more extended discussion of the many strengths and some weaknesses of Grant’s gender analysis, see also “Depleted Men, Emotional Women: Gender and Medicine during the Ming Dynasty,” in Angela Ki Che Leung, ed., *Medicine for Women in Imperial China* (Leiden, 2006), 179-196.

edited volumes of the NRI studies series (Hsu 2000, Lo and Cullen 2005).

The first two of the four SCC volumes reviewed—*Fermentations and Food Science* (2000) and *Ceramic Technology* (2004)—are the works of three (of over thirty) SCC collaborators and represent what Needham called the “[s]ciences and technologies [that] could be described.”<sup>4</sup> The second two volumes—*Medicine* (2000) and *General Conclusions and Reflections* (2005)—present his own final statements on the “social and economic factors [that] must be interpreted.”<sup>5</sup> Nathan Sivin’s introduction to *Medicine*, Christopher Cullen’s and Kenneth Robinson’s prefaces, Mark Elvin’s stimulating *Vale atque ave*, updated footnotes and bibliographies, and Needham’s final foreword to *General Conclusions and Reflections* considerably enhance the original essays and offer a fitting tribute to and account of Needham’s *magnum opus*. Finally, the two edited volumes—*Innovation in Chinese Medicine* and *Medieval Chinese Medicine*—represent the new directions the SCC project has taken through Christopher Cullen’s guidance over the past decade at the helm of the new NRI studies series.

## Before and After

These six new publications offer many reasons for returning to or newly exploring the SCC project and NRI studies series. What I imagine for *Early Science and Medicine* (ESM) readers who might be considering these new publications for their courses, personal interest, or own research is the kind of “before and after” experience I had just last month. I had on my reading desk a pre-circulated paper by Kathleen Crowther-Heyck on Christian natural philosophy and two Mosaic philosophers titled “Sacred Philosophy, Secular Theology: The Pious Physics of Levinus Lemnius (1505-1568) and Francisco Vallès (1524-1592).” The subject held no significance to me whatsoever and were as foreign as “Neo-Confucian philosophy and Taoist Eschatology” may well be to others. I thought

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<sup>4</sup>) SCC, vol. 7, pt 2, (2004), xlv.

<sup>5</sup>) Ibid.

at best the paper would be “good for me.” I never expected it to be a good read, nor one that would trigger me to think in new ways about the *Systematic Materia Medica* (*Bencao gangmu*, printed 1596). A Chinese contemporary of Lemnius and Vallès, Li Shizhen (1518-1593), wrote this exhaustive compilation of Chinese natural history and materia medica. Instead of relying on the Bible to legitimate and develop upon natural knowledge as did Lemnius and Vallès, however, the backbone of Li Shizhen’s “natural history” were two secular canonical texts from Chinese antiquity: the earliest topically-organized Chinese dictionary, called *Approaching Refinement* (*Erya*, ca. 3rd c. BCE), and the earliest Chinese anthology of poetry and songs, titled the *Book of Songs* (*Shijing*, ca. 1000-600 BCE).<sup>6</sup> Although their frame of reference, historical sources, and religious contexts differed, their impulse to apply textual exegesis of ancient texts to contemporary knowledge about nature was nevertheless comparable.

I could draw further comparisons and contrasts between the natural history of Lemnius and Vallès and that of Li Shizhen, but the point is rather the “after” experience of a sudden sense of significance and intellectual resonance upon reading and then discussing Kathleen Crowther-Heyck’s research in colloquium. I hope that something in the following overview of the recent publications coming out of the NRI will set off comparable chain reactions within individuals who will then engage (or reengage) with the *Dialogue des civilisations Chine-Occident* that Needham, Lu Gwei-djen, and their collaborators initiated and their “descendants” continue to sustain.<sup>7</sup>

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<sup>6</sup> See Carla Suzan Nappi, “The Monkey of the Inkpot: Natural History and Its Transformations in Early Modern China” (Princeton University, Ph.D. dissertation, 2006), 34-47.

<sup>7</sup> Title from Joseph Needham, *Dialogue des civilisations Chine-Occident: pour une histoire œcuménique des sciences*, edited by Georges Métailié, translated by Francine Fèvre and Marie-Brigitte Foster (Paris, 1991).

## Heaven and Earth

Few readers of *ESM* will be unfamiliar with the SCC series, or maybe even with the more recent NRI studies series. Perhaps for some, however, “Needham’s heavenly volumes and earthly tomes” do not ring celestial bells or terrestrial correlates.<sup>8</sup> What began as a proposal to write a single volume with Cambridge University Press at mid-century turned shortly thereafter into a seven-volume plan. The first two volumes—*Introductory Orientations* (1954) and *History of Scientific Thought* (1956)—came one after the other at a steady pace and fairly reasonable length. After the third volume *Mathematics and the Sciences of the Heavens and Earth* (1959) materialized just short of 900 pages, however, it became imperative to subdivide the celestial realm to better accord with terrestrial reality. The four remaining “heavenly volumes” of the SCC series were thereafter subdivided into ever more separate parts, which Needham often referred to as the physical “earthly volumes.”<sup>9</sup> In relation to the higher-order themes of the final four volumes, these now 20 parts are indeed their “earthly tomes”. *Ceramic Technology* is the most recent and twelfth part that makes up the “heavenly volume” V on Chemistry and Chemical Technology. *Fermentations and Food Science and Medicine* are the fifth and sixth parts, respectively, of volume VI on Biology and Biological Technology.

The seventh final volume, *The Social Background*, concludes the SCC series with just two parts: Christoph Harbsmeier’s both erudite and entertaining monograph on *Language and Logic* (1998)<sup>10</sup> completed nearly a decade ago and Joseph Needham’s own *General Conclusions and Reflections* (2004), which can best be understood as the flaming phoenix of the series. If it were not for the daily side-by-side conversations Needham had with one of his most senior and dedicated collaborators (since 1949), the late Kenneth Robin-

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<sup>8</sup>) The metaphor comes from the Chinese numerical system of 10 celestial stems and 12 earthly branches, which when combined together form the 60 unique pairs at the basis of the traditional Chinese counting system for mathematics, astronomy, and the calendrical sciences.

<sup>9</sup>) SCC, vol. 7, pt 2, (2004), xv.

<sup>10</sup>) See D.E. Pollard’s review, *The China Quarterly*, 155 (1998), 693–695.

son, in the last years of his life in his office at the NRI, the SCC series would never have come full circle, as it fortunately has, to the mind, motivations, and concluding words of its primogenitor.<sup>11</sup> Despite the obvious continuity of and remaining gaps (i.e., the as yet unpublished but projected parts) within the SCC series, the final Needham volume simultaneously provides a “bookend” that offers a sense of closure to the series and an unexpected new opening for serious consideration of the current relevance and possible futures of Needham’s legacy.<sup>12</sup>

I begin with the two new earthly tomes of *SCC* on the ceramic and food processing technologies “that can be described,” then move to the three volumes on medicine—Needham and Lu’s reprinted essays in *SCC* VI, pt 6, *Innovation in Chinese Medicine*, and *Medieval Chinese Medicine* that deal more with social and economic factors “that must be interpreted”—and conclude with Needham’s *General Conclusions and Reflections* and post-Needham reflections on his legacy.

## Ceramic Technology

China not only has evidence on 11,000 continuous years of ceramic manufacturing, but also for well over 1,500 years of the past two millennia China produced ceramics for the world economy and, for most of that time, also controlled a monopoly on porcelain. One of the reasons for this dominance can be attributed to Chinese emperors who, since the Tang dynasty (618-907), patronized ceramic production for the burial, religious ritual, and imperial household needs of the state. Imperial patronage significantly contributed to both technological transfer (from tributary gifts and samples from private kilns) and innovation (to meet imperial demand). This process became even more concentrated in China’s “porcelain city” when

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<sup>11</sup> The late Kenneth Robinson (1917-2006) worked with Needham since the 1940s, beginning in 1949 the section on “acoustics” in vol. IV, *Physics*, pt 1, and was associated with the SCC project for most of the second half of the twentieth century.

<sup>12</sup> I borrow “possible futures” from the title of the subsection in Elvin, *SCC*, vol. 7, pt 2 (2004), xxxvi-xl.

in the first year of the Yuan dynasty (1278-1368) the Mongol rulers formally made the southern center of ceramic production at Jingdezhen the imperial kiln and established a new "Porcelain Bureau" there to manage porcelain production (pp. 184-201). Jingdezhen became from then on the center of ceramic production for the Imperium and later the world market.

How were ancient Chinese pots made, glazed, fired? Why did China discover porcelain around 600 CE, more than 1000 years before the West learned to manufacture it? When and how did Chinese porcelain-making techniques finally diffuse to Europe? Why has China "been, without doubt, the single most important influence on the course of world ceramics" (p. 709)? Rose Kerr and Nigel Wood, with additional contributions by Ts'ai Mei-fen and Zhang Fukang, synthesize for the first time the Chinese historical sources, finds from archaeological excavations, science of ceramics, and secondary sources in multiple languages into a definitive, massive, and beautifully illustrated tome on Chinese ceramic technology from antiquity to the present. The historical record on Chinese ceramics is more continuous and extensive than anywhere else in the world, and world scholarship on the subject has exploded in the past 50 years.

The contributors frame their synthesis of this vast literature and analysis of every aspect of Chinese ceramic technology into seven sections. Section I, "Setting the Scene," introduces "the status of ceramics in early China" and provides "introductory remarks on raw materials, firing, forming, and glazing." Issues of consumption, connoisseurship, status of potters, the primary evidentiary record, and secondary scholarship are discussed here. The rest of the volume focuses on production rather than consumption of Chinese ceramics. Section II, "Clays," covers earthenwares, stonewares, porcelain, and tea wares throughout Chinese history with chapters divided along northern and southern developments. One chapter singles out Jingdezhen to examine more broadly imperial patronage and control, labor relations, mining, and the special quality of kaolin and other porcelains that Jingdezhen kilns produced. Section III, "Kilns," examines firing methods from Neolithic bonfire kilns, up-draught kilns, and reduction firing, to cross-draught, Chinese-style kilns, and

the full range of kilns at Jingdezhen. Section IV, "Manufacturing methods and sequences," takes the subject from Neolithic to Bronze Age to later ceramic-making techniques. Section V, "Glazes," spans from Ash-glazes, colored, lead, high-firing lime, and high-temperature colored porcelain glazes, with special attention again to northern and southern porcelain glazes. Section VI, "Pigments, Enamels, and Gilding," covers these processes from antiquity to the present and gives a good sense of the science underlying what made Chinese ceramics aesthetically exceptional and economically unprecedented.

Like the opening section on "Setting the scene," the final, seventh section on "Transfer" will probably most interest non-specialists. Chinese ceramic technologies spread throughout the world in three ways: through local technology-transfer (as occurred through most of East and Southeast Asia), by remote transfer through superficial imitation (mostly in South and West Asia, Europe, Scandinavia, Russia, North and South America), and through transfer by reconstruction through scientific analysis. Despite European attempts to understand Chinese porcelain-making techniques since the second half of the 16th century, the last type of transfer did not begin until after the 1900 publication of the Frenchman Georges Vogt's first, and still unsurpassed, scientific analysis of Jingdezhen porcelains. China maintained the edge in world ceramic history, despite a lull in dominance during the 19th-20th centuries, because of its unmatched native raw materials, the exceptional technical skills of its artisans, and, most importantly, the complex culture that both created native demand and developed a sophisticated market system within and outside of China for ceramics. Readers will not find in this volume, however, analyses of the complex ceramic or porcelain cultures of consumption in China or in the world.<sup>13</sup> However, whether one appreciates Chinese blue-and-white porcelain or Yixing red stoneware, Jingdezhen glazes or Korean celadon, Swatow-style exports or British bone china and Wedgwood, Rose Kerr and

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<sup>13</sup>) For the best analysis of Chinese connoisseurship and consumption of ceramics (among other things) in the early modern period, see Craig Clunas, *Superfluous Things: Material Culture and Social Status in Early Modern China* (Cambridge, 1991).

Nigel Wood's *Ceramic Technology* will not disappoint. Their narrative will ensure that readers visit or revisit the myriad ceramic exhibitions in the museums of the world with greater appreciation of China's contributions as well as the technology, art, economics, and history of ceramics in human civilization.

### **Food and Fermentation**

The fifth part of *SCC VI* changes focus from China's ceramic vessels to their delectable contents. Fifty-plus years of inquiry, observations, and research into the history, technology, and practice of processing food products in China went into this volume. The "Author's Note" alone is worth reading for H.T. Huang's power to bring vividly back to life the sights, sounds, and even flavors of the foods available during the summer and fall of 1942 in his ancestral village Hetang, located 70 kilometers north of Fuzhou in Fujian province. Huang became Needham's first Chinese secretary when they met on 15 May 1943 while Needham was in China to found the Sino-British Science Cooperation Office in Chongqing, Sichuan province, during the second Sino-Japanese war (1937-1945). In the fall of 1944, Huang started a D.Phil in Chemistry at Oxford, after which he worked in U.S. food processing and pharmaceutical industries. Huang was also one of the early *SCC* collaborators,<sup>14</sup> a program director of the NSF in Washington D.C. in the early 1980s, a former Deputy Director of the NRI in the 1990s, and, for a time, coordinator of the *SCC* series. Little did he realize in 1942, however, that he would spend the rest of his life on and off researching nearly every aspect of most of the traditional foods the villagers made that half a year when he found himself in between jobs. The list makes one's mouth water and whets one's appetite: deep-fried crullers and bright buns, rice congee with roasted peanuts, long filaments of sliced noodles and fine wheat-flour noodles, fermented soybeans and soy sauce, steamed-rice wine made from red ferment

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<sup>14</sup> H.T. Huang wrote the final section on "Plants and insects in man's service" in *SCC* Vol. VI, pt I, *Botany*, 471-553, which focused on the natural plant products and biological agents, used by the Chinese to control insects.

and ginger root pickled in the same red residual mash, pickled vegetables and salted duck eggs, dried bean curd and soft bean-curd custard, malt syrup candy, and glutinous rice pastries. Huang does not disappoint either in the following six hundred-plus pages of copiously illustrated, richly detailed, and densely researched “Fermentations and Food Science” in Chinese history.

The eight sub-sections provide an overview of the subject: a) an introduction to “Food resources in ancient China” and the “Ancient Chinese culinary system”; b) a literature review of primary and secondary sources; c) an analysis of Chinese fermentation processes and the evolution of wines; d) a study of soybean processing and fermentation; e) a discussion of food processing and preservation techniques; f) a succinct history of tea processing and use; g) a short review of nutritional deficiency diseases; and h) an epilogue with theoretical conclusions.

The section on soybean processing and nutritional deficiency diseases gives a good sense of the substance of the whole. The legume soybean is unique among the other four staple “grains” of ancient China (millet, wheat, barley, rice) in that it did not become a cultivated crop outside of East Asia until the twentieth century. Furthermore, its current use outside of East Asia for products such as edible oil (since WWI) and protein-rich defatted meal for animal feed considerably differs from the main products based on it central to Chinese cuisine: soybean sprouts, soybean milk, frozen, fried, dried and smoked, and fermented bean curd, fermented whole beans, soybean paste, and, of course, soy sauce. Through these processed soybean products, the Chinese resolved the two main problems of making soybeans palatable for human consumption, namely their digestibility and their generation of gas and flatulence, and created enough vegetable-based protein to help sustain China’s large population through the past two millennia.

Huang’s review of the four main nutritional deficiency diseases—goitre, beriberi, night blindness, and rickets—draws from a rich medical record that described symptoms clearly enough to associate with these modern disease categories, though this does not mean that a one-to-one correspondence can be made as easily as Huang and others tend to do. Although Chinese physicians did not know

the biochemistry of vitamins, essential amino acids, or trace elements—all discoveries of the early twentieth century—Huang nevertheless shows how some of their food therapies and medicinal formulas addressed the nutritional deficiencies. Furthermore, he credits the medical concept of yin-yang, in the case of goitre at least, to rationalize the use of seaweed from the ocean for an illness known to occur only among inhabitants of mountainous regions, and the five phases concept, which similarly legitimated the use of liver, associated with the Wood phase and the eyes (and a good source of Vitamin A), for the eye diseases of night blindness.

Huang approaches Chinese food science and technology with the training of a biochemist and the methods of a scientifically trained historian of science. He traces the origin and development of Chinese food products, explains the scientific basis of traditional Chinese processing technologies, and whenever possible, makes comparisons with similar processes in European and other cultures in the world. China contributed to world cuisines, for instance, mould ferments from grains, which the Chinese used to create the most diverse array of fermented foods and drinks of any culture in human history, and the rotary quern, which made it possible for the Chinese to convert wheat into gluten and pastas and also soybeans into soy milk and tofu.

Similar to *Ceramic Technology*, this volume comprehensively covers production but not the consumption of food. If readers seek anthropological, sociological, or cultural interpretations of food consumption in Chinese culture, they must look elsewhere.<sup>15</sup> If readers are looking for a thorough analysis of the archeological, classical, historical, medical, literary, scientific, and secondary literature on the processing side of Chinese cuisine, they will likely find all the

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<sup>15</sup> The following are representative titles: K.C. Chang, ed., *Food in Chinese Culture: Anthropological and Historical Perspectives* (New Haven, 1977); Eugene Anderson, *The Food of China* (New Haven, 1988); Frederick J. Simoons, *Food in China: A Cultural and Historical Inquiry* (Boca Raton, 1991); David Y.H. Wu and Tan Chee-beng, eds., *Changing Chinese Foodways in Asia* (Hong Kong, 2001); Gang Yue, *The Mouth That Begg: Hunger, Cannibalism, and the Politics of Eating in Modern China* (Durham, NC, 1999); Judith Farquhar, *Appetites: Food and Sex in Post-socialist China* (Durham, NC, 2002).

information and references they require related to Chinese fermentation and food science in this treatise.

## Medicine

With the publication of part 6 of *SCC* VI, the “heavenly volume” on Biology and Biological Technology has finally realized its earthly form. As befits the completion process of *SCC* since 1995, this tome contains five previously published essays, which Joseph Needham and Lu Gwei-djen mostly co-authored between 1962 and 1988, and which are now, with a single exception, out of print. Gathered together for the first time, these five essays—“Hygiene and Preventive Medicine in Ancient China” (1962), “China and the Origin of Qualifying Examinations in Medicine” (1962), “Medicine in Chinese Culture” (1966, still in print in Needham’s *Clerks and Craftsmen*), “China and the Origins of Immunology” (1980), and “Forensic Medicine in Ancient China” (1988)—represent the scope, development, and pioneering aspects of their joint scholarship on Chinese medical history. The topics cover the earliest evidence of public health and preventive medicine, the early imperial initiatives in medical examinations and institutions, the history of smallpox variolation and inoculation (immunology essay), and a survey of the Chinese literature on forensic medicine. These essays remain the only synthetic introductions to these subjects.

Nathan Sivin, professor emeritus of Chinese culture and the history of science at the University of Pennsylvania, has considerably added to the usefulness of this collection of essays by bringing their bibliographies up to date with the most recent scholarship. In doing this, he has both compiled an unprecedented introduction to the collaborative work of Needham and Lu Gwei-djen in Chinese medical history and written an excellent guide to current insights and issues for future research. In the introduction, Sivin discusses the recurrent themes in Needham’s *SCC*, evaluates the theoretical foundations of Needham’s collaborative work with Lu on Chinese medical history, and summarizes new trends related to the history of medicine and sinology in China. This introduction stands well on its own as a historiographical essay on Chinese medical history, from

the work of the earlier generation of the 1950s and 1960s, which Needham and Lu represent, to the most recent books, articles, and dissertations on the subject from the 1980s through 2000.

In addition to placing Needham and Lu's scholarship within their context, Sivin succinctly summarizes developments over the past half a century in medical history, sinology, and research in Asia, namely in the People's Republic of China, Japan, and Taiwan. Most readers should find his section on research in Asia illuminating. In all cases, Sivin provides insightful, terse, and minimalist editorial comments in the footnotes of each article so as to preserve the original arguments of the authors and to demonstrate that, in many ways, their essays still hold their own today, because they established the literature reviews and bibliographic foundations upon which scholarship on these subjects continues to build upon. Sivin, however, makes an exception with the article "China and the Origins of Immunology," in which Needham and Lu wrote the first extended account on the history of smallpox and its treatment from inoculation to vaccination in China and the West. Sivin appends a critical correction of their arguments on the Taoist origins of smallpox variolation. This section may well make readers wish Sivin had not restrained himself from doing the same with the remaining four essays, though a great deal of time would have been required for that task. By relying on footnotes to update the other four essays, the general reader must make the comparison of old and new that Sivin would have been in a better position to formulate explicitly. Sivin's critical introduction, however, makes up for this imbalance by providing an excellent review of both the strengths and weaknesses of Needham and Lu Gwei-djen's legacy to the history of medicine in China.

### **Innovation in Chinese Medicine**

From March 8 to 11, 1995, the NRI hosted a workshop on change in Chinese medical history in honor of the life and work of Lu Gwei-djen (1904-1991). Joseph Needham attended the workshop and then passed away a fortnight later, making it his last academic venue. Conceived more as a tribute to than a *Festschrift* for Lu

Gwei-djen, *Innovation in Chinese Medicine* continues her instrumental efforts to broaden the scope of inquiry outside Europe and apply to China the same serious questions historians of medicine have asked of European and US medical history. As such, this volume marks the first collective statement of the post-Needham-Lu generation in Chinese medical history. Historians of medicine from antiquity to the early-modern period should find many articles in this book, as well as the other edited volume on *Medieval Chinese Medicine*, that resonate with their own work in terms of method, argument, and sources.

Whereas Needham and Lu wrote comprehensive histories of each medical topic from the earliest records to the end of the imperial era, the twelve articles in this volume all focus on specific examples of innovation in Chinese medicine. Instead of emphasizing origins, temporal precedence, cross-cultural comparisons, or similitude with modern science, these examples of medical innovation center on the tension between convention and controversy in specific Chinese intellectual traditions, social groups, and medical milieus. Six themes comprised of two articles each organize, more or less chronologically, this volume's twelve articles on change within Chinese medical history. In addition to an informative introduction to the rationale and structure of the book, the editor also summarized and contextualized the two articles of each subsection and thus made the narrative line remarkably clear through a wide range of topics.

The first theme, "Vessels (*mai*) and *qi* in the Western Han (206 BCE-9 CE)," examines the twin notions of circulatory tracts and vital energy in the Chinese medical body that legitimated the earliest practices of needling (acupuncture) and cautery (moxibustion) therapy (Lo, Hsu). "Correlative cosmologies" determines when numerology was first integrated into Chinese medicine (Harper) and then discusses how the elaborate numerological system of "five circulatory phases and six seasonal influences" became imposed on medicine and triggered innovations in conceptions of body, etiology, pathology, and therapeutics (Despeux). "Dietetics and pharmacotherapy" similarly pinpoints the first seventh-century emergence of *materia dietetica* (Englehardt) and considers the tenth-century

creation (and later disappearance) of a new drug for treating intermittent fevers, arsenious acid (Obringer). The fourth theme, “The canons revisited in late imperial China,” examines late-imperial reappraisals of canonical works in materia medica based on a new emphasis on the “investigation of things” (Métailié) and of formularies for epidemic fevers coming out of regional skepticism of universal canons (Hanson). “Medical case histories” analyses physicians’ descriptions of their clinical encounters from the earliest examples in the Han dynasty to the sixteenth-century appearance of a new medical genre, the collected case records of a single physician (Cullen), and concludes with how during the early twentieth century Chinese physicians modified this genre to better accord with Western biomedical practices (Andrews). “Medical rationale in the People’s Republic” completes the volume with two modern examples of clinical innovation: the “new acumoxa” movement of the early PRC period, which illustrates unification through new forms of political indoctrination (Taylor), and ethnographic research from the mid-1990s on new prescriptions for treating dizziness, which, nevertheless, reveals the persistence of pluralism within government-run institutions (Scheid).

From the earliest articulations of vessels and *qi* to modern revisions of acumoxa and herbal therapies, classical Chinese medicine has been in a continual process of transformation. *Innovation in Chinese Medicine* weaves this central theme through over two millennium of evidence. Although not intended as a survey, readers would be hard pressed to find a better introduction to the subject or a more compelling model of method in the field.

## Medieval Chinese Medicine

In the spring of 1900, the Taoist Abbot Wang—self-appointed guardian of the Buddhist Mogao caves located just outside of the ancient Silk Road oasis town Dunhuang in modern-day Gansu province—discovered a hidden entrance to a library that had been sealed in about CE 1035. From 1907–1909, over 100,000 documents, manuscripts, paintings, textiles, and artifacts traveled on the backs of camels and in the holds of ships from Dunhuang to libraries in

London, Paris, Beijing, Taipei, and St. Petersburg. Long recognized as the single most important manuscript discovery for medieval Chinese social history, vernacular literature, and Buddhism, it would take nearly a century for an international group of scholars to focus on the medical manuscripts in the Dunhuang collection.

Whereas *Innovation in Chinese Medicine* spans the published record of classical Chinese medicine of mostly elite and literate physicians at the center of Chinese culture, *Medieval Chinese Medicine* explores the medical manuscripts of provincial Dunhuang largely focusing on the Sui (581-618) and Tang (618-907) dynasties. Instead of the official, elite, and urban views presented in most histories of Chinese medicine, these manuscripts shine fresh light on the popular healing practices, demonic rituals, love potions, and cautery therapies at the far western frontier of the empire.

The Director of the International Dunhuang Project (IDP) at the British Library, Susan Whitfield, narrates the discovery and subsequent dispersion of the Dunhuang manuscripts in the course of the 20th century and summarizes the extraordinary international collaboration that began in London in 2000. By 2005, this research resulted in the first book in a Western language on the Dunhuang medical manuscripts. Four themes organize the eighteen contributions that comprise this volume: I. "The manuscripts"; II. "Divination, iatromancy, and related art"; III. "Self-cultivation and the popular medical traditions"; IV. "Pharmacology"; and two appendices that provide a glossary of Dunhuang materia medica and abstracts of all of the 74 Dunhuang medical manuscripts found in British, French, Russian, Japanese, and Chinese collections.

Christopher Cullen's introduction gives abstracts of each contribution and contrasts the more secular practices of elite medicine and the Tang state with the "lost world" of religious, divinatory, and demonic realm of healing of Dunhuang medicine. Paul Unschuld and Zheng Jinsheng's summary, "Manuscripts as sources in the history of Chinese medicine," could not state more strongly the limits of the printed medical literature for accessing the Chinese healing cultures that fell far under the radar of "elite preoccupations." They review the extraordinary medical manuscripts on bamboo slips uncovered in archeological finds that have transformed the

field since their discovery in the early 1970s and 1980s, and trace the Chinese medical manuscript tradition through the 20th century. Wang Shumen turns her attention to the Dunhuang medical manuscripts proper including their classification, location, preservation, interpretation problems, and value for expanding our knowledge of medieval Chinese healing practices.

The remaining contributions focus on particular genres, topics, and illnesses—mantra, iatromantic diagnosis, aphrodisiacs, moxibustion, sexual cultivation, diet regimens, pharmacology, materia medica, decoctions, madness, and cardiovascular dysfunction. Although some of these articles are highly technical and intended for a specialist audience, read selectively they succeed in revivifying the medical practices of a medieval Chinese town on the Silk Road—perhaps as different from metropolitan medicine in the Tang capital at Chang’an as from contemporary medical practices in Byzantium at the other end of the Silk Road.<sup>16</sup> The Dunhuang manuscripts remind historians of medicine in any culture that medical practitioners, healing practices, and domestic medicine are always more diverse, plural, and complex than the selective and edited printed evidence has preserved anywhere.

## General Conclusions and Reflections

Part 2 of *SCC VII* will forever find its resting place in private, public, and university libraries at the far right end of the “heavenly volume” series. Whereas Needham’s initial spark in 1937 for the *SCC* project occurred while working with three young Chinese biochemists, Jared Diamond’s catalyst in 1972 for *Guns, Germs, and Steel* was a conversation with Yali, a charismatic New Guinean politician. Yet, both used comparable intelligences among humans of different races to contrast with asymmetric scientific results (Needham) and inequitable wealth and power (Diamond). Needham found that “it was from working with these young biochemists that I found that

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<sup>16</sup> See John Scarborough’s summary “Symposium on Byzantine Medicine: Introduction” and other articles in *Dumbarton Oaks Papers*, vol. 38, Symposium on Byzantine Medicine (1984), ix–xvi.

their minds were exactly like my own,” and this thought famously led him to ask “why modern science had not originated in China.”<sup>17</sup> Diamond similarly wrote that “He [Yali] and I both knew perfectly well that New Guineans are on the average at least as smart as Europeans,” yet, he could not immediately answer Yali’s question, “Why is it that you white people developed so much cargo and brought it to New Guinea, but we black people had little cargo of our own?”<sup>18</sup> That both Needham and Diamond had to secure the stakes of their ensuing arguments on the side against racial differences in intelligence attest to the pernicious continuity during the twentieth century of their opposition. Needham’s arguments may now seem outdated but they continue to hold historical relevance as reflections of the Eurocentric indifference and ignorance his SCC project initially faced. Despite methodological transformations in the history of science and of world history, Needham’s essential humanism, anti-parochialism, cross-cultural bridge making, and sustained critique of Eurocentrism remain relevant today.

The final volume is best read in this light, as a key chapter in the historiography of the history of science and as a conclusion to a project that has no parallel in any other civilization, European or non-European. The publisher’s promotion could not be more apt: “Needham was always original and often provocative, and the interest of his viewpoint remains even when the context of the original controversy may have been modified with the passing of years.”<sup>19</sup> In addition to Needham’s “General Conclusions” about “Science and Civilization in China,” “Chinese Inventions and Discoveries,” and “Modern Science—Why from Europe?,” the final volume of SCC contains three of Joseph Needham’s original essays—“Science and Society in East and West,” “The Roles of Europe and China in the Evolution of Oecumenical Science,” and “History and Human Values: A Chinese Perspective for Science and Technology.” This volume also includes two co-authored contributions, “The Nature of Chinese Society: A Technical Interpretation” with Huang Jen-yü

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<sup>17</sup> SCC, vol. 7, pt 2, (2004), 199.

<sup>18</sup> Jared Diamond, ‘Prologue’ to *Guns, Germs, and Steel: The Fates of Human Societies* (New York, 1997), 4.

<sup>19</sup> Assessment on NRI website: <http://www.nri.org.uk/newvolumes.html>.

(Ray Huang) and “Literary Chinese as a Language for Science” with Kenneth Robinson. The volume eloquently concludes with a soliloquy that Robinson wrote shortly after Needham’s funeral based on conversations he had with him from 1949-1995, but in the form of an imaginary conversation with Needham during the funeral service (pp. 232-40).

## Possible Futures

The elegies, obituaries, tributes, reviews of scholarship, and biographical memoir published since Needham’s death, all offer illuminating accounts of his extraordinary life and assessments of his world-transforming scholarship. Timothy Brook opened his review of “The Sinology of Joseph Needham” with the unforgettable line: “Rarely does even a great scholar go beyond altering his field to changing the way in which people think about the world.”<sup>20</sup> Bray stated in her eulogy: “Needham was a pioneer in the critique of Western intellectual preeminence that is nowadays a commonplace of the culture wars.”<sup>21</sup> Robert Multhauf remarked: “To find his equal as a contributor to the field to which this journal is dedicated, it might be necessary to go back to Johann Beckmann (1739-1811), sometimes cited as the “Father” of the history of technology.”<sup>22</sup> The opening lines of the biographical memoir of Needham for the Fellows of the Royal Society further emphasized yet another, particularly British, aspect of Needham’s singular life: “The number of people who are C.H., F.R.S. and F.B.A.<sup>23</sup> can be counted on one finger of one hand. Joseph Needham’s death on 24 March 1995 leaves no living person in this category.”<sup>24</sup> As befitting the occa-

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<sup>20</sup> Timothy Brook, “The Sinology of Joseph Needham,” *Modern China*, 22 (1996), 340-348.

<sup>21</sup> Francesca Bray, “Eulogy: Joseph Needham,” *Isis*, 87 (1996), 313.

<sup>22</sup> Robert P. Multhauf, “Joseph Needham (1900-1995),” *Technology and Culture*, 37 (1996), 882.

<sup>23</sup> The acronyms refer to the Order of the Companions of Honour, Fellow of the Royal Society, and Fellow of the British Academy.

<sup>24</sup> J.B. Gurdon, Barbara Rodbard, “Joseph Needham, C.H., F.R.S., F.B.A., 9 Decem-

sion, these accounts of Needham's life and life's work summarized his contributions, assessed their significance, qualified their limitations, and lamented their lack of assimilation into the mainstream of the history of science. Few had yet considered his legacy's future. Why, in other words, should historians of science, technology, and medicine as well as historians of Europe, China, and world history, continue to read Needham, the SCC series, and the new output of the NRI in the post-Needham world?

Several books published have tackled this issue head on since 1995. The first in this genre resulted from a conference held in New Delhi in September 1996 called "Science the Refreshing River," in homage to Needham's institutional, disciplinary, and civilizational boundary crossing. The essays in this volume critically engage his legacy in terms of three realms: "The social epistemology of Needhamian historiography," the "Historiography of the sciences" (including Needham's surprisingly limited relevance to the history of sciences in India), and assessment of his central tenet of "The universality of science."<sup>25</sup> Shortly after, Morris Low's edited *Beyond Joseph Needham* offered 16 articles to present new directions in the field in Southeast as well as East Asia.<sup>26</sup> The next work in this genre was published in 1999. Originally asked to collaborate on the part of volume VII of *SCC* intended to compare "China's development with the emergence of capitalism in Europe," Timothy Brook and Gregory Blue ended up publishing their conclusions outside the *SCC* framework.<sup>27</sup> Brook and Blue's edited volume on China's challenge to "historical capitalism" is therefore best read in conjunction with Needham's own final *SCC* volume. Needham concluded that the social, economic, and intellectual transformations under European

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ber 1900-24 March 1995," *Biographical Memoirs of Fellows of the Royal Society*, 46 (2000), 366-376.

<sup>25</sup> See S. Irfan Habib and Dhruv Raina, eds., *Situating the History of Science: Dialogues with Joseph Needham* (Oxford, 1999). See also Nathan Sivin's review, *AHR*, 106 (February 2001), 131.

<sup>26</sup> Low, ed., *Beyond Joseph Needham: Science, Technology, and Medicine in East and Southeast Asia*, *Osiris*, 13 (1998).

<sup>27</sup> See Timothy Brook and Gregory Blue, eds., *China and Historical Capitalism: Genealogies of Sinological Knowledge* (Cambridge, 1999).

capitalism—and not civilizational genius (as many of his predecessors and contemporaries believed)—explained “why modern science had not developed in China but only in Europe.” Brook and Blue, however, challenge the very concept of capitalism as an ideal system and necessary prelude of a uniquely European origin for capitalist development. They criticize that the Eurocentric concept of capitalism has not only negatively (and inaccurately) portrayed Chinese civilization as despotic, feudal, and stagnant, but that it has skewed Chinese as well as European assessments of Chinese history.<sup>28</sup> The essays in this volume by Immanuel Wallerstein, Francesca Bray, and R. Bin Wong, in addition to Blue and Brook’s own, are intended to correct these Eurocentric assessments and to establish a new foundation more appropriate for Chinese history.<sup>29</sup> Jack Goody further synthesized the issues swirling around the “great debate about the economic rise of the West” and the “great divergence” between Europe and Asia that have continued in the wake of “the Needham question.”<sup>30</sup>

Both Jack Goody, in his recent *Theft of History*,<sup>31</sup> and Mark Elvin, in his contribution to the final volume of *SCC*,<sup>32</sup> raise critical problems in method and errors of interpretation with which all historians of science, and especially historians of Europe, should be

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<sup>28</sup> Other books that participated in this revision of Chinese, European, and global economic history and history of technology and science at the end of the 1990s include the following: R. Bin Wong, *China Transformed: Historical Change and the Limits of European Experience* (Ithaca, 1997); Timothy Brook, *The Confusions of Pleasure: Commerce and Culture in Ming China* (Berkeley, 1998); Andre Gunder Frank, *ReORIENT: Global Economy in the Asian Age* (Berkeley, 1998); Francesca Bray, *Technology and Society in Ming China (1368-1644)* (Washington, DC, 2000); and Kenneth Pomeranz, *The Great Divergence: China, Europe and the Making of the Modern World Economy* (Princeton, NJ, 2000).

<sup>29</sup> For the history and rationale of *China and Historical Capitalism*, see Brook and Blue’s (1999) preface and introduction, ix-xi, 1-9.

<sup>30</sup> Jack Goody, *Capitalism and Modernity: The Great Debate* (Cambridge, 2004).

<sup>31</sup> See ch. 5 “Science and civilization in Renaissance Europe,” which focuses on “The Needham Problem,” in Jack Goody, *The Theft of History* (Cambridge, 2006), 125-153.

<sup>32</sup> See Elvin’s response to Needham in his *Vale atque ave, SCC*, vol. 7, pt 2, (2004), xxiv-xliii.

cognizant before making further facile conclusions on European uniqueness or Asian exceptionalism. Claims about value-laden institutions thought to be unique to, or even invented in, the West—democracy, mercantile ‘capitalism’, the bourgeoisie, freedom, individualism, and even romantic love—Goody warns, rest far too often on limited knowledge of the other. Such institutions can be found in variant forms across a broad swath of human societies, not just those found on the European continent. Goody’s revisions concern not just Needham’s assessments of the comparative history of science, technology, and medicine but of the categorical distinctions that historians of Europe continue to use to “divide and conquer” world history. Rather than organize historical analysis according to categories—European antiquity, democracy, feudalism, capitalism versus Asian despotism, bureaucratic feudalism, Asiatic modes of production, proto-capitalism—Goody argues that the civilizations of Eurasia would be better understood as variations of one another. Instead of binaries that do not allow for variations, plurality, or contradictions, Goody posits the notion of a sociological grid of various types, or what Elvin calls a “disaggregation of variables” to shift away from the monolithic binaries imposed on the history of civilizations to a more subtle, integrated, and ultimately accurate comparative world history.<sup>33</sup>

In order for change toward more productive dialogue in this direction, historians of science and medicine have to be convinced that this integration of EASTM, and more broadly the history of non-western STM into their courses and monographs, is analytically valuable in the current history bazaar. Elvin suggests a few core arguments. His primary recommendation converges with Goody’s challenge to European uniqueness, namely that “no new idea about the origins of modern science in western Europe should have *droit de cité* until it has been tested against the Chinese case to see if it effects a discrimination that is both precise and relevant.”<sup>34</sup>

Elvin points out, for instance, that failure to make a comparison with the earlier invention of printing (8th c.) and the more exten-

<sup>33</sup> See Introduction, Goody, *The Theft of History* (Cambridge, 2006), 1-9, 151-153.

<sup>34</sup> SCC, vol. 7, pt 2 (2004), xli.

sive book culture in China makes Adrian Johns's otherwise richly documented *The Nature of the Book* one-dimensional. Furthermore, this blind spot restricts to only European science his statement that "the social structures of science were invented to cope with an explosion of printed information."<sup>35</sup> Although China did not experience the same consequence after a comparable, if not similar, explosion 500 some years earlier, a comparison of parallels and differences with "the nature of the Chinese book" would have further refined Johns's interpretation of the "nature" of the European one.<sup>36</sup>

To be fair to Johns, when he was a graduate student in the early 1990s at Cambridge University's Department of the History and Philosophy of Science (HPS) on Free School Lane—just a ten-minute walk to the NRI—there were no formal academic arrangements and few informal interactions between the HPS and the NRI. The HPS graduate students certainly all knew Needham by name, but no faculty at HPS assigned them his *SCC* (or any of his other hundreds of non-scientific books and articles) as required reading; nor were seminars ever offered at the NRI for them to attend. The priorities of the two institutions toward graduate teaching and research resided elsewhere. Johns would have neither been encouraged to read the *SCC* nor expected to walk over to the NRI. Without such institutional support or academic training, one cannot expect him to have read, much less integrate into his first academic monograph, the material in *SCC*'s earthly tome on *Paper and Printing* (1985) in China.

The major collaboration going on in the early 1990s was rather at the upper-end of the academic echelon between the then Master of Darwin College, Sir Geoffrey Lloyd, and Needham's collab-

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<sup>35</sup> Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago, 1998); the quotation is from "The Birth of Scientific Reading," *Nature* 407, no. 6818 (1998), 287. Cited by Elvin in *SCC*, vol. 7, pt 2 (2004), xxv, fn. 4.

<sup>36</sup> For an eloquent overview, see Denis Twitchett, *Printing and Publishing in Medieval China* (New York, 1983). For evidence of the invention of printing in the early 8th c. and its development under Song imperial patronage and private publishers in the 10–11th c., see Tsien Tsuen-Hsuei, *SCC*, vol. 5, pt 1, *Paper and Printing* (1985), 146–172.

orator on several of the sections on alchemy for SCC, Nathan Sivin.<sup>37</sup> This collaboration had concrete, and for some controversial, results that not only have been published, but also have clearly transformed thereafter the intellectual commitments and scholarship of both collaborators.<sup>38</sup> Perhaps, at least, some of G.E.R. Lloyd's comparative works on ancient Greek and Chinese science and medicine, curiosity, and more recently, wisdom and morality, are being assigned to current HPS graduate students.<sup>39</sup> It is only through integration into the historiography of the field and into graduate teaching that such scholarship acquires meaning, and a relevant future, within the history of science discipline.<sup>40</sup> As personal experience has convinced me, one-on-one collaborations in teaching can be carried out in practice with great success. Because of the immense value to the comparative studies of history of science, technology, and medicine this research should no longer be relegated to the margins—within

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<sup>37</sup> The first publication based on their initial conversations was the final chapter "A Test Case: China and Greece, Comparisons and Contrasts," in G.E.R. Lloyd, *Demystifying Mentalities* (Cambridge, 1990), 105-134.

<sup>38</sup> See G.E.R. Lloyd and N. Sivin, *The Way and the Word* (New Haven, 2002). Many, though certainly not all of G.E.R. Lloyd's publications since *Demystifying Mentalities*, compare the ancient Greek and Chinese worlds. See especially his *Adversaries and Authorities: Investigation into Ancient Greek and Chinese Science* (Cambridge, 1996). Nathan Sivin's primary research since *The Way and the Word*, though not comparative, has been to apply the same cultural manifolds method to the high point of the Chinese computational tradition, the *Season-Granting Astronomical System* (*Shoushi li*, 1276-1282) produced under the patronage of the Khubilai Khan (1215-1294). For the first publication on this research, see Sivin, "Calendar Reform and Occupation Politics," *Ziran kexueshi yanjiu* (*Research on the History of the Natural Sciences*), 24, Supplement (2005), 58-67. The 700+ page book manuscript is titled *Granting the Seasons*.

<sup>39</sup> G.E.R. Lloyd, *The Ambitions of Curiosity: Understanding the World in Ancient Greece and China* (Cambridge, 2002); *The Delusions of Invulnerability: Wisdom and Morality in Ancient Greece, China and Today* (Cambridge, 2005).

<sup>40</sup> A notable exception to the lack of integration of Needham's scholarship in the history of science is Floris Cohen, ch. 6 "The Nonemergence of Early Modern Science outside Western Europe," pts 6.3-6.6, in *The Scientific Revolution: A Historiographical Inquiry* (Chicago, 1994), 409-490. For a very useful work treating the early modern period in China, see Benjamin Elman's recent *On Their Own Terms: Science in China, 1550-1900* (Cambridge, MA, 2005).

the small community of East Asian specialists, among the few scholars of Western science who seriously consider comparisons at all, or as inspiration for the history of science in other non-European cultures.<sup>41</sup> Serious engagement, and even basic familiarity, with the world of Chinese science, technology, and medicine that Needham and his collaborators brought to light further sharpens the arguments, qualifies the interpretations, and fine tunes the analytic framework of any analysis of western science before 1600.<sup>42</sup> Related to this point, Elvin argues that by 1600 the Chinese record had examples of all of the styles of thought that A.C. Crombie identified as the eventual key components of science.<sup>43</sup> The “scientific revolution” in seventeenth-century Europe should therefore be seen as a matter of the acceleration of these styles of thought developing and interconnecting, rather than a fundamental qualitative innovation or a matter of radical change.<sup>44</sup>

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<sup>41</sup> East Asian specialists are organized notably in the International Society for the History of East Asian Science, Technology, and Medicine and are found among the subscribers to *EASTM*: <http://www.nri.org.uk/ISHEASTM.html>. When speaking of scholars of Western history of science who consider China, I think not only of Lloyd and Cohen, but would also include the deterministic account by Harold Dorn, *The Geography of Science* (Baltimore, 1991), with which I disagree, and the more stimulating, if not completely convincing, account of differences in reason, rationality, and legal systems, by Toby E. Huff, *The Rise of Early Modern Science, Islam, China, and the West* (Cambridge, 1993). As for the inspiration of the SCC project for history of science in other non-European cultures, I am thinking particularly of India, where the historiography, though influenced by Needham's efforts, has definitely not taken a similar course as the SCC did in China. See Dhruv Raina and S. Irfan Habib, “The Missing Picture: The Non-emergence of a Needhamian History of Sciences in India,” in Habib and Raina, eds., *Situating the History of Science*, 279-303.

<sup>42</sup> *Ibid.*, xxix. For the only synthesis of the history of science, technology, and medicine in China from 1600-1900, namely the centuries that the SCC series does not cover, see Benjamin A. Elman, *On Their Own Terms: Science in China, 1550-1900* (Cambridge, MA, 2005) and its textbook version, *A Cultural History of Modern Science in China* (Cambridge, MA, 2006).

<sup>43</sup> The exception, Elvin notes, was probabilistic theorizing, which was not well developed either in Europe by 1600, though Chinese knowledge of probabilities were certainly “in play” in Chinese gambling, Go, and dice games.

<sup>44</sup> SCC, vol. 7, pt 2 (2004), xxviii. Elvin adds “probability excepted.”

The third, though by no means the last, point Elvin makes is that scholarship on “both sides of the aisle” reveals the shortfalls of applying categorical distinctions that do not stand up either to the complexity of historical change or the particularities of historical evidence. For example, Needham applied his concept of “bureaucratic feudalism” in contrast to European’s “military-aristocratic feudalism” without consideration of long-term changes over time in Chinese society and culture. Huff used the unexamined generality that Chinese mathematics “lacked the logic proof as well as the concept of mathematical proof” without integrating the recent scholarship of the French historian of early Chinese mathematics, Karine Chemla, who has found that the Chinese had “algebraic proof within an algorithmic context.”<sup>45</sup>

The interesting and perhaps, for some, most irksome quality of comparing science in China and Europe are the fault lines where the categories for comparison—like feudalism, capitalism, rationality, proof, and even “the Book”—themselves crack. For these among many other reasons the original Needham continues to be seismically challenging as well as historiographically interesting and the entire *SCC* and new *NRI* studies series should become bedrock reading; perhaps as much for historians of Europe as for historians of science, technology, and medicine anywhere in the world.

## Appendix I

### Science and Civilization in China *Series*

The *Science and Civilisation in China* series is the work of Joseph Needham, C.H., F.R.S., F.B.A. (1900-1995) and an international team of over 30 collaborators. Published by Cambridge University Press in seven volumes since 1954, from vol. 4 onward, each volume is divided into a number of parts. The project is now proceeding under the guidance of the Publications Board of the Needham Research Institute, chaired by Christopher Cullen.

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<sup>45</sup> *SCC*, vol. 7, pt 2 (2004), xxx-xxxii.

\*Indicates the four titles reviewed in this essay.

Vol. I. *Introductory Orientations*. Joseph Needham, with the research assistance of Wang Ling (1954)

Vol. II. *History of Scientific Thought*. Joseph Needham, with the research assistance of Wang Ling (1956)

Vol. III. *Mathematics and the Sciences of the Heavens and Earth*. Joseph Needham, with the research assistance of Wang Ling (1959)

Vol. IV. Physics and Physical Technology.

Pt 1. *Physics*. Joseph Needham, with the research assistance of Wang Ling, and the special co-operation of Kenneth Robinson (1962)

Pt 2. *Mechanical Engineering*. Joseph Needham, with the collaboration of Wang Ling (1965)

Pt 3. *Civil Engineering and Nautics*. Joseph Needham, with the collaboration of Wang Ling and Lu Gwei-djen (1971)

Vol. V. Chemistry and Chemical Technology

Pt 1. *Paper and Printing*. Tsien Tsuen-Hsuei (1985)

Pt 2. *Spagyric Discovery and Invention: Magisteries of Gold and Immortality*. Joseph Needham, with the collaboration of Lu Gwei-djen (1974)

Pt 3. *Spagyric Discovery and Invention: Historical Survey, from Cinnabar Elixirs to Synthetic Insulin*. Joseph Needham, with the collaboration of Ho Ping-Yu [Ho Peng-Yoke] and Lu Gwei-djen (1976)

Pt 4. *Spagyric Discovery and Invention: Apparatus and Theory*. Joseph Needham, with the collaboration of Lu Gwei-djen, and a contribution by Nathan Sivin (1980)

Pt 5. *Spagyric Discovery and Invention: Physiological Alchemy*. Joseph Needham, with the collaboration of Lu Gwei-djen (1983)

Pt 6. *Military Technology: Missiles and Sieges*. Joseph Needham, Robin D.S. Yates, with the collaboration of Krzysztof Gawlikowski, Edward McEwen, and Wang Ling (1994)

Pt 7. *Military Technology: The Gunpowder Epic*. Joseph Needham, with the collaboration of Ho Ping-Yu [Ho Peng-Yoke], Lu Gwei-djen, Wang Ling (1987)

Pt 9. *Textile Technology: Spinning and Reeling*. Dieter Kuhn (1986)

Pt 11. *Ferrous Metallurgy*. Don Wagner (in press as of 3/2007)

\*Pt 12. *Ceramic Technology*. Rose Kerr and Nigel Wood, with additional contributions by Ts'ai Mei-fen and Zhang Fukang (2004)

Pt 13: *Mining*. Peter Golas (1999)

Vol. VI. Biology and Biological Technology

Pt 1. *Botany*. Joseph Needham, with the collaboration of Lu Gwei-djen, and a special contribution by Huang Hsing-Tsung (1986)

Pt 2. *Agriculture*. Francesca Bray (1988)

Pt 3. *Agroindustries and Forestry*. C.A. Daniels, Nicholas K. Menzies (1996)

\*Pt 5. *Fermentations and Food Science*. H.T. Huang (2000)

\*Pt 6. *Medicine*. Joseph Needham and Lu Gwei-djen, ed. by Nathan Sivin (2000)

Vol. VII. Science and Chinese Society

Pt 1. *Language and Logic*. Christoph Harbsmeier (1998)

\*Pt 2. *General Conclusions and Reflections*. Joseph Needham, ed. by Kenneth Girdwood Robinson, with contrib. by Ray Huang, intro. by Mark Elvin (2004).

## Appendix II

### *Needham Research Institute Studies Series*

The Needham Research Institute Studies series publishes original new work on East Asian culture and science, which develops or connects to the publication of the *Science and Civilisation in China* series. Christopher Cullen is the series editor.

\*Indicates the two edited volumes reviewed in this essay.

Christopher Cullen. 1996. *Astronomy and Mathematics in Ancient China: The Zhou bi suan jing* (Cambridge: Cambridge University Press). ISBN 0521550890

Robert Wardy. 2000. *Aristotle in China: Language, Categories and Translation* (Cambridge: Cambridge University Press), ISBN 0521771188

\*Hsu, Elisabeth, ed. 2001. *Innovation in Chinese Medicine*. Contributors: Elisabeth Hsu, Vivienne Lo, Donald Harper, Catherine Despeux, Ute Engelhardt, Frédéric Obringer, Georges Métaillé, Marta Hanson, Christopher Cullen, Bridie J. Andrews, Kim Taylor, Volker Scheid (Cambridge: Cambridge University Press), ISBN 0521800684

Lu Gwei-djen and Joseph Needham, reprint with a new introduction by Vivienne Lo. 2002. *Celestial Lancets—a History and Rationale of Acupuncture and Moxa* (originally Cambridge: Cambridge University Press, 1980; rpt. London: RoutledgeCurzon), ISBN 0700714588

Ho Peng Yoke. 2003. *Chinese Mathematical Astrology* (London: RoutledgeCurzon, Taylor & Francis Group), ISBN 0415297591

Grant, Joanna. 2003. *A Chinese Physician—Wang Ji and the 'Stone Mountain Medical Case Histories'* (Cambridge: Cambridge University Press), ISBN 0415297583.

Taylor, Kim. 2004. *Chinese Medicine in Early Communist China, 1945-63: Medicine of Revolution* (London: RoutledgeCurzon), ISBN 0415342953

\*Lo, Vivienne and Christopher Cullen, eds. 2005. *Medieval Chinese Medicine: The Dunhuang Medical Manuscripts* (London: RoutledgeCurzon), ISBN 0415342953.

Ho Peng Yoke. *Explorations in Daoism: Science in Literature* (London: RoutledgeCurzon: in press as of March 2007).