<running head>Mei | Reflections on Needham's Intellectual Heritage

<section head>Forum: History of Science, Technology, and Medicine: A Second Look at Joseph Needham

<title>Some Reflections on Joseph Needham's Intellectual Heritage

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Abstract: In this essay, I reflect on Joseph Needham's intellectual heritage, its impact on understanding the world history of knowledge circulation, and its broad influence on generations of scholars. I present two case studies of paktong and iron/steel to show what Needham himself achieved and what recent progress has been made, highlighting the change of research paradigm from a patriotic or nationalistic approach to a global history approach. I argue that Needham's work still sets a marker for ongoing research in many respects and that, especially, his cross-culturally comparative approach to global circulations of knowledge and technology remains of deep relevance to contemporary scholars.

<a head>Introduction

As a founder of the field of East Asian history of science, technology, and medicine, Joseph Needham (1900–1995) left a distinct imprint on the field, and his intellectual influence has been profound. As Leon A. Rocha has written recently, "There is a political vision, a spirit of openness, an ethical imperative embedded in Needham's idea of 'oecumenism' that may be worth inheriting: that modern science and medicine (as we currently know them) are not a complete and settled project; that they may not have a monopoly on 'truth'; that there is still the possibility that non-Western cultures can revise

our ways of knowing and seeing; that doing the history of science and medicine in those non-Western cultures (China, India …) may help towards building a pluralistic science in the future that fully acknowledges the complexity of nature and reality and that encompasses the partial perspectives from different classes, genders, ethnicities and cultures."{1} The deep relevance of Needham's work to ongoing scholarship is eloquently encapsulated in this statement. In the present paper, I shall take two case studies, paktong and iron/steel technology, to show how research has moved on since Needham's work, and how that work still remains meaningful and relevant to current research in certain ways. I shall also argue that rather than seeing Needham's work as entirely outmoded, there is always something to be gained from revisiting it, albeit with a critical eye and attention toward newer developments.

<a head>Needham and Paktong

About thirty-five years ago, when I began my master's degree research at the Beijing University of Iron and Steel Technology, the thesis topic my supervisor, Professor Tsun Ko, chose for me was paktong, or "white copper," an alloy of copper and nickel or of copper, nickel, and zinc. This had become known in China by the fourth century CE and was produced on a relatively large scale in southwestern China during the Ming and Qing dynasties (mid-fourteenth to early twentieth centuries CE). The first major reference book Professor Ko asked me to consult was Joseph Needham's Science and Civilisation in China, volume 5, part 2, published in 1974. Under the subtitle "Silver Uniform-Substrate Alloys," Needham took seventeen pages to present his detailed research on the history of paktong, one of the "Chinese artificial silvers," in his words.{2}

To me this research can be regarded in many ways as typical Needham, a piece of writing exemplified not only by his detailed examination of primary Chinese textual

evidence in order to trace back the early history of paktong in China, but also by his inquiry into the export of paktong to Europe starting early in the seventeenth century. A further example that demonstrates his strong interest in applying a cross-culturally comparative approach to the subject concerned is his critical review of the issue of "Chinese Nickel in Greek Bactria," which attempted to reconstruct a possible trade connection between China and Central Asia on the basis of the discovery of cupro-nickel coinage in the Greek kingdoms in Bactria during the first half of the second century BCE.

As a young scholar who had just entered the research field of the history of science and technology in the mid-1980s, I was deeply attracted and impressed by the history of paktong, but at the same time it seemed quite clear to me how difficult it would be to carry out further research that would go beyond Needham's work, since it appeared to present such a complete narrative of the history of paktong in China and its standing in world history. Professor Ko must have noticed my worries and thus pointed out to me that Needham's work was conducted mostly based on primary and secondary books and research papers, and what I needed to do was something different. He then guided me to consult geological investigation reports as well as the local histories of Yunnan and Sichuan provinces to look for clues to locate ancient mining and smelting sites for paktong. Field investigations of these sites then followed, as did laboratory examinations of ancient mining and smelting samples collected from the production sites. Based on the new evidence gleaned from my field investigations and laboratory work, I completed my master's thesis, which offered a new understanding of the paktong smelting process in ancient China—that paktong was smelted by mixing copper ore with nickel ore rather than using a copper-nickel ore as suggested by previous studies (including Needham's).{3}

In 1994, when I visited the Needham Research Institute (NRI) in Cambridge as a

one-year visiting scholar, I was surprised to learn that a great number of eighteenth- and nineteenth-century artifacts made of paktong, such as candlesticks and fire grates, had survived in the UK and that they had become collectible as they were considered quite rare and valuable. I immediately realized that research on paktong was far from complete and that much more could be learned from the surviving paktong pieces, which had not received sufficient attention in previous research. In 1995 I published my first paper in English summarizing the research results of my year-long visit to the UK, which focused on the export of paktong to Europe from the seventeenth through nineteenth centuries, and included a few results of the analysis of paktong artifacts from both China (water pipes) and the UK (candlesticks).{4} British scholars who had conducted considerable analytical work on surviving paktong artifacts in both private and public museum collections also published the results of their analyses, throwing new light on the material and technological characteristics of both paktong and its imitation, "German silver."{5} In 1999 a major breakthrough in the study of paktong's history was made by Keith Pinn, who published Paktong: The Chinese Alloy in Europe, 1680–1820. This book presented substantial new information about the development of the paktong industry in the UK during the eighteenth and nineteenth centuries on the basis of the letter books of Boulton and Fothergill as well as Christie's records.{6}

I thought my interest in paktong would end there since I had decided to do my PhD research on early copper and bronze metallurgy at the University of Cambridge starting in 1995. However, fifteen years later, in 2011, when I was working as a professor at the University of Science and Technology Beijing, paktong reappeared on my research agenda because one of my PhD students seemed to have some potential to push this research forward once again. He did indeed do this, as evidenced by his thesis, published in English, Research on Chinese Paktong and Its Transmission to Europe during the 18th

and 19th Centuries, which contributed new understanding to the history of paktong, especially by revealing the commercial competition behind the various imitation activities relating to paktong in several European countries, such as Britain, Germany, Austria, and Sweden.{7} When we set out this new paktong research project, one of the key objectives was to establish a case that would still glorify the Chinese contribution to the development of world civilization, and we did not yet realize that the circulation and localization of knowledge itself had already emerged as a central theme in studies of the history of science and technology over the previous decade.

<a head>The Shift in Research Paradigms

The reason why I have taken the time to reflect on my involvement with paktong research over the past three decades is to present a personal case highlighting the relationship between Needham's work and the growth of a tiny research field like the study of the history of paktong. As we can clearly see now, there have been some significant shifts in research paradigms over the past three decades.

The first obvious shift is the growing importance of artifacts or material heritage in studies of the history of technology. As has been shown in the above introduction, research on the history of paktong over the last two decades has focused on the remains (slags and ingots) from production sites as well as surviving artifacts, contrasting with earlier text-based studies, including Needham's. If we look at the field of the history of metallurgy in China from a general perspective, the emphasis on studies of archaeological artifacts or production sites has emerged since the mid-1970s, when the newly established Archaeometallurgy Group of Beijing University of Iron and Steel Technology (BUIST) began to play a leading role in systematically applying modern analytical techniques to the examination of ancient metals from archaeological excavations. The last two decades

have witnessed a steady increase in the study of archaeological artifacts and other remains, which has provided considerable evidence for reassessing the history of metallurgy in ancient China. Such an emphasis on archaeological finds and material remains among Chinese scholars was deeply related to a growing interest in substantiating China's own cultural heritage and thus also its scientific legacy.

The second significant shift is the research focus. For a long period, as is well known, Needham seemed to be preoccupied by questions of priorities (who did what first). In his 1964 article on "Chinese Priorities in Cast Iron Metallurgy," Needham emphasized the significance of the age-long priority of China in the technology of cast iron and pointed out that "cast iron was regularly being used for agricultural tools and even weapons from the fourth century B.C. onwards in China."{8} To him, questions of priorities were important because they could suggest the transmission of a technology from one place to another, as we can see in the following statement of his: "As a general principle, I believe that the longer the time which has elapsed between the first successful achievement of an art or invention in one place and its appearance in another, the more difficult it is to entertain the idea of a purely independent invention. Nor am I convinced that the furnaces and bellows of pre-Renaissance Europe could easily have led to the making of cast iron without the stimulus coming from the east, and especially the mechanization of the blowers."{9}

Until the early 1990s, probably due to the influence of Needham's work, questions of priorities still occupied a central position in the research agenda of many Chinese scholars, especially those working in the field of the history of science and technology. Priorities in some technological inventions or innovations did matter at that time, and probably still do today in some corners, as they could be perceived of as bolstering a sense of national pride or glory. My own research on paktong in the mid-1980s was

motivated, to some degree, by a desire to demonstrate that as a unique alloy first made in China, paktong made a significant contribution to the development of metallurgy across the world. For many scholars, it was taken for granted that the mission to research the history of science and technology in China was inextricably linked to listing China's great achievements, thus demonstrating the major contributions they made to the world. Such a patriotic or nationalistic approach as research motivation was quite predominant during the 1970s–80s and can be discerned easily in many publications of the time.

Some changes emerged from the mid-1990s onward. From my personal perspective, the most revealing shift can be seen in studies of the origins of metallurgy in China, an issue that has been debated through the decades since the 1940s.{10} In 1993 Professor An Zhimin, a well-known senior archaeologist working at the Institute of Archaeology, Chinese Academy of Social Sciences, published a short paper in Kaogu (Archaeology, a national academic journal) openly challenging the then still-prevalent view that copper and bronze metallurgy originated independently in China and proposing an alternative possibility that metallurgy could have been introduced to China from the West via the prehistoric Silk Road.{11} Since then, the beginnings and early development of copper and bronze metallurgy within the borders of present-day China have become a hot topic and attracted considerable and long-standing interest among scholars both in China and the West.{12}

It seems that over the past two decades, questions about priorities (who did things first) have gradually lost their central position and stimulating power. In contrast to the previous emphasis on the Chinese priority of a technology or independent invention, in the field of archaeology and the history of technology, a diverse number of research interests have appeared with a wide range of focuses, such as the introduction of iron technology into China, steppe influence on early Chinese art, the presence of Persian

elements in the cultural heritage of the Qin Empire, and so on.{13} Such a shift in research focus is to some extent related to generational change but, more significantly, has also resulted from increasing academic interaction between China and the outside world. More and more Chinese scholars, especially from younger generations, now choose their research topics based on an academic perspective rather than patriotic considerations. For them, how China interacted with or was related to the Eurasian steppe or Central Asia seems more interesting and challenging.

The third shift goes deeper and concerns what questions can be asked if questions of priorities are put aside. Needham's approach to comparative history had a distinct tendency toward establishing a chronological setting for all the important events of technological development. This was because he had a strong belief in, and sought to uncover, the connections between all the civilizations of the world. His approach was also heavily descriptive. Once all the facts were presented, his narrative also ended. His history of paktong was just such an example of this. It was beautifully woven with all the kinds of evidence available to him at the time—Chinese primary sources, secondary studies on the export of paktong to Europe, and the Bactrian cupro-nickel coins—successfully demonstrating the priority of Chinese over Europeans in the production and use of cupro-nickel alloys. To him, paktong was just another arch or pillar in the bridge connecting China to the outside world. That is all; case closed. But is there anything missing?

Yes, in this case Needham did miss something important, namely, the socioeconomic context for paktong production and consumption. In China, paktong was just a common material and only used to produce objects for daily use—like water pipes, inkwells, and basins—which were mostly consumed by ordinary people. Its importance in society was rather limited. However, after paktong was imported into Europe, it was considered rare

and exotic there and thus was used to make expensive items such as candlesticks, fire grates, and domestic wares, designed to meet the needs of upper-class society. More significantly, the importation of paktong from China actually brought new knowledge of metals to Europe, subsequently stimulating chemical research and industrial manufacture there. A deeper question we should then ask is why the destinies of paktong in China and Europe were so different. To answer it we would have to return to the original socioeconomic contexts, which must have played a crucial role in shaping the trajectory of the technological developments involved.

<a head>Iron and Steel in Ancient China: A Further Case

In 1958 Needham published his monograph The Development of Iron and Steel Technology in China, which was based on his Second Biennial Dickinson Memorial Lecture to the Newcomen Society in 1956.{14} This pioneering work covered a wide range of topics, including the growth of iron and steel metallurgy, cast iron, wrought iron and steel, Chinese crucible processes, Chinese blast furnaces, China as an iron culture and the problem of its westward transmission, steel-making and hardening, co-fusion steel, direct decarburization steel, and wootz in China. It demonstrates, once again, his masterful ability to combine a global perspective and a comparative approach. It is worth noting that while cast iron artifacts from archaeological discoveries were cited as supporting evidence whenever available, the major discussions of the work were based on his systematic examination of ancient texts, such as Lü Shi Chun Qiu (Master Lu's Spring and Autumn Annals) and Wu Yue Chun Qiu (Annals of the States of Wu and Yue).{15}

When we look at the current state of studies of iron and steel technology in ancient China, we immediately notice that our understanding of many issues raised by Needham

sixty years ago has improved considerably. For example, the beginnings of iron metallurgy and early developments of iron technology in China have attracted substantial research interest over the past two decades, owing to a series of new archaeological discoveries of early iron objects in northwestern and northern China. Many more scholars now argue for the introduction of iron-smelting technology into the Central Plains of China from Central Asia via Xinjiang and the Hexi Corridor in Gansu.{16} Some others are still cautious about this issue.{17} Other progress can be seen in studies of iron-smelting furnaces, bloomery iron objects, steel-making technologies, casting technology for large iron objects, the iron industry during the Han dynasty, regional patterns of iron production, iron-making and environmental change, and so on.{18} It is worth noting that research on the early history of iron technology has been closely linked to the latest archaeological discoveries, while the application of modern scientific analysis to archaeological objects has also become routine practice.

As we can see, the general scope of studies of the history of iron and steel in ancient China falls within the issues outlined by Needham in his 1958 monograph, centering on the major technological innovations within China, such as the beginnings and early development of cast iron technology and its regional patterns.{19} However, it should be noted that no significant progress has been made on issues concerning cross-cultural transmissions of iron technology, which were examined in great detail in the sections entitled “China as an Iron Culture and the Problem of Its Westward Transmission” and “Wootz in China” in Needham’s 1958 monograph.{20} We must say that in this respect there is still a long way to go beyond Joseph Needham, and his writing on the development of iron and steel technology in China remains an outstanding presence, not just relevant, but a basic and compulsory reference for anyone entering this field.

<a head>Needham's Intellectual Heritage

The two cases (paktong and iron and steel technology) presented above reveal a complex picture regarding the relevance of Needham to our current research field. It is quite clear that on many fronts, Needham has become or is becoming an out-of-date figure, because of the tremendous level of research progress that has been made over the two decades since his death. We should admit that there are not so many people, especially among younger generations, reading Needham's work now. In the eyes of many people, he has gone, and rightly so. But nobody can deny that Needham left a distinct imprint on the field, and his intellectual heritage is rich and diverse, reaching well beyond the so-called Needham Question, and will surely be worthy of revisiting and further systematic examination.

In my opinion, one of the most significant aspects of Needham's intellectual heritage is his broad view of the connections between technological developments across cultures and regions through the ages. As I noted earlier, his research on the history of both paktong and iron and steel exhibits a global approach or perspective, such as the export of paktong from China to Europe and the westward transmission of Chinese iron culture. Although in many cases he seems to have been more concerned with the immense debt Western civilization owed to China, the recent research carried out in China has actually revealed substantial evidence for the cultural and technological stimulation China received from neighboring regions over the centuries.{21} Whatever the direction of movement of ideas and material cultures, from prehistory to the historical periods, China was undoubtedly a key player in the development of world civilization. In many ways, Needham can be seen as a pioneer in advocating the global circulation of knowledge and technology, as demonstrated by his ceaseless dedication to integrating China into world history.

<a head>Conclusion

In reflecting on Needham's work on ancient metal technology in China, this paper suggests that Needham's intellectual influence has been profound in studies of the history of science and technology in China. It also points out the significant shift in research paradigms over the past two decades, notably from a patriotic perspective to a global history approach. It argues that Needham's work remains deeply relevant to contemporary scholarship and still sets a marker for ongoing research in many respects. Needham's intellectual heritage is unique, substantial, and multidimensional, and it will surely continue to encourage and inspire new generations of inquisitive minds.

<footnotes>

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{8} Joseph Needham, "Chinese Priorities in Cast Iron Metallurgy," Technology and Culture 5, no. 3 (1964): 398–404, at 402.

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