# Knowledge *in* Translation

Global Patterns *of* Scientific Exchange, 1000–1800 CE

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# Introduction

## Knowledge *in* Translation

*Patrick Manning*

THE CHAPTERS IN THIS BOOK EXPLORE the exchanges of knowledge about the natural world during the early and middle years of the second millennium CE. Our purpose in this exploration is to combine the approaches of history of science and world history to these materials. The authors and editors find that, when considered together, their explorations confirm that cosmopolitan networks of scholarly knowledge existed centuries ago. These networks linked the regions of the world in which literacy was well established; they can be seen as having laid the groundwork for what eventually became known as scientific knowledge.

Exchanges in knowledge persisted across Eurasia and beyond, despite inherent and serious difficulties in communication. The specific obstacle to communication on which we focus is that of language—the distinctiveness and multiplicity of languages, and the need to surmount linguistic obstacles through the art of translation. We explore the process and the results of translation as an essential element of the preservation and expansion of scientific knowledge.[1] Of course, we acknowledge that the barrier of language was only one of the limits on scholarly communication: physical, social, cultural, and temporal barriers also had to be overcome. Physical obstacles were imposed by great distances and the need to cross mountains, deserts, and oceans; sociopolitical obstacles arose from the limits on

movement sometimes imposed by states; cultural limits emerged from the varying styles of life among societies. Temporal obstacles centered on the long time periods that sometimes separated authors from readers. Yet the obstacles to communication were overcome, one by one. The chapters describing these writings reveal spatial connections across most lands of the Eastern Hemisphere and encompass some regions of the Western Hemisphere. Equally, the contributions to this volume reveal deep temporal connections, as the authors refer to writings across the second millennium and reach into the Ptolemaic times of the first millennium and even to earlier times of the Han dynasty and Classical Greece. Further, the chapters show linkages among various topics and connections at social scales from individual relations to ties at the civilizational level.

Nevertheless, we argue—to put it strongly—that it was the act of translation that did the most to overcome all other obstacles. It was through the linguistic formulation in the mind of the translator that space, time, and cultural difference could be overcome to enable the steady development of widely dispersed funds of knowledge. The translations in which we are interested are those in which the authors and readers seek information on the nature and functioning of the natural world—on science, as we would say today.[2] Translation, as a framework for study of the history of science, can be seen to encompass other frameworks. That is, the study of translation can be applied equally to the medieval and early modern eras; it applies to translations within contiguous spaces as well as those reaching to languages based in distant regions. Further, the issue of translation is present no matter what the topic under discussion; it goes beyond the written text to address the spoken word.

The role of translation in cross-cultural communication, and our study of that role, may highlight key moments of transmission, insight, and critical interpretation across linguistic and faith communities, or across boundaries of shared practice, or shared knowledge about the natural world. Translation arguably goes beyond achieving equivalence from language to language, and adds value. It brings new or revised texts for the destination language, potential recognition of accomplishment for the source language and culture, and valuable debate within the destination language, as new ideas are compared with existing ideas. As Scott Montgomery argues, "In the history of knowledge, the power of translation is commensurate with the power of the word."[3]

The history of science has been deeply involved in translation but, with exceptions such as that of Montgomery, the literature has tended to address



translation more in descriptive than analytical terms. Studies in world history, despite their attention to connections among many cultural and linguistic groups, have not commonly addressed the question of translation explicitly. The authors in this volume—literate in languages including Arabic, Catalan, Chinese, Greek, Hebrew, Italian, Japanese, Latin, Minnan, Ottoman, Persian, and Spanish—explore the role of translation in science through varying analytical frames. Thus, we are analyzing translation explicitly, yet through the varying perspectives associated with the crossing of boundaries in language and framework. We find that translation is not a single process but a variety of means for transferring or linking knowledge from one community to another. Our results yield multiple situations for translation and multiple dynamics in the transmission of knowledge.

The world of the second millennium CE was multilingual. In small communities and with interconnection through trade and migration, it was common for people to speak different languages with varying levels of fluency. But to know languages through their written expression, and to know them at roughly parallel levels of expertise in order to translate from one to another, was a highly specialized requirement. Completing the task of translation required that the translator be knowledgeable in at least two languages and also in the discipline under study. Such a task, always requiring effort, was all the more difficult in the era before dictionaries were readily available. Even then, there inevitably remained the problem of untranslatable terms and concepts—terms for which one had no way to be sure that there were equivalent meanings in any two languages. Skilled translators, linking not just two texts but two social situations out of which the texts arose, had to decide what degree of specificity to use in linking the characteristics of the culture expressed in one language with that expressed in another. Further, the translation of works from times long past raised the same difficulty to a higher degree, in that there was no direct way for the translator to experience both social situations.

## Objectives and Organization

Our work begins with a principal focus—translation as a key element in the exchange of knowledge and the construction of scientific inquiry—and peers into the complexities of this issue across fields of knowledge, a wide geographical range, and a long time frame. It is our expectation that the results of this collaborative exploration will not only reveal details about processes of translation but also suggest wider interpretive perspectives

on the history of science. Each of the four parts of the book focuses on translation in a selected realm of knowledge across a range of time and space. The studies extend from the tenth to the nineteenth centuries; they center on Eurasia from Pacific to Atlantic but also address Africa and the Americas. Part I, "Mapping the Earth," includes four cartographical studies relying on both maps and texts, each ranging across linguistic as well as geographic boundaries. In Part II, "Constructing Society," two studies address material construction—the engineering of waterways and the assembly of the elements of textiles—and a third explores the conceptual and administrative construction of empire. Part III, "Advancing Health and Welfare," presents four studies ranging from physical health through medicine and *materia medica* to the search for individual and collective welfare through divination. Part IV, "Charting the Skies," includes five studies of astronomy, addressing efforts to calculate the distances of planets, comprehensive astronomical observation, applying astronomy to human welfare through astrology, exchanging astronomic texts, and using the sun and the moon as tools in navigation. Manuscript texts are central to the analysis in each chapter, but variations in material culture and conceptualization distinguish the four parts from each other. The varying material and conceptual elements include maps and lists of places in part I; creation of textiles, administrative structures, and structures to control water in part II; medication, medical technology, and the search for other factors related to welfare in part III; and sky charts, calendars, and timetables in part IV.

In sum, these chapters bring together studies of history of science from the tenth to the nineteenth centuries CE, addressing connections among widely ranging sociogeographic terrains, and emphasizing perspectives drawn from the literatures in history of science and world history. The analytical focus on translation and its complexities provides the basis for our study of processes and trajectories in the exchange of knowledge, as they contributed to preservation and expansion of scientific study.

## Global Patterns in Scientific Exchange

What was the global trajectory of scientific knowledge from 1000 to 1800, by field and in general? What is the appropriate summary of qualitative and quantitative change in scientific knowledge as it expanded, contracted, and transformed in its nature, its location, and its implications for society? Our focus on translation caused us to give particular attention to the specific dynamics of exchange of knowledge in various times, places, and



fields of knowledge. We encounter repeatedly the question of whether there was a sudden acceleration in scientific knowledge in early modern times—either worldwide or in Europe. Rather than offer a general response to this question, we seek to contribute on a more specific level: we describe and analyze the varying dynamics of knowledge exchange over a millennium. We expect that articulation of the varying dynamics and consequences of knowledge exchange will contribute positively to the resolution of the larger issue.

Recent summary statements on the evolution of scientific study, as expressed in the collective Cambridge histories of the fields of history of science and world history, offer a mix of parallels and contrasts. For medieval history of science, an authoritative overview concludes by invoking "the growing awareness of cross-cultural interaction in the history of medieval science."[4] A parallel survey of history of science for the succeeding early modern period, in contrast, emphasizes innovation and rapid change, though within the narrower spatial limits of Europe: it focuses on the excitement brought to Europe by new discoveries from the distant East and West, and on science as "one particularly dynamic field of innovation in early modern Europe."[5] In the *Cambridge World History* series, a chapter on science from 500 to 1500 CE argues that from Toledo to Chang'an to Timbuktu, "the spread of science was accomplished through books, artefacts and, above all, through the mobility of practitioners."[6] The volume on the succeeding period, focusing on the nurturing of global connections, includes a chapter on technology but none on science: the omission of any focus on scientific advance in this era is remarkable.[7]

These surveys present readers with contrasting approaches to medieval and early modern science in both literatures: in history of science, the focus shifts from broad and expanding exchange of knowledge to a regionally focused and productive acceleration; in the world history literature, emphasis shifts from expanding exchange of knowledge to the influential developments in empire, commerce, and new technology. Each of these transitions may be important in the world history of science. To assist in sorting out these interpretations, one may offer two sets of distinctions. First, these alternative trajectories of scientific change may be labeled as "evolving scientific exchange"—the notion of continuing exchange and fluctuating advance in scientific knowledge, as emphasized by scholars working on the medieval era—and "emergence of innovative science," as described by scholars for early modern Europe. Second, to address the origins and causes of each sort of change, one may observe that historians

of science have concentrated on *endogenous* interpretations, tracing the development of scientific thinking within a community of scientists, either localized or reaching across geographical and cultural boundaries. World historians, in contrast, have interpreted scientific advance with *exogenous* interpretations, emphasizing the interplay of technology, empire, and political economy as factors that generated scientific advance.[8] In this broad discourse, it is notable that historians of science have chosen to back away from the myth of "Scientific Revolution," in which earlier analysts overstated the originality, the rapidity, and the determinative influence of early modern scientific study in Europe.[9]

But if we give up on the notion of an essential Scientific Revolution as the turning point in the history of science, how are we to sort out the possible interpretations of scientific change? The notion of the Scientific Revolution suggested to some that science arose at a single inflection point in space and time. Recent work, including the essays in this volume, shows that the interchanges, advances, and losses in scientific knowledge were distributed in a far more complex pattern across space and time. From a world-historical standpoint, we should keep asking when knowledge expanded (by field of knowledge and by type of knowledge within fields); and we should ask where knowledge expanded (by region and by social strata). Patient scholarship, one may hope, will clarify the many regional exchanges and advances in knowledge, and may contribute steadily to clarification of the complex trajectory of scientific knowledge from medieval times to the expanded scientific establishment of the world today.

In practice, the chapters in this volume give most emphasis to "evolving scientific exchange," though they include episodes of "emergence of innovative science." The chapters give primary attention to endogenous analysis of scientific discourse, though several chapters give attention to exogenous factors of change such as empire and long-distance commerce. This framework may provide a basis for rereading works by George Saliba, Margaret Meserve, and Pamela Long, in which they link the contributions of earlier exchange of knowledge to the emergence of new and innovative science.[10] Kenneth Bartlett, in a skillful comparison of the Florentine intellectuals Machiavelli and Guicciardini, shows that the "new" could lead in different and even contradictory directions.[11]

The historical trajectory of acceleration in scientific knowledge and practice is an empirical question, but it is also a question of historical method and theory. Readers and researchers of today live in the aftermath of a great wave of European political and cultural hegemony. The twentieth-



century sequence of empire, war, and decolonization has been succeeded by a world in which individuals and societies are greatly unequal but in which power and social recognition are much more widely distributed than in the era of European empire. We now share a global consciousness that appears to be more persistent than the flashes of global vision that arose during earlier centuries in times of war and other moments of great crisis. The scholarship of today is attempting to learn to what degree this global consciousness, when focused on the past, provides us with new and more connected interpretations of history. To complete this reconsideration of the past, scholars must ensure that their tools, fashioned during and perhaps after the era of Eurocentrism, do not distort the view of the period before European hegemony.

## Literary Theorists and Translation

We turn back now to translation as a device for exploring intimate scientific communication, yet also for analyzing large-scale changes in the history of science. Literary theorists have given great attention to translation, and their observations may be helpful to historians of science at this moment.[12] Emily Apter proposed a "translation zone" as a space of critical engagement linking minds and texts, a richly liminal area beyond the units of each polity or language community.[13] She poses a range of theses for translation studies ranging from "everything is translatable" to "nothing is translatable." In conclusion, she identifies the role of translation in turning nature into data—a concept of interest in that it suggests that scientific analysis, in a different way, also turns nature into data. This work, like others exploring translation, draws on "The Task of the Translator" by Walter Benjamin (1923), along with his later reconsideration of the topic, including such notions as the "afterlife" that a translation gives to a text.[14] David Damrosch sought to demonstrate the application of the framework of world literature to the problem of translation with three extended examples of how the process of translation can expand the analysis and understanding of a text. His examples were a concise work of ancient Egyptian love poetry, the reflections of a thirteenth-century female mystic, and Franz Kafka's final novel.[15] These analyses make clear how the choices of translators contribute to a revealing but rarely definitive analysis of the original text. Apter returned to the problem of translation in 2013 with *Against World Literature*, in which she traced the twenty-first-century expansion of works in translation studies and world literature, but found the combination to be "too

pluralistic, too ecumenical," fearing that courses in translation were being presented as a "humanities lite," so that "at its very core World Literature seemed oblivious to the Untranslatable."[16] This assertion, apparently brash, fit with a pattern that appeared in many arenas within expanding global studies. That is, the initial work of globalists centered on broadening their perspective and encountering the outer limits of the global, while the succeeding emphasis turned first to identify the specificity of the local within the global and then to explore the interaction and mutual dependence of the local and the global.

The academic field of world history, born in an English-only era, has given little formal attention to translation. Translation has been left as a technical issue in the exploration of sources.[17] The great debate in the formative years of world history was over Eurocentrism—that is, the claim that the world should be seen, inclusively, as composed of interacting regions rather than as a set of isolated regions sequentially affected by diffusion of influence from Europe. In this debate, world historians drew on Edward Said's critique of Orientalism—but they focused on interactions in material and ideological arenas, bypassing the commentary in Said on translation and multilingualism.[18]

In contrast to the world-historical literature, the area-studies literatures in history have given greater attention to translation. Sheldon Pollock, a scholar in Sanskrit language, literature, and history, convincingly adopted the term "cosmopolis" to describe the usage of Sanskrit, from the first century CE, as a literary language from Afghanistan to Java. This literary community, while not unrelated to the conquests of the earlier Mauryan Empire, extended far beyond the empire's linguistic and political boundaries. Alexander Beecroft adopted the term as part of his typologically fertile review of *The Ecology of World Literature*, expanding its application broadly in time and space.[19] Of Beecroft's numerous and overlapping instances of cosmopolis, those that can be said to have functioned during the second millennium CE—the time frame of this volume—include the cosmopoleis of Chinese, Persian, Arabic, Greek, Latin, and, arguably, others, including Hebrew. Both authors and readers in each cosmopolis gained access to a wide range of works. Language variety was such that the speech community of most people in each cosmopolis was generally different from the literary language of the cosmopolis. The problem of translation thus arose both within each multilingual cosmopolis and between one cosmopolis and the next—though it is the latter issue that has gained the most attention in translation studies. In sum, the notion of "cosmopolis" appears to



be a productive addition to analysis within historical and also to literary studies. It provides, for instance, a framework for considering the point that Persian became the intellectual language of the Mongol Empire, and that a Persian cosmopolis remained in effect in South Asia during the Mughal era.[20] If we move forward to our own time, we can argue that today's predominance of English in global communication, both academic and popular, presents a new situation. Yet it is not irrelevant to label this as an "English cosmopolis" and compare it with other examples of cross-cultural communication through a shared language, as in the earlier cases relying on Sanskrit, Chinese, Persian, Latin, French, and others.

## Knowledge in Movement: Metaphors and Dynamics

Historians of science have proposed various metaphors and dynamics for the exchange of knowledge, perhaps seeking to locate the most appropriate term for conveying the communication of scientific information. In these wide-ranging conversations, however, the metaphors and dynamics selected for discussion have not commonly emphasized language or translation. Kapil Raj has gained wide attention for his application of the term "circulation," in which he seeks "to ground the circulation of knowledge and knowledge-related practices in specific localities."[21] Raj, writing about the era of global empire, carries on the campaign against Eurocentrism. Eurocentrism is surely not vanquished—authors in this volume note instances of texts whose authors have assumed European or Christian scientific work to be inherently superior.[22] Fa-ti Fan expresses support for Raj's emphasis on spaces of circulation of scientific knowledge, preferring it to Bruno Latour's diffusionist view of centers of calculation. These various terms are less than perfect substitutes for each other, as they involve slightly different dynamics but are also proposed for somewhat different social situations.[23] The concept of circulation, thus, has similarities to Peter Galison's notion of trade in physics (involving exchange among parallel scientific subcultures), and to Mary Louise Pratt's notion of a contact zone for knowledge linkages in a situation of asymmetrical power.[24] Sujit Sivasundaram addresses related questions in methodology, emphasizing the benefits of reading widely and using documents for unexpected purposes: he tells tales of using Scottish missionary sources to reveal perspectives of Tahitians and of using palm-leaf manuscripts from Ceylon as a key to reading European botanical gardens. Sivasundaram, along with others, sees merit in applying Bourdieu's theory of practice to the exploration of scientific practice.[25]

These analytical frameworks, contrasting proposed dynamics of scientific change, suggest that no single image or metaphor will be sufficient to express the range of interactions in the communication of scientific knowledge. It may be that one such image—perhaps "circulation"—will become the most general and best established such term. Nevertheless, a full analysis of scientific change requires that researchers explore other metaphors to understand multiple dynamics and the social situations in which they have unfolded.[26] The design of this book, indeed, is to extend the scope of inquiry, exploring the history of science in the context of world history and perhaps other fields. The term "circulation" has been employed in slightly different forms in South Asian and world history, coevolving in each case with the term "connection."[27] Hence, it may be seen as a positive contribution of this book that the authors have articulated a number of alternative such metaphors and dynamics.[28]

The dynamics of historical change, once identified in general, are applied to historical situations. Comparison of overviews in history of science and world history, as noted above, yields alternative foci in explaining changes in the history of science, especially during the early modern period. Analysis within history of science, commonly, centers on explaining intellectual changes in terms of other intellectual changes.[29] World history, with the broader task of explaining "the construction of a global world," has focused especially on tracing material and political changes, explaining them primarily with shifts in material conditions.[30] Indeed, it appears that the field of world history, in sharp contrast to European history, has not yet found a way to place scientific debate and advance as a central factor in explaining "the construction of a global world." Technology, in contrast, holds a position of importance in narratives of world history—arguably, history of technology is attributed a more influential role in world history than it is in the history of science.[31] In general, this type of linkage of fields of historical study provides an opportunity to appeal to a wider range of causal factors in explaining change in any arena of human society.

Some of the main shifts in material conditions unfolding at the global level in the second millennium CE were major climate shifts, notably the Medieval Warm Period from the tenth through thirteenth centuries and the succeeding cooling, up to the seventeenth-century low point of the Little Ice Age. The expansion in global maritime voyages brought the Columbian Exchange of animal and plant biota, great expansion in maritime migration and long-distance commerce, global exchanges of new technology, construction of new empires (governed by Europeans, Asians, and Africans). Waves of disease—led by the Black Plague of the fourteenth century (and its successors) and by the great decline in Amerindian populations—struck every region. These numerous shifts in global conditions, important in themselves, may also be considered as possible influences on the nature and extent of scientific communication. We end up, therefore, with at least three categories of causal factors to consider in tracing world-historical changes in history of science: dynamics of communication, global material conditions, and the practice of translation.[32]



## Exploring Cases and Dynamics

The authors in this volume have used both descriptive and metaphoric terms to propose several overlapping dynamics of the communication of knowledge. I conclude with brief summaries of the topics and dynamics presented in the chapters to come, hoping to convey the analytical richness that can arise from historical interpretations assembled with a focus on translation. Some focus on the perspective of the author or creator, others on the perspective of the reader. In some cases a monarchy may be seen as creator or consumer of knowledge, while in other cases the exchange of knowledge takes place in the realm of civil society.

Our chapters open with studies of mapping the Earth. Four chapters convey distinctive dynamics in the production and exchange of maps. Katrin Kogman-Appel considers the circumstances of Elisha Cresques, the creator of the 1375 map known as the Catalan *mappamundi*. She concludes that Iberian scholars working in Hebrew at that time had access to a particularly wide range of texts and translations in Arabic, Hebrew, and Latin that enabled Cresques to create a map that drew successfully on multiple cartographic traditions and facilitated study in scientific terms. Kogman-Appel thus identified propinquity, in space and culture, as a factor that facilitated advances in analysis and cartographical display. Karen Pinto, also for the western Mediterranean, compares two culturally different mapping traditions—Islamic and medieval European—and demonstrates their interaction. She traces the individual hands of annotations and marginalia in Arabic and Latin on a ninth-century T-O map and on a twelfth-century Arabic cartogeographical manuscript, and seeks to identify the authors of the annotations. In doing so she documents the multidirectional diffusion of cartographic ideas that influenced key figures in the Christian and Muslim Mediterranean and strengthened both the Christian and Muslim cartographic traditions. Pinto uses the term "con-

vivencia" to describe the cordial relations across confessional lines and the resulting benefits to cartography. Rila Mukherjee traces the advances and regression in European mapping of the Ganges delta from the fifteenth to the eighteenth century. Cartographers in northern Europe, working with recently translated maps of Ptolemy, but without the accurate though hidden Indian Ocean maps of Portuguese voyagers, made speculative maps of the Ganges into the eighteenth century. The results, while uneven, reveal the importance of Ptolemy's conception of the relationship between mountains and rivers in a continental region. In Mukherjee's view, Ptolemy's geological theory provided valuable support to cartographers who had to work without the empirical detail of surveys of the Ganges. In a fourth cartographic presentation, Robert Batchelor compares the cartographic approaches of the land-based Ottoman and Safavid empires to the Indian Ocean and Southeast Asia with the seventeenth-century Fujianese "Selden Map," which documents ports and maritime routes traveling outward from East Asian seas. Batchelor emphasizes that "maritime flexibility" and practical "repositories of navigational skill and wayfinding," in contrast to terrestrial centralism and efforts to create a singular global vision, provided an advantage for maritime maps and argues, "This early modern meeting of traditions gave impetus to a final shift from the quantitative to the mathematical, to use Needham's terms."

In three chapters on the construction of human society through empire, trade, material culture, and engineering, a similar range of dynamics emerges. Huei-Ying Kuo, exploring a thirteenth-century Chinese manuscript based on commercial and imperial information collected at the port of Quanzhou, analyzes the contradictory twentieth-century interpretations of this text by American translators and Chinese readers. Kuo shows how the readers, in debating terms in the original and the translation, revealed their contending views of Song-era China as a network of commercial stations or as the administration of continental lands. She argues that "ideological shackles" limited the vision of twentieth-century readers. BuYun Chen's essay enters the realm of material culture in her exploration of "bingata," a brightly patterned cloth produced on the Ryukyu archipelago. Following Meiji Japan's annexation of the Ryukyu Kingdom, Tokyo-based Japanese intellectuals traveled to the islands and described *bingata* as a superlative example of local folk craft. Chen shows that, on the contrary, the "production secret" of bingata resulted from exchanges of knowledge among painters and textile artisans, as well as from the trade in textiles and painting manuals. Such exchange centered on the centuries of



Ryukyu tradition including tributary relations with Ming and Qing China and artisanal exchange with the port of Fuzhou. In a very different sort of social construction, Ruth Mostern considers the long administrative effort to control flooding of the Yellow River after the initial floods of 1048. Thus she relies on translation in material culture more than on a strictly linguistic translation. As she argues, the governing philosophy of "efficacy," which called for caution in interfering with nature, remained unchallenged even as it proved ineffective in ending the breaching of levees—as sediment flowed relentlessly downstream from the loess plateau.

Four chapters focus on attempts to understand the natural world for purposes of advancing human health and welfare. Irina Podgorny traces the location and linkage of animals that appeared similar—the "great beasts" on every continent, as they were described over several centuries. Observers showed special interest in the hooves and nails of these beasts, especially as they were widely thought to cure epilepsy. She resolves the mystery of the parallels among great beasts by documenting the "scenarios and trading zones" that spread ideas of the pharmaceutical utility of hooves and nails in many cultures over the course of three centuries. Francesca Fiaschetti investigates the place of divination in the Mongol courts, treating divination as a platform for scientific translation. She argues that Mongol rulers sought "centralization and institutionalization" of the processes of divination to help them select the order in which they drew on competing traditions of scientific knowledge. Nükhet Varlık analyzes the circulation of numerous treatises on the diagnosis and treatment of plague, written from the fifteenth century in Ottoman Turkish, Persian, and Urdu, for general audiences. As Varlık notes, "Both the disease itself and the knowledge of it took different forms and meanings in different contexts, as a result of biological, social, and historical factors." She traces a process of "vernacularization" as authors sought contact with the local conditions of their readers but also wished to be consistent with the universal knowledge of plague. M. A. Mujeeb Khan explores tenth-century medical encyclopedias created in Persia and Japan, tracing their role in the evolving medical literature of each region. Khan focuses on "transposition" rather than translation, defining transposition as the act of appropriating knowledge from one source, with the faithfulness of the excerpting less important than the actual act of transposition. Transposition itself thus served as a form of new knowledge creation, simply by bringing the knowledge (i.e., excerpts, summaries of quotations, etc.) to the new context, both in its reinterpretation through its repositioning in this new context and its isolation from its

original, larger narrative. Transposition led to quite different trajectories in the evolution of medical encyclopedias in Persia and Japan.

We complete the volume with chapters addressing the understanding of the skies. Bernard R. Goldstein and Giora Hon detail the history of a cosmological principle, the nesting hypothesis for planetary distances, from Ptolemy's *Planetary Hypotheses* in the second century CE, through its persistence in Arabic, Hebrew, and Latin texts to its decline in the seventeenth century. This hypothesis put the Sun, Moon, and planets in orbs around the Earth at distances deemed to fit almost perfectly so that there are no significant gaps between the orbs of adjacent planets. Goldstein and Hon emphasize that recurring confidence in the nesting hypothesis was enhanced by the often misleading appeal to numerical agreement to confirm a theory. Roxann Prazniak recounts the achievements of the innovative observatory built in the thirteenth century at Marāgha, the initial capital of the Il-Khans. The exchange of information included translating and setting equivalences in calendars throughout the Mongol realm: Prazniak emphasizes the advantages of imperial centralization for the compilation of astronomical information at this scale. Margaret Gaida examines the afterlife of the translation from Arabic to Latin of one of the most popular texts on astrology in the medieval period. Drawing from a pool of over two hundred extant manuscripts of Alcabitius's *Introduction to Astrology*, she assesses the marginal comments and annotations of Latin readers to determine their attitudes toward the Arabic astrological tradition. She observes that in approximately thirty copies of the text, ranging from the thirteenth to fifteenth centuries, scribes continued to employ Arabic technical terms and readers often cited other Arabic astrological authorities in the margins. She concludes that Latin readers held the Arabic astrological tradition in high esteem, and regarded Arabic texts as valuable sources of astrological knowledge for centuries after the translation of the text in the twelfth century. Dror Weil traces the dispatch of Arabo-Persian astronomical texts and their reception, translation, and naturalization in China from the thirteenth to fourteenth centuries. He argues that the fourteenth century, amid the sociopolitical changes that China underwent, saw a transformation in the ways Chinese astronomical institutions accommodated Arabic and Persian knowledge. A project of translation of Arabic and Persian texts replaced the use of original texts and ushered in a new form of East–West intellectual engagement. Pat Seed traces the translation of celestial science into celestial navigation in fifteenth-century Portugal, as the drive of the monarchy to sail to the Indian Ocean led to engaging skilled Jewish mathematicians in performing trigonometric calculations that traced locations of the Sun and the Moon in place of the stars. They put the astrolabe to a new purpose, and made it possible for navigators to measure longitude and latitude anywhere on the seas.



OF THE NUMEROUS AND DISTINCTIVE DYNAMICS of knowledge exchange documented by the authors in this volume, most can be linked (though in varying fashions) to the trajectory of "evolving scientific exchange." A few highlight rapid change and thus contribute examples to the trajectory of "emergence of innovative science"—including chapters by Kogman-Appel, Prazniak, and Seed. Still other chapters focus on dynamics that point in other directions: Kuo's "ideological shackles" affect the interpretation of the history of science as much as the past exchange of knowledge under study; Mostern's attention to the philosophy of "efficacy" argues that an area of intellectual rigidity restrained innovation even in a global center of innovation; and Fiaschetti's emphasis on divination as a form of knowledge enabled Mongol sovereigns to set priorities in relying on competing bodies of scientific knowledge. Indeed, each of the authors has found a distinctive path for exploration of translation and its logic. They document the conveyance of understandings and misunderstandings, not only across languages but across space, time, and topics—distinguishing the perspectives of author, translator, and reader. The chapters trace many of the paths by which knowledge has been retained, conveyed, updated, and put to new purposes.

This volume addresses major issues in processes of scientific exchange and advance during a long era of dramatic change in human society. By combining approaches drawn from history of science and world history, we seek to add to the number of causal factors under consideration, the dynamics of their interaction, and the range of possible consequences of scientific change. We may hope to contribute to an orderly if complex interpretation of the history of science, but we are skeptical that any single model of circulation or connection will integrate these factors smoothly. While our studies are monographic rather than synthetic, certain broad patterns appear in our work and call for additional specification. The studies in this volume indicate that, by the beginning of the second millennium CE, there was already a significant network of communication on knowledge of the natural world, stretching across much of Eurasia and parts of Africa. This network grew in breadth and depth across the centuries, though including regional declines as well as advance. The many moments

of important discoveries do not yet reveal any one definitive break. From the standpoint of the present, we can be sure that some important processes of acceleration arose. We are not prepared to offer grand hypotheses on the nature of those processes. But we believe that the specific processes of translation and communication presented in these chapters, along with the global framework in which they are presented, can contribute to unraveling the great mystery of scientific advance.

# NOTES

## Introduction. Knowledge in Translation

1. In addition, we treat the study of translation as a tool for analysis, contributing to understanding the full range of patterns of communication and the efforts to overcome multiple obstacles to communication.

2. These are literal translations—connections across languages and their scripts—but also include metaphoric translation of cultural practices.

3. Scott Montgomery, *Science in Translation: Movements of Knowledge through Cultures and Time* (Chicago: University of Chicago Press, 2000), 13.

4. Michael H. Shank and David C. Lindberg, "Introduction," in *The Cambridge History of Science, vol. 2: Medieval Science*, ed. David C. Lindberg and Michael H. Shank (Cambridge: Cambridge University Press, 2013), 26. The same volume includes a chapter on the organization of knowledge by Joan Cadden, a chapter on translation of Greek and Islamic science to Latin Christendom, and a chapter on geography by David Woodward. Other chapters in the volume address translation, the organization of knowledge, geography, medicine, and astronomy.

5. Katharine Park and Lorraine Daston, "Introduction: The Age of the New," *The Cambridge History of Science, vol. 3: Early Modern Science*, ed. Park and Daston (Cambridge: Cambridge University Press, 2008), 2–3.

6. Charles Burnett, "The Transmission of Science and Philosophy," in *Cambridge World History, vol. 5: Expanding Webs of Exchange and Conflict, 500 CE–1500 CE*, ed. Benjamin Z. Kedar and Merry E. Wiesner-Hanks, 339–58 (Cambridge: Cambridge University Press, 2015), 345–48.

7. The concise introduction to the volume notes the many topics to be addressed in this era but makes clear that the primary emphases will be on empire and political economy. Sanjay Subrahmanyam, "Introduction," in *The Cambridge World History*, vol. 6, part 1, ed. Jerry H. Bentley, Sanjay Subrahmanyam, and Merry E. Wiesner-Hanks, 1–23 (Cambridge: Cambridge University Press, 2015).

8. Neither endogenous nor exogenous interpretations are posed as formal dichotomies in either literature, but the practical contrast in approaches becomes evident to the reader.

9. Park and Daston ask, "Where is the Scientific Revolution? Our avoidance of the phrase is intentional." Instead, they comment briefly on "the mythology of the Scientific Revolution." Park and Daston, "Introduction," 12, 15–16.

10. George Saliba, *Islamic Science and the Making of the European Renaissance* (Cambridge, MA: MIT Press, 2007); Margaret Meserve, *Empires of Islam in Renaissance Historical Thought* (Cambridge, MA: Harvard University Press, 2008); Dimitri Gutas, *Greek Thought, Arabic Culture: The Graeco-Arabic Translation Movement in Baghdad and Early 'Abbāsid Society (2nd–4th/8th–10th Centuries)* (London: Routledge, 1998); Pamela Long, *Artisan/Practitioners and the Rise of the New Sciences, 1400–1600* (Corvallis: Oregon State University Press, ca. 2011). Among world historians, Janet L. Abu-Lughod's *Before European Hegemony* emphasizes the demonstration of widespread commercial exchange before the modern period, without trying to explain any later transition. Janet L. Abu-Lughod, *Before European Hegemony: The World System A. D. 1250–1350* (New York: Oxford University Press, 1989).

11. In an era of discovery that brought new information on the Americas and on classical texts, Macchiavelli expressed interest only in the latter, while Guicchiardini focused on the implications of the former. Kenneth Bartlett, "Burckhardt's Humanist Myopia: Machiavelli, Guicciardini and the Wider World," *Scripta Mediterranea* 16–17 (1995–96), 17–30.

12. David Damrosch, in an overview of world literature, described his concern as "with tracing what is lost and what is gained in translation, looking at the intertwined shifts of language, era, region, religion, social status, and literary context that a work can incur as it moves from its point of origin out into a new cultural sphere." Damrosch, *What Is World Literature?* (Princeton, NJ: Princeton University Press, 2003), 34.

13. Apter describes "a zone of critical engagement that connects the 'l' and the 'n' of transLation and transNation." Emily Apter, *The Translation Zone: A New Comparative Literature* (Princeton, NJ: Princeton University Press, 2005), 5.

14. Walter Benjamin, "The Task of the Translator," in *Walter Benjamin: Selected Writings, Vol. 1, 1913–1926*, ed. Marcus Bullock and Michael W. Jennings, 253–63 (Cambridge, MA: Harvard University Press, 1996).

15. Damrosch, *What Is World Literature?* 147–205.

16. Emily Apter, *Against World Literature: On the Politics of Untranslatability* (London: Verso, 2013).

17. Journals and monographs in world history appear overwhelmingly in English, though there are also significant publications in Chinese and German. Textbooks appear in multiple languages. Historians use many languages in research but carry on little discourse about multilingualism and translation in analysis at the level of world historiography. The contrast with literary studies is striking.



18. Edward W. Said, *Culture and Imperialism* (New York: Knopf, 1993), xxv.

19. Sheldon Pollock, *The Language of the Gods in the World of Men: Sanskrit, Culture, and Power in Premodern India* (Berkeley: University of California Press, 2006); Alexander Beecroft, *An Ecology of World Literature: From Antiquity to the Present Day* (London: Verso, 2015).

20. On Persian language in the Mongol era, see Roxann Prazniak (ch. 13 in this volume). On a parallel example for Turkish influence in India, see Sheldon Pollock "Ramayana and Political Imagination in India," *Journal of Asian Studies* 52 (1993), 261–97.

21. Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Scientific Knowledge in South Asia and Europe, Seventeenth–Nineteenth Centuries* (New York: Palgrave Macmillan, 2007), 21.

22. Our standpoint in this volume will be to assume that Eurocentrism in historical interpretation is a known factor, and that techniques can be developed to address it. Our task is to focus on how to use the contemporary tools of history of science and world history to interpret scientific communication across language frontiers. Of course, power and hegemony were present throughout the medieval world, but the ideology of civilizational hierarchy was not firmly established until the nineteenth century.

23. Fa-ti Fan, "The Global Turn in the History of Science," *East Asian Science, Technology and Society* 6 (2012), 249–58; Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, MA: Harvard University Press, 1987); Peter Galison, "Trading with the Enemy," in *Trading Zones and Interactional Expertise: Creating New Kinds of Collaboration*, ed. Michael E. Gorman, 25–52 (Cambridge, MA: MIT Press, 2010); Mary Louise Pratt, "Arts of the Contact Zone," *Profession* (1991), 33–40. In another variation, the term "exchange of knowledge" was developed for exploring exchanges including hierarchical relations (colonizer and indigenous, free and slave) and the contrast of state and civil society in exchanging knowledge across the lines of social encounters. See, for instance, Patrick Manning, "Building Global Perspectives in History of Science: The Era from 1750 to 1850," in *Global Scientific Practice in an Age of Revolutions, 1750–1850*, ed. Patrick Manning and Daniel Rood, 1–18 (Pittsburgh: University of Pittsburgh Press, 2016), 8–16.

24. Galison argues further for an "intercalated" situation, in which scientists bring together varying traditions that become linked without losing their character, and for "pidgin languages" as vehicles for scientific communication across these boundaries. Peter Galison, "Trading Zone: Coordinating Action and Belief," in *The Science Studies Reader*, ed. Mario Biagioli, 137–60 (New York: Routledge, 1999). Pratt hints effectively at such complexities with her notion of the "contact zone." Pratt, "Arts of the Contact Zone."

25. Sujit Sivasundaram, "On Methods, Questions, and Theory," *Isis* 101, no. 1 (2010), 146–58. Bernard S. Cohn, *An Anthropologist among the Historians and Other Essays* (Delhi: Oxford University Press, 1987), 56.

26. A related issue may be emphasized in world history, where the term "connection" has been widely adopted to describe interaction and change at the global level. Critics of "connection," to the degree that they seek to displace it as a term of analysis, might do better to set it in the context of a wider range of dynamics of global interaction. Along this line, see the argument of Sebastian Conrad that adoption of new clock

technology in Japan depended not just on a connection with European technology but also on an appropriate social situation. Sebastian Conrad, *What Is Global History?* (Princeton, NJ: Princeton University Press, 2016), 68–69.

27. Claude Markovits, Jacques Pouchepadass, and Sanjay Subrahmanyam applied the term "circulation" in 2003; Subrahmanyam used it earlier in an essay linking it to "connection." In another lineage of the term "connection," Manning (2003) expanded it at length, drawing on inspiration from Crosby (1986). Sanjay Subrahmanyam, "Connected Histories: Notes towards a Reconfiguration of Early Modern Eurasia," *Modern Asian Studies* 31, no. 3 (1997), 735–62; Claude Markovits, Jacques Pouchepadass, and Sanjay Subrahmanyam, "Introduction: Circulation and Society under Colonial Rule," in *Society and Circulation: Mobile People and Itinerant Cultures in South Asia, 1750–1950*, ed. Claude Markovits, Jacques Pouchepadass and Sanjay Subrahmanyam, 1–22 (Delhi: Permanent Black, 2003); Patrick Manning, *Navigating World History: Historians Create a Global Past* (New York: Palgrave Macmillan, 2003), 3, 65–66, 280–81; Alfred W. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900–1900* (Cambridge: Cambridge University Press, 1986). More recently, Duara emphasizes "circulation" in a world historical interpretation. Prasenjit Duara, *The Crisis of Global Modernity: Asian Traditions and a Sustainable Future* (Cambridge: Cambridge University Press, 2015), 81.

28. In an early and valuable use of metaphors in exploring the history of science, Hugh Kearney distinguished organic, mysterious, and mechanical images underlying three traditions of early modern science. Hugh Kearney, *Science and Change, 1500–1700* (New York: McGraw-Hill, 1971).

29. The *explanandum* (that which is to be explained) and *explanans* (that which conveys the explanation).

30. Subrahmanyam has suggested an alternative narrative of the early modern world, focusing on connections brought by the spread of myths. Subrahmanyam, "Connected Histories."

31. Joel Mokyr's approach to technology in history focused on the most advanced technologies, while the approach of Arnold Pacey emphasized the interplay of varying levels of technology. Mokyr, *The Lever of Riches: Technological Creativity and Economic Growth* (New York: Oxford University Press, 1990); Pacey, *Technology and World Civilization: A Thousand-Year History* (Cambridge, MA: MIT Press, 1991).

32. In addition, we may rely on translation not only as an interpretive framework but also as a methodological tool—a means to explore other sources of change.