Relocating Modern Science

Circulation and the Construction of Knowledge in South Asia and Europe, 1650–1900

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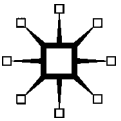

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Introduction

Modern science is widely considered a purely West European creation, originating in the 'scientific revolution' of the sixteenth and seventeenth centuries and owing nothing to other cultures or times. Accordingly, academic interest in the relationship of modern science to the rest of the world has traditionally focused mainly on two sets of issues.

The first pertains to the reasons for the putative emergence of modern science within the narrow boundaries of West Europe, a subject on which a plethora of writings by historians of science celebrating the epistemological, sociological, and economic uniqueness of the West has continued to appear ever since the establishment of the domain as a full-fledged discipline at the turn of the twentieth century.[1] Indeed, of all the questions dealt with by the history of science, this is probably

[1] Although European autarky has always underpinned history of science writing—see, for instance, Pierre Duhem, *Le système du monde*, 10 volumes (Paris: A. Hermann, 1913–59)—the *locus classicus* for this question is Herbert Butterfield, *The Origins of Modern Science* (London: G. Bell & Sons, 1949). See also Alexandre Koyré, *From the Closed World to the Infinite Universe* (New York: Harper, 1958); idem, *Metaphysics and Measurement: Essays in Scientific Revolution* (Cambridge, MA: Harvard University Press, 1968); A. Rupert Hall, *The Scientific Revolution 1500–1800: The Formation of the Modern Scientific Attitude* (London: Longmans, Green & Co., 1954) published in its second edition as *The Revolution in Science* (Harlow: Longman, 1983); Robert S. Westfall, *The Scientific Revolution in the 17th Century: The Construction of a New World View* (Oxford: Clarendon Press, 1992); and Marcus Hellyer, ed., *The Scientific Revolution: The Essential Readings* (Oxford: Blackwell, 2003). For a critical appraisal of this quest for origins, see Andrew Cunningham and Perry Williams, 'De-centring the "Big Picture": The Origins of Modern Science and the Modern Origins of Science', *British Journal for the History of Science*, vol. 26, no. 4 (1993), pp. 407–32; and Steven Shapin, *The Scientific Revolution* (Chicago & London: University of Chicago Press, 1996).

the one for which the discipline is generally best known. Perhaps the least hubristic—certainly among the most comparativist—reflections on the origins question have come from Joseph Needham. Like many intellectuals of his generation, Needham was convinced of the universality of science as a human enterprise—as the expression of an innate curiosity fundamental to human nature throughout time and space.[2] Intrigued by the momentous scientific and technological achievements of China till the fifteenth century, he asked why modern science did not rise there rather than in Europe. The answer to what has come to be called Needham's 'Grand Question' lay, according to him, in the resilience of China's agrarian bureaucratic culture which hindered the emergence of mercantile and industrial capitalism, a *sine qua non* for the emergence of mathematical rationality, the bedrock of modern science. Thus, Chinese, like Indian, or Arab, science was based on local, 'ethnic-bound', categories which allowed the diffusion of technical innovations but prevented that of their underlying theoretical systems. On the other hand, modern science, because it is founded on mathematical reasoning, can be completely appropriated by all humans and is thus 'ecumenical'. Yet, despite its uniqueness, modern science was not created *ex nihilo*. Rather, it subsumed the medieval learning of both West and East 'like rivers flowing into the ocean of modern science'.[3] For Needham, then, while modern science is uniquely Western in origin, it is culturally universal.

The second set of issues takes for granted the Western origins of modern science and is instead concerned with the modalities of its spread from West Europe to the rest of the world. George Basalla's are

[2] For the *Zeitgeist* of Needham's generation, see Gary Werskey, *The Visible College. A Collective Biography of British Scientists and Socialists in the 1930s* (London: Free Association Books, 1988).

[3] Joseph Needham, 'The Roles of Europe and China in the Evolution of "Ecumenical Science"', in idem, *Clerks and Craftsmen in China and the West* (Cambridge: Cambridge University Press, 1970), p. 397. Although Needham never did arrive at a definitive answer to his 'Grand Question', fragments of it are strewn in a number of passages of his magnum opus, *Science and Civilisation in China*, 7 vols (Cambridge: Cambridge University Press, 1954–2005) and in various essays, in particular Joseph Needham, *The Grand Titration: Science and Society in East and West* (London: George Allen & Unwin, 1969). For a critique of Needham's theses, see Nathan Sivin, *Science in Ancient China: Researches and Reflections* (Aldershot: Ashgate, 1995).

probably the best known, and undoubtedly the most controversial, thoughts on this question. In an epoch-making paper that appeared almost forty years ago, Basalla proposed a three-stage model of evolutionary progress for the globalization of what he simply called 'Western Science'.[4] A preliminary period of scientific exploration, where non-European (i.e. 'non-scientific') societies serve as passive reservoirs of data, leads to a second one of colonial dependence in which European scientific institutions encourage Western scientific activity outside Europe—by European colonists or settlers, or else by acculturated indigenes. Eventually, colonized societies gain maturity, a phase characterized by a struggle to establish independent, national scientific traditions based nonetheless upon Western professional standards. Basalla's model is a typical product of the Cold War era and echoes Rostow's anti-communist, five-stage model for economic development based on the American ideal. It has, thus—not surprisingly—attracted much critical response.[5]

The problems set out by both Needham and Basalla have, in their own way, dominated thinking among most historians and sociologists of science working on topics outside the West. Such scholars have in recent years loosely constituted themselves as an academic community

[4] See George Basalla, 'The Spread of Western Science', *Science*, no. 156 (5 May 1967), pp. 611–22; and idem, 'The Spread of Western Science Revisited', in Antonio Lafuente, Alberto Elena, and María Luisa Ortega, eds, *Mundialización de la ciencia y cultura nacional* (Aranjuez, Madrid: Doce Calles, 1993), pp. 599–603.

[5] Walt Whitman Rostow, *Stages of Economic Growth: A Non-Communist Manifesto* (Cambridge: Cambridge University Press, 1960). For critiques of Basalla's model, see, in particular, Roy M. MacLeod, 'On Visiting the "Moving Metropolis": Reflections on the Architecture of Imperial Science', *Historical Records of Australian Science*, vol. 5, no. 3 (1982), pp. 1–16; Ian Inkster, 'Scientific Enterprise and the Colonial "Model": Observations on the Australian Experience in Historical Context', *Social Studies of Science*, vol. 15, no. 4 (1985), pp. 677–704. See also various essays in Nathan Reingold and Marc Rothenberg, eds, *Scientific Colonialism: A Cross-Cultural Comparison* (Washington, DC: Smithsonian Institution Press, 1987); Deepak Kumar, ed., *Science and Empire. Essays in Indian Context* (Delhi: Anamika Prakashan, 1991); Patrick Petitjean, Catherine Jami and Anne-Marie Moulin, eds, *Science and Empires: Historical Studies about Scientific Development and European Expansion* (Dordrecht: Kluwer Academic Publishers, 1992); and Lafuente *et al.*, eds, *op. cit.*

called 'Science and Empire' studies.[6] Historical studies of science outside the West, particularly in India, have thus mainly centred on bringing to light the contributions of non-Western cultures to the 'ocean of modern science' on the one hand, and on the diffusion and response to modern science on the other.[7]

With Needham and Basalla, these studies share the belief that science is the embodiment of the basic values of truth and rationality, the motor of moral, social, and material progress, the marker of civilization itself. It is not surprising then that the history of science has become the site of controversy, with nationalist historians pressing the claim of scientificity for their indigenous knowledges and ways of

[6] The name 'Science and Empire', however, is as unsatisfactory as it is Eurocentric. Regions like China or Persia, or even the Ottoman empire, which were empires in their own right, are not the subject of investigation for this domain—they become so only when and inasmuch as they come into contact with modern West Europeans. Both the terms, 'science' and 'empire', are taken to apply only to modern West European enterprises. However, for an interesting attempt to study the Chinese scientific endeavour in an imperial context in its own right, see Laura Hostetler, *Qing Colonial Enterprise: Ethnography and Cartography in Early Modern China* (Chicago & London: University of Chicago Press, 2001).

[7] See, for instance, Morris F. Low, *Beyond Joseph Needham: Science, Technology, and Medicine in East and Southeast Asia*, *Osiris* (2nd series), vol. 13 (Chicago & London: University of Chicago Press, 1998). For South Asia, see in particular Devendra Mohan Bose, 'History of Science in India: How it Should be Written', *Science and Culture*, vol. 29, no. 4 (1963), pp. 163–6; David Kopf, *British Orientalism and the Bengal Renaissance: the Dynamics of Indian Modernization 1773–1835* (Calcutta: Firma K.L. Mukhopadhyay, 1969); Devendra Mohan Bose, Samarendra Nath Sen and B.V. Subbarayappa, *A Concise History of Science in India* (New Delhi: Indian National Science Academy, 1971); Deepak Kumar, ed., *op. cit.*; idem, *Science and the Raj, 1857–1905* (Delhi: Oxford University Press, 1995); Ahsan Jan Qaisar, *The Indian Response to European Technology and Culture (1498–1707)* (Delhi: Oxford University Press, 1999; orig. publ. 1982); and Pratik Chakrabarti, *Western Science in Modern India: Metropolitan Methods, Colonial Practices* (Delhi: Permanent Black, 2004). For other regions, and more generally, see Roderick Weir Home, ed., *Australian Science in the Making* (Cambridge: Cambridge University Press, 1988); Lewis Pyenson, 'Science and Imperialism', in Robert C. Olby, Geoffrey N. Cantor, John R.R. Christie and M.J.S. Hodge, eds, *Companion to the History of Modern Science* (London & New York: Routledge, 1990), pp. 920–33; Petitjean, *et al.*, eds, *op. cit.*; S. Irfan Habib and Dhruv Raina, eds, *Situating the History of Science: Dialogues with Joseph Needham* (Delhi: Oxford

knowing. In the hands of religious and political extremists, this has led to a lot of chauvinistic gerrymandering, if not pure historical falsification.[8]

We are then presented with the following dilemma. Are we to understand modern science purely as an emanation out of West Europe, constituting the Great Divide between the West and the Rest, and reaching non-European peoples only as they come into contact with Europeans and capitalism? Or are we to think solely in terms of competing nationalist narratives claiming precedence in scientific reasoning for their respective societies?

One way out of this predicament has been to question the moral and political values of modern science. Indeed, there have been plenty in recent times who have sought to denounce science—and all other institutions of modernity—as alienating and dehumanizing, and, in certain cases, to open up alternative visions of what science might be.[9]

University Press, 1999); and Roy M. MacLeod, ed., *Nature and Empire*, *Osiris* (2nd series), vol. 15 (Chicago & London: University of Chicago Press, 2000). There are, of course, a few exceptions to this admittedly schematic presentation: see, notably, James E. McClellan III, *Colonialism and Science: Saint Domingue in the Old Régime* (Baltimore: Johns Hopkins University Press, 1992).

[8] For a sample of such work in the Indian context, see K. Ramasubramanian, M.D. Srinivas and M.S. Sriram, 'Modification of the Earlier Indian Planetary Theory by the Kerala Astronomers (*c.* 1500 AD) and the Implied Heliocentric Picture of Planetary Motion', *Current Science*, vol. 66 (1994), pp. 784–90; Saroja Bhate and Subhash Kak, 'Panini's Grammar and Computer Science', *Annals of the Bhandarkar Oriental Research Institute*, no. 72 (1993), pp. 79–94; Subhash Kak, 'Computational Aspects of the Aryabhata Algorithm', *Indian Journal of History of Science*, vol. 21, no. 1 (1986), pp. 62–71; idem, 'The Astronomy of the Vedic Altars and the Rgveda', *Mankind Quarterly*, vol. 33 (1992), pp. 43–55; idem, 'Early Theories on the Distance to the Sun', *Indian Journal of History of Science*, vol. 33 (1998), pp. 93–100; B.N. Narahari Achar, 'On the Astronomical Basis of the Date of Satapatha Brahmana: A Re-Examination of Dikshit's Theory', *Indian Journal of History of Science*, vol. 35, no. 1 (2000), pp. 1–19. For a critique of nativist positions, albeit from a narrowly scientistic perspective, see Meera Nanda, *Prophets Facing Backward: Science and Hindu Nationalism* (Delhi: Permanent Black, 2005).

[9] Theodor W. Adorno and Max Horkheimer, *Dialektik des Aufklärung. Philosophische Fragmente* (Amsterdam: Querido, 1947); Herbert Marcuse, *One-Dimensional Man: Studies in the Ideology of Advanced Industrial Society* (London:

More recently, in the wake of Foucault-inspired arraignments of modern science, the latter is now seen in some quarters as a hegemonic 'master narrative' of Western power, a discursive formation through which the rest of the world was simultaneously subjugated and relegated to the role of Europe's binarily opposed Other. The spread of Western science is, in this view, achieved by means of the often violent imposition of 'rationality' on cultures originally endowed with 'another reason'. However, far from replicating those in Europe, the resulting practices are, according to this view, but hybrid or pale copies of the former, valid only locally, in contrast to the supposed universality of the original—a mere travesty of Western knowledges.[10]

Their political appeal notwithstanding, these critiques tell us nothing of the nature of putative non-Western 'reason(s)' which, if only through the Manichaean thrust of their argument, are assumed to have preserved a pristine innocence through the millennia preceding contact with Europeans. More importantly, they share with the more optimistic earlier positions the widely accepted idea that there is something essential and unified called modern science which, like modernity itself, originated in West Europe and subsequently spread to the rest of the world. But does historical investigation bear out these assumptions?

Recent scholarship tends to belie these commonly considered articles of faith. Indeed, in the past two decades the claimed unity of modern knowledge practices across European space has been convincingly

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Routledge & Kegan Paul, 1964). See also Daryl E. Chubin and Ellen W. Chu, eds, *Science off the Pedestal: Social Perspectives on Science and Technology* (Belmont, CA: Wadsworth, 1989); and, for a more constructive critique, Jeet Pal Singh Uberoi, *The Other Mind of Europe: Goethe as a Scientist* (Delhi: Oxford University Press, 1984); and idem, *The European Modernity: Science, Truth and Method* (Delhi: Oxford University Press, 2002). See also Ashis Nandy, *Alternative Sciences* (Delhi: Allied Publishers, 1980).

[10] A typical example is Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton: Princeton University Press, 1999). See also David Arnold, *Science, Technology and Medicine in Colonial India* (Cambridge: Cambridge University Press, 2000); and, in a more nuanced form, Christophe Bonneuil, 'Mettre en ordre et discipliner les tropiques: les sciences du végétal dans l'empire français, 1870–1940', unpublished doctoral dissertation, Université de Paris VII, 1997.

demolished. In place of a unique 'modern science', it is now accepted that there are many national and local knowledge traditions and dynamics spread across most of North and West Europe, with diverse, and at times contradictory, intellectual agendas and influences throughout the early-modern and modern periods.[11]

Furthermore, a number of prominent imperial historians, although focusing primarily on the British empire, have called into question the concept of a simple diffusion to the rest of the world of the fundamental values of modernity—values such as democracy, justice, and the welfare state. They have argued that modernity and its institutions are not simple emanations from a pre-existing centre, but are rather the result of 'a complex saga of the collisions, compromises, and comings together' of England with the many countries it came to dominate, including Ireland, Scotland, and India. By focusing on the processes of construction, they thus imply that Great Britain, its modern institutions, and its empire were co-constituted.[12]

In an unrelated but parallel tendency, colonial historians too have widened the focus of their studies from 'the colonized' to the contingent and shifting political terrain on which the very categories of colonized and colonizer have been shaped and patterned at different times and spaces through a dialectic of contestation and refashioning of European claims to superiority.[13] Although more sensitive to the

[11] See Roy Porter and Mikuláš Teich, eds, *The Scientific Revolution in National Context* (Cambridge: Cambridge University Press, 1992); and idem, eds, *The Enlightenment in National Context* (Cambridge: Cambridge University Press, 1981).

[12] I refer here to David Washbrook, 'From Comparative Sociology to Global History: Britain and India in the Pre-History of Modernity', *Journal of the Economic and Social History of the Orient*, vol. 40, no. 4 (1997), pp. 410–43; various writings of Burton Stein, David Cannadine and, most notably, Christopher Alan Bayly, *Imperial Meridian: The British Empire and the World, 1780–1830* (London: Longman, 1989). The quotation is from Linda Colley, 'Clashes and Collaborations', *London Review of Books* (18 July 1996), p. 8.

[13] For a critical review of recent literature on the impact of intercultural encounter on both colonizers and colonized, see Frederick Cooper and Ann Laura Stoler, 'Between Metropole and Colony: Rethinking a Research Agenda', in idem, eds, *Tensions of Empire: Colonial Cultures in a Bourgeois World* (Berkeley, Los Angeles, London: University of California Press, 1997), pp. 1–56.

politics of power, this trend in colonial studies finds a sympathetic resonance in recent and growing scholarship in the history and anthropology of encounter, the central underlying theme of which is that implicit understandings influence every culture's ideas about itself and others. These understandings, however, are changed by experience in a constantly shifting process in which both sides participate, and that makes such encounters complex historical events and moments of discovery.[14]

Finally, historians, sociologists, and philosophers of science have in the past decades radically undermined the traditional understanding that modern science has its own logic of development based on rigorous, immutable, explicit, and empirically tested rules and methods which lie beyond the pale of social and historical analysis. Moving away from a conception of science as a system of formal propositions or discoveries, these recent studies seek to understand the making, maintenance, extension, and reconfiguration of scientific knowledge by focusing equally on the material, instrumental, corporeal, practical, social, political, and cognitive aspects of knowledge. Systematically opting for detailed case studies of the processes through which knowledge and associated skills, practices, and instruments are created in preference to grand narratives or 'big-picture' accounts, they have demonstrated the negotiated, contingent, and situated nature of the propositions, skills, and objects that constitute natural knowledge.

This new scholarship has convincingly shown that scientific research is not based on logical step-by-step reasoning but on pragmatic judgement, much as in the practical crafts. More importantly, and perhaps more surprisingly, scientific knowledge turns out on this showing to be local everywhere. Indeed, locating knowledge making in precise contexts of time and place—typically in enclosed spaces like laboratories, observatories, museums, cabinets of curiosities, botanical and zoological gardens, libraries, and hospitals—has been one of the principal accomplishments of these recent studies of science.

[14] See Stuart B. Schwartz, ed., *Implicit Understandings: Observing, Reporting, and Reflecting on the Encounters between Europeans and Other Peoples in the Early Modern Era* (Cambridge: Cambridge University Press, 1994); Martin Daunton and Rick Halpern, eds, *Empire and Others: British Encounters with Indigenous Peoples, 1600–1850* (Philadelphia: University of Pennsylvania Press, 1999).

Accounting for the mobility of natural knowledges beyond their site of origin—their spread and eventual universalization—has accordingly become another major concern. Scholars in science studies have convincingly shown that scientific propositions, artefacts, and practices are neither innately universal (because of their epistemological force) nor forcibly imposed on others. Rather, they disseminate only through complex processes of accommodation and negotiation, as contingent as those involved in their production. As one scholar has aptly put it, there is no 'algorithmic recipe' for successful replication.[15]

At the same time, mathematics and natural and experimental philosophy, long held to epitomize scientific knowledge, have progressively lost their pride of place to a host of other domains of natural knowledge, and now share increasing historical attention with subjects like navigational astronomy, natural history, medicine, and geographical exploration.[16] And, although the laboratory still remains the predominant site of knowledge production for science studies, some scholars have recently turned their attention to knowledge-making activities outside the strict precincts of segregated spaces. Attention has thus

[15] For an excellent introduction to these new approaches in the history, philosophy, and sociology of science, along with a substantial bibliography, see Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge University Press, 1998). Emblematic of the field is Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life* (Princeton: Princeton University Press, 1985); see also Adir Ophir and Steven Shapin, 'The Place of Knowledge. A Methodological Survey', *Science in Context*, vol. 4, no. 1 (1991), pp. 3–21; and Steven Shapin, 'Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science', *Transactions of the Institute of British Geographers*, vol. 23 (1998), pp. 5–12. The quote is from Harry M. Collins, *Changing Order: Replication and Induction in Scientific Practice* (London: Sage, 1985), p. 143.

[16] See, for instance, Nicholas Jardine, James E. Secord and Emma C. Spary, eds, *Cultures of Natural History* (Cambridge: Cambridge University Press, 1996); David Philip Miller and Peter Hanns Reill, eds, *Visions of Empire: Voyages, Botany and Representations of Nature* (Cambridge: Cambridge University Press, 1996); Marie-Noëlle Bourguet, Christian Licoppe and Heinz Otto Sibum, eds, *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to the Twentieth Century* (London & New York: Routledge, 2002); Pamela H. Smith and Paula Findlen, eds, *Merchants and Marvels: Commerce, Science, and Art in Early Modern Europe* (New York & London: Routledge, 2002).

turned to other sites of knowledge production, such as coffee houses, pubs, and breweries, albeit always within the European metropolis.[17] However, knowledge production in non-European spaces of modernity has not been studied by the social studies of knowledge tradition, having been largely left to anthropologists and other area studies specialists.[18]

Armed with these new findings, scholars have attempted to reframe our understanding of scientific activity in its complex relations with society, the state, and the economy. Science is thus not only taken to refer to the production of knowledge, but also to that of instruments, techniques, and services used in the production of knowledge. It refers equally to research for industrial applications and national prestige, to teaching and training of future generations of practitioners, and to the improvement of the public understanding of knowledge-making activities.[19]

This book lies at the intersection of these recent historiographical developments and understandings. It is an attempt to re-examine the nature of scientific knowledge making in the globalized space of early modernity in the context of European expansion. In particular, it looks at the role of intercultural encounter in the circulation of the specialized knowledges that constituted science in this period. It addresses the following questions: What was the nature of the vectors of knowledge transmission? Who were the agents involved in the transmission and appropriation of knowledge and skills in the spaces of intercultural encounter? Was this a simple process of diffusion and acceptance or was there an active process of reception and reconfiguration of the circulating knowledges and skills? If the latter, where—outside of European metropolitan centres—was knowledge being reconstructed

[17] See David E. Allen, *The Naturalist in Britain: A Social History* (London: Allen Lane, 1976); Anne Secord, 'Science in the Pub: Artisan Botanists in Early Nineteenth-Century Lancashire', *History of Science*, vol. 32, no. 3 (1994), pp. 269–315; Heinz Otto Sibum, 'Les gestes de la mesure: Joule, les pratiques de la brasserie et la science', *Annales HSS*, 53^{e} année, nos 4–5 (1998), pp. 745–74.

[18] See, however, Simon Schaffer, 'Golden Means: Assay Instruments and the Geography of Precision in the Guinea Trade' in Bourguet *et al.*, eds, *op. cit.*, pp. 20–50.

[19] See Michel Callon, ed., *La science et ses réseaux* (Paris: La Découverte, 1988).

and certified? What was the relationship of this knowledge with its metropolitan sibling? Were these knowledges transportable? If so, what happened in the process of displacement?

These questions are explored here by examining the historical record relating to one intercultural 'contact zone'—Europe–South Asia—between the late seventeenth and the late nineteenth centuries.[20] Given the range and duration of the encounter between South Asians and Europeans, as well as the existence of rich archival sources, this region provides the ideal opportunity to follow interactions between the different specialist cultures in the making of new knowledges.

By studying the construction of scientific knowledge in the contact zone itself, I hope not only to enlarge the scope of social studies of knowledge by bringing contact zones, along with novel historical source material, into their ambit as legitimate sites of scientific knowledge production, but also to show that important parts of what has been passed off as European, or Western, science were actually made elsewhere. This is part of the more general point that national and regional histories, especially since the first globalization of the sixteenth century, cannot be understood by limiting study to within their respective geographical boundaries.[21]

To be sure, this is not the first attempt to extend the locus of modern scientific knowledge construction beyond West Europe. In doing so,

[20] I take the term 'contact zone' from Mary Louise Pratt, *Imperial Eyes: Travel Writing and Transculturation* (London & New York: Routledge, 1992), pp. 6–7, as a convenient way to denote the space where peoples with different cultural and geographical origins and histories meet and establish ongoing relations, 'usually involving conditions of coercion, radical inequality, and intractable conflict'. As such, the 'contact zone' is an extension of the concept of the frontier in American historiography from a fixed geographical and temporal entity to a process of social, economic, and, sometimes, military intersection and interaction between different social and ethnic groups. See Richard White, *The Middle Ground: Indians, Empires, and Republics in the Great Lakes Region, 1650–1815* (Cambridge: Cambridge University Press, 1991); and James H. Merrell, *Into the American Woods: Negotiators on the Pennsylvania Frontier* (New York: W.W. Norton, 1999).

[21] This point is forcefully made in Serge Gruzinski, *Les quatre parties du monde. Histoire d'une mondialisation* (Paris: Éditions de la Martinière, 2004).

I follow the lead set by a small but growing number of scholars who have begun to study knowledge encounters in the context of the New World and the Pacific.[22] However, little attention has been focused on the other major contact zone, the Indian Ocean. And although inter-cultural scientific encounter in the South Asian context has recently been the subject of a major book, the discussion on science has been limited to debates *about* science and the status of scientific knowledge among learned South Asians and British in the nineteenth century—a second-order discussion and a step removed from the making of knowledge.[23]

The kinds of scientific knowledge considered here cover natural history, terrestrial surveying, map-making, law, linguistics, and public administration. Eclectic though the choice may at first sight seem to be, the grouping of modern legal, political, and administrative practices with the natural sciences is not fortuitous: recent research in the history of science has persuasively shown that quantitative objectivity in the modern sciences was significantly shaped by bureaucratic practices.[24]

Although none of its chapters addresses the subject directly, one of the aims of this book is to question the oft-used notion of 'colonial science' or 'colonial knowledge'. Such notions have been used to designate the classificatory and delineating discursive practices of European colonists relating to indigenous populations, languages, and objects in regions which they had come to dominate, practices that rendered

[22] See, for instance, Barbara E. Mundy, *The Mapping of New Spain: Indigenous Cartography and the Maps of the* Relaciones Geográficas (Chicago & London: University of Chicago Press, 1996); Merrell, *op. cit.*; Serge Gruzinski, *The Mestizo Mind: The Intellectual Dynamics of Colonization and Globalization* (New York: Routledge, 2002; French original published 1999); and Carmen Salazar-Soler, *Anthropologie des mineurs des Andes: Dans les entrailles de la terre* (Paris: Harmattan, 2002). For the Pacific, see Nicholas Thomas, *Entangled Objects: Exchange, Material Culture, and Colonialism in the Pacific* (Cambridge, MA: Harvard University Press, 1991).

[23] See Christopher Alan Bayly, *Empire and Information: Intelligence Gathering and Social Communication in India, 1780–1870* (Cambridge: Cambridge University Press, 1996).

[24] See Theodore M. Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life* (Princeton: Princeton University Press, 1995).

colonial rule possible.[25] The knowledges thus acquired are said to have a local or geographically circumscribed status, inasmuch as they apply specifically to each region and are thus not part of supposedly universal, or mainstream, science. As much through its stress on intellectual and material practices—rather than just on discursive ones—as through the variety of domains (both in the natural and social sciences) it examines, this book aims to advance an alternative vision of the construction and spread of scientific knowledge through reciprocal, albeit asymmetric, processes of circulation and negotiation, a vision at odds with current post-colonial thinking. The examples presented here try and demonstrate that South Asia was not a space for the simple application of European knowledge, nor a vast site for the collection of diverse information to be processed in the metropolis, nor indeed 'of complicated and complex knowledge created by Indians, but codified and transmitted by Europeans'.[26] On the contrary, South Asia was an active, although unequal, participant in an emerging world order of knowledge. As I shall endeavour to show, the contact zone was a site for the production of certified knowledges which would not have come into being but for the intercultural encounter between South Asian and European intellectual and material practices that took place here. In other words, although these knowledges had different trajectories in specialist communities in South Asia and Europe and were appropriated and integrated differently in the two regions (not least because of colonial domination), they partook of, and were constructed through, the same circulatory processes.

While drawing heavily upon the revisionist historiographies developed within recent imperial, colonial, and science studies, the perspective developed in this book nonetheless calls for a number of

[25] See, in particular, Bernard S. Cohn, *An Anthropologist Among the Historians and Other Essays* (Delhi: Oxford University Press, 1987); and idem, *Colonialism and its Forms of Knowledge: The British in India* (Princeton: Princeton University Press, 1996). See also Emmanuelle Sibeud, *Une science impériale pour l'Afrique? La construction des savoirs africanistes en France, 1878–1930* (Paris: Éditions de l'École des Hautes Études en Sciences Sociales, 2002).

[26] Bernard S. Cohn, 'The Command of Language and the Language of Command', in idem, *Colonialism and its Forms of Knowledge*, *op. cit.*, pp. 16–56; this quote p. 16.

displacements and relocations concerning the institutions, agents, practices, and objects so far studied, as well as a change in historiographical approach to take account of knowledge making in the globally distributed spaces of modernity.

In keeping with the shift from localities within the European metropolis to the contact zone without, attention needs to be turned away from the socially homogeneous enclosed spaces in which knowledges like pure mathematics and natural and experimental philosophy were formed, to the 'open air', where natural history and medicine, surveying and map-making, and linguistics and administrative sciences—domains characteristic of the extra-metropolitan context—were developed. I owe the expression 'open air' sciences to Michel Callon, who coined the term '*recherche de plein air*' to designate knowledge practices that necessarily involve negotiations between specialists and other heterogeneous groups in their very making and certification. These practices, as Callon stresses, are fundamentally different from 'field' sciences where practitioners simply take the world outside the confines of the laboratory to be an inanimate space for collecting data, which is then centralized and processed in the secluded calm of the laboratory.[27] Open air practices are, however, no less locally inscribed, inasmuch as knowledge constructed in one open air space has its specificities which distinguish it from others constructed in other open airs, in the same way as do knowledges constructed in different laboratories.

The areas of open air knowledge considered here, it is useful to remember, were often no less mathematically based than their indoor siblings and, with them, fed on a common core of material and social practices. Indeed, much important work even within European learned academies has focused on areas such as terrestrial surveying and mapping, for which institutions like the French *Académie Royale des*

[27] See Michel Callon, Pierre Lascoumes and Yannick Barthe, *Agir dans un monde incertain* (Paris: Le Seuil, 2001), p. 136 *et seq*. See also Henrika Kuklick and Robert E. Kohler, eds, *Science in the Field*, *Osiris*, (2nd series), vol. 11 (Chicago & London: University of Chicago Press, 1996); and Robert E. Kohler, *Landscapes and Labscapes: Exploring the Lab-Field Border in Biology* (Chicago & London: University of Chicago Press, 2002).

Sciences was best known during the seventeenth and eighteenth centuries.[28]

However, it was not the learned academies and universities, the traditional loci of knowledge-making activity in Europe, which were directly involved in producing knowledge overseas, although they often planned and oversaw transcontinental, and trans-oceanic, exploratory expeditions. Our second displacement thus requires a shift in focus to overseas trading companies which, along with religious missions, accounted for the main European institutions involved in overseas encounters, in particular with South Asia. Surprising as this might at first sound, trading houses, like the various European East India companies, played a central role in the early-modern knowledge-making process.[29] It is useful to remember that Gresham College, the forerunner of the Royal Society, was founded by a group of traders—the Mercer's Company.[30] And recent research has clearly brought to the fore the important part played by trading companies—as patrons of technicians and philosophical demonstrators—in transporting natural philosophy from exclusive areas such as Gresham College into

[28] Josef W. Konvitz, *Cartography in France 1660–1848: Science, Engineering, and Statecraft* (Chicago & London: University of Chicago Press, 1987).

[29] The recognition of the importance of trading companies to modern scientific knowledge formation has been slow amongst historians. See, however, Johan Leonard Blussé and Ilonka Ooms, eds, *Kennis en Compagnie: De Verenigde Oost-Indische Compagnie en de moderne Wetenshap* (Amsterdam: Balans, 2002); and Richard W. Hadden, *On the Shoulders of Merchants: Exchange and the Mathematical Conception of Nature in Early Modern Europe* (Albany, NY: State University of New York Press, 1994) which argues that the quantification of modern science evolved from commercial book-keeping and reckoning practices developed by merchants in the sixteenth and seventeenth centuries, and that the mechanistic view of nature grew out of day-to-day practices of social and economic relations. See also Steven J. Harris, 'Long-Distance Corporations, Big Sciences, and the Geography of Knowledge', *Configurations*, vol. 6, no. 2 (1998), pp. 269–304; and Frank J. Swetz, *Capitalism and Arithmetic: The New Math of the 15th Century* (La Salle, Il.: Open Court, 1987).

[30] Christopher Hill, *The Intellectual Origins of the English Revolution* (Oxford: Clarendon Press, 1965), pp. 33–4; and Francis R. Johnson, 'Gresham College: Precursor of the Royal Society', *Journal of the History of Ideas*, vol. 1, no. 4 (1940), pp. 413–38.

the wider European metropolitan public space.[31] Indeed, corporate commerce was quick to recognize that the continued existence and expansion of European overseas trade was largely dependent on scientific expertise and associated material practices. Thus, right from their inception, the trading companies supported and even employed mathematicians, practical astronomers, and hydrographers for navigation, and medics for treating crews and identifying commercially viable plants or derived products overseas.[32] They were thus key actors in the early modern enterprise of knowledge making and use.

For all that, trading companies did not simply stand beside learned societies as agents for the spread of natural philosophy, natural history, and practical mathematics. Quite the contrary, the worlds of trade and learning were very closely intertwined. Men of science invested substantial sums of money in international commerce. To take the case of England once more, a number of eminent Fellows of the Royal Society, like Robert Boyle, Isaac Newton, and Joseph Banks, to name but some of the most well known, counted among the directors or major shareholders of the likes of the English East India Company (hereafter EIC)—the longest lasting and most powerful of the British trading groups—or the South Sea Company. Initially enticed by the attractive dividends, reaching up to 20 per cent, offered by these investments, such men also found in it a sure means of raising their credit.[33] This in turn led to a more structured and durable relation between corporate trading groups and learned societies. For example, the Royal Botanic Gardens at Kew, under the leadership of Joseph Banks (who was

[31] Larry Stewart, 'Other Centres of Calculation, or, Where the Royal Society Didn't Count: Commerce, Coffee-Houses and Natural Philosophy in Early Modern London', *British Journal for the History of Science*, vol. 32, no. 2 (1999), pp. 133–53; and Jerry Brotton, *Trading Territories: Mapping the Early Modern World* (London: Reaktion Books, 1997).

[32] Harold J. Cook, 'Physicians and Natural History', in Jardine *et al.*, eds, *op. cit.*, pp. 91–105.

[33] Credit is taken here to refer to trust, authority or honour, and, at the same time, to the new social relations between the stockholder and the merchant. See Simon Schaffer, 'Defoe's Natural Philosophy and the Worlds of Credit', in John R.R. Christie and Sally Shuttleworth, eds, *Nature Transfigured: Science and Literature 1700–1900* (Manchester: Manchester University Press, 1989), pp. 13–44.

also president of the Royal Society), played an essential part in the economic management of Bengal by the EIC, and of Polynesia and the West Indies by the British government: British botanists selected the most profitable species of plants and a part of South Asia's agricultural production thus served to finance the import of tea and porcelain from China.[34] Some learned societies were even founded by employees of the EIC. The Royal Astronomical Society founded in 1820 by Henry Thomas Colebrooke (1765–1837), senior merchant of the Company, surveyor, Sanskritist, and historian of Hindu astronomy, is a good example.

Throughout the eighteenth and nineteenth centuries, a growing number of graduates from Scottish and North European universities in search of employment were absorbed into the ever-expanding overseas services of trading groups to occupy senior technical positions. There, as diplomats and military men, many of them reinforced the nexus between large-scale international trade and science. As engineers, veterinarians, doctors, naturalists, and geographers they could acquire substantial antiquarian collections and herbariums, thus gaining sufficient credit in order to become gentlemen scholars on returning home, further reinforcing the links between trading companies and learned societies in the European metropolis.[35]

But trading companies were also major employers of less-well-educated young men seeking to make a quick fortune and pick up new skills which they might put to profit upon their return to the metropolis. Some of these were to become prominent men of science. Thus, for example, Alexander Dalrymple (1736–1808), perhaps the ablest

[34] See Lucile H. Brockway, *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens* (New York: Academic Press, 1979); and John Gascoigne, *Science in the Service of Empire: Joseph Banks, the British State and the Uses of Science in the Age of Revolution* (Cambridge: Cambridge University Press, 1998).

[35] Huw V. Bowen, *Elites, Enterprise and the Making of the British Overseas Empire* (London: Macmillan, 1996). See also P.E. Razzell, 'Social Origins of Officers in the Indian and British Home Army: 1758–1962', *British Journal of Sociology*, vol. 14, no. 3 (September 1963), pp. 248–60. The strong presence of Scotsmen amongst European medical practitioners overseas is revealed for instance in Dirom Grey Crawford, *A History of the Indian Medical Service, 1600–1913*, 2 volumes (London: W. Thacker & Co., 1914).

hydrographer of his day, learned his trade while a merchant in the employ of the EIC. Soon after returning to Britain in 1777, he served as hydrographer to the Company before acceding to the same office with the Admiralty in 1795. These men, both more and less educated initially, along with their indigenous counterparts, thus constituted an invaluable population of mediators, or go-betweens, in the intercultural knowledge encounter with South Asia; they were mediators without whom the encounter could not have been sustained.

In attending to the lives and careers of some of these men, this book further shifts the locus of interest in the nexus between corporate trade and science from the European metropolis to the contact zone and to the dynamics of intercultural encounter. In so doing it turns away from the customary history of science as a narrative of the lives and works of its well-known heroes operating within the networks of a putative (European) 'Republic of Letters'. By focusing on the itineraries of initially unremarkable employees of trading companies who acquired their knowledge skills half a world away from the traditional venues of European learning and who introduced these skills into the mainstream of early-modern science, I shall attempt to bring to light some of the less-well-known practices and processes through which both modern science and many careers in science were fashioned.

Instead, then, of looking at sedentary lives, this book turns its attention to transformations in knowledge practices and in the men who embodied them, as they circulated, negotiated, and reconfigured their skills in the contact zone. It is important to stress that most of these men left Europe between the ages of fourteen and eighteen, and their years spent in distant lands were crucially formative. As they moved across seas and continents and encountered different skilled practitioners, their own interests, ambitions, and skills were transformed. As representatives of commercial, and later colonial, institutions, the skills they embodied were also incorporated into these institutions, and, in that sense, their expertise did not impact on metropolitan science alone, but simultaneously produced effects on a global scale.

Because of their commercial activity, European trading companies were obliged to develop intimate connections with traders and trading groups in other parts of the world, particularly in the Indian Ocean world, where Europeans were one of many players in the thriving

regional commercial networks which pre-existed their appearance in the region. This gave rise to new groups of specialized intermediaries only through whom did European trading houses have access not only to local commodities, but also to specialized knowledges crucial to their survival and to sustained trade.[36] These knowledges included the identification and value of potentially lucrative products, ranging from plants, herbs, and animals, to manufactured commodities, their geographical distribution, accounting and trading conventions, the maintenance and repair of ships and navigation, to name but a few. It is important to notice that the geographies of trade and knowledge networks thus largely overlapped not only in Europe but also in the Asian and Indian Ocean worlds, and it is this crucial shared connection which underwrote the intercultural knowledge encounter in the region.[37]

By looking at the indigenous groups which interacted durably with Europeans, we shall also follow the manner in which these groups participated in the making of scientific knowledges, artefacts, and practices; how they appropriated and eventually deployed them strategically to renegotiate their positions in the emerging colonial regime. We shall also examine their attempts at setting up educational curricula to institutionalize the new learning.[38] It is important, then, to note

[36] On the ineluctability of intermediaries, see Georges Roques, *La manière de négocier aux Indes 1676–1691* (Paris: École Française d'Extrême-Orient, 1996).

[37] Indeed, this book is deeply inspired by the perspective of connected histories laid out by Sanjay Subrahmanyam. See his 'Connected Histories: Notes Towards a Reconfiguration of Early Modern Eurasia', *Modern Asian Studies*, vol. 31, no. 3 (1997), pp. 735–62; idem, *Explorations in Connected History*, 2 volumes (Delhi: Oxford University Press, 2005). See also Frederick Cooper, 'Conflict and Connection: Rethinking Colonial African History', *American Historical Review*, vol. 99, no. 5 (1994), pp. 1516–45.

[38] This last aspect has been the principal focus of S. Irfan Habib and Dhruv Raina's groundbreaking work on the response to, and appropriation and reconfiguration of, modern science in northern India. However, they have mainly concentrated on the second half of the nineteenth and the early twentieth centuries—at the end of the period studied in the present book. This work has been recently republished in a single volume: see Dhruv Raina and S. Irfan Habib, *Domesticating Modern Science: A Social History of Science and Culture in Colonial India* (New Delhi: Tulika Books, 2004).

that this book stresses how self-shaping of the mediating agents on both sides of the encounter took place in the same breath as the shaping of scientific knowledge, of the institutionalization of encounter, and of empire.[39]

One of the principal focuses of the chapters that follow is therefore the historical contingency and mutation of existing notions and practices that movement itself introduces.[40] Indeed, this focus on circulation itself as a 'site' of knowledge formation constitutes a major change in approach with respect to science studies orthodoxy. For, as outlined above, social studies of science have so far, albeit implicitly, separated three moments in the making of knowledge: the collection of information or objects; their accumulation and processing within the local and segregated space of the laboratory; and, finally, the spread—and eventual universal acceptance—of the knowledge thus engendered. If most science studies scholars, when following the peregrinations of materials acquired in the field to the laboratory, and then of machines, instruments, printed (or written) results from their site of invention to other places on the globe, do not actually take for granted the supposedly immutable nature of both input and output, they do not deal with their mutations in the course of these displacements.[41] However, it is precisely the *mutable* nature of the materials—of the

[39] The concept of mediating agent in intercultural encounter has been thematized in Louise Bénat Tachot and Serge Gruzinski, eds, *Passeurs culturels: mécanismes de métissage* (Paris: Presses Universitaires de Marne-la-Vallée and Éditions de la Maison des Sciences de l'Homme, 2001).

[40] In focusing in this way on circulation, I follow the lead set by Claude Markovits, Jacques Pouchepadass and Sanjay Subrahmanyam, eds, *Society and Circulation: Mobile People and Itinerant Cultures in South Asia 1750–1950* (Delhi: Permanent Black, 2003).

[41] See, for instance, David N. Livingstone, *Putting Science in its Place: Geographies of Scientific Knowledge* (Chicago & London: University of Chicago Press, 2003). And at least one eminent scholar has actually proposed the construct of 'immutably mobile inscriptions' to account for the possibility of spread and universalization of scientific knowledge. See Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Milton Keynes: Open University Press, 1986), chapter 6. A recent book on the subject of intercultural scientific encounter is also based on a similar model. See Fa-ti Fan, *British Naturalists in Qing China: Science, Empire, and Cultural Encounter* (Cambridge, MA & London: Harvard University Press, 2004).

men themselves and of the knowledges and skills which they embodied—as also their transformations and reconfigurations in the course of their geographical and/or social displacements, that the focus on circulation helps bring to the fore.[42]

This shift in attention to circulation does not, however, imply that localities lose their meaning. On the contrary, each chapter seeks to ground the circulation of knowledge and knowledge-related practices in specific localities, from the early European littoral trading settlements to the colonial and metropolitan states and, indeed, beyond—into the Transhimalaya. Indeed, it is one of the main contentions of this book that localities constantly reinvent themselves through grounding (that is, appropriating and reconfiguring) objects, skills, ideas, and practices that circulate both within narrow regional or transcontinental—and indeed global—spaces.

The book is composed of six chronologically arranged chapters relating to encounter in different knowledge domains. Every chapter is a case study of a major scientific work, personality, institution, or project. Each of the cases selected is highly significant in its own area of knowledge. Each represents a major event in the history of science, society, and politics in South Asia as much as in Europe—and thus claims to be representative (if even in their 'exceptional normality', as in the first chapter) of scientific development in the period under consideration.[43] As such, the chapters may be read independently of each other, but when read together my hope is that they contribute

[42] A burgeoning interest in circulation as a site of knowledge-making is attested to in at least two recent publications by eminent historians of science, technology and medicine. See Yves Cohen, 'The Soviet Fordson. Between the Politics of Stalin and the Philosophy of Ford, 1924–1932', in Hubert Bonin, Yannick Lung and Steven Tolliday, eds, *Ford, 1903–2003: The European History*, 2 volumes (Paris: PLAGE, 2003), vol. 2, pp. 531–58; and Maneesha Lal, 'Purdah as Pathology: Gender and the Circulation of Medical Knowledge in Late Colonial India', in Sarah Hodges, ed., *Reproductive Health in India: History, Politics, Controversies* (New Delhi: Orient Longman, 2006), pp. 85–114. See also Stéphane Van Damme, *Paris, capitale philosophique de la Fronde à la Révolution* (Paris: Odile Jacob, 2005). It is also significant to note that the last quadrennial joint meeting of the British, Canadian, and American history of science societies, held in Halifax, Canada, in August 2004 had as its theme 'Circulating Knowledge'.

[43] The term 'exceptional normal' was coined by the Italian microhistorian Edoardo Grendi to refer to out-of-the-way historical cases which, because of

to a big-picture account of the changing nature of this particular intercultural encounter—from the eighteenth-century pre-colonial context of informal networks based on individual relationships to the late-nineteenth-century colonial one of large, hierarchized institutions—and the specific problems of scientific knowledge construction to which they give rise. When read as a whole, this book then bears upon the questions posed by Needham and Basalla as to the making and spread of modern science. However, by disrupting the diffusionist centre–periphery framework (and blurring the dichotomy) which underpins these questions—and which is, indeed, implicit in much of the social studies of knowledge tradition when it comes to setting modern science in a global context—it points to a completely different set of answers. By following the conduits and heterogeneous networks of exchange through which transfers of knowledge passed, by locating the spaces of circulation between South Asia and Europe in which they acquired meaning, and finally by focusing on the appropriation and grounding of these knowledges in specific localities within these spaces of circulation, this book seeks to throw new light on the co-production of the local and the global.

Each case study also deals with at least one important aspect of knowledge making. For, alongside the radical redefinition of science by social studies of knowledge, new approaches, new divisions, and above all legitimate new lines of inquiry have emerged. Each case study is organized around one or more questions that have been at the heart of much recent research in science studies: trust, replicability, calibration, standardization, action at a distance, the relationship between instruments and embodied skills, and translation. Thus, while the book is mainly about the history of scientific knowledge, this sociological, cultural, and anthropological focus will, I hope, make a further contribution in bringing this traditionally isolated, and daunting, domain of history into the ambit of mainstream history and its debates.

The book opens in the last decades of the seventeenth century. Making inventories of local flora was crucial to European nations engaged

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their unique and non-representative nature, bring into greater perspective the prevalent norms and conventions of the period. See Edoardo Grendi, 'Microanalisi e storia sociale', *Quaderni Storici*, vol. 7 (1972), pp. 506–20.

in ever-increasing trade networks across the globe during the seventeenth and eighteenth centuries. A knowledge of plants and their uses was important not only for introducing new commodities on the European markets but also to maintain the health of the thousands of sailors and traders who found themselves in hostile climes when in the tropics. The Portuguese, the Dutch, the English, and the French prepared voluminous herbals of Asian plants. A fourteen-volume painted herbal containing more than 700 Indian plants painted by Indian artists, commissioned by a French surgeon in Orissa at the end of the seventeenth century, and the correspondence associated with this project, helps us better understand the character of the early Indo-European economic and social networks that made such works possible. It also brings to light the complex processes of intercultural negotiation and collaboration involved in the making and legitimization of this botanical and medical knowledge.

In opposition both to the dominant vision of colonial science as a hegemonic European enterprise whose universalization can be conceived of in purely diffusionist terms, and to the more recent perception of it as a simple reordering of indigenous knowledge within the European canon, the second chapter seeks to show the complex reciprocity involved in the making of cartography within the colonial context. Focused on the early decades of British colonial conquest in South Asia and the formalization of intercultural encounter through the creation of administrative, military, and technical institutions which employed both Europeans and South Asians, it examines the resultant knowledge practices that co-emerged in terrestrial surveying and cartography in India and Britain. While noting that these practices were significantly different in each region—the former depending crucially on the accounts of indigenous travellers and surveyors, the latter mainly on trigonometrical instruments—the chapter nonetheless shows that the knowledge created in each context, while local in nature, nevertheless participated wholly in the emergence of transnational cartography.

Recent research in the history and sociology of science has convincingly shown that the certification of knowledge is inextricably dependent on practical solutions to problems of trust, authority, and moral order. 'Scientific knowledge is as secure as it is taken to be, and

it is held massively on trust', writes Steven Shapin. 'The recognition of trustworthy persons is a necessary component in building and maintaining systems of knowledge, while bases of that trustworthiness are historically and contextually variable.'[44] The social construction of truth and objectivity has been the subject of much recent work in science studies, emphasizing the homogeneous social status of scientific practitioners, and shared norms of civility as the principal factor conferring legitimacy to truth claims in early-modern Europe. However, the reliability of knowledge constructed beyond the closed walls of learned societies—especially knowledge constructed outside Europe—was acutely difficult to establish, and peripatetic men of science and travellers devised various strategies to secure the truth status of their testimonies. The problem assumed a qualitatively different dimension for the British in South Asia in the late eighteenth century in view of the sheer mass and diversity of knowledge being constructed in the colonial context. The third chapter thus casts William Jones's contributions to jurisprudence and linguistics as strategies aimed at establishing the common origins of speakers of Sanskrit, Latin, and Greek—namely Indian pundits and British gentlemen—thus arguing the potential for establishing a common civility. In this way it was possible to legitimize the nascent multicultural administrative, scientific, technological, and legal institutions required for colonial rule. At the same time, it was, as will be seen, these very contributions through which Jones shaped himself in order to be recognized as the founder of comparative linguistics and the monogenetic ethnology of the early nineteenth century.

The end of the eighteenth century saw Great Britain and its empire under severe threat from revolutionary France, both through its military strength and the force of its egalitarian ideals. In 1800, in an attempt to halt the propagation of the 'erroneous principles' of the French Revolution among its European employees, the EIC founded a college at Fort William in Calcutta. There, the future functionaries of the Company were taught European science and literature as well as the languages, sciences, philosophies, and stratified structure of

[44] Steven Shapin, 'Here and Everywhere: Sociology of Scientific Knowledge', *Annual Review of Sociology*, vol. 21 (1995), pp. 289–321.

Indian societies, so as to inculcate in them the 'true principles of religion and government'. Students of this college had as teachers not only British orientalists but also Indian pundits and munshis. In 1806, part of the teaching was moved to England, and some of the Indian teachers were also transferred to teach alongside the likes of the political economist Thomas Malthus. This seemingly unnatural alliance partook of a larger movement in England where reformers, allied with men of science, propagated a social and political model founded on global inequality, diametrically opposed to the universalist ideals of the French Revolution. The fourth chapter seeks thus to show that British orientalism in Bengal, far from constituting a discursive formation through which the 'Orient' was subjugated and relegated to the role of the binarily opposed other of an omnipotent 'Occident', was a powerful rhetoric aimed at forging an alliance between the British and Hindu elites in order to confine and finally vanquish the French and their ideology.

This recasting of British orientalism, and the general background of centuries of collaboration between South Asians and Europeans, enable us also to observe the reconfiguration of knowledge within South Asian society. The book now turns to the founding of Hindu College in Calcutta in 1816. This is commonly presented as the result of the intellectual awakening of Bengali Hindu elites through the transmission of British orientalist ideals. Although the college was founded for the sole purpose of educating *bhadralok* boys in European arts and sciences, a close examination of the choice and content of the scientific subjects in the syllabus shows that these differed substantially from those taught at the time in Britain, or even at Fort William. The argument here is that, contrary to conventional diffusionist wisdom, the transmission and reception of knowledge is an active process significantly fashioned by historico-cultural *a priori* of the agents—in this case, through the ideals of science projected in English and Scottish Enlightenment thought and through the interpretation that the *bhadralok* gave to these in their bid to legitimize themselves in the colonial context.

Stress has been put in recent science studies upon the incarnate nature of scientific knowledge and the embodied vectors by which it travels, whether that embodiment reposes in skilled people, scientific

instruments, or the transactions between people and knowledge-making devices.[45] The last chapter shows how the intercultural encounter in knowledge making extended also to the modification and adaptation of already existing scientific instruments and apparatus as well as to the conception and construction of entirely new ones. It analyses the well-known story of the late-nineteenth-century Indo-British survey of Transhimalayan Central Asia immortalized in Kipling's *Kim* and shows how the colonial and larger geo-political contexts shaped the methods and instruments used in one of the largest and most accurate mappings of the period. Indeed, the whole system was structured around a reconfiguration of embodied and instrumental competencies as employed in the Great Trigonometrical Survey of India, perhaps the most prestigious scientific institution of the British empire. Thus, through its study of the redistribution of the functions of the podometer, the sextant, and the magnetic compass in the bodies and apparel of Indian surveyors disguised as Tibetan Buddhist monks, the chapter attempts to understand the way in which local and *prima facie* outmoded techniques can be made to produce highly accurate, reliable, and reproducible knowledge on the one hand, and to create an 'Anglo-Indian' identity on the other. In so doing, it shows the tools of empire in a slightly different light from the largely accepted vision.[46]

[45] See the classic study of Harry M. Collins and Robert G. Harrison, 'Building a TEA Laser: The Caprices of Communication', *Social Studies of Science*, vol. 5, no. 4 (1975), pp. 441–50. See also Simon Schaffer, 'Glass Works: Newton's Prisms and the Uses of Experiment', in David Gooding, Trevor J. Pinch and Simon Schaffer, eds, *The Uses of Experiment: Studies in the Natural Sciences* (Cambridge: Cambridge University Press, 1989), pp. 67–104; idem, 'Self Evidence', *Critical Inquiry*, vol. 18, no. 2 (1992), pp. 327–62; and idem, 'Late Victorian Metrology and Its Instrumentation: A Manufactory of Ohms', in Robert Bud and Susan E. Cozzens, eds, *Invisible Connections: Instruments, Institutions, and Science* (Bellingham, WA: SPIE, Optical Engineering Press, 1992), pp. 23–56.

[46] See Daniel R. Headrick, *The Tools of Empire: Technology and European Imperialism in the Nineteenth Century* (New York: Oxford University Press, 1981); idem, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850–1940* (New York: Oxford University Press, 1988); and Michael Adas, *Machines as the Measure of Men* (Ithaca: Cornell University Press, 1990).