CHAPTER 1
INTRODUCTION: SCIENCE, COLONIALISM AND MODERNITY

The questions that can be asked about science in modern India are essentially those pertaining to the history and sociology of science elsewhere. What is the social character of scientific knowledge? Who produces science and why? How does science exercise authority within a society and across cultural divides? As historians and sociologists have begun to investigate science, less in terms of its self-declared aims and putatively objective interrogation of nature and more in terms of its internal ordering, social construction and cultural authority, it has become clear that science is 'a highly social activity', one that cannot be 'sealed off from the values of the society in which it is practised'.

It is increasingly recognised, too, if not yet universally accepted, that science, far from being monolithic, manifests itself across time and cultures in myriad forms, reflecting as much as informing a given society's cultural, economic and political modalities. Science thus 'reveals itself as much more contingent and culturally specific' than it was once assumed to be.

Individuals and groups produce scientific knowledge not in isolation but 'against the background of their culture's inherited knowledge [and] their collectively situated purposes' as well as through 'the information they receive from natural reality'.

The social character and cultural plurality of science has a particular bearing on the history of science, technology and medicine in India, which had a well-established scientific and technological tradition of its own long before being subjected to an extended period of European colonial rule. Although the history of science, technology and medicine continues to be presented in general histories as a record of Western discovery and dissemination, it has become more widely acknowledged than a generation or two ago that not all such histories can be conflated into a single story of European achievement or saga of European enterprise overseas. Particular attention has been directed to understanding the place of science in the colonial world of the eighteenth, nineteenth and early twentieth centuries, in situations in which the history of


2 Stepan, 'Eugenics', p. 10.

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Science often appears inseparable from the history of imperialism itself. Yet, at the same time, in order to understand the social authority and cultural context of science, it is necessary to look beyond the imperial system, beyond its ideologies and instrumentalities, and to look at the ‘recipient’ society and the manner in which Western science was received and situated in relation to indigenous epistemologies and practices. A history of science in India must also be a history of India, not merely a history of the projection of Western science onto India. One of the principal rationales for a work such as this, which seeks to give an interpretative overview of science, technology and medicine in India from the late eighteenth to the mid-twentieth centuries, must be that there is a new recognition of the centrality of science to an effective understanding of the history of India during the period marked by the rise, ascendency and retreat of British colonialism in South Asia.

It will be argued here, by way of introduction, that there were three main elements that broadly typified science, technology and medicine in India over this 200-year period. Firstly, there were the traditions of India’s own science, technology and medicine, themselves subject to wide internal variations and different historical influences and cultural practices, and the legacies these provided for the subsequent era of British rule. Secondly, there was the nature of Western (or ‘colonial’) science, technology and medicine as practised in India, their social and intellectual impact, their organisational forms and dual relationship to the colonial regime in India and to metropolitan science in Europe. And thirdly, there was the authority of science, technology and medicine as central attributes of India’s modernity, drawing upon indigenous as well as Western sources and finding contested expression in both imperial ideology and nationalist agendas. We will briefly consider each of these in turn.

INDIA’S SCIENTIFIC TRADITIONS

It would be erroneous to think of India as having a single scientific tradition. Over the millennia, India became heir to a wide variety of different oral and textual traditions, drawing upon exogenous contacts as well as indigenous roots. This plurality makes it difficult not only to characterise Indian science as a whole but also to determine the precise nature of its interaction with the forms of science and technology emanating from the West by the late eighteenth and early nineteenth centuries. Even within what is often thought of as the ‘Hindu’ tradition, there were several strands of scientific ideas and

practices, including a tradition of empirical, observational science (particularly developed in astronomy and medicine) that functioned alongside, and often in tandem with, various cosmological and astrological beliefs. Whereas astronomy in Vedic India was often closely connected with religious practice (because an accurate knowledge of equinoxes and solstices was needed for the proper timing of sacrifices and other rites), in the post-Vedic and early medieval period the study of astronomy, trigonometry and algebra saw a partial move away from the earlier stimulus of religion and ritual. Thus, one of the most important texts of the later period, the *Surya Siddhanta*, composed around AD 400, devoted a series of chapters to the motion and position of the planets, the nature and timing of eclipses, the rising and setting of the sun and moon, and astronomical instruments such as the armillary sphere; but it also dealt with cosmogony and ‘certain malignant aspects of the sun and moon’.

Although the richness and diversity of India’s ancient scientific traditions has long been recognised, over the past two centuries it has been the convention to see this as a history of precocious early achievement followed by subsequent decline and degeneration. The European Orientalist scholarship of the late eighteenth and early nineteenth centuries represented India as having had an ancient civilisation equalling, in some respects excelling or anticipating, those of classical Greece and Rome. ‘The Asiatics had climbed the heights of science before the Greeks had learned their alphabet’, one enthusiast declared. In astronomy, mathematics and medicine in particular, Hindu science was considered to have been remarkably advanced well before the dawn of the Christian era and to have been the source of discoveries and techniques that were only later taken up and incorporated into Western civilisation, such as ‘Arabic’ numerals and the use of zero. However, according to this Orientalist interpretation, Indian civilisation was unable to sustain its early achievements and lapsed into decline. There followed an uncritical reliance upon earlier texts: tradition replaced observation as surely as religion supplanted science. This was in part attributed to an increasing rigidity in Hindu society of caste practices and religious belief, but also to the rise of Muslim power in South Asia after AD 1100. Although introducing some scientific and technical skills of its own, Islam was largely seen to have been destructive of the remnants of the old Indian civilisation. The breakup of the Mughal Empire after 1707, the division of India into warring factions and regional

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states, and the resulting age of 'anarchy' were adduced as further evidence for the stagnation and decay of Indian science, technology and medicine. The history of Indian science thus served as a mere prologue to the eventual unfolding of Western science in South Asia as science was rescued from centuries of decline and obscurity by the advent of British rule and the introduction of the more developed scientific and technical knowledge of the West. This Orientalist triptych – contrasting the achievements of ancient Hindu civilisation with the destruction and stagnation of the Muslim Middle Ages and the enlightened rule and scientific progress of the colonial modern age – has had a remarkably tenacious hold over thinking about the science of the subcontinent. It was a schema deployed not only by British scholars, officials and polemicists but also by many Indians, for whom it formed the basis for their own understanding of the past and the place of science in Indian tradition and modernity. It is still not uncommon for Indian writers to remark, with evident regret, that the ‘creative spirit’ of Indian science sunk to its ‘lowest ebb’ between the twelfth and the mid-nineteenth centuries.8

Of late, though, some historians of science have sought to break the Orientalist mould. One of the ways in which they have done so has been by looking afresh at the science, technology and medicine of medieval and early modern India, thus revealing the neglected importance of the Muslim contribution to India’s scientific traditions or illuminating the emergence, through science, of a dynamic and syncretic Indo-Muslim culture. Medicine has been particularly prominent in this historiographical trend. The mutual enrichment brought about by a ‘creative synthesis’ between Hindu Ayurveda and Unani-tibb, with its Graeco-Arabic origins, and the apparent absence of rivalry or enmity between its practitioners, the vaids and hakims, have served to exemplify the continuing vitality and fruitful intermingling of scientific traditions in India well into the eighteenth century, though one might equally argue that Unani physiology and pharmacology were interacting as much with the Indian environment and the region’s rich materia medica as with the Ayurvedic system as such.9 There has also been a new effort to demonstrate that India, far from existing in cultural and technological isolation and being averse to all innovation, had over the centuries borrowed extensively from, and contributed generously to, the scientific and technical knowledge of neighbouring regions, from the Middle East and Central Asia to China and Southeast Asia, and in

fields as diverse as agriculture, architecture, astronomy, chemistry, medicine, metallurgy, textile production, shipbuilding and armaments. This celebration of cultural eclecticism and trans-regional exchange aligns the history of Indian science more closely with the models of creativity, diffusion and interaction advanced for China, the Muslim Middle East and other non-European culture areas in recent decades, particularly through Joseph Needham’s magisterial account of Science and Civilisation in China and through other revisionist histories, such as Lynn White’s, that have authoritatively established Europe’s long-standing debt to Asian technology.

It follows from this revisionist argument that Europe did not impact upon a stagnant and unchanging India. From the late fifteenth century onwards, scientific, medical and technological exchanges continued through the agency and impetus of trade and warfare and through the migration of scholars, merchants, physicians and craftsmen. Contacts flourished in two main directions – with the wider world of Islam (linking India with Iran, Central Asia and the Middle East) but also, increasingly, with the expanding commercial and technological power of Europe. Astronomy, medicine, textiles and arms-making benefited from the fashioning of an Indo-Muslim polity and culture under the Mughals, but India also profited in such areas as shipbuilding and horticulture from contacts after 1498 with the Portuguese and later with the Dutch, French and English. If there remained a gulf between the craft technology of the uneducated artisan and the science of the literati, if there were few individuals before 1750 to whom one could convincingly apply the term ‘scientist’, then India was in these respects little different from early modern societies in Europe, China or elsewhere. The intellectual activity of religious and cultural elites and the skills of artisans jointly fashioned for India a distinctive place in the annals of science and technology, even if they existed largely in isolation from one another – except when, for instance at the court of Akbar, the needs of warfare and the prompting of intellectual curiosity brought them temporarily together.

Although from the early sixteenth century the Mughal court was a vital source of patronage for science and technology, dynastic decline in the eighteenth century did not entirely plunge India into obscurity, even if the number...
of manuscripts produced in Sanskrit, Persian and Arabic on scientific and technical subjects showed signs of slowing down. 14 A positive interest in science (and, increasingly, in reconciling the sciences of East and West) flourished under royal patronage in the regional courts of India, from the astronomical observatories built by Raja Jai Singh between 1722 and 1739 at Jaipur, Delhi, Mathura, Ujjain and Benares, to the eclectic medical interests and library of Indian and Western medical texts assembled by Serfoji, the last Maratha ruler of Tanjore. 15 New centres of learning sprang up, some, like Hyderabad under its Nizams or Lucknow under the Nawabs of Awadh, specialising in Islamic science and Unani medicine, while other older, mainly Hindu, seats of learning such as Benares and Nadia in Bengal continued to flourish. Despite the withering away of Mughal power, Delhi remained a significant focus for science, art and literature, and, until the cataclysmic events of 1857, enjoyed a twilight ‘renaissance’. 16 There were, however, some areas in which India appeared unresponsive to new technologies. Despite the introduction of the printing press by the Jesuits in Goa in the mid-sixteenth century, it had little influence on India before the late eighteenth century, though its spectacular take-off in the nineteenth century belies any suggestion that this was a consequence of some intrinsic ‘mechanical backwardness’. 17 Rather than providing proof of any sustained resistance to technological change, the slowness to adopt printing might rather be taken to indicate the selective manner in which Western science, technology and medicine were appropriated and the persistence of prestigious cultural values, embedded, in this instance, in the manuscript tradition and the skills of artisans and scribes. 18 Matters affecting proficiency in warfare were, by contrast, of more urgent concern and attracted a far more active response. This was the case not only with the Mughals, but also subsequently with the armies of Tipu Sultan of Mysore (until his defeat at Seringapatnam in 1799) and those of Ranjit Singh in Punjab, whose foun-

18 For printing and its uses, see C. A. Bayly, Empire and Information: Intelligence Gathering and Social Communication in India, 1780–1870 (Cambridge, 1996), pp. 231–43.
dries at Lahore and Amritsar manufactured heavy guns and mortars in the 1820s and early 1830s.\textsuperscript{19}

Just as it is necessary to rethink the chronology of Indian science and break down the old periodicity of the Orientalist model, so is it imperative to reassess the significance for science, technology and medicine of India’s vast land area and internal diversity. Although it is customary and convenient to speak of ‘Indian’ science or ‘Hindu’ medicine, such broad aggregations obscure the wide variations between one part of the subcontinent and another. As the examples in the previous paragraph suggest, the decentralised nature of India’s political and cultural system enabled, most obviously (though not uniquely) in the eighteenth century, several centres of science, technology and medicine to flourish at the same time and for each to develop its own distinctive characteristics. Diversity brought strengths as well as weaknesses. The decline of one centre did not preclude the survival and adaptation of another; India as a whole could profit from the varied intellectual and material products of its different regions and from their interaction and exchange. There were regional schools of Ayurvedic and Unani medicine, just as there were regional variations in the weaving and dyeing of cloth. The physical diversity of the Indian environment, South Asia’s almost continental proportions, and the multiplicity of its cultural and political constituencies not only contributed to internal variety and local specialisation but also, from an opposing perspective, challenged attempts (as by British rulers and nationalist scientists) to use the ideological agency and material instrumentality of science, technology and medicine to try to conquer and integrate India’s vast interior spaces.

Recurrent, too, in the history of science in India was a tension between the countryside and centres of courtly or regional power, or between cities old and new. Although colonial science might crudely serve to underline the cultural, commercial and political importance of the rise of the three coastal metropolises – Calcutta, Bombay, Madras – this would be to overlook the contribution made to their evolution by the artisans and intellectuals who flocked to them from older centres of manufacturing and scholarship. It would also be to ignore the resilience of other, more ancient centres of learning such as Benares and Delhi. It is not without significance that a number of universities with leading science departments by the 1940s – Lahore, Lucknow, Allahabad, and Dacca, to identify but four points along the Indo-Gangetic axis – were located in cities already prominent on the cultural and political map of India two centuries earlier.

As with cities, so with social groups. Some of India’s old intellectual elites resurfaced as agents and interpreters of the new scientific order, as in the case of the Brahmans, Vaidyas and Kayasthas who composed the bhadralok (middle-class intelligentsia) in colonial Bengal. It is suggestive, too, of the strength of these intellectual and social continuities that the only Nobel prize to be awarded to an Indian scientist before Independence went to a Tamil Brahmin, C. V. Raman, in 1930. But it should not be overlooked that other social groups (including Parsis, Indian Christians and lower-caste Hindus) also found a place among the practitioners of scientific modernity. The extent to which members of the old intelligentsia brought to their ‘modern’ avocations skills, insights and inspiration derived from ‘traditional’ backgrounds (rather than simply trading in their intellectual inheritance to acquire new Western knowledge) is an intriguing issue but one that historians have, as yet, scarcely begun to investigate.20

Equally, although the advance of British power in South Asia in the late eighteenth and early nineteenth centuries resulted in the overthrow or eclipse of a number of Indian states, culminating in the annexation of Awadh in 1856 and the extinction of Mughal Delhi two years later, it is striking how important India’s surviving princes and landed aristocracy were to the patronage of science (in its indigenous as well as Western forms) in the nineteenth and early twentieth centuries and in fields as diverse as astronomy, medicine and technical education. That India’s first major hydro-electric scheme was constructed in the princely state of Mysore in 1898 and that ten years later Bangalore became the site for the Indian Institute of Science, should alert us to the significance of even the circumscribed power of the princes in providing an alternative (often more adventurous) source of scientific support and technological initiative to that offered by the British. But if in this respect India’s continuing disunity appeared to favour the enterprise of science, in many other respects science in late-colonial India was plagued by the difficulty of trying to create and sustain organisations and institutions that would integrate India into a single scientific entity.

The reappraisal of the character of Indian science, technology and medicine before British rule, therefore, not only is of importance in itself, in establishing the vitality and diversity of an ‘indigenous’ tradition, but also has wide-ranging implications for understanding what happened after the establishment of the colonial regime. It becomes more difficult to treat India as a kind of scientific and technological tabula rasa, whose achievements lay in the

remote past and so were unable to affect or inform the course of Western science in South Asia. A recognition of the relative openness and adaptability of India’s pre-colonial scientific and technological tradition supports the view that an interactive model might be more appropriate for the colonial period rather than one that depicts either outright confrontation between two intransigent forces or an automatic unassailable Western ascendency. But, at the same time, pre-colonial science and its legacies should not be asked to explain too much. It is necessary to attach no less importance to the profound rupture caused to Indian society, materially and intellectually, by colonial intervention and the unprecedented impact made by the science, technology and medicine of the West.

COLONIAL SCIENCE

The history of science, technology and medicine in British India has often in the past been represented as essentially the story of the introduction and dissemination of Western ideas, practices and techniques. Such accounts make scant reference either to indigenous scientific, technological and medical traditions (except negatively, as a source of unreasoning and atavistic opposition to the legitimate progress of science, or as a lineage happily long extinct by the late eighteenth century), or to tensions and divergences between science as practised in the colony and that propagated in the capitals of Europe. Of late, however, as the history of science, technology and medicine in India has expanded and as the nature of Western science itself has been subjected to more critical appraisal, the relationship between India and Western science has come to be seen as more complex and less one-directional than previously assumed. The idea of a simple diffusion of a monolithic and progressive Western science into passively recipient extra-European lands has been challenged from several standpoints, not least by a more interactive and regionally focused understanding of how science developed in India from the late eighteenth century onwards.

But it is as well to begin with an ageing orthodoxy. The most influential statement of the diffusionist model of Western science was made by George Basalla in 1967, and though it now appears dated and simplistic in many respects it is still worth summarising as a basis for much of the ongoing discussion of colonial science. How, Basalla asked, did ‘modern science’ come to be diffused from its original home in Western Europe and ‘find its place in the

rest of the world? He argued that the process could best be understood through a three-stage model. In Phase One, Europeans established contact with new lands as part of the process of Western reconnaissance, trade, conquest, and colonisation. The ‘non-scientific’ society served Europe as a source of scientific data, garnered by Europeans through maps and surveys, and mineral, plant and animal specimens. In keeping with Europe’s interest at this stage in ‘the systematic exploitation of nature’, the dominant sciences of Phase One were botany and zoology, followed by astronomy, geology and geography. Although commercial motives provided some impetus for this scientific reconnaissance, Basalla attached more significance to the scientific culture from which Europeans came and to which they relayed back the results of their investigations. Phase-One science might be scattered around the globe, but only nations with ‘a modern scientific culture’, such as Britain, Holland and France, could ‘fully appreciate, evaluate, and utilise’ the knowledge thus acquired, though, in the course of assimilating new information from the wider world, Western science itself underwent modification.

In the second phase, that of ‘colonial science’, locally born or resident scientists (whom Basalla assumes to be Europeans) started to participate in scientific activities; local scientific institutions began to appear. While interest in natural history continued, almost all the scientific fields currently pursued in Europe were replicated overseas, but the local scientific community remained dependent upon European expertise and institutions and hence was reliant on ‘an external scientific culture’. Basalla stressed that by calling colonial science ‘dependent’ he did not mean that it was necessarily inferior science (though critics have taken that to be his implicit meaning), and he claimed that the term could be applied not just to formal colonies like India, but also to science in uncolonised territories like China and Japan, or to the United States until several decades after its independence. The dependent status of colonial science ensured that many of its practitioners continued to receive their training in Europe and directed colonial scientists into areas of enquiry laid down by Europe. It remained difficult for colonial scientists to enter Europe’s leading scientific societies and to gain access to those prestigious and influential ‘invisible colleges’ where the latest scientific ideas were debated and new agendas drawn up. The local scientific community had not yet reached the critical size necessary for ‘reciprocal intellectual stimulation and self-sustaining growth’.

In time, as substantially larger numbers of scientists came to be trained and to work locally, extra-European societies in Phase Three strove to establish an ‘independent scientific tradition’ and a ‘national science’ of their own. Political independence might help to inspire greater scientific autonomy, but more