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RESEARCH ARTICLE

The trope of the microscope in nineteenth-century India

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Abstract

Of all the many instruments that symbolized scientific endeavour in British India by the end of the nineteenth century, microscopes were among the most iconic, and yet, for both empirical and ideological reasons, their rise to scientific authority was slow and often contested. Moving from recreational use and marginal scientific status in the 1830s, by the 1870s microscopes were becoming integral to colonial education and governance and deployed across a wide scientific spectrum, their expanding use and heightened public presence facilitated by a rich and diverse visual culture. The eventual triumph of the microscope in India cannot be detached from its ongoing entanglement with local issues and agencies, its ascent to medical authority in particular constrained by scepticism about its utility. In this battle of instruments and imaginaries, microscopes – political emblems as well as material objects and scientific tools – pose critical questions about the visibility of science in a colonial context, about evolving techniques of seeing and representation, about the racialization of science and about the individual or collective authority of those who sought empowerment through the lens.

The Victorian era ushered in a new age of visuality. As more sophisticated optical instruments came into use and new observational techniques arose, they informed a growing visual sensibility and ocular capability that was manifest across the arts and sciences and underpinned the socio-scientific controversies of the time.[1] Yet the question is rarely posed as to how these new optical instruments and modes of seeing fared outside Europe and North America, the geographical heartlands where their role has most often been analysed.[2] How did 'universal' instruments like microscopes acquire a local history and what factors – social, political, environmental – informed that localism?[3] How did they function in relation to the wider visual culture of science in the colonies? Here locality is represented by British India, and 'visual culture' is taken to mean three strands of historical enquiry. First, there were the optical instruments themselves – microscopes – by means of which scientific observations were made and recorded, and hence the local history of their introduction, dissemination and use; second, there were the social institutions, representational

[1] Kate Flint, *The Victorians and the Visual Imagination*, Cambridge: Cambridge University Press, 2000; Kevin Z. Moore, 'Viewing the Victorians: recent research on Victorian visuality', *Victorian Literature and Culture* (1997) 25(2), pp. 367–85.

[2] W.F. Bynum, *Science and the Practice of Medicine in the Nineteenth Century*, Cambridge: Cambridge University Press, 1994, pp. 99–102, 123–7; Jutta Schickore, *The Microscope and the Eye: A History of Reflections, 1740–1870*, Chicago: University of Chicago Press, 2007.

[3] Cf. Nicola Williams, 'Do microscopes have politics? Gendering the electron microscope in laboratory biological research', *Technology and Culture* (2023) 64(4), pp. 1159–83.

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forms and visual media through which scientific observations were presented to the scientific community and to the public; and third, there was the social and scientific authority invested in such optical instruments and visual technologies in a politically subordinated and racially divided society.

While foregrounding microscopy, this article points more generally to the relative neglect of visual objects and optical media in discussions of science, technology and medicine in British India, a lacuna all the more striking given the breadth and sophistication of science and the visual culture serving science in South Asia by the 1900s. There is an abundance of literature on scientific ideas, institutions, personalities and careers in British India, but remarkably little on the instruments that made such scientific pursuits possible or around which scientific controversy often revolved.[4] Scholarship on scientific education and technical instruction, and on colonial pedagogy as a whole for British India, has favoured text over image, printed word over visual representation. The objectivity and meaning of such imagery might be debated, yet it retains the power to narrate stories of science not evident from manuscript or print sources alone. It is evident, too, that India's colonial regime invested considerable political authority and administrative resources in demonstrating the superiority of Western – or 'modern' – ways of seeing and in tutoring the indigenous population in the use of optical instruments. Medical colleges, scientific and technical institutes, art schools, exhibitions and *conversazioni* were all vehicles for the dissemination of visual technologies and education in their use.

Like the telescope, the microscope was understood as the instrument of a 'highly civilized ... condition of society'.[5] While that assertion was freely made in nineteenth-century Europe and North America, it assumed added significance when applied to a colonial situation in which the microscope, alongside other optical devices, was charged with representing and propagating Western scientific techniques and civilizational values among a subject population whose claims to science and civilization were routinely questioned. It was often pointed out that microscopy was not itself a science but the servant of many sciences, and yet the microscope symbolized scientific endeavour and authority to a degree unmatched by any other instrument of the period.[6] It made science visible, not just through what the lens revealed, but also as the emblem of what scientists did and what science stood for.[7]

By discussing microscopes, I caution against a technological teleology in which it is assumed that, because such instruments existed and had the potential to contribute to science, they were actually adopted and used in that way, and argue instead that for much of the period microscopy was an embattled pursuit and heavily reliant on other means of visual representation to attain its effect. While microscopy has been assigned a significant place in histories of medical practice and scientific research in India by the close of the nineteenth century, the earlier – and ongoing – struggle to establish its scientific status and professional credibility has largely been overlooked.[8] My interest accordingly lies less in what India's microscopists 'discovered' than in the microscope as icon and instrument

[4] Notable exceptions include Simon Schaffer, 'The Bombay case: astronomers, instrument makers and the East India Company', *Journal for the History of Astronomy* (2012) 43(2), pp. 151–80; Lachlan Fleetwood, *Science on the Roof of the World: Empire and the Remaking of the Himalaya*, Cambridge: Cambridge University Press, 2022, Chapter 2.

[5] William Jeaffreson, *A Practical Treatise on Diseases of the Eye*, London: Henry Renshaw, 1844, p. 294.

[6] W.H. Seaman, 'Is there a science of microscopy?', *Microscopical Journal*, 1890, cited in 'Microscopical Society of Calcutta', *Indian Medical Gazette* (1890) 25(9), pp. 280–4, 284.

[7] This was particularly true of medical science: Deborah Jean Warner, 'The campaign for medical microscopy in antebellum America', *Bulletin of the History of Medicine* (1995) 69(3), pp. 367–86, 369.

[8] But see Mark Harrison, *Public Health in British India: Anglo-Indian Preventive Medicine, 1859–1914*, Cambridge: Cambridge University Press, 1994, p. 113; Prakit Chakrabarti, *Bacteriology in British India: Laboratory Medicine and the Tropics*, Rochester: Rochester University Press, 2012, pp. 25, 39, 73.

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of scientific authority, and in situating the microscope, as a material object and cultural artefact, within a wider field of colonial science.

The iconic microscope

Microscopes are objects to be seen as well as instruments for seeing. In a series of photographs, the malariologist Ronald Ross was shown working or sitting alongside a microscope of increasing size and sophistication as his career progressed. The earliest of these images was taken in Darjeeling in 1898 following his discovery of the mosquito's role in malaria transmission, while the later ones, taken after Ross left India and joined the Royal Army Medical Corps (Figure 1), continue into the 1920s. This repeated representational trope, closely identifying Ross with the instrument of his scientific achievement, is hardly surprising. By the late nineteenth century and the early twentieth it was common for scientists, in India and elsewhere, to pose alongside their microscopes as the essential tool of their trade.[9] But for Ross the microscope bore particular significance. Having entered the Indian Medical Service (IMS) in 1881, he began to investigate the 'malaria problem' and the stages by which the parasite passed from the mosquito to its human prey. To facilitate his research, he even devised a portable microscope, 'useful for the high powers but capable of being slung round the shoulder like a pair of binoculars'.[10] Finally, in 1897–8, Ross proved the presence of the malaria parasite in the gastrointestinal tract of an *Anopheles* mosquito. The microscope was thus the emblem of his success, just as his earlier struggle with an old and battered instrument in Secunderabad epitomized his long and arduous quest for scientific recognition.[11]

In the photographs Ross is not seen in a laboratory or (after 1898) even in India: the gleaming microscope stands on his desk 'as a sort of scientific ornament'.[12] Without his microscope, Ross would not have been able to establish the mechanism of malaria's transmission and achieve international renown, and yet it was necessary for the microscope to have outgrown its earlier reputation as a mere 'toy' for this imagery to convey its full public and professional significance.[13] The iconic microscope established Ross as a central figure in the field of tropical medicine, 'its ideology European, its instrument the microscope, its epistemology the germ theory of disease'.[14] No photographs of Ross with a microscope appeared in his *Memoirs*, but he repeatedly claimed in that work that, prior to his momentous discovery, scientific microscopy in India had been largely neglected. 'Even the great bacteriological discoveries of Pasteur and Koch', Ross wrote, 'were scarcely recognised, or were ridiculed, and Laveran's was almost unheard of. Apart from individual workers such as [Henry] Vandyke Carter, [Timothy] Lewis, and [D.D.] Cunningham, the services did not concern themselves much with medical investigation'.[15] In making this self-serving observation, Ross greatly overstated the prior neglect of microscopy in India, not just in relation to medical research (his primary concern) but with respect to scientific enquiry more generally.[16] The suggestion that, until Ross solved the 'malaria mystery', India's medical

[9] As with Pasteur in 1885: Bynum, op. cit. (2), p. 108.

[10] Ronald Ross, *Memoirs*, London: John Murray, 1923, p. 131; Edwin R. Nye and Mary E. Gibson, *Ronald Ross, Malariologist and Polymath: A Biography*, Basingstoke: Macmillan, 1997, pp. 231–4.

[11] Ross, op. cit. (10), pp. 217–21.

[12] Nye and Gibson, op. cit. (10), p. 234.

[13] Ross, op. cit. (10), pp. 127–9, 153–78.

[14] Roy MacLeod, 'Introduction', in Roy MacLeod and Milton Lewis (eds.), *Disease, Medicine, and Empire: Perspectives on Western Medicine and the Experience of European Expansion*, London: Routledge, 1988, p. 7.

[15] Ross, op. cit. (10), p. 126.

[16] Harrison, op. cit. (8), p. 57.

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Figure 1. Ronald Ross, undated photograph by Elliott and Fry, public domain, Wellcome Collection, https://wellcomecollection.org/works/cgjt87bh. No copyright.

establishment (and the wider scientific community) had scant interest in microscopy and remained ignorant of its scientific importance is unsustainable.

The photographs of Ross and his microscopes project a familiar image of the 'heroic' white male scientist, but there are abundant contemporary or near-contemporary photographs to suggest that microscopes, whether employed in investigative science or routine diagnostics, were not the exclusive domain of the European male.[17] There are, for example, photographs taken between the 1890s and 1920s in India that show white (more rarely Indian) women with microscopes. These include one of Dr Marion Hunter in the laboratory of the temporary plague hospital at Poona in 1898, the year of Ross's scientific breakthrough (Figure 2). The image of Hunter, seen here with Drs Lloyd Jones and Ernest Marsh, complicates the Ross story in several ways. The presence of two microscopes in this photograph, along with test tubes and other apparatus, does more than indicate (as the sign on the wall tells us anyway) that this was a laboratory, albeit a makeshift one. As the sole woman doctor at the plague hospital in 1897–8, Hunter encountered hostility from one of her male colleagues, Dr Adams, who resented that she had been entrusted with the women's and children's wards previously assigned to him. In entries he made in his plague album, Adams sneered at Hunter for merely holding a licentiate degree and suggested that she was only appointed because she had an influential uncle, Sir W.W. Hunter.[18] In fact, like Adams (and Ross), Hunter had a diploma in public health (hers being the first awarded to

[17] On the 'heroic' microscopist see L.S. Jacyna, '"A host of experienced microscopists": the establishment of histology in nineteenth-century Edinburgh', *Bulletin of the History of Medicine* (2001) 75(2), pp. 225–53, 226.

[18] David Arnold, 'Dr Hunter's plague: gender, race and photography in British India', *Indian Journal of Gender Studies* (2014) 31(1), pp. 7–27.

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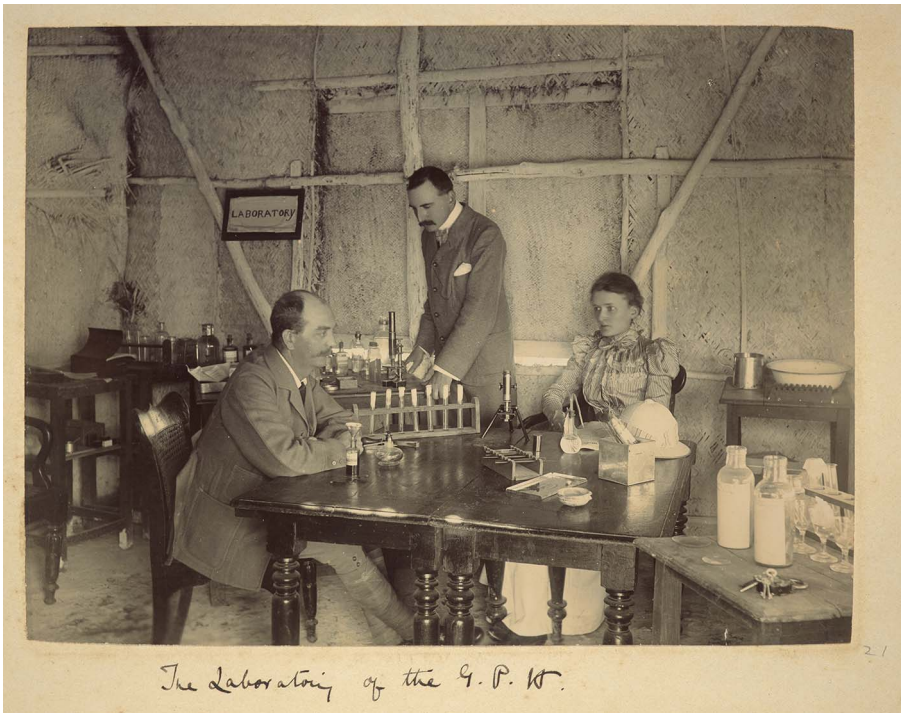


Figure 2. The laboratory of the General Plague Hospital, Poona, 1898, in C.H.B. Adams, 'Poona plague pictures, 1897–1908', Getty Research Institute, Los Angeles (96.R.95). No copyright.

a woman in Cambridge), an indication of how relatively common a training in bacteriology and microscopy had become among European medical and scientific personnel in India by the late 1890s.[19] There was, however, a degree of artificiality about the Poona image and its evident staging for the camera. Hunter appears smartly dressed and bareheaded, not wearing the white uniform and straw boater she wore for her ward duties. Adams caustically remarks in his album, 'Dr Jones is tired of looking thro' a microscope that hasn't a specimen under it & Miss Hunter doesn't seem to be doing much.'[20] As in the Ross photographs, one of the iconographic functions of the microscope was as a scientific prop, a signalling of scientific status. That Hunter sent this image to the London press further suggests that she saw it as a way of signifying that she was a qualified doctor and fully merited her place alongside men in the plague laboratory.

The visual pairing of (wo)man and microscope was less evident with respect to Indians. In keeping with the dominant scientific practice of the time, Indians (as Figure 3 shows) were more likely to appear as unidentified laboratory assistants, engaged in routine microscopy, than as leading researchers and investigators. While the provenance of this photograph is unclear, it is likely to represent the work of the Kala-Azar Commission in Assam in the 1920s. Like Alexandre Yersin's straw mat hut in plague-stricken Hong Kong, the Indian 'laboratory' was not infrequently an ad hoc structure, in which the microscope

[19] K.M.H[unter], 'Diploma in public health', *London School of Medicine for Women Magazine* (1896) 4, pp. 149–50.

[20] C.H.B. Adams album, 'Poona plague pictures, 1897–1908', Getty Research Institute, Los Angeles (96.R.95), at https://primo.getty.edu/permalink/f/19q6gmb/GETTY_ROSETTAIE1067253.

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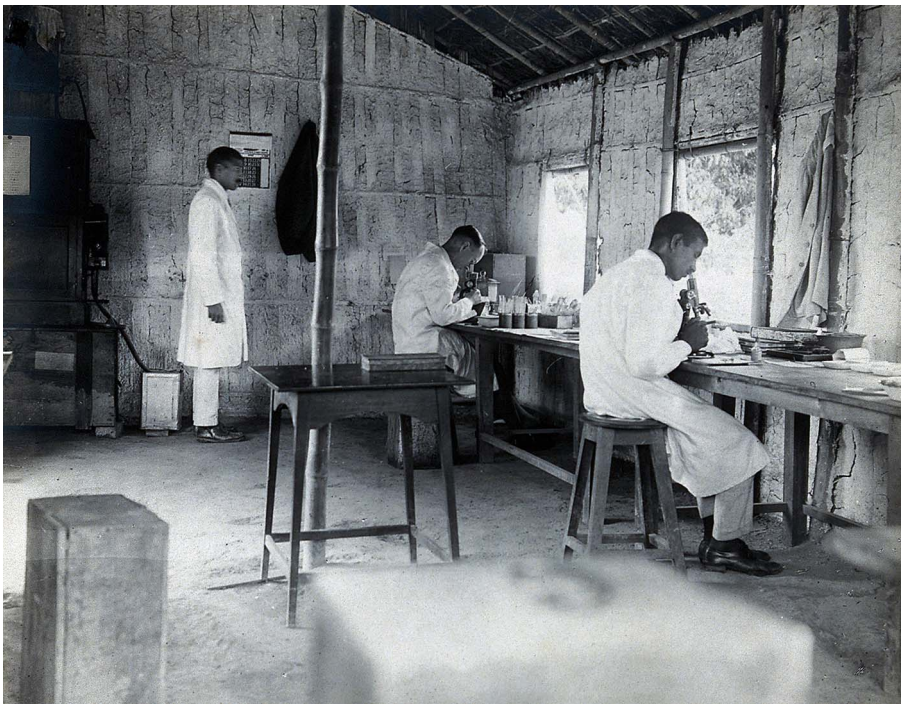


Figure 3. A field laboratory in India, undated, public domain, Wellcome Collection, 564954i. No copyright.

was almost the only apparatus.[21] When it came to microscopy Indians were often 'invisible technicians', though here, at least, they are partly visible.[22] Even by the early 1900s the use of Indians as routine microscopists was common, qualifying the impression Ross helped to create of microscopy as a highly specialized craft and 'heroic' practice. At Nagpur jail in 1900 Burmese prisoners examined blood samples for evidence of malaria, and 'very soon became expert in detecting and distinguishing the various kinds of parasites'. Ko Tha Aung, 'one of the most intelligent of our observers', was praised for developing 'an exceptionally keen interest in the subject' of malariology.[23] Similarly, in the Andamans prisoners trained for malaria work became 'conversant with the different forms of parasite, can make and stain their own preparations, and in some cases can perform differential blood counts'.[24] The microscopic technique that won Ross a Nobel Prize had, within a few years, become a routine task for Indian convicts. But if the employment of convicts and subordinate laboratory staff represents one aspects of the normalization (and downgrading) of microscopy by the early twentieth century, the relative absence in this period of photographs of Indians posed alongside their instruments as scientists in their own right points to another. By the time Indians had attained positions of influence and command in their fields, especially

[21] Andrew Cunningham, 'Transforming plague: the laboratory and the identity of infectious disease', in Andrew Cunningham and Perry Williams (eds.), *The Laboratory Revolution in Medicine*, Cambridge: Cambridge University Press, 1992, pp. 209–44, 229–30.

[22] Steven Shapin, 'The invisible technician', *American Scientist* (1989) 77(6), pp. 554–63; for their probable identity see *Reports of the Kala-Azar Commission, India, No. 1 (1924–25)*, Calcutta: Thacker, Spink, 1926, pp. 1, 3.

[23] Andrew Buchanan, *Malarial Fevers and Malarial Parasites in India*, Nagpur: Nagpur Central Jail, 1901, pp. 1, 4.

[24] Ernest E. Waters, 'Malaria as seen in the Andamans penal settlement', *Indian Medical Gazette* (1904) 39(1), pp. 7–11, 11.

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in the state's scientific services, a training in microscopy and regular use of a microscope had become so commonplace that it was seldom remarked upon or given iconographic recognition.

The slow dawn of Indian microscopy

Microscopes have slipped all too easily into the historiography of science in India, their arrival unexplored, their utility unchallenged. If in Britain by the mid-nineteenth century microscopes had become 'one of the most important auxiliaries to science and a direct incentive to original work', what value did they have in India?[25] Little can be said about their ownership and use before the 1840s, apart from newspaper notices attesting to their sale among the personal effects of Europeans who had died or were retiring from India.[26] Wills and inventories further indicate ownership by Europeans whose professional needs or recreational tastes also encompassed binoculars, telescopes, surveying equipment and chronometers. Some Indian princes also possessed microscopes or, like the raja of Kota in 1834, received them as gifts from the governor general.[27]

Microscopes were advertised for sale to medical students or for such institutional customers as colleges, laboratories and clinics, but they were more widely used for entertainment and for battling European ennui. Popular works on microscopy published in Britain, such as Gosse's *Evenings at the Microscope*, were widely presented for sale through the English-language press.[28] In 1888, for example, Kemp & Co. advertised a selection of microscopes, ranging in price from fifteen to four hundred rupees, with the caption 'They offer an agreeable and fascinating occupation to all who find their "after business hours" hang heavily'.[29] A few months later, in warning against tropical lassitude, the firm recommended microscopy as a means of 'awakening ... a life-long interest' and gaining 'fullness of mind' and 'healthy mental food'.[30] As elsewhere, the microscope could be both 'an instrument of scientific research' and, more often in India, 'a means of gratifying a laudable curiosity and of obtaining a healthy recreation', a pleasurable instrument for engaging with the fascinations of nature and the 'wonders' of Creation.[31] In 1850s Madras, as photography took off, Lieutenant Mitchell experimented with photographing 'microscopic objects', such as the scales of a butterfly's wing or parasites on poultry. 'In India', he observed, 'people [meaning Europeans] are compelled to look very much to in-door employment during their hours of relaxation and this is especially the case with Ladies'; 'the Microscope', he added, 'is eminently suited to a Lady's use. The labour is light, and the employment one of surpassing interest'.[32]

While little of this had much scientific merit or added greatly to the scientific understanding of India, microscopes were enlisted to popularize science among Indians as well as Europeans and to display, as entertainment and spectacle, the superiority of Western

[25] Jabez Hogg, *The Microscope: Its History, Construction, and Application*, 15th edn, London: George Routledge and Sons, 1898, preface to 1854 edn, p. v.

[26] *Bombay Times*, 13 February 1841, p. 97; 7 June 1845, p. 375.

[27] Dr O. Wray, 1 December 1836, L/AG/34/27/113; Major R. Hornby, 11 January 1837, L/AG/34/27/114; Surgeon F.C. Brown, 2 February 1840, L/AG/34/27/120, F/4/1513, 59673, India Office Records (IOR), British Library, London.

[28] Philip Henry Gosse, *Evenings at the Microscope*, London: Society for Promoting Christian Knowledge, 1859.

[29] *Times of India*, 10 January 1888, p. 1.

[30] *Times of India*, 11 September 1888, p. 7.

[31] William B. Carpenter, *The Microscope and Its Revelations*, 2nd edn, London: John Churchill, 1857, p. v; John Harley Warner, '"Exploring the inner labyrinths of creation": popular microscopy in nineteenth-century America', *Journal of the History of Medicine and Allied Sciences* (1982) 37(1), pp. 7–33.

[32] 'Reports of the committee appointed to adjudicate the Photographic Society's medals', *Madras Journal of Literature and Science* (1859) 6(9), pp. 178–88, 183, 187.

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science and technology. An exhibition in Bombay's town hall in 1851 was accompanied by a lecture in Gujarati and Marathi explaining the use of an oxyhydrogen microscope; celebrations for the Parsi new year in 1878 were enlivened by musical entertainments and scientific exhibits, including 'a good display of microscopes'.[33] At a meeting in Bombay in 1880 to mark the opening of the new university buildings, microscopes and microscope slides were much in evidence. On show were microscopic specimens of 'the infusorial animalcules' attached to aquatic plants, minute crustaceans extracted from the city's water supply, the internal organs of worms, the blood of a toad – all made visible through the microscope lens.[34] Mid-century India had its own, if circumscribed, version of 'microscope mania'.[35] Similarly, at scientific meetings and exhibitions from the 1840s onwards, microscopes were often displayed, and in many of these *conversazioni* Indians were both organizers and attendees. In the 1880s the state of Kolhapur staged a series of Christmas events, organized by Balaji Prabhakar Modak, principal science teacher at Rajaram College.[36] From a modest collection of laboratory apparatus in 1883, by December 1885 the event had grown to cover five days, with 14,000 visitors, and a programme printed in Marathi and English. Among items on view were microscopes, telescopes, a Morse code transmitter, a heliostat, surgical instruments, steam engines, water pumps and surveying equipment.[37] In nineteenth-century India's scientific 'conversations' microscopes were a common presence.

Learned societies, too, showed an interest in microscopy. In 1848 Dr H.J. Carter spoke to the Bombay branch of the Royal Asiatic Society on Porbandar limestone, a material that contained 'microscopic … shells, of the most exquisite beauty in their forms and symmetrical development'. The more these fossils were magnified under the microscope, the speaker declared, 'the more minutely could be distinguished the figure of the innermost recesses of the cells or chambers they represented'. Carter embellished his talk with drawings of some of the 'most beautiful' of his microscopic images, the aesthetic appearance of the microscopic imagery seemingly as significant as its scientific 'fidelity'.[38] A decade later, Carter published a note on his microscopic observations of the marine 'animalcules' that periodically turned the sea around Bombay red.[39] According to his namesake, Henry Vandyke Carter, in 1858, H.J. Carter was 'probably the greatest scientific worker in Bombay', albeit 'plodding most perseveringly' with 'a little French microscope'.[40]

In the 1850s, meetings of the Bombay Geographical Society and Grant Medical College's scientific society regularly used microscopes to view botanical, geological and pathological specimens.[41] The instrument captured the cosmopolitan appeal of popular science, with Indians as likely as Europeans in Bombay and Calcutta to lecture (or be lectured) on 'the wonders of the microscope', often in conjunction with other visual aids.[42] When Bhau Daji, a prominent Bombay physician and owner of several microscopes, spoke on Indian botany to a racially mixed audience in 1859, his talk was illustrated with microscope slides but also accompanied by 'rich botanical drawings beautifully executed by a Hindoo artist from living

[33] *Bombay Times*, 22 February 1851, p. 129; *Times of India*, 14 March 1878, p. 3.

[34] *Times of India*, 29 March 1880, p. 3.

[35] Warner, op. cit. (31), p. 7.

[36] Abhidha S. Dhumatkar, 'Forgotten propagator of science: Kolhapur's Balaji Prabhakar Modak', *Economic and Political Weekly* (2002), 37(48), pp. 4807–16.

[37] *Times of India*, 9 January 1886, p. 4.

[38] *Bombay Times*, 14 June 1848, p. 453.

[39] H.J. Carter, 'Note on the red coloring matter of the sea round the shores of the island of Bombay', *Madras Journal of Literature and Science* (1859) 6(9), pp. 153–8.

[40] Henry Vandyke Carter, diary, 1 April 1858, HVC 5818, Wellcome Collection (WC), London.

[41] *Bombay Times*, 28 May 1857, p. 1005; 19 February 1859, p. 116.

[42] *Times of India*, 29 March 1880, p. 3.

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specimens'.[43] The use of 'native' artists in the service of western science had a long history in India, going back to the late eighteenth century; microscopy added a further dimension to this association.

Ross failed to mention in his memoirs that in 1889 he had been elected to the Calcutta Microscopical Society. Established two years earlier by W.J. Simmons, the society was the first such organization in India and, it was claimed, the only one east of Suez.[44] Perhaps Ross thought his election unworthy of mention since it was 'a society mainly of amateurs'.[45] Certainly, amateurs constituted the majority of members, but at its meetings Simmons read lengthy résumés of articles from British and American microscopical journals and led discussions on recent research in India, such as D.D. Cunningham's cholera investigations.[46] But like many other scientific organizations in India, the society had difficulty retaining its largely European membership, due to 'the enervating effect of the climate' and 'the constant social flux peculiar to the place. People go home or are sent away from Calcutta, and in their new homes forget the Society'.[47] Perhaps Ross, too, had simply forgotten.

The didactic lens

In 1854 the *Bombay Times* observed that hitherto microscopes, telescopes, cameras and other 'elegant appliances' had been employed in India 'rather in the light of playthings and toys for the entertainment of the frivolous, than as amongst the great engines of substantial information'.[48] The *Times* was reflecting a view of microscopy widely held in the West, but the remark did not reflect the extent to which the microscope in India was becoming a serious instrument in colonial pedagogy and institutional practice. Even if among the public the microscope had barely moved beyond being 'a costly toy', in medical colleges and government departments it was making its presence felt.

Botany offers some examples of this. In his brief career as an East India Company surgeon, William Griffith was one of the first scientists in India to use a microscope systematically, spending several hours a day examining botanical specimens.[49] Griffith made extensive drawings of his microscopical observations, some of which were published after his death in 1845. As professor of botany at Calcutta Medical College, he encouraged students to take up microscopy, proposing that microscopes rather than gold medals be awarded as prizes. He recommended the 'excellent' instruments made by Andrew Ross in London, costing five pounds each.[50] On his death Griffith bequeathed his treasured microscopes to his geologist friend Richard Solly, and for much of the century the advice of metropolitan experts, like John Quekett of the Royal Microscopical Society, was sought as to the most suitable instruments.[51] Microscopes were part of the routine commerce of scientific exchange between Britain and India.

But where Griffith championed microscopy, many of his contemporaries were chary. In 1832 Robert Wight, one of the leading plant collectors and taxonomists of the period, was

[43] *Times of India*, 21 December 1859, p. 812; 24 January 1861, p. 3.

[44] 'The Calcutta Microscopical Society', *Indian Medical Gazette* (1889) 24(7), pp. 217–18.

[45] *The Indian Museum, 1814–1914*, Calcutta: Baptist Mission Press, 1914, p. 119.

[46] 'Microscopical Society of Calcutta', *Indian Medical Gazette* (1890) 25(9), pp. 280–4.

[47] 'Microscopical Society of Calcutta', *Indian Medical Gazette* (1891) 26(4), pp. 110–11, 110.

[48] *Bombay Times*, 26 September 1854, p. 4322.

[49] Griffith to William Hooker, n.d. (*c.* November 1841), director's correspondence, LIV, f. 230, Royal Botanic Gardens, Kew; William Griffith, 'On the ovulum of *Santalum, Osyris, Loranthus* and *Viscum*', *Transactions of the Linnean Society of London* (1845) 19, pp. 171–214.

[50] *General Report on Public Instruction in the Bengal Presidency, 1843–44*, Calcutta: G.H. Huttmann, 1844, p. 57.

[51] J. McClelland to secretary, Bengal, 5 August 1846, F/4/2188: 106999; Bengal, Military, 17 August 1853, E/4/821, pp. 1215–16, IOR, asking Quekett's advice on microscopes for Calcutta Medical College.

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given an expensive Ross microscope, yet showed no great interest or proficiency in its use. He abstractly extolled the virtues of the instrument, 'but largely', Henry Noltie observes, 'as a means of revealing levels of natural wonder not visible to the human eye'. Its use provided Wight with 'evidences of complex structure and organization in the filmy dust of the moth's wing, or the equally minute particle of matter constituting a grain of pollen', but, as a means of establishing taxonomic affinities, the instrument 'was largely unused by Wight'. It was left to Griffith to instruct one of Wight's artist assistants, Rungiah, in its use, an example of how the role of Indian illustrators was changing with the arrival of microscopy.[52] Wight showed some embarrassment at his neglect. Griffith, however, assured him that 'the use of the microscope, and of keen knives, are very good adjuncts [to botanical science], but many of the higher branches of botany do not require them, such as the distribution of vegetables, the changes induced by cultivation, etc, etc.', subjects of greater interest to Wight's employer, the East India Company.[53] As long as economic botany in India remained primarily concerned with classifying and making inventories of 'useful' plants, there seemed little incentive to take microscopy more seriously.

Nor was the benefit of microscopy to medical science immediately obvious to many investigators. Edmund Parkes in the 1840s used a microscope in his research on dysentery without it adding much to his understanding of the disease; he relied far more on what post-mortem evidence revealed to the naked eye.[54] Allan Webb, professor of anatomy in Calcutta, found the microscope useful in training students for the subordinate medical service, less so for his own research. 'Microscopical Anatomy', he declared in 1850, was 'fully elucidated [for students] both in diagrams of great beauty and fidelity, as well as by the daily use of the microscope'. The microscope revealed to them the 'secrets of physical existence'.[55] Yet, when it came to his own investigation into elephantiasis, the instrument proved of little value: 'the microscope did not detect anything' abnormal in the cutaneous cells, muscles and nerves; the microscopical appearance of the organs was 'quite healthy'.[56] The microscope was the key to understanding the physiological changes caused by elephantiasis, cholera, typhoid and other 'blood-diseases', Webb believed, but exactly what those changes were and how they affected human anatomy remained obscure.[57] The microscope was an aid to understanding human (and plant) physiology; in pathology it had little value.

As the century progressed, the use of microscopes in medical education became more widespread. While the 'education of the eye' was enjoined for medical students everywhere, in India it was claimed that 'natives' required an additional effort to cast off their 'prejudices' and 'superstitions' and learn to see in a scientific manner. Understanding anatomy and pathology required a new 'condition of mind'.[58] At Grant Medical College in the 1850s students in the physiology class were instructed in the use of the microscope for examining the 'characteristic peculiarities' of vegetable and animal tissues.[59] Microscopy was included

[52] H.J. Noltie, *The Life and Work of Robert Wight*, 3 vols., Edinburgh: Royal Botanic Garden, 2007, vol. 1, pp. 56, 100.

[53] Noltie, op. cit. (52), vol. 1, p. 100, citing Griffith's *Posthumous Papers* (1848).

[54] E.A. Parkes, *Remarks on the Dysentery and Hepatitis of India*, London: Longman, Brown, Green and Longmans, 1846, p. 49.

[55] Allan Webb, *The Historical Relations of Ancient Hindu with Greek Medicine*, Calcutta: Military Orphan Press, 1850, pp. 6, 20.

[56] Allan Webb, *Elephantiasis Orientalis, and Specially Elephantiasis Genitalis, in Bengal*, Calcutta: Bengal Military Orphan Press, 1855, pp. 8, 17–18, 33.

[57] Allan Webb, *Pathologia Indica, Or the Anatomy of Indian Diseases*, 2nd edn, Calcutta: Thacker, Spink, 1848, p. xix.

[58] Joseph Fayrer, 'Introductory address to students of the Calcutta Medical College, June 15th, 1863', in Fayrer, *Clinical Surgery in India*, London: John Churchill & Sons, 1866, pp. 707–14; Charles Morehead, *An Introductory Lecture Delivered in the Grant Medical College at Bombay on the 15th June 1853*, Bombay: Education Society's Press, 1853, pp. 19–21.

[59] *Bombay Times*, 16 April 1853, p. 724.

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in the curriculum of Madras Medical College by the 1880s, even if a lack of instruments left students labouring under 'great disadvantages'.[60] The high cost of imported microscopes was a perennial complaint, the suggestion in this instance being that, beyond a certain number, students should purchase their own. The arrival of a dozen instruments from Britain eased the situation, enabling students to develop 'a deep interest' in microscopy.[61]

Microscopes also entered, unheralded, into routine service in several government departments, mainly as an aid to inspection and quantification. In 1856, for example, the Benares Opium Agency purchased a pair of compound microscopes to assess the drug's morphine content. The chemical content of *Cinchona* was similarly subjected to microscopic scrutiny.[62] A further use was to investigate the commercial possibilities of such products as cotton fibres or the diseases of tea and tobacco plants, thereby enlisting the microscope in the official quest for agricultural improvement, increased trade and higher revenues.[63] Detecting adulterants in foodstuffs or pollution in urban water supplies was another common use by the 1880s, signalling the advent of a regulatory system of inspection and governance at the municipal and provincial levels.[64] Microscopes were employed in criminal investigations and forensic science too, serving in the laboratories of the provincial chemical examiners as a means to detect bloodstains and poisons. In the Baroda poison case of 1877–8 the 'microscope at once settled the question' as to the type of arsenic used and hence the identity of the likely perpetrator.[65] In the ever-widening ambit of regulatory use, under the 1883 Emigration Act microscopes were to be provided for every ship carrying indentured labourers from Indian ports, the purpose being to detect onboard pathogens.[66]

Even while its value in research remained limited, by the latter part of the nineteenth century microscopy had become integral to the training given to students and apprentices in such diverse fields as geology, entomology, agriculture, veterinary science and forestry. In 1876 two microscopes were provided at government expense for the newly opened Saidapet Agricultural College; by the 1880s students at agricultural and veterinary colleges were expected to have a working knowledge of the microscope and its uses.[67] At the Forestry School in Dehra Dun, founded in 1878 to 'afford the natives of India scientific teaching in the principles and practice of forestry', second-year students received instruction in the use of microscopes to 'illustrate the anatomical structure of plants, and the germination and development of seeds of the principal forest trees'. Entrants for the Indian Forest Service and recruits for the Geological Survey were introduced to microscopy at Coopers' Hill engineering college in Surrey.[68]

[60] *Annual Report of the Madras Medical College, 1878–79*, Madras: Government Press, 1879, p. 147; *Annual Report of the Madras Medical College, 1882–83*, Madras: Government Press, 1883, p. 10.

[61] Madras Military, no. 287, 21 June 1883, IOR; *Annual Report of the Madras Medical College, 1883–84*, Madras: Government Press, 1884, p. 6.

[62] Bengal, Separate Revenue, 11 June 1856, E/4/836, pp. 607–8; India, Revenue and Agriculture (Economic Products), no. 4, 2 August 1898, IOR.

[63] *Bombay Times*, 14 April 1852, p. 253; *Times of India*, 16 September 1861, p. 3.

[64] C.H. Cayley, 'Report on the analyses of the Bombay water-supply', *Administration Report of the Municipal Commissioner for the City of Bombay, 1900–1901*, Bombay: Times of India Press, 1901, pp. 492–4.

[65] *Bombay Times*, 19 October 1859, p. 669; *Report of the Chemical Analyser to the Government, Bombay, 1874–75*, Bombay: Government Press, 1874, pp. 6–7; 'Report of the chemical examiner to government, 1874', Bengal, Medical, no. 172-12/13, 27 May 1874, IOR.

[66] India, Revenue and Agriculture (Emigration), 30 July 1903, L/PJ/6/643: 1701, IOR.

[67] *Annual Report of the Superintendent of Government Farms, Madras Presidency, for the Year Ending 31st of March 1877*, Madras: Government Press, 1877, p. 44; Madras, Government Order 315, 20 May 1886, in India, Home (Education), nos. 30–2, July 1886, National Archives of India (NAI), New Delhi.

[68] *Indian Forester* (1882), 7(4), p. 395, and (1888), 14(6), p. 281; J.A. Godley, India Office, to Alexander Taylor, Coopers' Hill, 7 February 1884, L/PWD/8/65: 25, IOR.

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Although the most celebrated microscope-aided discoveries of the late nineteenth century occurred in relation to human disease, other fields of research and its practical application – as in botany and veterinary science – also relied heavily on microscopy. In 1888, following Pasteur's investigation into anthrax, a Cirencester-trained Indian, N.N. Banerji, was sent to Paris to study his laboratory techniques and was charged with introducing and manufacturing the vaccine for cattle in India. Similarly, in the silk industry, again following the path blazed by Pasteurian microscopy, N.G. Mukherji was commissioned to investigate silkworm disease in India.[69] For a predominantly agrarian society, in which the pathology of plants and animals was of immense financial, commercial, even military significance, the microscope became an instrument of wide utility. It is indicative of the importance of this non-human element that the first bacteriological laboratory in India opened in 1890 for the microscopical investigation of bovine, rather than human, disease.

And yet, despite the contribution of Indians like Banerji and Mukherji to the advancement of science and despite Indian engagement in the scientific 'conversations' of the period, there remained a strong feeling – certainly among Europeans – that this was their instrument, one without indigenous precedent, and a clear demonstration of the superiority of Western scientific and technical achievement. In the nineteenth- and early twentieth-century colonial imaginary, India was a battlefield in which Western instruments, machines and appliances of various uses and descriptions – and the technologies and knowledge systems implicated in their use – were pitted, rhetorically and practically, against inferior Indian devices and scientifically illiterate practitioners. Optics was one of the fields in which precolonial science was seen to be most deficient, and nowhere was this sense of superiority more keenly expressed than with respect to medicine. In an indignant response to pressure from government for a greater accommodation of Indian medical traditions, the director general of the IMS wrote in 1918 that supporting these ancient systems would throw India back five hundred years. 'They ignore all instruments of scientific investigation, such as the Stethoscope, Ophthalmoscope, Microscope, Sphigmograph, Uroscope, Haematometer, and so on', he raged. 'They know nothing of X-rays and electricity, ignore bacteriology and antiseptics.'[70] Nor was this hegemonic view necessarily confined to Europeans, for it was shared by many Indians educated in Western science and medicine. In a lecture at Grant Medical College in 1882, J.C. Lisboa argued that modern instruments, such as the microscope, the ophthalmoscope and the stethoscope, clearly differentiated the modern scientific user from the *vaid*s and hakims, the practitioners of indigenous medicine, 'who were quite ignorant of the uses of such instruments'.[71]

There was, though, a degree of irony about the lauded superiority of the microscope. A medical member of the Indian Cattle Plagues Commission in 1871 sought the help of microscopy in trying to identify the cause of epizootic rinderpest. But, he grumbled, 'Modern microscopy demands very perfect instruments of high magnifying powers, chemical appliances and a large sacrifice of time.' It required, 'for any degree of success, the special and exclusive employment of an expert in a laboratory' – resources he clearly lacked. He persisted in conducting a bovine post-mortem but admitted that his use of the microscope was simply to verify 'recorded appearances' rather than 'prosecute systematic

[69] India, Revenue and Agriculture, nos. 2–41, October 1888, IOR; Nitya Gopal Mukerji, *Handbook of Sericulture*, Calcutta: Bengal Secretariat Press, 1899, Chapter 2.

[70] W.R. Edwards, 27 June 1918, India, Home (Medical), no. 26, July 1919, NAI. That the microscope could be incorporated into a revitalized Ayurveda can be seen from Projit Bihari Mukharji, *Doctoring Traditions: Ayurveda, Small Technologies, and Braided Sciences*, Chicago: University of Chicago Press, 2016, Chapter 4.

[71] *Times of India*, 18 January 1882, p. 3.

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research'.[72] It was not uncommon into the 1870s for civil and army doctors, when asked for their 'microscopical observations', to reply that they had no microscope or lacked one of sufficient powers to be of practical use.[73] Sweat obscured the microscopist's vision; viewing slides, especially unstained objects, when the light outside was either dazzling or funereal, was a frequent challenge. Insects, snakes and scorpions invaded the laboratory, forcing the researcher to abandon work.[74] The build-up of a fungal film on the lens during the rainy season made it hard to see clearly. In commending their microscopes in 1888, Kemp & Co. stressed that these were new instruments, 'free from those annoying fungoidal growths on the lenses' that proved so troublesome in the monsoon months.[75] One despairing IMS officer asked readers of the *Indian Medical Gazette* in 1898 whether they, too, had found that 'objectives, particularly the high-powered ones, deteriorate rapidly and, in many cases, become useless after a few years'. The editor responded, citing his own experience of a 'cataract' forming on his microscope lens after barely four years' use.[76]

By the 1880s a wide range of instruments were available in India, varying greatly in price and sophistication, with German firms competing strongly against British makers. As laboratory science grew in intricacy and scale, so the demand for more (and more expensive) equipment increased accordingly. In 1899 W.B. Bannerman at the Plague Research Laboratory in Bombay submitted a lengthy list of his requirements, including a Zeiss microscope, costing fifty pounds, 'there being none in the laboratory at present'.[77] The growth in microscopy and laboratory science created a parallel demand for Indian technicians, laboratory assistants and 'artists', charged with preparing and staining slides, making sketches, reproducing lithographs and photographs and colouring illustrations for monographs and reports. Indians were said to have a 'natural' aptitude for such 'patient and minute' (if poorly remunerated) work. Sometimes art college students were entrusted with this task, but by the late nineteenth century many scientific institutions were recruiting Indians directly for this purpose.[78]

Vandyke Carter and the art of medical microscopy

Henry Vandyke Carter is a pivotal figure in this story, his career in India from 1858 to 1884 spanning the period in which medical microscopy moved from the margins to the mainstream. He was already relatively well known before he embarked for India, having illustrated the first edition of *Gray's Anatomy*; when he arrived in Bombay to take up a professorship of anatomy and physiology at Grant Medical College, he was described as 'the author of the beautiful plates by which Gray's Anatomy is illustrated'. Teaching microscopy was one of Carter's passions at Grant, where, he reported, the microscope was 'frequently brought in to aid the illustration of lectures' and the identification of the 'principal [human] organs and tissues'.[79] But it was through his own research that Carter made the greatest contribution to microscopy in India. He pursued several research projects which combined his exceptional skill as a microscopist with his remarkable talent as anatomical illustrator. Where many contemporary naturalists and anatomists relied on Indian artists to illustrate

[72] *Report of the Commissioners Appointed to Inquire into the Origin, Nature, etc. of Indian Cattle Plagues*, Calcutta: Superintendent of Government Printing, 1871, p. 899.

[73] Tilbury Fox and T. Farquhar, *On Certain Endemic Skin and Other Diseases of India and Hot Climates Generally*, London: J. and A. Churchill, 1876, pp. 51, 223.

[74] D.D. Cunningham, *Plagues and Pleasures of Life in Bengal*, London: John Murray, 1907, p. 32.

[75] *Times of India*, September 11, 1888, p. 7.

[76] A.E. Grant, 'Microscopic work in India', and editor's reply, *Indian Medical Gazette* (1898) 33(12), p. 479.

[77] W.B. Bannerman to chief secretary, Bombay, 5 August 1899, India, Home (Medical), no. 64, August 1899, IOR.

[78] *Review of Education in Bengal, 1892–93 to 1896–97*, Calcutta: Bengal Secretariat Press, 1897, p. 109.

[79] *Annual Report of the Grant Medical College, Bombay, 1859–60*, Bombay: Education Society's Press, 1860, pp. 7–9.

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their work, Carter produced his own artwork; he had a keen aesthetic sense combined with an eye for detail and colour.[80] One of his early projects concerned urinary calculi or stones. Chemical analysis formed part of this investigation, but it was primarily through the microscope that he was able to discern, appreciate and convey through hand-drawn plates the intricate form and delicate structures of these 'hurtful concretions'. 'Some specimens', he noted, displayed a 'special beauty', just as his 'beautifully illustrated' plates particularly attracted reviewers' attention.[81]

Carter's study of calculi – still in the mode of descriptive physiology rather than investigative pathology, still tinged with a sense of the 'wonders' of microscopic nature – was uncontroversial, but another of his projects, on the fungal infection he named mycetoma ('Madura foot'), was hotly disputed. From his close microscopical observations Carter produced colour drawings of the fungal spores and filaments by which (he argued) the disease penetrated the human foot. He differentiated between two types of fungus – one 'black or dark brown', the other 'more or less pale; pink, brown, or yellowish' – providing detailed colour plates to highlight the distinction.[82] Paradoxically for such a disfiguring affliction, what struck many reviewers of *On Mycetoma* was the beauty of Carter's images. But his artistry was almost a distraction, for he failed to convince critics that the fungus was the cause and not just an accidental or opportunist complication. Kenneth McLeod, editor of the *Indian Medical Gazette*, observed that the 'eleven chromolithographs which illustrate the text form of themselves a most valuable contribution to the pathology of this malady'. They reflected 'very great credit on Dr Carter not only as an artist, but as an accurate delineator of the appearances represented by the disease'. Yet, when it came to explaining the aetiology of mycetoma, McLeod believed that Carter was 'on the wrong track'.[83] Other critics, too, questioned Carter's conclusions, arguing that other microscopists had failed to discover any evidence of the black fungus to which he attached such importance.[84]

It was not uncommon in the India of the 1870s and 1880s to treat the revelations of the microscopist with scepticism. The press often claimed that microscopes alone proved nothing; what an observer saw through the lens might simply be the result of an over-fertile imagination. 'It has been stated', Bombay's *Times of India* remarked in reviewing Carter's study of relapsing fever, 'that a man with a high-power microscope may see anything he wishes to discover, and neophytes often see more than other people'. In this instance, the *Times* sided with Carter, who had 'made the study of the microscope almost the sole business of his life, and, therefore, was not at all likely to be deceived'.[85] Doubts, however, persisted as to whether the spirillum that Carter identified through his microscope had any functional connection with relapsing fever, the governor of Bombay facetiously remarking that Carter was simply observing his own eyelashes.[86] Three years earlier, the *Times* had voiced its own reservations, invoking a familiar environmentalist argument that detecting the presence of microscopic 'animalcules' was seldom sufficient to explain the observable facts of epidemic disease. 'This', it commented, seeking a macrocosmic rather than microscopic explanation,

[80] On Carter's aesthetics see Ruth Richardson, *Mr. Gray's Anatomy: Bodies, Books, Fortune, Fame*, Oxford: Oxford University Press, 2008.

[81] H. Vandyke Carter, *The Microscopic Structure and Mode of Formation of Urinary Calculi*, London: J. and A. Churchill, 1873, pp. 9, 27; Carter, 'Memorial' to the Secretary of State for India, 18 August 1884, p. 3, HVC 5281, WC.

[82] H. Vandyke Carter, *On Mycetoma, Or the Fungus Disease of India*, London: J. and A. Churchill, 1874, p. 1.

[83] [Kenneth McLeod], 'The etiology of Madura foot', *Indian Medical Gazette* (1875) 10(1), pp. 44–6.

[84] Jabez Hogg, 'Mycetoma: the fungus-foot disease of India', *Monthly Microscopical Journal*, March 1872, pp. 98–100; Fox and Farquhar, op. cit. (73), pp. 42–51.

[85] *Times of India*, 11 November 1881, p. 2.

[86] N.H. Choksy, 'Bombay relapsing fever', in William Ernest Jennings (ed.), *Transactions of the Bombay Medical Congress, 1909*, Bombay: Times Press, 1910, pp. 168–94, 168.

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'is especially the case in India, where all maladies are more of less affected by malarious influences, and where their symptoms are more or less marked, modified, or exaggerated, by peculiarities of climate'.[87] Seeing the world through a microscope lens equated with a narrow vision: no one 'who relies on it can grasp a big idea'.[88]

Carter described himself as a 'lone man', an 'exile' in India.[89] Yet, for all the criticisms, his microscopy earned him an international recognition rare among researchers in India at the time. Decades before Ross, he was conversant with the most recent developments in medical microscopy in Europe, including the identification of Hansen's leprosy bacillus and Laveran's malaria plasmodium.[90] But, theoretically and empirically, his laboratory was India. During his leprosy investigation he travelled extensively, interviewing lepers and studying their surroundings; during the epidemic of relapsing fever in Bombay he took his microscope with him to the famine camps and twice fell victim to the disease.[91] Like the botanists in India who observed their plants *in situ* rather than as desiccated specimens back in Europe, Carter demonstrated the advantages of investigating diseases microscopically among the people and in the localities where they actually occurred. But when in 1884 Bombay's surgeon general urged his inclusion in a cholera commission, praising him 'as an original enquirer and microscopist', Carter's name was omitted.[92] Ross thought that Carter should have become India's surgeon general; Carter's own frustration was that he was denied promotion even to provincial sanitary commissioner, a position he believed commensurate with his seniority and talent as a microscopist.[93] When it came to high office in India, microscopy was no great asset.

The microscopical imaginary

While Carter made passing reference to India's intra-tropical location, the idea of the tropics was not central to his conceptualization of disease. But by the 1880s India's human diseases (along with animal and plant disorders) were increasingly situated within the rubric of the tropics. Importance was attached to the idea that the diseases of the tropics were in nature, severity or extent distinct from those of the temperate zones and were profoundly influenced, if not actually caused, by environmental or macrocosmic factors specific to warm climates – heat, dust, humidity, the seasonality of the monsoons, the superabundance of plant and insect life, the deadly (if elusive) miasma such conditions were thought to engender.[94] A prime example of this environmentalist imaginary as applied to India can be found in the work of Joseph Fayrer. A long-serving member of the IMS and one-time professor of surgery in Calcutta, in 1882 Fayrer published a treatise on malarial fevers in India closely identifying them with the climate and the geographical locations in which they occurred.[95] Significantly, in contrast to Carter, Fayrer used a microscope only sparingly, mostly, like many anatomists before him, simply to confirm or supplement

[87] *Times of India*, 11 June 1878, p. 2.

[88] *Times of India*, 20 August 1880, p. 2.

[89] Carter to Eliza Carter, 9 February 1883, Carter Mss 5810, WC.

[90] H. Vandyke Carter, *On Leprosy and Elephantiasis*, London: Eyre and Spottiswoode, 1874; H.V. Carter, 'Note on some aspects and relations of the blood-organisms in ague', *Scientific Memoirs by Medical Officers of the Army of India* (1888) 3, pp. 139–67.

[91] *Times of India*, 18 March 1890, p. 5.

[92] T.B. Beatty to secretary, Bombay, 3 September 1884, India, Home (Sanitary), no. 27, October 1884, NAI.

[93] Ross, op. cit. (10), p. 174; Carter, 'Memorial', op. cit. (81), pp. 1–3.

[94] David Arnold, 'Introduction: tropical medicine before Manson', in Arnold (ed.), *Warm Climates and Western Medicine: The Emergence of Tropical Medicine, 1500–1900*, Amsterdam: Rodopi, 1996, pp. 1–19.

[95] Joseph Fayrer, *On the Climates and Fevers of India*, London: J. and A. Churchill, 1882.

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observations made, post-mortem, with the naked eye.[96] Likewise, Fayrer possessed little illustrative skill, making only crude sketches of his microscopical observations of healthy or defective cells. Indeed, his greatest contribution to the visual culture of nineteenth-century science in India was his study of snakes, vividly illustrated in colour plates by students from the Calcutta School of Art.[97]

We enter a seemingly different world of instrumentality, imaginaries and illustrative techniques with the appointment in 1872 of T.R. Lewis of the Army Medical Department and D.D. Cunningham, IMS, charged by the government of India with uncovering the aetiology of cholera – another disease for which environmentalist explanations had long prevailed in India.[98] Lewis and Cunningham undertook extensive microscope-based laboratory work and field studies to address the challenges posed by the emergence of germ theory and bacteriological research in Europe. Lewis appeared particularly well qualified for the task.[99] A skilled microscopist, versed in the latest techniques, he was conversant with current medical research in Germany, especially that of Max von Pettenkofer, whose claims for the primary role of air, water and soil in transmitting cholera and typhoid were central to Lewis and Cunningham's own agenda and appeared congruent with the environmentalist paradigm in India.[100] Lewis, whose research also encompassed filaria and leprosy, displayed a new visual and technical competence – not just in terms of what he saw under the microscope and the up-to-date chemical tests and staining techniques he employed, but also through his experiments with lithography, photography and microphotography as diagnostic tools and representational media, although, like Fayrer, he turned to students at Calcutta's School of Art to make engravings from his microscopical observations.[101] These enabled him to demonstrate successive stages, invisible to the naked eye, in the development of the filaria 'worm' and other blood parasites.[102] Like Carter's work on the relapsing fever spirillum, Lewis's account of filaria flagella proved significant for veterinary research in India, a demonstration of how closely microscopy connected plant and animal, as well as human, pathology.[103]

However, Lewis and Cunningham failed in their quest for the cause of cholera. For all the sophistication of their microscopy, they remained committed to the environmentalist imaginary, to the idea that climate, soil, dust, heat or humidity must somehow be causative factors or have a decisive effect on the dissemination of the pathogen.[104] When Robert Koch

[96] Fayrer, 'Register of operations', 1858–68 and 1868–72, RAMC/1090/1 and RAMC/1090/2, WC; Joseph Fayrer, *Clinical Surgery in India*, London: John Churchill & Sons, 1866.

[97] Joseph Fayrer, *The Thanatophidia of India: Being a Description of the Venomous Snakes of the Indian Peninsula*, London: J. and A. Churchill, 1872. There are many examples of this reliance on Indian artists: see, for example, the hand-drawn plates by A.C. Chowdhary and S.C. Mondul in A. Alcock, *Illustrations of the Zoology of the Royal Indian Marine Ship Investigator*, Calcutta: Office of the Superintendent of Government Printing, 1901.

[98] Mark Harrison, 'A question of locality: the identity of cholera in British India, 1860–1890', in Arnold, *Warm Climates and Western Medicine*, op. cit. (94), pp. 133–59.

[99] 'Biographical sketch of Timothy Richards Lewis', in W. Aitken, G.E. Dobson and A.E. Brown (eds.), *In Memoriam: Physiological and Pathological Researches: Being a Reprint of the Principal Scientific Writings of the Late T.R. Lewis*, London: Lewis Memorial Committee, 1888, pp. xxiii–xxvii.

[100] Pettenkofer's agenda is most evident in T.R. Lewis and D.D. Cunningham, *The Soil in Its Relation to Disease*, Calcutta: Government Printing Office, 1875.

[101] T.R. Lewis and D.D. Cunningham, *A Report on Microscopical and Physiological Researches into the Nature of the Agent or Agents Producing Cholera*, Calcutta: Superintendent of Government Printing, 1872; T.R. Lewis, *A Report on the Microscopic Objects Found in Cholera Evacuations* (1870), in Aitken, Dobson and Brown, op. cit. (99), p. 64.

[102] T.R. Lewis, *On a Haematozoon Inhabiting Human Blood: Its Relation to Chyluria and Other Diseases*, Calcutta: Office of the Superintendent of Government Printing, 1872.

[103] J.H. Steel, 'On relapsing fever of equines', *Veterinary Journal* (1886) 22(3), pp. 166–74; A. Lingard, 'A new species of trypanosome found in the blood of rats', *Journal of Tropical Veterinary Science* (1906) 1(1), pp. 5–14.

[104] T.R. Lewis and D.D. Cunningham, *Cholera in Relation to Certain Physical Phenomena*, Calcutta: Office of the Superintendent of Government Printing, 1878.

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visited Calcutta in December 1883 and announced that he had found the agent of the disease in a comma-shaped bacillus, Lewis was loud in his condemnation. He claimed that Koch was basing his claims on bacteriological samples that he (Lewis) had examined before they were sent to Germany and in which no evidence for a causative bacillus had been found. Koch had, in his view, compounded this error in India by identifying with cholera one of the numerous microorganisms Lewis already knew of and judged to be harmless. Abetted by Fayrer, Lewis then spearheaded international opposition to Koch, visiting France, scene of a recent cholera outbreak, to show how mistaken the eminent German bacteriologist had been.[105] Together they attended international sanitary conferences to uphold the British position that cholera epidemics were triggered by environmental factors, not by human transmission, and hence that the threatened imposition of quarantine measures against India was unwarranted. Both he and Fayrer were patriotically convinced of the superior insights of British microscopists who, unlike Koch, were familiar with the distinctive nature of Indian conditions.[106]

Nor were Lewis and Fayrer lone dissenters. In August 1885 a correspondent of the *Times of India* observed that it was 'nearly time to give up the microscope in the search after the origin of cholera'. Offering atmospheric electricity as an alternative explanation, the writer added, 'for the last few years searching after micro-organisms we have gone off the track altogether'.[107] A sceptical view of Koch's bacillus also dominated the early issues of the government of India's *Scientific Memoirs*, which began publication in 1885. Cunningham, Carter and others used their own microscopy expertise to contest or modify Koch's claims, Cunningham in particular doubting that the bacillus could alone be responsible for such deadly epidemics.[108]

The eventual vindication of Koch's theory cast a dark shadow over medical microscopy in India. And yet, paradoxically, the controversy enhanced rather than diminished the microscope's authority in India. Aside from a few entrenched sceptics, the episode showed the indispensability of the microscope whether in trying to prove or to disapprove a given hypothesis in medical science; it tied disease to the visibility under the lens of specific 'germs' rather than elusive miasma. The cholera controversy also opened the way for reimagining the tropics, not by abandoning the familiar idioms of heat, humidity and season, but by associating them with pathogens and parasites that were exceptionally, if not uniquely, to be found in tropical regions.[109] The microscope placed the idea of the tropics on a sound scientific footing, just as tropicality, in medical, veterinary and agricultural science, elevated the microscope in India to a position of unprecedented local and international authority. In its newly authoritative guise, microscopy functioned not only prospectively, laying the groundwork for future research, but also retrospectively, calling into question, for example, the loose category of 'fevers' that earlier investigators like Fayrer had employed, and highlighting the previously unrecognized extent of typhoid among British soldiers in India.[110]

[105] T.R. Lewis, 'A memorandum on the "comma-shaped bacillus" alleged to be the cause of cholera', in Aitken, Dobson and Brown, op. cit. (99), pp. 329–33.

[106] 'Biographical sketch', in Aitken, Dobson and Brown, op. cit. (99), p. xxvi.

[107] *Times of India*, 25 August 1885, p. 4.

[108] D.D. Cunningham, 'On the results of choleraic comma bacilli in earth, cowdung, and in human excreta', *Scientific Memoirs by Medical Officers of the Army of India* (1888) 3, pp. 11–16.

[109] For the compatibility of environmentalism with bacteriology, see Mary P. Sutphen, 'Not what, but where: bubonic plague and the reception of germ theories in Hong Kong and Calcutta, 1894–1897', *Journal of the History of Medicine* (1997) 52(1), 81–113.

[110] *Annual Report of the Sanitary Commissioner with the Government of India, 1906*, Calcutta: Superintendent of Government Printing, 1908, p. 12

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Admittedly, in the short term, the microscope might do more to spread confusion than to resolve it. The more widespread and influential microscope use became the more likelihood there was of unsubstantiated claims being made for the arrival of a disease or the manner of its causation and transmission. In 1898, the year in which Paul-Louis Simond established rat fleas as plague vectors, an IMS officer in Hyderabad reported that his microscopy and microphotography had conclusively revealed the presence of a plague 'virus' in the earthen floors of Indian dwellings. Rats and clothing might be implicated in the transmission of the disease, he conceded, but only because they came in contact with infected flooring. The evidence for this claim, based on his microscopy, was, he insisted, 'overwhelming'.[111] In general, though, the bubonic plague that reached Bombay in 1896 and then spread rapidly across India firmly established the utility of the microscope, especially when deployed alongside photography and other visual media – from micro-images of the plague bacillus to photographs illustrating rats and their fleas.[112] The combined image making of microscope and camera enabled magic-lantern slides to be produced in large numbers to be shown at lectures and exhibitions, fuelling the popular imagination as to the causes and vectors of disease. By the early 1920s Bengal's health department alone held dozens of lantern slides, including a series with Bengali captions illustrating the life cycle of *Anopheles* mosquitoes and the 'malarial microbe'.[113] At the medical congress held in Bombay in 1909 many of the scientific papers presented touched on the unique importance of microscopy to the investigation of tropical disease and the implementation of tropical hygiene. Optical instruments featured prominently on the trade stands while a 'pathological exhibition' included two hundred microscopes to be used for viewing 'microscopical … slides of interesting specimens'.[114] Microscopy had become the 'big idea'.

Conclusion

Over the course of the nineteenth century the local history of the microscope in India moved from merely recreational use to become enshrined in colonial pedagogy, state governance and a range of scientific and technical institutions. Its visible presence and functional remit extended far beyond the medical research on which most accounts of microscopy in India have focused. The instrument leant credibility to claims for the scientific superiority of the West and underpinned expectations that Indians should learn to see in a 'scientific' manner. The microscope formed part of the transracial 'conversation' of science in Victorian India, and yet when it came to laboratory science Indians were often relegated to subordinate roles, as assistants, technicians and artists, roles that were nonetheless essential for the conduct of science and dissemination of scientific knowledge. Despite the high scientific profile microscopy had come to occupy in India by the early 1900s, in its earlier history it faced multiple obstacles. The microscope seemed plagued with practical difficulties, by issues of cost and limited availability. Given a predominantly environmentalist understanding of disease causation and transmission, the evidence even of expert microscopists was often contradictory, contested or seen as only part of a more holistic explanation. Although Indians took up microscopy as part of their professional training and contribution to scientific endeavour, their labour was often disparaged or seen as less valuable than that of the 'heroic' European. While use of the microscope as a research tool

[111] E. Lawrie, Hyderabad, to secretary, Nizam's government, 12 September 1898, India, Home (Sanitary), nos. 150–8, November 1898, NAI.

[112] E.g. W. Glen Liston, *The Cause and Prevention of the Spread of Plague in India*, Bombay: Times Press, 1908.

[113] *Magic Lantern Slides on Public Health Subjects in the Bengal Public Health Department*, Calcutta: Bengal Secretariat Press, 1923.

[114] Jennings, op. cit. (86), pp. xix–xx; *Times of India*, 5 March 1909, p. 8.

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and as an instrument of colonial governance in India was far more extensive and influential than Ronald Ross's retrospective remarks implied, microscopists had to battle long and hard to attain a scientific authority of their own.

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