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THE NEW CAMBRIDGE HISTORY OF INDIA

III · 5

Science, Technology and Medicine in Colonial India

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IMPERIAL SCIENCE

Although a proposal to establish a department of science under the Government of India was made in 1884, anticipating the need for central direction and pooled expertise for agriculture, botany, forestry and related fields, the idea was rejected, and almost twenty years elapsed before a similar scheme came into being.[14] The need more effectively to harness science to the state first became a matter of political urgency under the viceroyalties of Elgin (1894–9) and Curzon (1899–1905). In December 1898, at a time of growing popular unrest, especially over its policy towards the plague epidemic that had broken out two years earlier, Lord Elgin's government belatedly recognised its isolation from modern science, finding itself 'almost without competent advisers in many branches of science'. When scientific issues required investigation, responsibility fell on officials 'who are neither by experience nor knowledge competent to offer a decided opinion as to the best course to be pursued'. The result, Elgin concluded, 'has too often been misdirected action and the best endeavours have proved fruitless because the best men have not been secured for the work required'. The Government of India accordingly asked for the advice of 'leading men of science' in Britain to exercise 'a general control' over research work proposed or carried out in India.[15]

At a time when India was developing its own scientific expertise, not least through the endeavours of Indian scientists, this might be considered a retrograde step, one that showed a marked lack of confidence in the emergent scientific community in India and aligned colonial science even more firmly with metropolitan authority. From Elgin's request emerged the Indian Advisory Committee of the Royal Society, a group of scientific experts, some of whom had Indian experience. But the Committee remained inoperative until 1903, nearly three years after its formal constitution, and more immediate action was needed. In the wake of famine as well as plague, Curzon and his advisers decided in 1903 to create their own body of experts, called the Board of Scientific Advice, to bring together the heads of India's scientific and technical services in twice-yearly meetings, but, again deferring to metropolitan science, the Board was required to submit an annual report to the Royal Society in London. Curzon believed that in a rapidly changing world of science and technology there was an urgent need for sound advice and practical research in India, especially in view of the fact that the Government of India owned

14 Kumar, *Science*, pp. 82–3.

15 Roy M. MacLeod, 'Scientific Advice for British India: Imperial Perceptions and Administrative Goals, 1898–1923', *MAS*, 9 (1975), p. 351.

'the largest landed estate in the world, that the prosperity of the country is at present mainly dependent upon agriculture, that its economic and industrial resources have been very imperfectly explored, and that funds available for scientific research are limited'.[16] The relationship between the two advisory bodies was always fraught. The obligation on the Indian Board to report to the London Committee and the long delays in receiving replies accentuated resentment that only 'applied' and not 'fundamental' research was deemed suitable for scientific workers in India. There was annoyance that India should be subjected to carping criticism from experts in London, even if some of them were old India hands. The relationship in effect broke down in 1910: the Advisory Committee in London virtually ceased to function after 1914, a fate followed by the Indian Board in 1922.

Roy MacLeod has seen the career of the Indian Board and its struggles with London as evidence that a 'new sense of scientific independence was beginning to assert itself' in India.[17] While a desire for greater autonomy may have been in evidence in the 1900s, it was only after 1945 that 'scientific independence', like its political counterpart, was substantially attained. The continuing role of the Royal Society as the mentor and overseer of science in India and the fate of India's own Board of Scientific Advice might, in fact, be seen as indications of the long-term failure of scientists in India to wrest autonomy, or even a major share of the decision-making process, from the colonial state and its metropolitan allies.

While upholding the ICS view that scientific experts existed to advise, not to administer, Curzon was more alive than many of his bureaucrats to the scientific spirit of the age and to the practical, as well as polemical, needs of high imperialism. He clearly believed that the value of science was far greater than had hitherto been realised in India. Science (and not just the grand public works that had dominated nineteenth-century thinking) could be a force for far-reaching change, an aid to more efficient government, and not least, in an age of increasingly assertive nationalism, a fresh source of legitimation for British rule. Addressing a medical conference in 1899, Curzon asserted that the British had come to India not just as conquerors but also as benefactors, bearing the gifts of their law, religion, literature and science. There might be those who questioned the value of Britain's laws and religion, but about science, especially medical science, he said, there could be no doubt. Medicine alone was justification for British rule. It was 'built on the bed-rock of pure, irrefutable science'. It was 'a boon . . . offered to all, rich and poor, Hindu and

16 Ibid., p. 355. 17 Ibid., p. 371; Kumar, *Science*, pp. 105–9.

Mahommedan, woman and man'. Medicine lifted the veil of purdah 'without irreverence'; it broke down the barriers of caste 'without sacrilege'. Medical science was 'the most cosmopolitan of all sciences' because it embraced 'in its merciful appeal every suffering human being in the world'.[18]

Agriculture, so long neglected, was now a high priority. Laying the foundation stone in April 1905 for the Indian Agricultural Research Institute at Pusa in Bihar, Curzon stressed the Government of India's special responsibility for promoting scientific research and education. It had, he believed, a duty to 'give the lead' to the provinces by creating model scientific institutes and recruiting and training experts of the highest calibre. Central government was alone in a position to provide the necessary funding, direction and coordination. The achievements of its specialist institutes would be taken up in the provinces and the resulting scientific discoveries and educational benefits would be passed on, via local institutes and technical officers, to improve the 'position and prospects' of the peasantry.[19] Only the Government of India could recruit and suitably reward the European scientists Curzon believed India needed to revitalise its agriculture, the talented individuals who would lock India into the global scientific community at the highest level. Internally, Curzon saw India as a single scientific empire, not a set of semi-autonomous provinces, each pursuing its own parochial agenda with inadequate resources. For Curzon, science was essential to the modern, paternalistic state. He professed to have the well-being of the masses at heart and yet responded to the challenge of middle-class nationalism by urging India's princes and traditional elites to help fund medical and scientific research; when Indians proposed their own scientific and technical projects he was far less enthusiastic. The full credit for scientific and technological progress should rest with the imperial regime.

For Curzon the central government and the institutions and services answerable to it were vital to the formation of an informed science policy and the practical application of scientific research. In addition to a number of recently formed research institutes (veterinary science at Muktesar in 1898, agriculture at Pusa in 1905, forestry at Dehra Dun in 1906), by 1914 there were nearly a dozen all-India ('imperial') services and specialist departments, including medicine, meteorology, veterinary science, botany, agriculture, forests and geology. These varied widely in form and function: some – like the Geological Survey – were committed to both original research and its practical application, others were largely confined to data collection and surveys. Compared with the ICS and IMS, these imperial services were remarkably, even absurdly,

[18] *IMG*, 34 (1899), p. 134. [19] *Speeches by Lord Curzon of Kedleston*, IV (Calcutta, 1906), pp. 126–9.

Table 5.1 *Composition and pay of India's scientific services, 1920*[20]

	Europeans	Indians	European pay	Indian pay
			(Rs per month)	
Agricultural Service	38	5	1,000	460
Bacteriological Service	24	5	1,220	520
Botanical Survey	2	–	1,000	–
Educational Service	34	3	910	490
Forest Service	9	1	1,040	660
Geological Survey	16	–	1,010	–
Meteorological Department	10	2	970	770
Munitions Board	11	1	780	300
Trigonometrical Survey	46[a]	–	–	–
Veterinary Department	2	–	1,110	–
Zoological Survey	3	1	970	700
Total	195	18		

Notes:
[a] All except one Royal Engineers, holding military rank and rates of pay.

small, but even in 1920, when their numbers had been depleted by war service and casualties, the predominance of Europeans, and their superior conditions of employment, remained evident (table 5.1).

The vision of these services as representing 'imperial science' – a science that was India-wide and not merely provincial, devoted to serving the needs of India and the empire, carried out by scientists of world renown – was not confined to Curzon, but permeated the thinking of many scientists themselves. Despite the mounting pressure for Indianisation, these remained essentially European services, and their racial exclusiveness helped, despite the ever-present personal and professional conflicts, to shape a shared scientific culture and a common ideal of scientific service to the empire as a patriotic and paternalistic duty. That the state was by far the largest employer of scientists in India further strengthened a sense of cohesion, even idealism. **Albert Howard**, brought to Pusa as an economic botanist in 1906, was attracted to the post by the prospect of developing his research on tropical agriculture (begun in the West Indies) and by the manner in which, under Curzon, scientists had been recruited to serve India and bring the benefits of Western science to its people.[21] Even at the end of the First World War, the Indian Industrial

[20] Prafulla Chandra Ray, *Indian Science Congress: Presidential Address* (Calcutta, 1920), p. 16.
[21] Louise E. Howard, *Sir Albert Howard in India* (London, 1953), pp. 13–15.

Commission, under **Sir Thomas Holland**, former head of the Geological Survey of India, could favourably represent scientific and technical workers as a 'caste', with an *esprit de corps* of their own, and recommend the extension of the centralised service model to chemistry and other scientific fields.[22]

The converse of this service ethos was racial discrimination and what Deepak Kumar has called a system of 'apartheid' in the science of nineteenth-century India. He cites specific instances, including the attitude shown by the Superintendent of the Geological Survey of India, H. B. Medlicott, in 1880 in opposing the appointment of **Pramatha Nath Bose**. Medlicott remarked of Bose, recently qualified in London: 'he is a Bengali and may be physically unfit for our work.' Although Bose was admitted as the Survey's first Indian member, Medlicott remained hostile, declaring that his work as an assistant superintendent was only satisfactory when it followed an established path: 'when he afterwards moved to ground in which he had no outline to start with and the [geological] formations were new to him, his scientific helplessness became at once apparent.' Medlicott was convinced that Indians as a whole were 'utterly incapable of any original work in natural science'. Their recruitment should wait until 'the scientific chord' among Indians was touched, 'if indeed it exists as yet in this variety of the human race'. He urged the government to 'exercise a little discretion with our weaker brethren, and not expect them to run before they can walk'.[23] Bose suffered further rebuffs, eventually resigning in 1903 when Holland, ten years his junior, was appointed Director of the Geological Survey.[24] Bose's riposte, like that of a number of other Indian scientists, educationalists and administrators who found their talents snubbed in British India, was to seek employment in a princely state. As state geologist to the Maharaja of Mayurbhanj, Bose helped locate the iron-ore deposits that subsequently supplied the Tata iron and steel works at Jamshedpur, and so helped lay the basis for India's industrial economy.

The prejudice against Indians and complaints about their supposed physical and mental inadequacies extended to their employment as subordinates in the Geological Survey and other scientific departments. When in 1874 the Government of India directed that Indian 'apprentices' should be taken on by the Survey, it was at once decided to exclude Bengalis who 'from deficiency of stamina and manliness' were deemed incapable of the arduous field-work required. Several Sikhs, in colonial sociology a more 'manly' race, recent graduates from Lahore, were chosen instead, but Valentine Ball found little to praise

[22] *Indian Industrial Commission, 1916–18* (Calcutta, 1918), pp. 88–9.

[23] Deepak Kumar, 'Racial Discrimination and Science in Nineteenth-Century India', *IESHR*, 19 (1982), pp. 69–70.

[24] Kumar, *Science*, pp. 214–16.

in their work. In his view, Indians, 'however intellectual, and however well they may have been educated in various scientific branches, have shewn little capacity for undertaking original scientific research'. Indeed, they seemed to be 'deficient in synthetical powers to an extraordinary degree'.[25] Little wonder, then, that Indians filled less than 10 per cent of posts in the scientific services by 1920, or that the few who were admitted faced prejudice and discrimination.

Racial discrimination extended into the universities, where academic staff were 'practically segregated into two distinct racial camps'.[26] Indians, even the chemist **Prafulla Chandra Ray** with his Edinburgh doctorate, were confined to the provincial educational and scientific services, and not recruited (and only rarely promoted) into the European-dominated imperial services. The physicist **Jagadis Chandra Bose** was an exception in being directly admitted to the Indian Educational Service, but as an Indian probationer he received only a third the pay of his British colleagues until in 1903, after years of protest, he finally received full 'European' pay. Racial discrimination, it is sometimes suggested, prevented Indians from making a greater contribution to scientific research and intellectual leadership in the years after 1890. This is clearly true in a number of fields (medicine is a conspicuous example), but one could also argue the reverse – that the experience of racial discrimination made some Indian scientists, like Ray, even more determined to succeed. It should be borne in mind, too, that in their student days many Indians received encouragement and drew inspiration from European teachers (as, for instance, Ray did from Alexander Peddler, Professor of Chemistry at Presidency College). Nor were they always subject, even in India, to a crippling discrimination. Bose, in some respects, was relatively fortunate. In 1897, at the Viceroy's instigation, he was awarded a research grant of Rs 2,000 a year on the grounds that he was 'the first explorer and inventor in the electrical sciences that India has yet produced'. Such a grant was virtually unprecedented for either European or Indian members of the educational and scientific services, and the Home Department was sceptical that Bose was worthy of such an honour. 'It is difficult', a member of the Secretariat noted, 'to appraise or even to estimate, the services actually rendered since their nature is not such as to lend itself to an expression of results.' He conceded that Bose might be 'an original thinker (a rare thing in an Indian)' and acknowledged that 'his scientific work has earned him the highest encomiums from authorities who are best fitted to judge of it'. But, in a comment that revealed an antipathy to scientific research, not just its Indian practitioners, the Viceroy was reminded that salaries were

25 V. Ball, *Jungle Life in India: Or the Journeys and Journals of an Indian Geologist* (London, 1880), p. 469.

26 Patrick Geddes, *An Indian Pioneer of Science: The Life and Work of Sir Jagadis C. Bose* (London, 1920), p. 35.

'paid for definite services'; they could not be raised just 'because an officer is of high intellect'.[27]

MEDICAL SCIENCE

There were few scientific fields in which India seemed so deficient by the 1880s as medicine. At the time, Ross later recalled, the medical services in India were so poorly organised and resourced that medical libraries 'did not even exist in the principal stations'. Individual medical officers 'often did good clinical work', but there was little systematic investigation of specific diseases, 'and almost no establishment for it'. The great bacteriological discoveries of Pasteur and Koch 'were scarcely recognised, or were ridiculed', and Laveran's work on malaria, a disease whose control was vital to India, was 'almost unheard of'.[28]

Ross had, in retrospect, reason enough to be scathing, having felt that he was consistently obstructed by the government and the IMS chiefs in his own search for the malaria parasite in the early 1890s. But he was by no means alone in his negative assessment. When Ernest Hart, editor of the *British Medical Journal*, visited India in 1894 to address the newly instituted Indian Medical Congress, he was equally critical. Having reviewed the dramatic advances that had taken place in medical research over the previous fifteen years, and the way germ theory had revolutionised medical thinking, Hart asked why it was that all the major discoveries in tropical pathology had been made by foreigners – French, German, even Japanese – not by Britons. In an age of imperial rivalry, it was galling to have to recognise that the pioneering work on cholera, malaria and, most recently, plague had been done by others. In part Hart blamed the want of proper instruction in tropical medicine in Britain – a cause Patrick Manson was soon to take up – which meant that doctors arriving in the tropics had laboriously to acquire a knowledge of tropical pathology for themselves rather than being armed with it from the outset. But, no less substantially, he believed that research in India, far from being encouraged, was squeezed out by the burden of administration and ward duties. 'There is a feeling', he remarked, 'that a man with a leaning to science, with a new scientific fact in his head, is regarded by officialdom as a nuisance, as a sort of pestilential fellow with a new bug.' With promotion by seniority and not merit, it made sense to 'avoid giving trouble at headquarters' and to follow a course of 'respectable conservatism' rather than pursue potentially controversial research.[29]

[27] Gilbert, 'Profession', p. 401.
[28] Ronald Ross, *Memoirs* (London, 1923), p. 126.
[29] Ernest Hart, *The Medical Profession in India: Its Position and Its Work* (Calcutta, 1894), pp. 73–5.

The conservatism of the IMS and the lack of medical research can be overstated. Ross himself singled out exceptions – such as Henry Vandyke Carter, a pioneer of microscopy in India, whose work included studies of leprosy and relapsing fever, and T. R. Lewis and D. D. Cunningham, who investigated the aetiology of cholera. Although Lewis left India in 1883, Cunningham remained until 1897 as Professor of Physiology in Calcutta and ran one of the few research laboratories in India. And though there was resistance from some old India hands to the new science of bacteriology, symbolised by the scepticism that greeted Koch's discovery of the cholera bacillus, there were encouraging signs of impending change. Reflecting the needs of veterinary science, an Imperial Bacteriological Laboratory opened in Poona in 1890. The appointment of E. H. Hankin as Chemical Examiner for the North-Western Provinces in 1892 brought to India 'an original worker saturated with the bacteriological doctrines and teachings of Pasteur and Koch'. Hankin, who possessed a 'brilliant pen', did much to 'educate and stimulate' the medical profession in India out of its sluggishness.[30] He was one of the instigators of a meeting at Lahore in 1893 which pressed for the creation of an anti-rabies Pasteur Institute in India (eventually established at Kasauli in 1900). In 1893 the Russian-born, Paris-trained bacteriologist Waldemar Haffkine arrived in India to conduct trials with an anti-cholera serum. When plague broke out in 1896, Haffkine, the only full-time bacteriologist in India, developed an anti-plague serum at his small laboratory in Bombay. There were, then, signs of change by the mid-1890s, though significantly neither Hankin nor Haffkine belonged to the IMS or the Royal Army Medical Corps. Ross's momentous discovery of the role of the anopheles mosquito in the transmission of malaria showed that an IMS officer could produce research of international importance. But it was work done against the odds, owing much to the encouragement Ross received from Manson in London and virtually nothing to colleagues in India: 'We IMS men are not meant for research . . . we are simply doctors,' Ross was once told by a colleague.[31] But it was indicative of the new mood that, when medical workers in India held their Congress in Calcutta in December 1894, the Viceroy, Elgin, attended and his government took seriously resolutions calling for the establishment of an all-India medical research institute and for central and provincial laboratories to investigate typhoid and cholera.

There were other, more urgent, pressures on the Government of India. The outbreak of bubonic plague in Bombay in 1896 brought a virulent new scourge to India: more than 400,000 deaths were recorded India-wide by the end of

[30] J. D. Graham, 'Medical and Research Organisation', *Seventh Congress of the Far Eastern Association of Tropical Medicine Souvenir: The Indian Empire* (Calcutta, 1927), p. 99.

[31] Ross, *Memoirs*, p. 243.

1900, and a further 8 million by the end of 1914. Like cholera before it, plague had international ramifications. For decades the British had been criticised at international sanitary conferences for not doing more to prevent the spread of cholera from India to neighbouring regions and, ultimately, to Europe and North America. Now in 1896–7 there seemed the likelihood that plague, too, would spread from Indian ports to the Middle East and Europe, unleashing a new Black Death. At the sanitary conference at Venice in February 1897 an international embargo was threatened against shipping from Indian ports unless the government took effective measures to bring plague under control. Fearing for the loss of its overseas trade, the government responded by introducing the Epidemic Diseases Act, one of the most draconian pieces of sanitary legislation ever adopted in colonial India. The Act authorised the compulsory hospitalisation of plague suspects, the destruction of houses and infected property, the physical examination of rail travellers, and the banning of fairs and pilgrimages. Although these measures helped calm international alarm, they provoked widespread resistance in the towns and cities of western and northern India over the following three years and deepened the government's dilemma as to how it should respond to the challenge of epidemic disease and mass mortality. Its response was further complicated when nineteen villagers at Malkowal in Punjab died in October 1902 of tetanus contracted from a contaminated needle while being inoculated with anti-plague serum from Haffkine's laboratory in Bombay. Haffkine was held directly responsible for the Malkowal 'disaster' and dismissed from his post in 1904; it was several years before his name was cleared and he never again had the opportunity to make a major contribution to bacteriological research in India. Contrary to rumour, anti-plague inoculation had not been made compulsory, but it was one of the most promising means of bringing the epidemic under control.

Eventually, in 1898–9, the government opted for a more pragmatic policy. It sought to avoid further confrontation by moderating its more extreme plague-control measures, accepting that large numbers of deaths were in consequence unavoidable, but trusting that public support for voluntary measures and an enhanced level of sanitary awareness would ultimately stem the epidemic. The Government of India grew wary of trusting medical and sanitary officers to make decisions that might have far-reaching implications for the relationship between the state and its subjects and was confirmed in its belief in the need for political control over medical policy.[32] None the less, the abandonment of the more coercive sanitary measures, the report of the Indian Plague Commission in 1901, and pressure from the medical establishment in

[32] Kumar, *Science*, p. 110.

Britain helped persuade the government that medical research had to be taken seriously.[33] The almost simultaneous discovery of the causes and modes of transmission of malaria and plague provided a much-needed boost to laboratory science in India, but also revitalised field research across a broad scientific spectrum, including medical entomology, helminthology, malaria surveys, and the investigation of the life-cycles and habitats of fleas, mosquitoes and other insect vectors.

Between 1900 and 1914 the government put in place the institutional structures and agencies that were to dominate medical research in India for decades to come, and which kept medical research in the state, rather than university, sector. A series of specialist institutions were created with the dual function of conducting research into plague, cholera and other tropical diseases and of producing the vaccines to combat them. These included the Central Research Institute at Kasauli in the Punjab hills in 1906, with special responsibility for malaria research, four state-aided Pasteur Institutes for the treatment of rabies and the preparation of anti-rabies serum, and two provincial bacteriological laboratories – at Bombay (renamed the Haffkine Institute in 1925) and at Guindy, Madras, where the King Institute of Preventive Medicine opened in 1904. To oversee the running of these institutes and to conduct research, a Bacteriological Department was created in 1906 (subsequently redesignated the Medical Research Department), with recruitment not confined to the IMS and an initial establishment of thirteen posts, soon raised to thirty. Through the initiative of Sir Harcourt Butler, Education Member of the Viceroy's Council, and Sir Pardy Lukis, the Surgeon-General, an Indian Research Fund Association (IRFA) was set up in 1911 to recruit and train medical researchers and to channel funds from the government and private benefactors into approved programmes of medical research. IRFA was a new kind of scientific agency for India (and even anticipated the creation of the Medical Research Council in Britain): it partly superseded the old IMS service model, but retained aspects of Curzon's focus on imperial science. IRFA symbolised the importance that scientific research had come to hold in state policy and in professional training and prestige. It was principally funded by an annual government grant of Rs 5 lakhs (the equivalent of £37,500) and at the height of its activities, in 1927–8, IRFA was spending Rs 11 lakhs a year on medical research in India. From 1913, research conducted under IRFA appeared in the *Indian Journal of Medical Research*, which rapidly established itself as leading international journal, publishing pioneering work on malaria, cholera, kala-azar,

[33] I. J. Catanach, 'Plague and the Tensions of Empire: India, 1896–1918', in David Arnold (ed.), *Imperial Medicine and Indigenous Societies* (Manchester, 1988), pp. 149–71.

plague and hookworm. Through the determined effort of Sir Leonard Rogers, IMS, Professor of Pathology at Calcutta Medical College, and with support from private funding, in 1921 the Calcutta School of Tropical Medicine was opened as a centre for the investigation of a wide range of tropical diseases.[34]

Taken together, these developments did much to reverse India's poor reputation for medical research and to cement its claim by the mid-1920s to have 'played a very distinguished part in the elucidation of tropical diseases'.[35] The research done, for instance, by Glen Liston on plague in Bombay, or by S. R. Christophers and a younger generation of IMS malariologists based at Kasauli, demonstrated that India was capable of frontline medical research. But the outcome was not all positive. The scientific work of the institutes and their small research staffs was often swamped by the demands of sera production, especially during the world wars when research came to a virtual standstill and energies were concentrated on producing vaccines for the armed forces. The dispersal of the leading research institutes throughout India made coordination difficult and undermined the Curzonian ideal of centralised research of all-India utility. Moreover, the old service ethos rapidly reasserted itself. Although it was recognised that, as outsiders to the colonial medical establishment, Hankin and Haffkine had helped get medical research moving in the 1890s, the Malkowal episode was not readily forgotten. It was held that, even though Haffkine had been a brilliant bacteriologist, he was a poor administrator and that, with few exceptions, IMS officers alone had the requisite combination of scientific skill and administrative authority to run a research institute. The IMS was denied a monopoly of research appointments, but it still retained a significant proportion of them. From research having been something the IMS did not do, the pendulum swung strongly in the opposite direction and the prospect of being able to conduct research on tropical diseases and possibly win a Nobel Prize (as Ross did in 1902 for his malaria work) was now advanced as a reason for the best medical minds to join the service. The 'facilities and opportunities' offered for medical research in India were unique, declared Lukis, now Director-General of the IMS, in 1917. 'There is scarcely one of the communicable diseases of India which will not repay further research.'[36]

The converse of this was the increasing isolation of medical research workers from everyday sanitary and medical practice. This elitism was exemplified not only by the professional and, still to a large extent, racial

[34] Helen Power, 'The Calcutta School of Tropical Medicine: Institutionalizing Medical Research in the Periphery', *MH*, 40 (1996), pp. 197–214.

[35] F. P. Mackie, 'Medical Research in India', in *Indian Empire*, p. 127.

[36] Pardy Lukis, 'Opportunities for Medical Research in India', *Indian Journal of Medical Research*, 4 (1917), p. 384.

exclusiveness of the IMS, but also by the fact that many of the medical research institutes and laboratories were located in the hills, in 'temperate' places, far from the main centres of population and from the diseases under investigation. Kasauli, at 6,000 feet above sea level, was a conspicuous example of this aloofness, but the fact that it was only three hours' drive from Simla, and hence under the watchful eye of the Government of India's Sanitary Commissioner, was seen as a strong argument in its favour. Other reasons were also advanced for keeping research laboratories and vaccine establishments in remote hill-stations. Public hostility to animal experiments and vivisection was one reason for moving the Imperial Bacteriological Laboratory from Poona to Muktesar, 7,000 feet up in the hills of Kumaon. Another argument used in favour of hill-stations was that the tropical climate of Calcutta and Bombay was inimical to advanced bacteriological work: serious science, it seemed, could be done only in cool locations and by research workers from the 'temperate' races. In 1891 the Viceroy, Lord Lansdowne, remarked to the Secretary of State that original scientific research demanded 'mental and physical qualifications' that were apparently not to be found in 'races bred in a tropical climate to the same extent that they exist in the more vigorous races of northern latitudes'.[37] Two years later the Principal of Grant Medical College reported that, whereas in Scotland the heart of a frog kept beating for at least 48 hours after it had been removed from its body, in the heat and humidity of Bombay it lasted barely 5 minutes. He concluded from this that sensitive physiological experiments could not be carried out except in the hills.[38] Such claims were taken seriously, with the result that medical researchers became a caste apart and medical research a privileged, predominantly white pursuit, deemed suitable for remote institutes but denied to under-funded university departments.

In fact, the isolation of many imperial research institutes bred boredom, bitter professional rivalries, and social and racial tensions, as well as provoking Indian criticism of the way in which science was being hidden from public scrutiny and accountability. When Britain's Surgeon-General was asked for his views on establishing a central bacteriological institute in the hills in 1900, he remarked that locating a small number of Europeans at a place like Muktesar, 'cut off from most of the advantages and comforts of civilised life', was bound to be 'very trying' for them. He cited the case of the forestry school at Dehra Dun to show that 'Europeans who remain for long periods in isolated places become especially liable to mental afflictions'.[39] In the short term, however,

[37] Kumar, *Science*, p. 191.

[38] G. A. Maconachie, to Surgeon-General, Bombay, 11 November 1893, in *Report of the Proceedings of the Central Indigenous Drugs Committee of India*, I (Calcutta, 1899), Appendix II, p. 7.

[39] W. R. Hooper, 10 May 1900, Revenue and Statistics Department, L/E/7/431: 1127, OIOC.

such remarks were ignored by an administration accustomed to believe in the virtues of hill-station life.

FORESTRY AND AGRICULTURE

Medicine was one area where the alliance of science and state grew appreciably closer during the late nineteenth and early twentieth centuries, but it was not the only one. State direction and a more consciously scientific approach also characterised colonial forestry from the 1860s onwards. In a work that underscores the importance of famine to the evolution of colonial science in India, Richard Grove has argued that the incentive for the development of colonial conservation and forestry policies came initially from an enlightened group of Company surgeons, who saw in rapid deforestation a major cause of desiccation, soil erosion and climatic change in India and hence a cause of India's apparently worsening droughts and famines. He claims that they were able to win government support for their scientific views, even though forest conservation ran counter to the Company's immediate commercial and financial interests.[40] Grove sees India more generally under the Company as playing a significant, pioneering role in the development of forest management and conservation policy, thereby demonstrating the error of those historians who have argued that 'science in the colonies was inherently secondary and far from the cutting edge of fundamental discovery'. In fact, he avers, 'the reverse seems to have been the case in many of the medical, field and meteorological sciences'.[41] There is, however, a danger of over-emphasising the impact of scientists (themselves mainly in government employment) on state policy, especially when scientific and technical officers were repeatedly reminded by their administrative superiors that their duty was to serve the empire, not to try to run it, and when financial and political considerations were so often given first priority. The extent to which surgeon-scientists were able to manipulate government policy under the Company thus remains in question. Madhav Gadgil and Ramachandra Guha have argued that in the second half of the nineteenth century the main incentive behind the government's forestry policy was a quest for financial gain rather than a simple acceptance of scientific arguments about desiccation and conservation. The setting up of an Indian Forestry Department in 1864, followed by the wide-ranging Indian Forest Acts of 1865 and 1878, can thus be seen as a pragmatic attempt to raise state income

[40] Richard H. Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600–1860* (Cambridge, 1995), ch. 8.

[41] Richard H. Grove, *Ecology, Climate and Empire: Colonialism and Global Environmental History, 1400–1940* (Cambridge, 1997), p. 2.

to fix nitrogen and produce substantial yields on the same ground year after year was, in the long run, one of the most significant investigations conducted by Pusa scientists, including the agricultural chemist Jatindra Nath Sen.

But, like the hill-station medical research institutes, Pusa had its problems. Provincial governments were anxious to pursue research into how local conditions affected crops, or the development of local hybrids, and did not always take kindly to advice from the pundits of Pusa. Albert Howard, who left the institute after eighteen years, commented ruefully on the artificiality of life there and the personal and professional tensions rural isolation induced. There were few visitors and few social contacts except with other members of staff. In order to attract and retain European experts, they had to be paid high salaries, housed in palatial bungalows and provided, at considerable cost, such special facilities as schools, a hospital, a club (initially reserved for Europeans) and what were reputed to be the finest tennis courts in India. Without the stimulus of proximity to the wider scientific community, there was a steady loss of efficiency and sense of purpose. Researchers tended to 'lose a proper sense of proportion'; 'difficulties of all kinds' arose.[57] After buildings at Pusa were damaged by the Bihar earthquake of 1934 it was decided to transfer the Agricultural Institute to Delhi. It is hard not to see the abandonment of Pusa and the move to India's new capital as symbolic of the wider fate of imperial science and the secluded institutes it had spawned.

AN INDIAN SCIENTIFIC COMMUNITY

The scientific developments of the period 1890–1914 cannot be explained by reference to imperial science alone. It is also necessary to take into account the advent of an Indian scientific community, which became conspicuous in the 1890s but built on earlier trends. One long-term factor in its emergence was the growth of Western education in India, supplemented by Indian access to higher education and professional training in the West.[58] Calcutta's elite educational institutions were important both for the interest in science they stimulated and for the opportunities they gave for individual advancement. **Mahendralal Sircar**, physician and founder of the Indian Association for the Cultivation of Science, the physicist Jagadis Chandra Bose and chemist Prafulla Chandra Ray all attended the prestigious Hare School in Calcutta. Mahendralal went on to Hindu College before joining Calcutta Medical College in 1855 and qualifying with an M.D. in 1863. The geologist Pramatha

57 Howard, *Howard*, p. 25.

58 For a discussion of scientific and technical education in India in this period, see Kumar, *Science*, ch. 4.

Nath Bose was educated at Krishnagar College before joining St Xavier's in Calcutta, winning a Gilchrist scholarship to study in London in 1874. Jagadis Chandra Bose also attended St Xavier's, where his interest in physical science was stimulated by the teaching of a Jesuit, Father Lafont, before going on to study in Cambridge and London. Ray, through ill health largely self-educated, attended Presidency College until he, too, received a Gilchrist scholarship, which enabled him to travel to Edinburgh to study chemistry in 1882.

But too much significance should not be attached to Western education alone. The first generation of Indian scientists were also heirs to intellectual and scientific traditions of their own. The Bengali *bhadralok* drew intellectual sustenance and cultural pride from a long tradition of indigenous learning, backed by at least a modicum of wealth, and high social status (coming principally from the Brahmin, Kayastha and Vaidya castes). Jagadis Chandra Bose, like Pramatha Nath Bose, from the Kayastha or writer caste, was born into a relatively prosperous family in Vikrampur, an ancient centre of Sanskrit and Buddhist learning in east Bengal. His Brahmo father, a deputy magistrate and later an assistant commissioner, dissuaded Bose from joining the ICS and encouraged him to pursue an alternative career. Ray also came from a landed, literate background in east Bengal: his father was a Persian scholar and one-time student at Krishnagar College. Ray, too, was drawn to the Brahmo Samaj, which he joined in 1882. The intellectual excitement of student life in Calcutta opened up for him a lifelong enthusiasm for Western literature as well as science, though this was always tempered by the kind of patriotic spirit that led him to write a prize-winning essay on the Indian Mutiny while a student at Edinburgh. Mahendralal Sircar, by contrast, came from the relatively low-ranking Sadgop community and claimed to be a peasant's son, though support from his uncle, a Calcutta lawyer, saw him through medical college and into what was a relatively lucrative medical practice until his dramatic conversion to homoeopathy. Beyond Bengal, a not dissimilar melding of social background and educational opportunity was also discernible. The physicist **Chandrasekhara Venkata Raman** was born into a Tamil Brahmin family: his mother came from a line of Sanskrit pandits; his father, from a family of minor landholders, became a physics lecturer at Vizagapatam College. Despite a B.Sc. and M.A. in mathematics from Madras University, Raman was at first unable to pursue a scientific career and in 1907 joined the Indian Finance Department. He was posted, providentially, to Calcutta, the capital of Indian science.[59]

[59] Geddes, *Pioneer*; Jogesh Chandra Bagal, *Pramatha Nath Bose* (New Delhi, 1955); Prafulla Chandra Ray, *Essays and Discourses* (Madras, 1918); Prafulla Chandra Ray, *Life and Experiences of a Bengali Chemist*, I (Calcutta, 1932); Sarat Chandra Ghose, *Life of Dr Mahendra Lal Sircar* (2nd edition, Calcutta, 1935); L. F. Rushbrook-Williams (ed.), *Great Men of India* (London, 1939).

Sircar and Raman, like the self-taught mathematician Srinivasa Ramanujan, were somewhat exceptional among the leading figures in Indian science in this period in not receiving part of their education abroad. Until the 1900s there were few opportunities to take higher degrees and pursue research in Indian universities. Travelling abroad, usually to Britain, gave Indian students not only a superior training to any they could receive at home, but also the sense, hard to attain in India at the time, of belonging to an international scientific community – being part of the latest research activity, mixing on more equal terms than was ever likely in India with leading scientists, gaining access to a scientific domain that was not bounded by Britain alone but embraced France, Germany and the United States as well. Pramatha Nath Bose later recalled the exhilaration he felt when his first research paper was published in a science journal in London: 'visions of occupying a niche in the modern Temple of Science began to float before my mind.'[60] The six years Ray spent at Edinburgh working with P. G. Tait and Alexander Crum Brown, two of the principal figures in physics and chemistry at the time, nurtured his enthusiasm for scientific research, but also made him acutely aware of India's deficiency in producing scientists of its own. As a student, he later recalled, 'I found to my regret that every civilised country including Japan was adding to the world's stock of knowledge but that unhappy India was lagging behind'. He dreamt of a time when India, too, 'would contribute her quota'.[61] For Ray, as for P. N. Bose, the experience of returning to India to encounter racial discrimination, European domination of the services and grudging official recognition for his scientific qualifications was made even more galling by having previously known, and participated in, a more open scientific community. But the experience also made Ray and others even more determined to try to transcend, through a dual dedication to science and nation, the prejudices and pettinesses of the colonial world.

Some insight into the scientific world that J. C. Bose and P. C. Ray entered on their return to India can be gleaned by looking at the Asiatic Society of Bengal, still in the 1890s India's principal scientific forum. In March 1895, when Bose was elected to the Society, it had six subject committees: philology, numismatics, history and archaeology, natural history, physical science, and anthropology. The membership of these committees included some of the leading names in Indian science at the time, including P. N. Bose, D. D. Cunningham, T. H. Holland, G. King, D. Prain and R. D. Oldham. Apart from 22 honorary members (mostly eminent European scientists who had never set foot in India), the Society had 295 ordinary members at the close of 1894. But when Bose rose at the monthly meeting in May 1895 to present the paper on

[60] Pramatha Nath Bose, *National Education and Modern Progress* (Calcutta, 1921), p. 52.

[61] Ray, *Life*, p. v.

electric waves that launched his international career, only thirteen members and three visitors were present. Seven months later when Ray gave his paper on mercurous nitrite at the December meeting, he was the third of four speakers, sandwiched between Grierson on Kashmiri and Prain on Indian poppies, but at least that evening the audience touched twenty.[62]

The low turnout was not perhaps surprising. Of the Society's 295 members, only a third lived in Calcutta; many of the 183 non-Indian members (who constituted 62 per cent of the total membership) were resident in Europe or on furlough. Given that more than a third of the 112 Indian members also lived outside Calcutta, a high level of absenteeism was to be expected. Of the 145 Europeans for whom occupational information was given in the annual report, a quarter belonged to the ICS, an indication of the service's professional and recreational interest in the sciences, languages and arts of India and of the Society's own importance as a link between science and state. (The Society itself sometimes acted as a scientific pressure group, as in 1871 when its Council successfully petitioned the Government of India, in the wake of the *Challenger* expedition, to undertake deep-water marine research.) Among the remaining Europeans there were twenty members of the army medical services (principally the IMS) and an equal number of army officers, reflecting the continuing importance of the medical services and army to Indian science and engineering. Of the other Europeans, twenty-nine belonged to the scientific and technical services, along with smaller numbers of academics, lawyers, civil engineers, businessmen, doctors, churchmen and missionaries. Some, given their addresses, were likely to have been planters in Bengal and Assam.

The Indian membership was markedly different. Just over half were princes, zamindars and other notables; some, such as the Raja of Vizianagram, were significant patrons of science, but others clearly had a more decorative role. Only three Indian members belonged to the ICS (bringing the Society's total ICS membership to forty-two, or 14 per cent); but there were also five Indians in the scientific and technical services (bringing their tally to thirty-four or 11.5 per cent), as well as deputy magistrates, teachers, doctors and businessmen. Of the forty-six Indian members not identified by their profession, a large number were probably lawyers, minor landholders and government servants.[63]

If these figures can be taken as an approximate indication of the nature of the scientific community in India in the mid-1890s, then the dominance of the state (represented by the army, the ICS, the IMS and the scientific and technical services) is clear. But among the Indian members, the state was less in evi-

[62] *Proceedings of the Asiatic Society of Bengal, January to December, 1895* (Calcutta, 1896), pp. 50–51, 79, 91, 191, 200. [63] Ibid., pp. iii–xiii.

dence; instead India's princes and landed elites held pride of place, though with what seems likely to have been a strong middle-class element. Overall, it is hard to escape the impression that in the capital of modern science in India the scope for Indian scientists was still remarkably small.

It might, however, be argued that the Asiatic Society was unrepresentative of the burgeoning interest in science across India as a whole. In late nineteenth-century India the engagement with science was certainly not confined to a few foreign-trained scientists and government servants, but was spread far more widely among India's old intelligentsia and its newer, Western-educated elites. The extent of this interest can partly be gauged through the existence of local societies and vernacular publications. One early example was Aligarh's Scientific Society, dating from 1864 and presided over by the Muslim 'moderniser' Sir Sayyid Ahmad Khan; another was the Bihar Scientific Society, established by Syed Imdad Ali, a sub-judge at Muzaffarpur, in 1868. The purpose of these societies was to spread the perceived benefits of modern science and technology through lectures and demonstrations, the translation of scientific and technical works and the publication of newspapers and tracts.[64] The Aligarh Society sought to translate scientific and technical works from English into the vernaculars, to locate and publish 'rare and valuable Oriental works', to publish any work 'which may be calculated to improve the native mind' and to present lectures on scientific and other 'useful subjects'. It translated some forty works on history, politics, trigonometry, algebra, arithmetic and especially agriculture, and in 1866 launched the *Akhbar Institute Gazette* to promote Western arts and sciences. Ahmad Khan planned to write an Urdu treatise on scientific methods of cultivation, but the project was never completed and the Society, from having had nearly 100 members in 1875, seems to have folded a few years later.[65]

Other societies and journals were published, particularly in Urdu and Bengali, to propagate Western medicine and sanitation or to integrate Western ideas with indigenous practices. The bi-monthly Urdu journal, *Guardian of Health*, published in Lahore from 1878 to 1888, sought to illustrate the principles of hygiene according to both 'the English and Native way of treating disease'.[66] Although such societies and journals were often short-lived and their effect localised, they were indicative of a widespread interest in bringing Western science and technology to a larger audience and in spreading its

[64] Kumar, *Science*, pp. 196–8.

[65] Hafeez Malik, *Sir Sayyid Ahmad Khan and Muslim Modernization in India and Pakistan* (New York, 1980), pp. 85–9.

[66] A. Neelameghan, *Development of Medical Societies and Medical Periodicals in India, 1780–1920* (Calcutta, 1963), pp. 75–6.

practical benefits and improving ideology. Although activities of this kind were to be found in most parts of India, Bengal, as the region where British ideas had their earliest and greatest impact, was particularly precocious and productive. As early as 1828 a Society for Translating European Sciences was established, and a Vernacular Literary Society followed in 1851. For several years Rajendralal Mitra ran the journal *Vividhartha Sangraha,* which sought to popularise geology, geography, physics and other sciences. Between 1868 and 1900, ten scientific and forty-seven technical journals were published in Bengal. Between 1875 and 1896, 776 science publications appeared in Indian languages in Bengal (more than half on medical topics), compared with 1,348 in all for Madras, Bombay, Punjab and the North-Western Provinces.[67]

The most momentous step in the creation of an Indian scientific community is often seen to be the founding of the Indian Association for the Cultivation of Science by Mahendralal Sircar in 1876. After receiving his M.D. in 1863, Mahendralal practised allopathic medicine for four years, but then rejected this in favour of homoeopathy, which he saw as a more rational medical system. Through the *Calcutta Journal of Medicine*, which he founded in 1868, Sircar called for greater Indian involvement in science, regarding it as the ultimate source of the 'superiority of the Western nations' and the key to India's progress and self-esteem.[68] In 1869 he published an article on the 'cultivation of science' in which he urged Indians to shake off their 'inherent indolence and apathy', become more self-reliant and look less to the state for their advancement. He commended the Asiatic Society (of which he was a member) for promoting science in India, but felt it had not done enough to help 'humble learners' develop an interest in science. A different kind of institution was required, one where public lectures and demonstrations would provide instruction for the masses and which was 'entirely under native management and control'.[69]

It took Sircar seven years to raise sufficient funds to launch the Indian Association for the Cultivation of Science. Public support for science was still clearly limited and the Association initially made little impact outside Calcutta. Ultimately, however, it was instrumental in establishing the principle that Indians were fit for 'pure' science and scientific research, and were not simply skilled artisans or departmental drudges without originality or initiative of their own. Where colonial science had been dominated by medicine and

[67] V. V. Krishna, 'The Colonial "Model" and the Emergence of National Science in India, 1876–1920', in P. Petitjean et al. (eds.), *Science and Empires* (Dordrecht, 1992), p. 64.

[68] *Indian Scientists: Biographical Sketches* (Madras, 1929), p. 34.

[69] Mahendralal Sircar, 'On the Desirability of Cultivation of the Sciences by the Natives of India', *Calcutta Journal of Medicine*, 2 (1869), pp. 286–91.

natural sciences, which focused attention on the investigation of the Indian environment, and even placed Indians themselves under scrutiny, Sircar directed Indian science towards physics, chemistry and other sciences that had little relevance to the externally perceived specificity of India and its peoples, but that helped Indians to connect with their own past and cultural legacies rather than to feel estranged from them. Although he saw science as having a practical role in Indian nation-building, Sircar was not content with the kind of functionalist approach that had dominated colonial science hitherto. Science had a 'higher and nobler claim than the narrow, utilitarian, Benthamite one. . . . It was the most powerful lever for progress, for the advancement of civilisation, for ennobling the mind of man'.[70] By the time of his death in 1904, Sircar had grown somewhat disillusioned with his grand project, lamenting the 'apathy of our people towards the cultivation of science'. But, the Association succeeded in taking science out of the narrow confines of the Asiatic Society and into a more public arena, in the process inspiring a new generation of scientists, including Jagadis Bose, Ray and Raman, and making Calcutta the undisputed centre of national science.

Other developments stimulated the growth of the Indian scientific community in these years. One was the rapidly changing political situation, especially the rise of militant nationalism and, in response to the Partition of Bengal in 1905, the Swadeshi movement. By arguing that India should produce its own goods rather than rely on British imports, proponents of the Swadeshi movement sought to strengthen India's drive for industrial self-reliance and, rather in contrast with Mahendralal Sircar's 'ennobling' view of science, emphasised the practical importance to India of science and technology. There had been moves in this direction even before 1905. In 1886 P. N. Bose published an influential pamphlet urging that more attention be given to technical and scientific education in Bengal, and five years later he established an Indian Industrial Association to promote the use of indigenous raw materials, though to little effect. The Association for the Advancement of Scientific and Industrial Education, founded by Jogendranath Ghosh in 1904, further sought to improve Indians' technical skills by financing their training abroad. In the same year the Dawn Society was launched to further the cause of national education. It took its name from the *Dawn* newspaper, founded in 1897 and an important vehicle for debates about the place of Western science and technology in India.[71] Under the stimulus of the Partition of Bengal, a series of new nationalist educational and technological initiatives arose. The Dawn Society

[70] *Indian Association for the Cultivation of Science: A Century* (Calcutta, 1976), p. 10.

[71] Dhruv Raina and S. Irfan Habib, 'The Unfolding of an Engagement: *The Dawn* on Science, Technical Education and Industrialization: India, 1896–1912', *SH*, 9 (1993), pp. 87–117.

became a National Council of Education, and Tarakanath Palit and Nilratan Sarkar launched the Society for the Promotion of Technical Education to implement an earlier project of P. N. Bose's for a Bengal Technical Institute. A rival faction within the National Council of Education formed the Bengal National College to further the cause of advanced scientific and literary studies. From these various initiatives eventually emerged the College of Engineering and Technology at Jadavpur and the University College of Science of Calcutta University.

Before 1900 little scientific research was conducted in Indian universities. Professorial chairs in botany, geology and chemistry were generally reserved for members of the IMS or the Educational Service. The great change came in the early twentieth century with the appointment by Curzon of a Universities Commission and the subsequent passing of the Indian Universities Act. This opened the way for universities to become centres of postgraduate training and research, able to appoint their own academic staff, maintain laboratories and museums and engage in all activities 'which tend to the promotion of study and research'.[72] In 1909, under its dynamic Vice-Chancellor, the lawyer and mathematician Asutosh Mukherjee, the University of Calcutta initiated postgraduate training and research in the sciences, creating over the next decade chairs in physics, chemistry, higher mathematics, botany and zoology.[73]

A further contributing factor was the role of Indian philanthropy, which helped to fund the rapid expansion of science in Indian universities and institutes and compensate for the colonial regime's relative indifference. When the government declined to finance the ambitious expansion of science teaching and research projected by Asutosh Mukherjee, Tarakanath Palit and Rash Bihari Ghosh donated Rs 2.4 million for the creation of chairs in physics and chemistry. Other wealthy Indians – landholders, lawyers and industrialists – provided scholarships and endowments that reduced financial and psychological dependence on the colonial state. Alongside British India's landed, commercial and industrial elite, the rulers or *diwans* (chief ministers) of princely states, notably Baroda, Hyderabad, Mysore and Travancore, showed a lively interest, in part prompted by considerations of political legitimacy and financial gain, in encouraging innovative scientific projects and in promoting technical education, as in the case of Baroda's Kala Bhavan Technical Institute.[74]

72 Subbarayappa, 'Science', p. 566.

73 P. C. Bagchi (ed.), *The Second City of the Empire: Twenty-Fifth Session of the Indian Science Congress Association, Calcutta, 1938* (Calcutta, 1938), p. 122.

74 Dhruv Raina and S. Irfan Habib, 'Technical Content and Social Context: Locating Technical Institutes. The First Two Decades in the History of the Kala Bhavan, Baroda (1890–1910)', in Petitjean et al., *Science*, pp. 121–36.

One of the most conspicuous examples of Indian philanthropy in these years (and of the limitations to which it was subject) was the 3 million rupees' worth of property set aside by the Parsi industrialist Jamsetjee Nusserwanjee Tata for an Indian university of science in 1896. This was to be the Indian equivalent of the Imperial Institute in London, conducting research across a broad range of scientific fields but with direct relevance to the needs of Indian industry. Curzon, however, did not regard a science university as either practicable or desirable for India and steered the project towards narrower objectives. Bangalore was chosen as the site for the Indian Institute of Science, despite its remoteness from existing industries, partly because the Mysore state was prepared to contribute to its costs, but also because the climate was deemed suitable for the European staff who were expected to run it.[75] Eventually opened in 1908, the Institute, with departments for electrical technology, biochemistry and inorganic chemistry, was at first far from successful. It had difficulty in attracting students and in becoming a genuinely all-India institution; it was widely criticised by nationalists for not doing enough to further Indian needs in technical education and applied science, and even the colonial authorities found it poorly organised and without clear institutional aims. It stumbled on under European management until 1933, when C. V. Raman became its first Indian director and tried to re-establish it as a centre for research in his own field, physics.

The ambiguities surrounding the enterprise of science in India between the 1890s and 1920s are further illustrated by the founding of the Indian Science Congress in 1914. In some respects the Congress seemed to look backwards rather than forwards. The inaugural meeting was held at the Asiatic Society's premises and under its auspices. Noting in his presidential address that it was exactly 130 years since the founding of the Asiatic Society of Bengal, Asutosh Mukherjee paid tribute to Sir William Jones and to the Society, which, throughout its long career, had been 'the principal source of inspiration in the organisation and advancement of scientific research of every description in this country'. But, looking to the future, Mukherjee emphasised the importance of making India's landed classes 'realise that science enables us to solve difficult agricultural problems and thereby to revolutionise agricultural methods' and he appealed to the commercial community to recognise 'the inestimable value of science as an essential factor of industrial regeneration'. It was of great value for scientists to meet together to discuss their work and exchange ideas, he said, but it was no less important for them to 'bring their aims and views prominently into public notice' and 'press them upon the attention of the

[75] Home (Education), 5–9, February 1902, NAI.

government'. Even the 'most enlightened governments' occasionally needed to be reminded of 'the full extent of the paramount claims of science upon the public funds'.[76]

The initiative behind the founding of the Science Congress came not, as might have been expected, from Indian scientists in Calcutta, but from two Europeans recently appointed to chemistry chairs – Professor P. S. MacMahon of Canning College, Lucknow, and Professor J. L. Simonsen of Presidency College, Madras. Disappointed at the apparent dearth of research in Indian universities and the manner in which research seemed to be the prerogative of the state services, they sought (as had M'Clelland seventy years earlier) to create an all-India science forum like the British Association for the Advancement of Science. MacMahon and Simonsen appear to have been unaware how much scientific work was actually going on in India at the time, especially in Calcutta, but, to their credit, the Congress was a conscious departure from service-dominated imperial science. Divided into six sections – chemistry, physics, geology, botany, zoology and ethnology – the Congress gave a firmer institutional basis for science than the Asiatic Society had done. A third of the thirty-five papers presented in 1914 were given by Indians (four out of seven in physics, but only one of nine in zoology). Some papers echoed the old natural history of the Asiatic Society; but others signalled the emerging force of Indian research in physics and chemistry.[77] At first some of India's leading scientists seemed wary of the Congress, perhaps suspecting that it would prove to be yet another organisation in which Europeans lorded it over Indians. Of the first six presidents, only Asutosh Mukherjee was an Indian. But when P. C. Ray became its President in 1920, and delivered a staunchly nationalist address, and when the following year Raman took over as secretary, the Indian Science Congress was well on the way to becoming a vehicle for Indian scientists and representative of the expanding range of research in Indian universities. In time the Congress became as important a forum for national science as the Asiatic Society had previously been for colonial science.

CHEMISTRY, PHYSICS AND PLANT PHYSIOLOGY

Apart from mathematics, to which Asutosh Mukherjee and Srinivasa Ramanujan made important theoretical contributions between the 1880s and early 1920s,[78] the sciences that most clearly heralded the rise of the Indian

[76] *JASB*, 10 (1914), pp. lxxxix–xci. [77] Ibid., pp. xcii–xciii.

[78] B. M. Sen, 'Progress of Mathematical Research in India', B. Prashad (ed.), *The Progress of Science in India during the Past Twenty-Five Years* (Calcutta, 1938), pp. 18–20.