THE CHARACTER OF THE INTRODUCTION OF WESTERN SCIENCE IN INDIA DURING THE EIGHTEENTH AND THE NINETEENTH CENTURIES *

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What is intriguing about the question of the introduction of Western science in India is the fact that, despite close and long contact with European science during its very creative and expansive phase, such introduction was extremely tardy and hardly noticeable until towards the closing years of the nineteenth and the beginning of the twentieth centuries. To explain this delayed transmission, the character and the purpose of the science that found itself transplanted, as also the social and psychological conditions of the people, have been discussed. From the very inception the European scientific work in India was limited to field sciences. The interest in science of the Jesuit missionaries was incidental, and their activity did not facilitate the transmission of European science. The study of plant science after European methods began from the seventeenth century, but here the motive was commercial. Likewise, the imperial needs of the East India Company for military, administrative and economic control of the sub-continent dictated the undertaking of extensive programmes of trigonometrical, topographical, hydrographic, geodetic and geological surveys. Although important contributions to geography, geodesy, astronomy and other branches of science resulted from these efforts, this failed to be of much help. In the early days, the Company followed a policy prohibiting the instruction to any Indian of the art of any kind of surveying. Later on, when the employment of Indians for Government scientific departments could not be resisted, opportunities were made available only for subordinate ranks. Due to such policy of exclusion from any effective participation in Government scientific undertakings, the exciting work of a century by many able minds was largely lost on the people. The Education Despatch of 1854 also failed to lead to the expected development in the field of scientific education and research primarily because of the non-teaching character of the universities and their failure to appoint university professorships in sciences. The soundness of the concept of scientific teaching and research in the universities was amply proved in the first quarter of the present century when, after the rise of university colleges of science, the leadership in fundamental research passed over largely to the universities. This emphasis on scientific research and the lead to create conditions for young Indians to engage in such creative enterprise came from the Indians themselves.

For a consideration of the question of introduction of modern European sciences into India, the eighteenth and the nineteenth centuries deserve

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special attention. The thin and sporadic flow of European medical men, naturalists, Jesuit missionaries and adventurers, which started in the sixteenth century, developed by the middle of the nineteenth century into a steady and regular stream of scientists, mostly medical men and army engineers. These men trained in European institutions and laboratories—some of them under leading authorities of the day—spent the best parts of their lives in India and left a splendid record of their work in the various branches of science. They were responsible for making available in India a large amount of European literature in science and technology and a sizeable store of scientific apparatus, chemicals and research tools of all descriptions demonstrated by their work the fruitfulness and advantages of research by the methods of Western science and founded some of the most important scientific institutions and societies the country possesses today.

In view of what is stated above, the question of the introduction of Western science in India may appear at first sight almost pointless. But what is intriguing is the fact that, despite such close and long contacts during the very creative and expansive phase of European science, its introduction to India was extremely tardy and hardly noticeable until towards the closing years of the nineteenth and the beginning of the twentieth century, and that it showed little or no sign of taking roots in the Indian soil. This situation presents a sharp contrast with what happened in Japan after the Meiji Restoration in 1867 when the Government took the Charter oath that 'knowledge shall be sought throughout the world, in order to establish firmly the foundation of the Empire' and adopted a vigorous policy of introducing Western science and technology.[1] While it took almost a hundred years to produce in India a P. N. Bose, a J. C. Bose and a P. C. Rây to do worth-while research work in geology, physics, plant physiology and chemistry,[2] it did not take Japan more than twenty years to produce, under the influence of American and British teachers like Mendenhall, Milne and Ewing, a band of young Japanese seismologists who were soon to command international recognition in the new science of geophysics.

For an explanation of such inordinate delay—I am more inclined to describe it as a failure—in introducing Western science in India, it is necessary to consider the character of the science that found itself transplanted to India, the purpose behind such transplantation, and the intellectual, social and psychological conditions of the people, essential for the reception of a new kind of knowledge. Here it is important to bear in mind the difference between the scientific efforts made by the Europeans in India and those by the Indians themselves. This is because in any consideration of the history of science in India during the eighteenth and the nineteenth centuries it has become customary to describe the work of European scientists on botany, zoology, geology, geodesy, geography, surveying and map-making, meteorology

and the like. Such work, however, fundamental and important and, therefore, relevant to the history of science of the period concerned, was in the ultimate analysis an extension of the over-all European scientific effort, about which there was hardly anything 'Indian' except that the objects of research, the living as well as the non-living, belonged inseparably to the geographical world of India.

From the very inception and by the nature of circumstances the European scientific work was limited to the field sciences. The Jesuit missionaries were primarily interested in the proselytizing activities and found it advantageous and necessary to study the manners and customs, the languages and the religious and social peculiarities of the inhabitants among whom they found themselves to operate. Their interest in sciences was incidental, although important work resulted from such secular interest of some of their members. Antonio Monserrate's interest in improving upon the geographical knowledge of India is reflected in the long list of latitudes and longitudes and an interesting map of India he appended to his *Commentaries*.[3] Similar interest in advancing the geography of India stimulated the work of a number of Jesuit and other missionaries during the seventeenth and the eighteenth centuries, of which special mention may be made of Johann Grüeber and Albert d'Orville, Nöel, Mandeslo, Pimentel, Calmette, Bucher, Barbier, Claude Boudier and Joseph Tieffenthaler.

From the point of view of transmission of European science, the Jesuit activity in India, unlike that in China,[4] was peculiarly barren and abortive. In their geographical explorations and travels, it is true, there is occasional mention of Indians being trained in the use of compass and other astronomical instruments, as for example in Tieffenthaler's exploration of the upper course of the Gogra for which he employed an Indian. The Jesuit contact in 1734 with Raja Jai Singh, the founder of the Jaipur and Delhi astronomical observatories, over the question of observational accuracy by the equipment he set up on the Islamic model and by the latest European instruments was fraught with promising possibilities which did not materialize. But apart from such few isolated instances there is nothing to show that the Jesuit contacts facilitated in any way the transmission of European science to India.

Indian plant and animal life attracted serious attention of European naturalists from the seventeenth century and some of the early and important contributions came from the Dutch and the Danes. During 1674-75, Henry Van Rheeds, the Dutch Governor of Malabar, collected, with the assistance of Indian Brahmins, a large number of Indian plants. His work enriched by 794 plants appeared from Amsterdam between 1686 and 1703 in 12 volumes under the title *The Hortus Malabaricus*. Scientific botany in India, however, commenced with John Gerard Koenig, Danish physician and pupil of Linnaeus, who arrived in India in 1768 to join the Danish mission at Tranquebar as a

physician. He was appointed 'Hon'ble Company's Natural Historian' (1778) under the Madras Government and died in 1785, leaving behind a mass of valuable manuscripts and herbarium collections which were bequeathed by the Company to Sir Joseph Banks in England.

In Koenig's time a Society of United Brothers was formed out of the members of the Tranquebar Mission, to which other naturalists were gradually drawn because of the Society's interest in the development of natural history. The most promising among them was William Roxburgh (1751–1815), sometimes described as 'Indian Linnaeus'. His *Plants of the Coast of Coromandel* (3 vols., 1795, 1802 and 1819), *Hortus Bengalensis* (1814) and *Flora Indica* (published posthumously with additions by Wallich, 2 vols., 1820 and 1824) bear testimony to his industry and scientific excellence.

Behind all such apparently disinterested endeavours to advance natural history in India, as elsewhere, lay the urge to find, transplant and acclimatize plants of economic and medicinal promise, around which centred so much political and economic rivalries and strife of the seventeenth and the eighteenth centuries. James Anderson's Nopalry at Marmelon, for example, which led to the Botanical Garden of Bangalore, arose out of his experiments with Cochineal insects, prompted by consideration of commercial possibilities.

William Roxburgh's selection to the post of naturalist in the Madras Government was facilitated by his discovery of indigenous pepper in Samulcotta in the Godavari district. In a despatch to England the Madras Government at Fort St. George wrote:

'We informed you that Mr. William Roxburgh had discovered that the pepper plant was a native of the Hills in the Rajahmundry Circar under Masulipatam, and that we had given directions in consequence to the Chief and Council there to assist him in procuring plants and proper ground for the purpose of making his experiments. By the Manship we have pleasure to send for the inspection of your Honours a small quantity of the pepper lately gathered in that District.'[5]

If considerations of economic exploitation motivated botanical researches, it is superfluous to emphasize the imperial needs of the East India Company to embark upon extensive programmes of carrying out trigonometrical, topographical, hydrographic, geodetic and geological surveys to ensure the military, administrative and economic control of the sub-continent. With the liquidation of the Maratha Confederacy (1817-18), the Company's power became absolute over a vast territory from the Bay of Bengal to the Arabian Sea. The Court of Directors of the Company were quick to see their opportunities and did not neglect to apply science and technology, as then known, to their best advantage, by 'the employing of Geographers, and Surveying Pilots in India; and the providing of astronomical instruments, and the

holding out of encouragement to such as should use them.'[6] Writing in 1788, Rennell informs us that in the course of thirty-five years (between 1753 and 1788) the Company 'caused a mathematical survey to be made of a tract equal in extent to France and England taken together beside tracing the outline of near 2,000 miles of sea coast and a chain of islands in extent 500 miles more'.

Great as the services of the long succession of able surveyors, mathematicians and astronomers were to the immediate cause of the empire-builders, it is no denying that their services to the sciences of geography, geodesy and astronomy were even greater and of more lasting benefit to mankind. Thomas Deane Pearse (1741–89) of the Bengal Artillery was an enthusiastic astronomer who took a continuous series of observations of latitude and longitude from 1774 to 1779 and again during his marches to and from Madras in the Mysore War of 1781–84, which were published in the *Asiatic Researches* (1, 57–80, 81–121). More gifted and accomplished as a mathematician and astronomer was Ruben Burrow (1747–92) who had acted as assistant to Maskelyne, Astronomer Royal at Greenwich in the latter's observations for terrestrial attraction at Mt. Schehallien in Scotland before coming out to India as a teacher in mathematics to the Engineer Officers at Fort William. Michael Topping (1774–96) was responsible for the establishment of an astronomical observatory in Madras (1790), which was later on transferred to Kodaikanal in 1899. To William Lambton (1753–1823) belongs the credit of introducing into India in 1802 the benefit of trigonometrical survey as the most scientific basis for mapping the country. In 1865 Basevi and others undertook an extensive pendulum operations to determine the figure of the earth, which led to the discovery of gravity anomalies.[7] The Venerable Archdeacon Pratt of Calcutta, an accomplished mathematician, worked out his famous theory of isostatic compensation.[8]

As to geological and related studies, the beginnings may be traced to the last quarter of the eighteenth century. Benjamin Heyne, a member of the Society of United Brothers and Superintendent of the Samulcotta nurseries after Roxburgh, carried out researches in mineralogy and metallurgy. Henry Westley Voysey (*d.* 1824), a surgeon and geologist to the Great Trigonometrical Survey, contributed to the geology of the rocks with which diamond matrix is likely to be associated and to the theory of sandstone formations in India. A brilliant series of discoveries of, and researches on, Siwalik fossil fauna were made by H. Falconer and P. T. Cautley, who were jointly awarded in 1837 the Wollaston medal of the Geological Society of London. The Geological Survey of India was organized from 1851 with the arrival of Thomas Oldham, Professor of Geology in Dublin.

The returns of scientific instruments and appliances supplied to the various scientific services, as given by Black[9] for the years 1887 to 1890, at once

indicate the variety and the range of most sophisticated and precision instruments, then available, which were provided for scientific investigations in the country. During these years the examiner of scientific instruments at the India Store Depot at Lambeth, England, tested on an average about 10,000 instruments, valued at 30,000*l*., as against 7,000*l*. in 1871. To say the least, all this represented a sizeable scientific undertaking of no small credit to the foreign government who had initiated such efforts. The question is: Did all this help to introduce Western science to India?

How could it? Throughout the eighteenth and for a good part of the nineteenth century the Court of Directors of the East India Company 'insisted on the secrecy of maps and surveys and restricted the art of surveying to their own covenanted or military servants'. At first this bogey of secrecy was raised to prevent maps and documents falling into the hands of their rivals, the French, the Dutch and others. Later on this was developed, for political reasons, into a definite prohibition against the instruction of any Indian in the art of any kind of surveying. Phillimore has given several instances, from the records, of surveyors employing Indians to act as guides in uncharted routes and training them, to their great advantage, in the elements of surveying, but such practice was always discouraged and often drew sharp and adverse comments from the higher authorities. On one occasion, on the advice of the Military Accountant-General, the Surveyor-General was informed that the employment of 'natives in taking surveys ... is a practice which Government are by no means disposed to encourage, or to authorize any remuneration to be made for such services'.[10] On another occasion, the Surveyor-General regretfully informed his officers that 'the Government have notified to me that they wish to throw cold water on all natives being taught, or employed in making Geographical discoveries'.[11]

In civil revenue surveys, restrictions against the employment of Indians were relaxed, not because country-born surveying assistants were found to be quite efficient, but primarily because they could be employed very cheaply. This principle was consistently applied whenever demand for technical assistants arose, whether in surveys or for medical assistance or in connection with civil engineering works. But in every case, where pressure of circumstances so demanded, opportunities and facilities for training were created for the filling up of the subordinate assistant ranks only. The General Order of the Governor-General, dated 23-1-1835, establishing the Calcutta Medical College, regulated that, 'as inducement for Pupils of respectable class to enter the Institution, the pay of the Native Doctors, who shall have been educated at the College, and have received the certificates of qualification, shall be 30 Rupees per month, rising to Rs.50/- p.m. after 14 years of service', whereas the European Assistant to the Superintendent of the College 'shall draw a salary of 600 Sonat Rupees per month, in addition to his Regimental Pay and Allowance'.[12]

In the Geological Survey the first Indian apprentice (Ram Singh) was recruited in 1873 and two (Kishen Singh and Hira Lall) the following year, of whom two retired as Sub-Assistants.[13] The first appointment of an Indian (P. N. Bose) in a graded post did not take place until 1880.[14] Thus the Indians were excluded, as a matter of policy, from any effective participation in the Government scientific undertakings through the various surveys and departments as mentioned above, and the exciting work of a century by many able minds was largely lost on the people. It is no wonder that in preparing his bibliography for the article 'Mathematical and Physical Science' for the centenary review of the work of the Asiatic Society, the reviewer could mention only two papers by two Indian authors out of a total of 347 papers, and for another article on 'Geology', only three papers by two Indian authors out of a total of 296 papers.[15]

Another opportunity for the introduction of Western science presented itself through education after the Orientalists lost their battle to the Anglicists during the first quarter of the nineteenth century. The educational minutes and despatches of the period are full of references to the need for the study by the Indians of European science and literature. The General Committee of Public Instruction, appointed by the Government in July 1823, was charged with the task of suggesting 'such measures as it may appear expedient to adopt with a view to the better instruction of the people, to the introduction of useful knowledge, including the sciences and arts of Europe, and to the improvement of their normal character'.[16] Gradually mathematics and science classes were started in the Calcutta Madrassa, the Sanskrit College and other institutions. The study of natural philosophy, chemistry in particular, received a further impetus when the School for Native Doctors was established by the General Order dated June 21, 1822, and medical classes were opened at the Sanskrit College and the Madrassa at Calcutta in 1826. At the Calcutta Medical College founded in 1835 chemistry, natural philosophy and botany, along with the conventional branches of medicine and surgery, were given due importance, and capable men like O'Shaughnessy and Wallich were appointed to teach them.

The Despatch of 1854 reiterated, as its object, 'the diffusion of the improved arts, science, philosophy and literature of Europe; in short of European knowledge', and recorded its appreciation of the high attainments of some of the Indians in English literature and European science. The great merit of the Despatch lay in its proposal for the establishment of universities, definition of their functions as examining bodies, and its recommendation for the institution of professorships in the various branches of learning, including the sciences, civil engineering, law and languages. The first two were implemented, and the following half century (1857–1902) witnessed the development of five universities and the growth of colleges from 27 in 1857 through 75 in

1882 to 126 in 1902. In the ten years between 1881 and 1891, the number of students in the colleges registered an increase from 5,399 to 12,424.[17] The notable part played by the universities in the intellectual and political regeneration of the country has been freely acknowledged.

But in the field of scientific education and research no such development followed the Despatch of 1854. The primary reason was the non-teaching character of the universities established in this period and the failure to appoint university professorships as recommended by the Despatch. In the newly-constituted Presidency College out of the old Hindu College, provisions for professorships for natural philosophy and geology were, however, made by the Government, but the non-Governmental Colleges where the majority of students received instructions had no means to appoint qualified science teachers and establish laboratories and, therefore, to offer science courses. The soundness of the concept of scientific teaching and research in the universities was proved only recently in the first quarter of the present century when the Calcutta University College of Science and Technology was established in 1916, to be followed soon by similar postgraduate departments in other universities. In recording the surprising growth of research activity all over India, consequent upon the development of universities as research centres, the University Education Commission remarked: 'While before 1920 scientific research was mainly a monopoly of the scientific services, after 1920 the leadership in fundamental research in most of the sciences passed over largely to the universities'.[18]

It is important to note that this emphasis on scientific research and the lead to create conditions for young Indians to engage in such creative enterprise came from the Indians themselves. In 1869, long before the organization in the first quarter of the present century of scientific research at the universities, Mahendra Lal Sircar, a graduate of the Calcutta Medical College, put forward before the citizens of Calcutta a plan for founding a research institution, equipped with library and laboratories.[19] Influenced by the example of the Royal Institute of London and the British Association for the Advancement of Science, he sought to establish such an institution for the dual purpose of diffusing the knowledge of science and in extending the bounds of such knowledge by original research. He believed that the acquisition of science in the schools and colleges was not enough 'because such a thing is impossible in *statu pupillaris*. Men must continually be at a subject, observing and experimenting, before he can acquire that knowledge of it which will enable him to feel his own deficiencies and the deficiencies in the branch of science which he has made his speciality—before, indeed, he can be engaged with any hope of success in researches which will improve both himself and his science'.[20] The inherent limitations of the study of science in a government institution under a permanent stamp of inferiority convinced him that

such an enterprise must be undertaken wholly under Indian initiative and management, for he said: '... one characteristic of my scheme is that we should endeavour to carry on the work with our own efforts, unaided by Government, or perhaps more properly speaking, without seeking its aid ... I want freedom for the institution. I want it to be entirely under our own management and control. I want it to be solely native and purely national.' His efforts led to the foundation in 1876 of the Indian Association for the Cultivation of Science, to which C. V. Raman was attracted 31 years later to start his researches, first in accoustics and later on in optics, x-rays and magnetism, culminating in his discovery of the new scattering phenomenon, the Raman Effect. More important than his own brilliant investigations was the development of a research school in physics which, by responding to the demands of developing universities, brought about a fundamental change in the scientific effort of the country.

It will, therefore, be correct to say that science returned to India largely as a consequence of the movement for national self-determination.[21] Its return was delayed to the extent this movement for self-determination was delayed. As soon as this vital social rôle of science is realized it is futile to expect its appearance in a colonial type of administration dominated by one-sided commercial preferences and characterized by its fundamentally negative attitude to all developmental programmes. In such a situation field sciences may be developed as administrative convenience and necessity by imported scientists, but not basic laboratory science in universities and institutions open to the people for their fullest participation.

This dependence of the growth of science on socio-economic and political factors in the case of India has been recently shown by Prof. P. C. Mahalanobis.[22] In 1947 India became independent, in 1951 she adopted a planned programme of economic development and in 1955 the Indian Parliament accepted socialism as political goal. The Second Five-Year Plan, with its emphasis on industrialization, sought to increase the production of steel from one million to six million tons and establish a number of factories for heavy machineries, heavy electrical equipment, machine tools, oil, chemicals and for several light industries. Between 1947 and 1959, 15 new universities and four higher institutions, empowered to award degrees, were established as against 19 between 1857 and 1947. In nine years between 1947-48 and 1956-57 the number of educational institutions of different types had more than doubled (382,636 in 1956-57 against 171,061 in 1947-48), and that for technical and professional education registered a threefold increase. In fact, more new institutions came to be established during this period than had been set up during the whole of the British period. The enrolment at the university levels increased by 100 per cent from 399,500 in 1950-51 to 778,600 in 1956-57 (compare these with the figures 5,399 for 1881

and 12,424 for 1891). As to the number of scientists defined as persons having obtained at least a master's degree in science, 31,880 scientists were produced by Indian universities between 1910 and 1956. Of them, 15,668 were produced in the first 37 years and 16,218, that is, more than half, in the remaining nine years from 1947 to 1956.

The exponential growth of science in the twentieth century, more markedly from 1947, coinciding with the period of active growth of the national movement, as against the static state of scientific education and research prevailing for the greater part of the nineteenth century despite the sizeable activity of imported scientists, neatly summarizes the delayed introduction of Western science in India.

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[2] Bose, P. N., the first Indian to join the Geological Survey of India in 1880 on a graded post, was the first to introduce into the G.S.I. the study of micro-section; he discovered most of the well-known iron ore deposit of Central Provinces (now Madhya Pradesh) and the large deposits of iron ore in Mayurbhanj in Orissa, which led to the foundation of Tata Iron and Steel Company and the iron and steel works in Bhilai in the 2nd Plan. Bose, J. C. (1858–1937), Professor of Physics at the Presidency College and later Director, Bose Institute, Calcutta, carried on his early researches on the polarization of electric rays by double-refracting crystals, determination of the wave-length of electric radiation by diffracting grating, etc., and later on studied plant physiological problems, e.g. response in the living and the non-living, nervous mechanism in plants, etc.; he was elected Fellow of the Royal Society of London in 1920. Rây, P. C. (1861–1944), Professor of Chemistry at the Presidency College, Calcutta, and later on at the University College of Science, carried out researches on mercurous nitrite, pioneered the study of the history of science through his work, *Hindu Chemistry*, established an Indian school of chemistry, founded the Indian Chemical Society and initiated a number of chemical and pharmaceutical manufacturing industries.

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[17] *The Report of the University Education Commission* (1948-49), pp. 22-23.

[18] *Ibid.* (1948-49), p. 145.

[19] Sircar, M. L., 'On the Desirability of a National Institution for the Cultivation of Sciences by the Natives of India', *Calcutta Journal of Medicine*, August, 1869.

[20] Mahendralal Sircar's speech before the meeting of subscribers on April 4, 1875, *Records of the Indian Association for the Cultivation of Science.*

[21] In 1876, the Indian Association (different from the Indian Association for the Cultivation of Science, established in the same year) was established as a political society to rouse political consciousness and organize meetings of protests against anti-national Government measures, such as the Vernacular Press Act, the Arms Act, the Cotton Duty, etc. The Indian National Congress was established in 1885.

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