

ORGANIZING FOR SCIENCE

The Making of an
Industrial Research Laboratory

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I must also state that Chapter 3 was written during my tenure as ICSSR Fellow at Delhi School of Economics and Chapter 6 was published earlier in *Contributions to Indian Sociology*.

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CHAPTER I

THE PROBLEM

I

This study is an attempt to understand the problems of scientists in an industrial research laboratory in Delhi. It is written with the basic belief that the world of scientists in an industrial research laboratory can be treated as a microcosm of the problems of science and technology in a developing society. It holds that to understand the problems of science and technology, one has to understand not only the history of the industry and the technology, but also the changing relations between science and technology, not merely in one country but in a comparative framework. The problems of scientists vis-à-vis industry have also to be located in a wider framework, that is, the sociology of a science laboratory has to be an intrinsic part of the sociology of a developing society. The wider questions of the bigger problem have to be reflected in the more limited study; a sociology of science in India has to be a study of underdevelopment. It is only within such a framework that the problems of the transfer of technology assume a meaning and take on a connotation beyond the provincial explanations of management theory—a boundedness that facilely believes that the only solutions to success lie in the alterations of a few organizational variables—motivation, career structure, goals and hierarchy.

The necessity of adopting a wider socio-historical perspective was emphasized by the scientists themselves. A former Director General of the Council of Scientific and Industrial Research of India captured it eloquently in a set of interviews:

Sheshadri died last week. There was hardly a murmur, only an obituary short and antiseptic, ejected out of a machine, a facile act rubbing out a debt to the past. Who remembers Bhatnagar or Saha today? Yes. I admit your science of science as it styles itself is a big subject. I met Derick de Solla Price once, when I was Director General. He came to me full of his

theory of the exponential growth of science, graphs, calculators and all. Statistics, elegant and lifeless. Statistics do not bleed. Body counts of periodicals, scientists, publications, these are indices that do not add up to science. They reveal little about the content of science. Say little about questions I am interested in. Why is it with all the money we are pouring into science today—350–400 crores recurring, why is it that science in India has failed, when in the years of colonialism it was such a vital force? This is what we must try to understand. You can't do that if you begin with the ready-made organizational scripts the CSIR provided in 1947. You have to shift your time markers back to the very beginning. The genesis is all important even if the first acts ended in abortions.

Yes. It is a question of perspective and perspective is all important. I think it is a function of two elements, a conceptual framework and a sense of history. To this possibly I would add a third—the choice of problems, the search for the big questions, not always answerable. Science can ask limited questions, but sociology cannot limit its questions, especially those it asks of science. I think it is specially important today when social scientists come armed with questionnaires ready to wrestle with reality in two hours, regimenting responses, the yeses and nos, as if an aggregation of these is an approximation of reality. Henry Tizard once said a scientist is judged by the choice of problems, and I will begin by stating mine. Why is it that science in India has remained aloof and elitist? What is the actual relation between science and technology? What is the relation of the state to the innovation process? I would like you to provide an analysis of a technology; to consider this cluster of variables—state, science, technology. A study of the inter-relationships of these three have all the makings of a fascinating sociological exercise. Let us begin with history.

History is important. But I think we read the wrong history books. We read the history of physics, Rutherford and Dirac at Oxford and Cambridge, of a science that believed in the ideology of science for science's sake, that held it could sustain itself on shoestring and beeswax. This selective study of science created a myth, a myth of the science for science's sake, a myth we will have to dispel. We will have to begin not with physics, but with chemistry and the history of chemistry in Germany in the 1870's.

* * *

I admit this reflects a frog-in-the-pond syndrome. To the frog the pond constitutes the limits of the universe. My pond was the laboratory. But rather than transcend this bias, I shall articulate it, seeking to find and capture the problems of a wider society within the confines of one institutional structure—an Industrial Research Laboratory. The industrial research laboratory reflects at best the dialectic between nationalism and imperialism and it is in the interplay of the two forces that science and

scientificized technology play a crucial role. The phenomenon of industrial research is something unique. It reflects an institutional complex that arose late in history, the rationalized application of science to the problems of manufacture. One should analyse it with special reference to the development of synthetic chemistry in Germany.

In the following section we shall analyse the nature of this development.

II

Industrial research as an organizational innovation was a German contribution and it was the outcome of a particular type of relationship between the university, industry and the state.

Scientific education in Germany was the responsibility of the state. As a result of state subsidies higher education was cheap and a university course in chemistry cost a mere £ 12 a year. (Haber, 1958, p. 71.) The rewards for science were high and German scientists like Liebig, Kekule and Helmholtz were not only highly feted but handsomely paid. (Haber, 1958, p. 71.) The state of professionalization was such that a student could visualize a career in science either in the universities, or in the research laboratories sponsored by German firms alive to the commercial possibilities of science. Joseph Beer in his *Emergence of the German Dye Industry* describes it thus: 'Co-operation with the universities was so actively sought that a veritable competitive struggle arose between them over the control of the most important laboratories. In time, each managed to establish strong ties with certain schools to the exclusion of others'. (Beer, 1959, p. 64.)

The symbiosis between the university and industry went even further. Paul Hohenberg points out that entrepreneurs were active in entrusting managerial powers to scientists, thus shifting the focus of decision-making from the factory to the laboratory. What was even more impressive was the alacrity of the entrepreneur in backing every promising scientific move with the required capital. The outstanding instance was the case of the Badische Anilin und soda-sabrik (BASF) which invested eighteen million marks in the development of synthetic indigo and did not sell a pound of it until eighteen years after the research was begun.

The nature of risk-taking that confronted science-based firms also brought about certain radical changes in the nature of these

firms. The production of synthetic indigo illustrates the nature of this transformation. Indigo was synthesized from a derivative of cinnamic acid by Adolf Von Bayer in 1880 and, as already noted, it took eighteen years from the laboratory process of Von Bayer to commercial production in 1897. It was the uncertainties inherent in the process which prompted certain changes in the nature of the science-based firm. It brought about the depersonalization of the Schumpeterian innovator. (Hohenberg, 1967, p. 61.) The first phase of the synthetic industry was marked by inventors like Perkin, who not only synthesized Mauvine, but, realizing its commercial possibilities, also set up a successful firm. The acts of invention and innovation were combined in the same person. In the second phase of chemistry, the inventor might have been a single individual but innovation demanded huge investments and a large organization which no single individual could afford. Innovation became corporate. The synthesis of indigo in fact heralded the rise of a new kind of firm—the science-based multinational. This was a knowledge-centered firm which applied science to the creation of new commodities. Secondly, not only was production on a large scale but the uncertainties inherent in the process necessitated the integration of all the operations concerned. The firm had to encompass every aspect of the innovation chain from raw materials, intermediaries, by-products, research, production, markets, advertising and after sales service. The development of synthetic indigo was enacted within a competitive framework which strained the finances of both Hoechst and BASF. BASF, which was first in synthesizing indigo, soon found itself in danger of being outstripped by Hoechst. The firms realized that such competition was an uncertainty they could well do without, and this led to the idea of a fusion of interests between the various synthetic dyestuff groups, a federated structure, an *intergemeinschaft*. Elaborate negotiations resulted in the amalgamation of three firms into the first of the great scientific cartels—IG Farben. The formation of IG Farben anticipated by a few years the other chemical multinationals, ICI in Britain and Dupont in USA (Beer, 1959, p. 125.)

The outstanding characteristic of the structure of German science lay in the effective integration it had achieved between science and technology. The development of professionalized science in Germany, integrated to industry and encouraged by the

state, stands in sharp contrast to British moves to reform science. In 1895 the Germans had established the *Physikalisch Technische Reichanstalt*. British scientists agitated for an equivalent—the National Physical Laboratory, which was established as a laboratory for the maintenance of national standards and the testing of instruments in 1902. The latter was the first instance of state participation in research. A few more feeble moves resulted in the establishment of the Imperial College of Science and Technology and provision in the National Insurance Act for a medical research fund.

The inception of World War I found Britain fighting an enemy on whom she was totally dependent for 'optical glass for her range finders, the dyes for her uniforms, magnetos for transport, tungsten for steel, zinc for smelting'. (Armytage, 1965, p. 215.) One of the outstanding instances of such inadequacy was the dyestuff industry, 88 per cent of which was controlled by the Germans. The first steps the British government took were feeble ones—an attempt to float a National Textile Corporation. Meanwhile, scientists keen to achieve an institutional integration of science and technology formed an unofficial pressure group, 'the Neglect of Science Committee'. It is interesting that almost all the participants at the conferences convened by the committee conceded the excellence of British achievements in pure science. What they criticized was the insufficient application of science to industry. They felt that the true applied science laboratory had not yet emerged in England. (Levine, 1967, p. 71.)

It was precisely this disjunction that the scientists set out to bridge. They persuaded the Board of Trade and Education to recognize the need for governmental assistance for research in industry, which led to the establishment of the Haldane Committee. Realizing that even this was inadequate the government established the Department of Scientific and Industrial Research in 1916. The NPL was removed from the control of the Royal Society and placed under the aegis of the state. The government also provided for the application of science to specific industries. By 1920 over twenty industrial research associations dealing with photography, glass, fuels, radio, etc. had been established.

Having briefly analysed the development of industrial research in Germany and Britain, let us now proceed to understand the

institutional implications of industrial research for the former colonized societies like India.

III

The history of industrial research can be divided into several phases, the first of which centres around the synthesis of the aniline dye. In this phase processes were still simple, knowledge of the technique bordered on the empirical. The manufacturing units were small and none of the products managed to supplant natural vegetable matter. The second phase, which began with the synthesis of alizarin, was far more scientific, with scientists systematically experimenting on molecular dyestuffs architecture according to the theoretical blueprints furnished by Kekule. As a result of the researches almost all the natural dyestuffs except indigo were displaced. The production of the madder dye, estimated at 70,000 tons annually, declined and large areas in France which specialized in its production faced ruin. It was the profits from the synthesis of alizarin that enabled Hoechst and BASF to finance the long and uncertain investigations into the synthesis of indigo. Synthetic indigo introduced into the market in 1897 forced natural indigo, on which India had a monopoly, into obsolescence. Within a span of ten years exports of indigo fell from 19,000 tons in 1895-6 to approximately 11,000 tons in 1913-14. Over 200,000 acres of land devoted to indigo lay idle. With the start of the War there was a temporary boom when the British army needed dyes for khaki uniforms and 21,900 acres were sown to meet the demand. One must emphasize that it was not the foreign planters who were to bear the costs of obsolescence but the tenants. It was this that led to Gandhi's movement at Champaran. Mahatma Gandhi, whose nationalism had so far confronted the obsolescence of man by machine, came face to face with the obsolescence created by science.

The next phase in the rise of chemistry culminated in the synthesis of ammonia. Prior to World War I Britain and Germany depended on the Caliche deposits of Chile for their fertilizer inputs. Chile supplied 55 per cent of the world's requirements. The Malthusian spectre of population outrunning food supply attracted the attention of scientists to the problem. In 1898 Crookes hinted that the solution lay in the working out of a commercially feasible

process for tapping nitrogen from the atmosphere. The problem demanded a remarkable synthesis of scientific insight and technological competence and inevitably the solution came from Germany, from the BASF scientists, Haber and Bosch. It is interesting that the time gap between a scientific idea and its commercialization was already decreasing. In the case of indigo it took eighteen years, but with synthetic ammonia it was a mere six years. The Haber Bosch process, regarded as one of the outstanding feats of scientific engineering, could not have been attained without state assistance which was manifested in liberal subsidies. This alliance of the university scientist, the entrepreneur and the state created an institutionalized system of obsolescence—industrial research—which wrecked the Chilean economy, where the export of fertilizers accounted for 80 per cent of the government's income.

This book takes as its basic problem a sociological understanding of how societies like India responded to the phenomenon of industrial research.

CHAPTER 2

THE RISE OF INDUSTRIAL
RESEARCH I

I

The introduction of western science in India can be divided into three phases. The first of these was called the era of the Great Surveys. It was a period that involved the development of a host of field organizations under the inspired impetus of the Asiatic Society of Bengal. The establishment of the universities in the presidency towns of Calcutta, Bombay and Madras and their transformation from mere examining bodies to active agencies combining the functions of teaching and research constitute the hallmarks of the second phase. The relation of science to the economy was not the primary concern in either of these two phases. It is only in the third phase that systematic institutional links were sought between science and the Indian economy. This culminated in the establishment of agricultural research and in the eventual rise of the industrial research laboratory.

Although this book is basically concerned with industrial research in India, a sociology of industrial research necessitates a historical perspective and demands that we reconstruct the first two phases of Indian science. There are two reasons for this. First, there is an element of continuity between the three phases. But more importantly, the debates relating to the establishment of these organizations did not deal only with managerial issues. They were concerned not merely with the structure of science but with the evolution of Indian society.

The institutionalization of western science in India commences for all practical purposes with the establishment of the Asiatic Society of Bengal in 1784. The Society was established by Sir William Jones, a distinguished orientalist and judge at the Supreme Court of Calcutta. Like a few other officers of the East India Company, he found in India not just an expanse of territory

to be conquered but a new and almost untapped realm of knowledge for the West. William Jones was not the first of these investigators. He had been preceded by a number of scholars in the eighteenth century. In geography, D'Arville was already collating the work of Jesuit missionaries like Claude Boudier, Barbier, Bouchet and Calmettee. In botany, the amateur researches of Heinrich Van Rheed had resulted in the twelve-volume *Hortus Malabaricus*. The Tranquebar missionaries had established the United Brotherhood which was dedicated to the pursuit of botanical researches in India. The publications of these scholars were scattered randomly in British and French journals of the time. (Bagchi, 1965, p. 11.) Jones realized that the isolated efforts of these scholars were not enough. He understood the collective nature of the scientific act and the importance of communication and exchange in science. He sought to provide for a co-ordinated body of knowledge through the establishment of the Asiatic Society. Jones, as Suniti Kumar Chatterjee pointed out, was not the first orientalist, but he was the first man to institutionalize orientalism as a specific branch of intellectual endeavour. (Chatterjee, 1946.)

On 15 January 1784, William Jones, along with thirty other officers of the East India Company, inaugurated the Asiatic Society in the rooms of the Supreme Court of Calcutta. In his inaugural address he stated the objectives of the society.

You will investigate whatever is rare in the stupendous fabric of nature, will correct the geography of Asia by new observations and discoveries, will trace the annals and even the traditions of those nations who from time to time, have peopled or desolated it, will bring to light the forms of government with their institutions civil and religious; you will examine their improvements and methods in arithmetic and geometry, in trigonometry, mensuration, mechanics, optics, astronomy and general physics, their systems of morality, grammar, rhetoric and dialectic, their skill in chirurgery and medicine, and their advancement whatever it may be in anatomy and chemistry. To this you will add researches into their agriculture, manufacture and trade, and whilst you enquire into their music, architecture, painting and poetry, will not neglect those inferior arts by which the comforts and even the elegances of social life are supplied or improved. . . . If it is asked, what are the intended objects of this enquiry, within these spacious limits we answer, man and nature, whatever is performed by one or produced by the other. (Chatterjee, 1946, p. 413.)

The British officers who established the Asiatic Society transplanted with them an early characteristic of western science of the time, the cult of the amateur. The objectives of the Society had all the imperialism of the amateur. The only boundaries it accepted were the geographical limits of Asia. The Society was closely modelled on the hebdomadal gatherings of the Royal Society of London, a body which for the most part came from the leisured classes that pursued science for education and entertainment. Jones hoped that this group of amateurs would advance to maturity just as the Royal Society, which was initially only a meeting of a few literary friends at Oxford, rose gradually to a splendid zenith when Halley was its Secretary and Newton the President. In the India of the time the dominance of the amateur was inevitable. Lewis Fermor points out that 'during the early days, the East India Company employed no scientists as such although the Company entertained the services of medical officers, surveyors and assayers at the Mint. As a consequence, the early scientific work in India was practically all amateur work done in their spare time by medical men who were interested in science, by enthusiastic army officers, and by officers in civil employ'. (Fermor, 1935, p. 18.) The Asiatic Society provided full freedom to these amateur scientists by providing them not only a forum for discussion, an avenue for publication in *Asiatic Researches* and the journal of the Society but with that absolute requisite of the field sciences, the museum. It is the field activities of the Society that led to the establishment of the Great Surveys.

The early issues of the Society's journal were dominated by orientalists. The only scientific contributions came from mathematicians like Barrow and Pratt. It was only in 1808 that the dominance of the orientalists began to recede, when the Society was bifurcated into two sections grouped under the rubric of literature (philosophy, history, antiquities) and the other grouped under the general label of physics which included natural history, philosophy and medicine. The second committee lay dormant for twenty years and its revival signalled the outburst of activities in the biological and geological sciences, out of which came the Great Surveys.

As one of its first Indian directors pointed out, the Zoological Survey, was a product of the evolution of over a century of research in systematic zoology initiated by the naturalist members

of the Asiatic Society. The Survey was an eventual organizational spin-off formed by converting the zoology and anthropology sections of the museum into a separate government department. The superintendent of the relevant sections became the first director of the Survey in July 1916.

The Asiatic Society was not involved in the establishment of the Royal Botanical Gardens, the first institution for botanical research in India, but it did play a crucial role in its development. The Sibpur Gardens were established to facilitate the introduction and acclimatization of economic plants into India. James Falconer, a member of the Society, recommended the introduction of *Cinchona* plantation into India. Falconer also established the feasibility of tea cultivation in India, and, under the aegis of William Bentick, the officers of the Sibpur Gardens established the industry in 1835.

But the epitome of the Imperial Survey was the Geological Survey of India (GSI). The first contributions to Indian geology were the inspired work of amateurs whose researches were published in the journals of the Society. Voysey, the father of Indian geology, was attached to Colonel Lambton's survey as a surgeon. P. M. Benza, who contributed to the geology of the Nilgris, and Malcolmson to an understanding of the Deccan Trap, belonged to the Madras Medical Service. Adams, Hardy, Spilsbury, all contributors to early Indian geology, belonged to the Bengal Medical Service. The official history of the GSI begins with the rise of the coal mining industry in India when a coal committee was established by Auckland in 1795 and recommended the geological survey of the coal belt of India. The East India Company obtained the services of David Hiram Williams of the Geological Survey of Great Britain. Williams, who surveyed the Ramgarh and Karimpura coalfields, laid the foundations of the GSI in 1854. In its early years, the GSI was housed in the Asiatic Society.

The GSI offered great possibilities for industrializing India and even though the efforts of the Survey represent imperialism at its best its researches had compiled a vast record of the mineral wealth of India. Yet little or nothing was done to utilize it. As early as 1902 the Survey possessed a nucleus of experts on industrial minerals ready to spearhead an industrial utilization drive. The Government vetoed all such moves, contending that the Survey was

established to facilitate the export of minerals to other countries and in fact transferred these experts from the Survey to the new Bureau of Mines, an organization with the purely administrative function of inspection to assure the implementation of safety rules in the mines. 'The mineral development of India was left largely in the hands of private enterprise which concentrated mainly on rich occurrences of ore and minerals whose exploitation for export or other use required little risk and practically no capital.' (Fox, 1943, p. 14.)

Throughout the eighteenth and nineteenth centuries, a host of organizations broke off from the Asiatic Society to lead an independent existence of their own. The final roster of institutions the society initiated, suggested, nursed or nurtured, included the Royal Botanical Gardens, the Indian Museum, the Zoological Gardens, the Survey of India, His Majesty's Mint, the Meteorological Department of the Government of India, the Linguistic Survey, the Medical College of Bengal, the School of Tropical Medicine, the Geological Survey and the Anthropological Survey of India. With the formation of each of these organizations there was a corresponding decentralization of activity. Scientific activity now tended to be concentrated in the Surveys and the scientific researches once published in the general compendiums of the Society were now localized in the specialized memoirs of each Survey. The specialization of science was eventually to have an indelible impact on the Society (Brahmachari, 1931, p. xxiii) and by 1896 Alfred Pedler, Professor of Chemistry at Presidency College, could not decide whether the Society was an anomaly or an anachronism. The genesis of the Society and its social distance from the scientific centres of Europe had rendered it a unique, a group of amateurs in the age of the specialist professional, but Pedler pointed out that the development of scientific societies in Europe was towards ever-increasing specialization. 'Each specialization had its own society in Europe'. There was already a tendency for British officers to submit their researches to these magazines, for they were then sure that their papers would find a receptive audience. They preferred this to sending contributions to the *Journal of the Asiatic Society* where a paper could be the only one of its kind. In prescient words, Pedler remarked 'In the case of Europeans who are temporarily resident in this country hoping to return to their native land later on this tendency can readily be

understood and perhaps excused. On the other hand, for workers whose home is in India, and who will probably do all their work here, there is not the same reason for sending original papers to societies in Europe but the natural tendency should be to contribute to societies like our own, for their work would be published in the land in which they live and where they would be fully recognized by their countrymen. Indeed it might be argued that it borders on want of patriotism for the native to send his original work to be published in Europe'. (Pedler, 1896, p. 18.) But soon after Prafulla Chandra Ray's paper on mercurous nitrite appeared in the *Journal of the Asiatic Society*, its review in *Nature* delivered a coup de grace to the pretensions of the Society. 'The *Journal of the Asiatic Society* of Bengal can scarcely be said to have a place in our chemical libraries. The current number, however, contains a paper by Dr. P. C. Ray of Presidency College, Calcutta, on mercurous nitrite that is worthy of note'. (Ray, 1932, p. 114.)

The Society's preoccupation with its amateur membership is reflected in a series of Presidential addresses (Pedler 1896, Brahmachari 1931, Fermor 1935, Fox 1943). The majority of them saw in it not the vestige of an old era in science but property to be preserved, by adapting to new situations. The members emphasized that, while it led to greater efficiency the specialization of science brought with it a certain narrowness. There was a necessity to transcend the specialization and excessive technicality of modern science, for communication between the scientific estate and the political world and to translate the esoteric dialects of science into a popular idiom. These requirements led to the Indian Science Congress in 1915, the first meeting of which under the presidency of Asutosh Mukherjee was held in the rooms of the Asiatic Society. The proceedings of the Congress were published by the Society and the day-to-day administration between sessions delegated to it. The necessity of an academy or institute encompassing the various specialist societies and representing the scientific profession vis-à-vis the state was recognized by the Society. At the Indian Science Congress of 1934, the Society helped inaugurate the National Institute of Sciences, a body equivalent to the American Academy of Sciences. The Institute was housed for 10 years in the Royal Asiatic Society. Lewis Fermor, its president also served concurrently as the first President of the National

