Prafulla Chandra Ray and Marcelin Berthelot: Chemist-Historians

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The Young P.C. Ray and the Inauguration of the Social History of Science in India (1885–1907)

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This paper discusses two projects in the early life of the Indian chemist, P.C. Ray, rightfully considered the founder of the 'school of chemistry' in modern India. Ray scholarship has often considered these years of his life as important from the point of view of an appreciation of the history of alchemy in India, but not in terms of his scientific contributions. It is only after 1907 that the Ray legend became the subject of serious scientific consideration. This paper discusses Ray's evolution till 1907, by examining the relationship between his project on the history of chemistry in India and his scientific researches on mercury. Further, it goes on to suggest that this effort was part of the larger programme of the cultural legitimation of modern science, and the two projects otherwise considered distinct, mutually informed each other during these years. While identifying the context of Ray's project, this exercise in social epistemology locates the factors that have clouded the recognition of the thematic unity of Ray's endeavour.

THIS PAPER, DIVIDED into two parts, seeks to explore the interplay between historical consciousness and politics in Ray's project. This reconstruction necessitates a sensitivity to the history of chemistry as well as to political movements. For it is not coincidental that in a strange reversal of historical reflection, the historical narrativisation of the antiquity of a discipline preceded the introduction of its modern variant in India. At stake is an interpretation of the transmission of scientific ideas viewed not merely as 'reception', but also of assimilation that leads to an interrogation for the social studies of science.

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Traditionally, philosophies of science have endeavoured to undo the filigree of the context of justification from that of discovery, thereby de-emphasising the shaping of scientific research programmes or the environment of research by the historical narrativisation of science. This has largely to do with how 'influence studies' and historiographies premised upon pre-Kuhnian philosophy of science, have visualised the act of historical narrativisation. From the vantage point of the politics of scientific knowledge, a shift in narratorial stance could be fruitful. The shift is a pressing consequence of the historiographic upheaval raging in post-colonial societies, and in the case of India it would possibly mean relocating the colonial enterprise as it was relevant to 'changing Indian concepts of cultural identity' (Lelyveld 1993: 665–82). This account is disposed to the consciousness and agency of the colonised, and the dialogue and sometime militant opposition, that created the space for the ideological grounding of science in India.

Towards the third quarter of the nineteenth century, Indians at the periphery of the world of science were seeking out an exemplar for emulation, in order to reduce the distance separating the centre from the periphery. While discussing the patterns of emulation at the periphery, Gizycki is careful to point out that such programmes do not involve mere imitation but of adapting existing institutions, drawing them closer to models drawn from the centre (Gizycki 1973: 474–94).[1] To comprehend this process of adaptation in both institutional and cultural terms we will propose a periodisation in the stages of the adaptation, and the role of individuals in this process.

The first stage is one where the auto-didact has a significant role to play. The auto-didact is situated in the indigenous systems of knowledge, and is pedagogically instructed in modernity. The auto-didact assigns himself or herself the task of setting the terms of the dialogue through the activity of translation, which could be construed to mean the actual translation of textbooks of modern science into the vernaculars, which in turn requires the production of a cultural lexicon of metaphors and images that renders the world epistemologically refigurable in a frame that is recognisable and appealing; further translation would also mean domesticating this knowledge through the definition of a grammar.

The second stage is marked by a shift in location from the auto-didact/man of letters to the professional such as M.L. Sircar, founder of the Indian Association for the Cultivation of Sciences,

and University figures like J.C Bose, P.C. Ray, and Hakim Ajmal Khan would also fall into this category. These people hoped to salvage and revitalise those elements of the traditional systems of knowledge that are reconfigurable in the light of modern science. In addition to promoting science and instituting procedures for legitimating their ideological programme in scientific terms, the scientist became a partisan of the burgeoning nationalist struggle of the time. By 1914 through the efforts of the purveyors of science of the previous two stages, modern science came onto its own in India. The first Indian Science Congress was organised, and the peers of Indian science graduated that critical number of students to ensure the further replication of the scientific research system. The choice of research problem in the exact sciences was divorced from its cultural grounding, and research programmes were defined by issues raging in the metropolises of science—this is the third stage.

There is a remarkable difference in the three stages, particularly between the first two and the third. These differences may be seen as outcomes of the evolving nationalist movement, within which the scientific system is situated. According to Macleod (1982), British recognition of Indian independence did not come in 1947 but in 1914, the year the Science Congress was organised. The conflict between different systems of knowledge is the most conspicuous during the first two stages, which also makes this a rich area for the cultural studies of science. The tension between notions of modernity and tradition, both within colonial discourse as much as within the world of the colonised, is most acute in these stages. This tension is apparent in the ambiguity regarding both nationalism and internationalism. As indicated elsewhere, the first generation of Indian scientists, while positioned within so-called traditional societies, looked upon tradition critically, in order to revitalise these systems of knowledge and apprehended in science the social embodiment of the internationalist ideal (Habib and Raina 1989).

An issue of significance for the cultural studies of science is the examination of the 'process' of the acculturation/domestication of modern scientific knowledge in the indigenist idiom. Depending upon the perspective, some historians prefer the term 'cultural redefinition' (Metcalf 1986), a term this work has been predisposed to; encompassing as it does a civilisational finding relating to science, that denies percolation models sufficient explanatory potential and rejects the axiom that the method and verities of

science are unattenuated by the cultural milieu it perfuses (Shapin 1983). India is among the former colonies where by the late nineteenth century a section of the intelligentsia had launched a project of reinventing modernity, and since science was the beacon of modern rationality, cultural appropriation necessitated the recovery of the idiom of rationality from within Indian society's cultural resources (Habib and Raina 1992).

The theme of this paper is the cultural redefinition of science in the second stage outlined earlier. A question germane to this stage of the cultural redefinition/appropriation of science is: when and under what conditions is the cultural redefinition of science possible? Further, could the choice of problems for scientific research or the structuring of a scientific research programme depend upon cultural and political considerations? To substantiate upon the nature of these connections two hypotheses will be examined:

> *Hypothesis* 1 (H1): Essential to the cultural redefinition/appropriation of modern science is the establishment of a dialogue with the recipient culture's system of theoretical knowledge.
> *Hypothesis* 2 (H2): The legitimation of science as a new knowledge form requires the possibility of deploying this knowledge for utilitarian ends as well as within emancipatory social movements.

This paper probes the corpus of work and activity of P.C. Ray, considered by many as the founder of the tradition of modern chemistry in India.[2] In the first part of the paper Ray will be ideologically situated within his political context. A socio-epistemological reading of the dialogue Ray instated between the system of modern chemistry and the Indian system of alchemy follows. Ray, the chemist, launched the history of chemistry in India and laid the foundation of the social history of science. The second part of the paper suggests the interlocking of these two identities and is manifest in a chemical research programme marking the early years of his career. This informs our understanding of the cultural redefinition of science in non-European contexts and the peculiar engagement of the ideology and the practice of science.

The Chemists' Millennium

A feature of science based ideologies is their circularity, in that they aspire to become a science. But this becoming requires what Canguilhem calls 'a constituted model of what science is' (Canguilhem 1988). The reconstruction that follows unfolds facets of nineteenth century perceptions of science in India, and the ideological legitimacy that was sought in science. For the student, Prafulla Chandra Ray, son of a traditional Sanskritist and Persian scholar, the world was already riven by the two cultures divide. In fact, it was a world peopled by the icons of the European Renaissance, and significantly by the nineteenth century Bengali Renaissance. The pantheon included figures such as Raja Ram Mohun Roy, the initiator of the project of critical modernity in India (Sarkar 1975b: 46–68), Debendranath Tagore, Keshab Chandra Sen, Akshay Kumar Dutt, the Bengal positivists, litterateurs such as Bankim, and radicals like Iswara Chandra Vidyasagar who had opposed equally strongly the teachings of Vedanta as well as those of Bishop Berkeley. These figures drew inspiration in part from the European Renaissance and partly reclaimed the Indian past in very imaginative ways.

Committing Science to Nationalism

A typical conception of science in the late nineteenth century was that the wealth of nations was tied up with the state of development of the institutions of science and with the capacity for technological innovation; in this conflation of science and technology, science came to be coupled with nationalism (Paul 1985; Dubos 1950).[3] When P.C. Ray returned from England, having obtained his doctoral degree under Dr Crum Brown at Edinburgh, the nationalist movement in India was still in its incipient stages. But modern science and technology was not the panacea for the shortcomings of Indian society. More than nationalism, Ray's close relationship with the needs of the peasantry 'and the masses in general' was reflected in his later years in famine and flood relief work (Ray 1932: 40–41) and the mobilisation of the new knowledge in the task of 'development'.

His politics was at one level predisposed to the emancipation of the 'oppressed', and in the vocabulary of his times, opposed to

European rule over the Asian people. He writes that at the time of the Russo-Turkish wars, he closely followed the heroic defence of Plevna by Osman Pasha and Ahmed Mukhtar Pasha, for as an Asian his sympathy was entirely enlisted on the side of the Turks (Ray 1932: 43). However, his first act of sedition was committed as a graduate student in 1885 at Edinburgh, when he participated in an essay competition on 'India Before and After the Mutiny'. The essay competition was obviously organised by the prolocutors of British rule in India. Naturally, he did not win the award, but the British sense of fair play required that his essay be bracketed *proxime accesserunt*, despite the '. . . bitter diatribes against British rule' (Ray 1932: 62). During those years he appeared to go along with elements in the Indian National Congress who promoted the doctrine of mendicancy to make the British see reason. However, by 1905, the scene of struggle had changed, and more militant forms of opposition had acquired currency (Sarkar 1975a; Chandra 1969). Ray observed: 'The disillusionment was not long in coming. There is not in the history of the world a single instance of a dominant race granting concession to a subject people of its own free will and record' (Ray 1932: 63).

This transformation followed the partition of Bengal in 1905, but sections of the Bengali scientific community subscribed to the programme of *swadeshi* (economic self-reliance), or constructive modernisation, as different from the path of militant struggle adopted by other sections of the community. This meant shifting the focus of discussion to scientific and technical education appropriate to the needs of Indian society, and in tune with the programme of industrialisation being drawn up by the burgeoning Indian industrial interests (Sarkar 1975 a; Raina and Habib 1993). Ray was closely associated with the National Council of Education (hereafter NCE), a pedagogic programme committed to *swadeshi*; and after retiring from Calcutta University joined the University College of Science and Technology. In addition, scientific self-reliance, since the days of M.L. Sircar, required establishing a system of scientific research in India under Indian control and Indian management (Sarkar 1946; Raina and Habib 1995). Research was not part of the charter of Calcutta University and Ray entirely sympathised with the programme of the NCE and was involved in it, so that students of science in India could devote themselves to 'original investigations', and that in the heated moments of 1907 was perceived within the community to

be the need of the hour (Ray 1918: 23). Much later, in the 1930s, Ray was resentful of the fact that the British had failed to recognise the nationalist aspirations of the Indians, and invoked the republicanism of Voltaire and Rousseau, as did his nineteenth century Indian forebears (Habib and Raina 1992), to caution the British of the inevitability of the realisation of the aspirations of the Indian people (Ray 1932: 65).

Swadeshi, a programme aimed towards economic and scientific self-reliance, has been well documented in the literature (Chatterjee 1986). One of the early tasks Ray set himself, after he returned from England, was the local manufacturing of some of the chemicals imported from England—some of which he borrowed from British Pharmacopoeia (Ray 1932: 99–100).[4]

The aim here is not to discuss Ray's programme of industrialisation, but the relationship between his scientific research programme and his deliberations on the history of Indian alchemy during the 1885–1907 period. To fathom the latter it is imperative to examine his relationship with the nationalist movement. In the 1920s Ray was closely involved with the political fronts of the freedom struggle, and for all practical purposes was a practising Gandhian, much to the disappointment of his more radical students.

In early 1901, Gopalkrishan Gokhale was in Calcutta and Mahatma Gandhi was his guest. Through Gokhale Ray met Gandhi and was actively involved in preparing the stage for Gandhi's first public appearance in Calcutta. The attraction Gandhi had for him was not merely political but extended to their shared devotion to asceticism (Ray 1932: 128).[5]

The Promise of the Millennium

It is interesting to note how Ray, on his return to India, chose his first research problems. These had to do with the application of chemical knowledge to the extraction of chemicals that were hitherto being imported from England. The findings of this research were published in the *Journal of the Asiatic Society of Bengal* and *A Chemical Examination of Foodstuffs* between 1889 and 1894 (Ray 1932: 84). But the dream that inspired this research was that of Berthelot; a dream that prophesied that by the year 2000 AD all the necessary articles of food would be prepared chemically by chemists from the very elements and '. . . when foreign lands would not be

worth fighting for, when wars and annexations would be things of the past as rich harvests would be gathered in the laboratory' (quoted in Ray 1918: 2).

The chief contribution of chemistry in attaining this millenarian vision derived from, what Ray believed to be, Wöhler's inimitable invention of the field of synthetic organic chemistry (Ray 1918: 2). And it was in this field that Ray hoped to create a degree of specialisation in India, albeit he himself was trained as an inorganic chemist. Chemistry was for Ray, in his public incarnation, the only among the sciences 'calculated to develop the resources of our country and increase its wealth' (Ray 1918: 116–17). This raised the issue of whether chemistry qualified to be a science or merely technical knowledge concerning a particular domain. In promoting the cause of the Bengal Chemical and Pharmaceutical Works, and the need for a research facility that was imperative for this range of industry, Ray pointed out that even as a bread and butter science, chemistry had little need to be self-defensive, for as a science it did essentially gratify a fundamental human intention of unveiling the secrets of nature.

Prefigurations of the Historical Project

At a distinctly visceral level the empirical method of science found empathy within Ray's outlook since it further appealed to the Baconian metaphor of the scientist as a humble artisan probing the creation of divinity. The edge of this psychological imputation is blunted in that this Baconian vision echoes within the Bengali Bhadralok discourse on science, but Ray was fairly acute in his deployment of the understanding that the cultivation of sciences must proceed alongside the application of the arts, if the transformative potential of science was to be realised (Ray 1918: 10). More importantly, this view was informed by the social history of science in Europe during the 1780–1850 period. Naturally he was drawn to the notion of the republic of science defined through the meritocracy of ideas and the radical political view this entailed. According to Ray,

> If one studies the history of the progress of the technical arts and scientific inventions in Europe he will find solitary individuals working at a disadvantage and labouring under immense

> initial difficulties giving to the world the results of their indefatigable zeal and devotion, which have revolutionized the industrial world. They were almost invariably innocent of a high class education. A Le-Blanc dies in poverty in a foreign land . . . . James Watt . . . of humble origin and yet, struggling against the odds and surmounting insuperable obstacles . . . (Ray 1932: 96).

The most remarkable feature of this genre of writing is the evangelical, missionary inflection that addresses the underprivileged amongst his readers through the utopian promise of science as a worthy profession. The poverty of Bengal in the early years, and later the poverty of India were to be his chief concerns; and he saw his research activity as a means of alleviating this poverty. The 'whole of Bengal is Nature's laboratory', a bounteous nature that scatters her gifts in profusion (Ray 1932: 88).

The early years of Ray's life as presented in his autobiography are fascinating, for the principal metaphor signifying the educational ideal is that of the humble artisan picking up the tools of the trade. The early years are years of apprenticeship, a sort of preparation for the project of the future, and in this his father (Ray 1932: 27) and the particular complex of Bengali culture played a significant role. This early exposure to the writings of Prafulla Chandra Bannerji, Ramdas Sen and Rajendralal Mitra were to imprint themselves on his mind; and Ray believed that his predisposition to antiquarian studies was acquired then; that this training was to provide him in good stead when he wrote his *History of Hindu Chemistry* (Ray 1932: 34).

In addition, the nineteenth century was also the century of comparative philology and the Orientalist project in India and Ray drew inspiration from it. The Orientalists were an important influence in his early years, but later Ray radically departed from an essential Orientalist dichotomy (Said 1978). His philological mentor appears to have been his father, and the mature Ray like most classicists had acquired familiarity with some of the classical languages, like Sanskrit and Latin, not to mention the staple fare of the nineteenth century, namely, French and German (Ray 1932: 37–38). This was essential to his historical project, and he sought the help of a Sanskrit pandit to decipher some of the treatises on Indian alchemy. We shall discuss the break with Orientalist

historiography that surfaced in the late nineteenth century history of science writing that was announced through Ray's history.

In addition to the departure from Orientalism, there is in Ray's writing a recuperation of the compositeness of Indian culture that was being threatened under imperial rule. This compositeness of Indian culture and the religious tolerance prevalent on the Indian subcontinent were effective rebuttals of Western constructions of India as the land of blind bigots. The rejection of this essentialisation was the key to his disidentification both with imperialism and Orientalism. For he writes:

> We find there is a tendency among a certain class of writers to single some of the worst type of Mohammaden despots and bigots, and institute a comparison between India under them and the India today . . . . It is forgotten that at the time when the Queen of England was flinging into flames and hurling into dungeons those of her own subjects who had the misfortune to differ from the dogmatic niceties, the great Mogul Akbar had proclaimed the principles of universal toleration, had invited the moulvie, the pandit, the rabbi, and the missionary to his court, and had held philosophical disquisitions with them . . . . Religious toleration, backed by a policy dictated no less by generosity than by prudence, was the rule and not the exception of the Mogul rulers (Ray 1932: 66).

This was an ideological battle, not only with the British, the quotation being from an essay he wrote in England, but also signalled his distancing himself from Orientalism.

Ray's turning towards the history of science is a turn towards novelty. The purpose of the history of science is more than pedagogic, for it directly impacts upon industrial culture; it is a way of analysing India's strengths and weaknesses, and a bedrock from where future action must evolve. Consequently, he pleaded for the establishment of a school of synthetic organic chemistry in India. The supplantation of the natural dyestuff indigo by artificial indigo, following the synthesis of alizarine in the laboratory had sealed the fate of indigo growers and the textile dyeing industry in India. India had to learn from the efforts of the Swede, Berzelius, the French chemist Gay-Lussac and the German chemists Wöhler and Liebig. 'The history of the modern supremacy of Germans in

the industrial world is the history of the triumphs achieved by generations of silent and patient workers in the laboratory' (Ray 1918: 4–5).

This history of science was not a pragmatic inventory of the past that was to inform the present, but rather was on its own a text on the revolutions occurring in the realm of ideas, almost running parallel to the political revolutions that swept across Europe in the eighteenth and nineteenth centuries. Thus, the history of science became a legitimatory trope for the articulation of the politics of change.[6] Ray compared the condition of chemistry in India in 1910 to that in England in the 1840s (Ray 1918: 36). He read the history of science as a text on revolutionary change.

Furthermore, in articulating the need for chemical research in India, Ray emphasised that the radical programme of science ought to be mobilised within the framework of the resurgent political mood of the times. The politicised climate was receptive to revolutionary discourse; and Ray portrayed his heroes as the martyrs of science: Bruno, Galileo and Paracelsus the 'ideal chemist . . . an honest seeker after truth, who pursues knowledge for its own sake' (Ray 1932: 37). The history of the different branches of science provided ample illustration of the 'insuperable difficulties' faced by the votaries of science during the early stages (Ray 1932: 36). These difficulties do not merely reflect the obstacles in Ray's programme of founding a school of chemistry, but also the difficulties faced by the nationalists in furthering their ends.

An attempt will be made to situate Ray's historiographical deliberations in order to decipher how his reflections on history and science inform each other. For it is here, in humility, that this paper makes a brave claim. A number of scholars (Bannerjea 1990; Chatterjee 1986; J.N. Ray 1961; P. Ray 1966; Rosu 1986; Sen 1986) have come close to deciphering this relationship, but have been prohibited on historiographic grounds from doing so. This taboo is rooted in a particular view of historiography and the history of science, and this reading suggests that Ray either suppressed his appreciation of this relationship or was a victim of the condition.

While the origins of the project can be traced back to the correspondence between P.C. Ray and Berthelot, an attempt will be made here to unravel the complexity involved in the undertaking. Ray adopts Berthelot as his exemplar, but Ray's history of alchemy

departs from the Orientalist premises underlying Berthelot's project. If that be the case, Ray's history of Indian alchemy must be seen as a major historiographic landmark, and it could be reasonably argued that the subsequent concerns of the social studies of science in India in more ways than one prefigure in Ray's writing. Further, this project was foremost on Ray's mind during the two decades 1885–1905, at the end of which Ray again concentrated on research on synthetic organic chemistry, the founding of a school of research on the same lines, and the ensuing application of this knowledge to industry. Ray's institution of a dialogue between Indian alchemy and modern chemistry informs his ideas on industrial chemistry as well.

The Beginnings of the Social History of Science in India

> . . . I have special reason to look back to this period of my life with mingled joy and delight. When you learn a new language, you have a new world revealed to you as it were (Ray 1932: 37–38).

It is likely that in the narrative to follow there would be a tension between what is referred to as the 'member's account' and the 'stranger's account' (Shapin and Schaffer 1985: 4). The following discussion will offer a 'charitable interpretation' (Shapin and Schaffer 1985: 13). Thus, if it is less sympathetic to Berthelot, it is not to vindicate Ray, but rather to place Ray's project at the centre of an alternative construction of the history of science. During the years 1885 to 1915 Ray saw himself as essentially dedicated to chemistry: 'Chemistry claimed me exclusively as her own' (Ray 1932: 67). He commenced his doctoral work in 1885 and retired in 1936. Upon completion of his doctoral work he confesses to have become 'so passionately fond of chemistry' that he decided to stay on in England for an additional year 'to pursue my studies uninterruptedly to my heart's content' (Ray 1932: 68). This courtship with chemistry was to continue throughout his life; for he perceived himself as an ardent devotee and student even at the end of his career.

To his non-scientific readership the adventure of science and its methods, allegedly all its own, was to be illustrated through personal

example. From 1889, when he returned to India, until 1897 (Bannerjea 1990: 269) he did a great deal of work on the detection of adulteration of edible fats and foodstuffs based on physico-chemical data, the results of which he published in the *Journal of the Asiatic Society of Bengal*. The autobiography mentions in graphic detail his pursuit of what to the Western mind appears quaint, but in another sense is an indication of the patient extension of the empirical methods of chemistry to problems that were no longer central to the European researcher. Furthermore, importantly, in these pages we see the insinuation of the idea that the wealth of nations flows out of the toil of the scientist's laboratory.

The legitimatory agenda that underlies this persuasive writing cannot be overlooked; for he appeals to that realm within Indian culture that could be cognitively commensurable with the programme of modern science. Thus, he projects India as the tabula rasa for the cultivation of the sciences for a millennium (Ray 1918: 37). However, over the past 300 years the lamp of knowledge has glowed brightly only in Europe, and it has been extinguished in India. The latter has come to pass because the schools of Indian atomism and logic, like Nyaya, have been eclipsed by the rising tide of idealistic philosophies such as Vedanta (Ray 1918: 38). With the eclipse of the schools of logic and atomism, science on the subcontinent went into decline. If the decline were to be reversed, the light of science must shine again. In so reframing the argument, Ray was neutralising the cultural import of science as Western, and thereby instituting the possibility of dialogue, rather than be pre-empted into a programme of hegemonic erasure of traditional knowledge by modern.

In his research on the history of the medical sciences in ancient India, Ray observed the existence of elements of rationalism and the spirit of inquiry. In the canonical medical works of Charaka and Susruta, Ray noted elements of the empirical method and rational inquiry. Yet he did not refer to it as an empirical science, but one in which the practice of developed elements of surgery reveal the depth of knowledge gained from 'experiment and observation'[7] (Ray 1918: 186–87).

This very science, employing a biological metaphor, has like 'a potato taken kindly to the soil of Bengal' (Ray 1918: 44). The biological metaphor is suited to the cultural appropriation of modern science. For the last six centuries, Bengal had been the

home of the Nawadwipa school of logic; and the efforts of the physicist J.C. Bose heralded a new age; the transition from the age of logic to the age of the physical sciences, in analogy to the European Renaissance's break with the scholasticism of the medieval monasteries. But if science in India was to be revitalised, the question remained what sort of science was to be recovered, and what was its nature.

The history of techniques offered ample evidence of the existence of strong empirical traditions of metallurgy and other technical crafts in India. The Iron Pillar at Delhi was testimony to this tradition of metallurgy. But why did this empirical–technical tradition fall into decline? Ray addressed this question in the chapter 'Knowledge of Technical Crafts and Decline of the Scientific Spirit', in the *History of Hindu Chemistry* (Ray 1902, 1907). The divide between the arts, that were relegated to the lower castes, and the intellectual portion of the community precipitated a situation where 'the how and why of phenomenon were lost sight of, the spirit of inquiry died out . . . (India's) soil was rendered morally unfit for the birth of a Boyle, a Descartes, or a Newton . . .' (Ray 1918: 71–72).

Similarly, the decline of surgery followed the introduction of caste injunctions upon those who performed dissections upon the human body. The interdiction imposed on dissection presaged the end of surgery in India (Ray 1918: 191). The close link between practices and theoretical knowledge was a key concept in this historiography. Furthermore, other than enabling the secularisation of the history of science in India, Ray was a pioneer in the social history of science writing in the country (Chattopadhyaya 1986: 8). He was the first to recognise that the internal account is not sufficient to explain the dynamics of science and the unfolding of its history. In this historical project we witness an attempt (*a*) to recover the past of science in India, (*b*) to legitimate science, but also (*c*) an attempt towards a social critique, for there was no use lamenting the past (Ray 1918: 123). The spirit of inquiry had to be reinstituted.

The Revitalisation of Indian Alchemy

In 1894, while the idea for setting up the Bengal Chemical and Pharmaceutical Works was mooted, Ray had already begun to

devote time to the study of Indian alchemy. By 1888, he was scanning Indian materia medica. Having carefully studied Udoychand Dutt's *Materia Medica of the Hindus* and Kannai Lal Dey's *Indigenous Drugs of India*, Ray collaborated with traditional scholars, the Kavirajas,[8] to commence preparations of Kalmegh (Andrographia paniculata), Kurchi (Holarrhena antidysentrica), Vasaka syrup (Adhatoda Vasica), etc. The programme was inspired in terms of the epistemology of modern medicine. For, as he writes: 'All that was needed was that their active principles should be extracted according to scientific up-to-date methods and that they should receive the imprimatur of the practitioners' (Ray 1932: 104). Ayurvedic medicine was to be reconstituted along modern lines. His fascination for pharmacopoeia spanned a decade and a half. The programme of revitalisation did not merely extend to Indian pharmacopoeia, but also to agriculture, given the different soil types, crops, and agricultural practices in India. Ray also drew up a scheme of research priorities for disciplines where chemistry's impact was most significant (Ray 1918: 13–14, 66–67).

The Bengal Chemical and Pharmaceutical Works was conceived as an industry with an in-house research laboratory that would develop efficient processes for manufacturing chemicals that were being imported from Europe. This required the skills of an analytical chemist, and Ray had trained several of them and soon preparations like Syrup Ferri Iodidi, Spirit of Nitric Ether, and Tincture of Nux Vomica rolled out of his laboratory. About these first attempts he said, '. . . the very idea of locally manufacturing pharmaceutical preparations, which hitherto had to be imported, acted like a tonic' (Ray 1932: 106). The programme of economic self-reliance had to be premised upon a programme of scientific and technological self-reliance—in concrete terms this is what *swadeshi* was all about.

The history of chemistry was an economic morality tale illustrating the tremendous transformation of Western society. Wöhler's synthesis of urea led to the forging of linkages between the research system and industry. The exemplar of this transformation was a German one. The case of alizarine was especially significant since it had hit Indian indigo industry the hardest, jeopardising the lives of thousands of planters and those associated with the textile industry. The establishment of a system of industrial chemistry was

thus imperative for the health of the economy. He then drew up a plan for the development of the chemical industry, which commenced with the manufacture of acids and reagents absolutely essential for any chemical processing industry. Here, he proposed the installation of a sulphuric acid plant as the 'mother of all industries' (Ray 1918: 52–53). Based on the manufacture of reagents and acids, he planned the manufacturing process: starting from soaps to paper pulp to fertilisers and oils and the whole range that follows suit.

Rewriting the History of Chemistry in India: French Inspiration

The industrial successes of chemistry, tied up with marked advances in chemical knowledge, generated in the latter half of the nineteenth century a significant body of scholarship on the history of chemistry. Through one such effort the history of chemistry in the modernist vein was launched in India. The renowned French chemist Marcelin Berthelot published his *Les Origines de L'Alchimie* in 1885. However, the work was incomplete in its treatment of the Iranian, Indian and Chinese sources. This hiatus was bridged by a three-volume opus, infused with the scientism of the *troisième republique* (Bensaude-Vincent 1992: 141).

The central thesis the work sought to place on irrefutable foundations concerned the origins of alchemy in ancient Greece and its diffusion in the Mediterranean basin, and subsequently to the Orient. The task necessitated a study of comparable practices and doctrines in Asia (Rosu 1990: 191).[9] Ray's examination of the development of Indian alchemy was at variance with Berthelot's account. The former's historical research in the area commenced sometime in 1894, for he mentions Berthelot's *L'Alchimie Grecs*, Kopp's *Gesichte* and Udoychand Dutt's *Materia Medica of the Hindus* (Ray 1932: 115). The historical project was underway, for in 1896, Ray wrote to Berthelot, offering textual evidence that refuted Greek influence in Indian alchemy.

There is in Berthelot's *Les Origines* a passage that may have provoked a response from Ray. The passage reads:

> Le mercure, . . . joue un si grand role chez les alchimistes, est ignoré dans l'ancienne Egypte. Mais il fut connut des Grecs et des Romains. On distingue même le mercure natif et le mercure

> préparé par l'art, fabriqué en vertu d'une distillation veritable, que Discoride decrit (Berthelot 1885: 231).

This Greek origin of the science of mercury, and the fact that *Les Origines* contains one reference to India regarding damascene steel, and another imputing Alexandrian influence to an Indian alchemical text (Berthelot 1885: 140), may have initiated a project on the history of Indian alchemy, to restore a sense of balance to the history of science (Raina 1997).[10] Ray's letter to Berthelot dated 1896, contested the claim that the Syrian Nestorians carried Greek alchemy to India and China (Berthelot cited in Ray 1932: 116). This was the beginning of an exchange between the two, and the beginning of the history of alchemy in India. A few historiographical remarks on Berthelot would help highlight Berthelot's influence on Ray, and the difference that earmarks Ray's inauguration of the discipline.

Situating Berthelot

The history of this exchange, however, suffers from the drawback that all Berthelot's letters to Ray have been lost, but through the efforts of Arion Rosu, some of Ray's letters to Berthelot, currently in the possession of Berthelot's family, have been reproduced by Rosu (Rosu 1986, 1990). Rosu has identified the influence of the Orientalists on Berthelot's work, and the subsequent development of the French Indological tradition in the area of alchemy. While Rosu is primarily concerned with foregrounding Berthelot as the founder of a particular genre of the history of alchemy, the focus in this section is on Berthelot in relation to Ray. Berthelot and his friend, the Orientalist Ernest Renan, attended a course at the College de France offered by the philologist Eugène Burnouf (1801–52).

Two essential features of Berthelot's history of alchemy were: (*a*) the developments in modern chemistry served as a bedrock for recovering the positive traces in alchemy ('retrouver les traces positives'), and (*b*) the histories of Kopp and Hoeffer served as models, but Lepsius' work on Egyptian metalwork and its adaptation in the hermetic school were of special interest (Rosu 1990: 189). In historiographic terms this meant that Berthelot was the first among

the nineteenth century savants to apply the exact sciences in order to gain an understanding of Egyptian metalwork (Rosu 1990: 190).

Rosu, with the historian's privilege of hindsight, pointed out the limitations in Berthelot's history. The first has naturally to do with the incipient stage of interdisciplinary research in the nineteenth century, reflected, according to Rosu, in a collaboration between a Hellenist or Orientalist ignorant of chemistry and a scientist lacking a sensitive insight into the meaning of obscure texts. Second, Berthelot interpreted the mystical doctrines of the alchemists with excoriating contempt, that revealed his poor understanding of the same (Rosu 1990: 191). The less edifying and more critical writing on Berthelot finds his treatment of alchemy equally problematic, for, according to Berthelot, alchemy was no more than a low rate chemistry (Guillemain 1992: 110). Furthermore, while positivism inflected his scientism, he adopted history as a shield to insinuate a quaint rejection of novelty in the name of modernity (Bensaude-Vincent 1992: 142). There are three interesting outcomes of his encounter with Ray: (*a*) it enlarged his vision of the origins of alchemy beyond the Mediterranean, (*b*) while his history was philologically and historiographically limited, it marked an epoch in the institutionalisation of the history of alchemy, and (*c*) Palmyr Cordier, a doctor and Berthelot's contemporary, initiated the French tradition of the history of Indian medicine and the collection of alchemical manuscripts (Rosu 1990: 202).

The Berthelot–Ray Encounter: The Seeds of Disidentification

The year 1894, according to Ray, was an eventful year in his life, for not only did he move to his new laboratory, but he also commenced his researches with redoubled effort, and he began his researches into the history of chemistry (Ray 1932: 112–15). Of the nineteenth century histories of chemistry, Kopp's *Geschichte der Chemie* had been his favourite reading since his days as a student pursuing a doctoral degree in chemistry at Edinburgh (Ray 1932: 110). In addition to the work of Kopp, the histories of Thomson and Hoeffer exercised an important influence (Ray 1918: 75). He was introduced to metallic preparations in Indian traditions of alchemy through Udoychand Dutt's *Materia Medica*. While teaching at Presidency College in 1894, he chanced upon Berthelot's *L'Alchimie Grecs* (Ray 1932: 115).

Ray, the probable beginner in the field, wrote to the then pope of chemistry, saying that he had read the latter's work, but was aware of certain thirteenth century Indian manuscripts that did not reveal Greek or Syrian Nestorian influence. Obviously, Ray had sent Berthelot his research papers recommending his scientific credentials. Berthelot responded: 'J'ai reçu vos recherches de chimie, qui sont fort interessantes et j'ai vu surtout avec plaisir comment la science avec son caractère universel et impersonnel est cultivée chez tous les peuples civilisés, en Asie, aussi bien qu'en Europe et en Amérique' (Ray 1932: 116). Regarding Ray's countering his thesis, Berthelot asked: 'Mais je serais très curieux de connaître les traités indiens du XIIIe siècle que vous me singalez. Ont-ils été imprimés?' (Ray 1932: 116–17). Delighted by the nature of the response, Ray wrote an essay on *Rasendra Samgraha*, a thirteenth century Sanskrit manuscript and mailed it to Berthelot. Berthelot reviewed it in *Journal de Savants* in April 1898 (Berthelot 1898: 227–36). The source of difference remained, as evident from the tension in the text: 'D'après ce savant, il existe des traités d'alchimie écrits en sanscrit remontant au XIII siècle et qui renferment des préceptes pour préparer les sulfures de mercure noir et rouge et le calomel employés comme médicaments'. However, a riposte to a mere paper prompted Ray: 'I must write a history of Hindu chemistry modelled upon the exemplars before me' (Ray 1932: 117).

The title of P.C. Ray's first piece on the history of Indian alchemy is interesting: *Materials for a Neglected Chapter in the History of Chemistry or Contributions on Indian Alchemy*, a manuscript numbering 43 pages. The title and its inspiration itself reflect its intent as a narrative of justice, of balance as an imperative. This negligence of a field so dear to Ray was not solely an outcome of Orientalist ignorance, for though the Orientalists and other scholars had studied Indian philosophy, mathematics, astronomy, and to some extent, chemistry, the latter had been neglected on account of its complex and technical nature (Ray 1932: 119).

The first volume of Ray's *History of Hindu Chemistry* appeared in 1902, and was highly recommended, given the fact that it was the first work of the kind. Most of the reviews acknowledged the original nature of the work, the facility with the classical languages, but more importantly, recognised the healthy distance maintained between 'stupid and senseless nationalism' and the internationalism

of science (Hartog cited in Ray 1925: 107; Ray and Dutta 1911: 461). Gradually, the work became a standard reference in histories of pharmacopoeia and histories of chemistry: Svante Arrhenius, amongst many others, assigned priority to India in the use of mercurial and metallic drugs over Paracelsus, based on Ray's work. But more importantly, was Berthelot's polite but almost gentle retreat in the review of the book in 1903 that appeared in *Journal des Savants*: 'C'est un chapitre ajouté à l'histoire des sciences et des l'espirit humain, chapitre particulièrement util pour la connaissance des rélations intellectuelles réciproques qui ont existé entre les civilizations orientales et occidentales'. The unidirectional model for the transmission of ideas had been transmuted into one of reciprocal exchange across civilisations. Prior to this, the realm of disagreement hovered around contesting interpretations of 'exchange'; for Berthelot it meant an imparting from Greece, for Ray, a two-way process.

Nevertheless for Ray, Berthelot remained the guru, in characteristic Indian fashion: an exemplar of the chemist and the historian of chemistry. In 1907, when the second volume of Ray's *History of Hindu Chemistry* was published, Berthelot was no longer alive, and Ray dedicated it to the 'sacred memory' of the 'great savant and chemist' (Ray 1907). A quarter of a century later he referred to his communication with Berthelot as the turning point in his career as a student of the history of chemistry (Ray 1918: 75–76). But even so, while Ray did move the mountain, in the course of their correspondence, Ray conceded to Berthelot that India did not produce texts similar to that of Zosima and the Greco-Egyptian alchemists. In a letter dated 22 September 1898 Ray writes: 'I entirely agree with you that there is an absence of theories met with in the writings of the Greeks and the Arabians, and that we have to deal with only a collection of technical recipes and general principles' (reproduced in Rosu 1990: 203–4). It is only much later that Ray broke away from the scientism immanent in Berthelot's understanding of alchemy.

The Turn to the Social History of Science

In addition to revealing the significant contributions of Indian alchemy, Ray pioneered the social history of science in India, for the answer to the question concerning the causes for the decline of

the sciences in ancient and mediaeval India, he reckoned, may only be found within the politics of the community and the nature of knowledge claims they espouse. A detailed frame for the secularisation of the history of the chemical sciences in India appears to have been developed by Ray.[11]

A brief discussion of the late nineteenth century tradition of chemistry writing follows. Ray acknowledged acquaintance with Thomas-Thomson's *History of Chemistry* (1830–31); Ferdinand Hoeffer's *Histoire de la Chimie* (1842); and Hermann Kopp's *Geschichte der Chimie* (1843). As Colin Russel (1988: 275) has pointed out all three were practising chemists and like all historians of chemistry at the time, Ray also confessed that Kopp was his starting point. Further, two points need to be mentioned in situating Ray among the late nineteenth and early twentieth century historians of chemistry. 'Dotage theory' suggests that nineteenth century historians of chemistry were 'retired chemists spending their declining years rewriting the history of their subject' in 'the best possible light', lacked the tools of historical analysis, were Whig historians, in that they were concerned with what their generation considered 'successful science' (Russel 1988: 280–81). At the risk of producing a hagiography of Ray, it is essential to point out Ray's departure to show where he did not fit in with the elements of dotage theory. This is evident from the following: (*a*) his best work in chemistry was still before him. His project on the history of science began at about the same time as his work for which he was elected Fellow of the Royal Society (he was around 31 or 32 years of age at that time): in fact it may even be argued that the historical project was an indulgence of his youth; (*b*) he provided the first insights into the social history of science in India, and set the frame for subsequent externalist research. Along with Berthelot and Thomson (Russel 1988: 284), Ray shared a refreshing familiarity with original sources; and (*c*) he overtly disassociated himself from Whig history (Ray 1932: 120), particularly of the British variety, and his own project sought to bring into the field of vision not what was already there, but that which had been lost. The essential historical incommensurability underlying the Berthelot–Ray exchange is situated at the semantic (in the sense that each attributed a different meaning to the exchange of knowledge) and hermeneutic (how the alchemical texts were to be interpreted) levels. In addition, while Berthelot saw Greece as a singular source

of influence, Ray's model was based on the polygenesis of knowledge. It is the hermeneutic argument that we will now turn to.

Beyond Orientalism

Prior to Ray's work, most scholarship on the history of chemistry was confined to the Orientalists. Even so, the history of the cultivation of the experimental sciences was a neglected area. Orientalist writing was partially responsible for the notion that the Hindus were a spiritual people, whose writings were confined to transcendental teachings. This view Ray ascribed to the emphasis Orientalists gave to a study of the scriptures. Further, lest he might endanger his own interpretation by bending over backwards—the danger of conceptual presentism—Ray did not over exaggerate the claim of the sciences of antiquity to be experimental sciences, but added that even in Europe the term was of recent origin (Ray 1918: 73).

Ray axiomatically stated that experiments and observations 'constitute the fundamental bases of Sciences' (Ray 1918: 74). The alchemical knowledge of India is to be interpreted through this epistemic grid. This reading is reinforced by invoking passages from two important alchemical works, of the thirteenth or fourteenth century AD, *Rasendrachintamani* by Ramchandra and *Rasaprakasa Sudhakara* by Yasodhara. Quoting from Ramchandra's work:

> That which I have heard of learned men and have read in the Sastras but have not been able to verify by experiment I have discarded. On the other hand those operations which I have, according to the directions of my sage teachers, been able to perform with my own hands—those alone I am committing to writing.

Or again: 'Those are to be regarded as real teachers who can verify by experiments what they teach—those are to be regarded as laudable disciples who can perform what they have learned—teachers and pupils, other than these are mere actors on the stage' (Ray 1918: 75).[12] In recuperating the traditional sciences, from the Ayurvedic, tantric and iatrochemical periods, Ray lent credence

to the aversion of science to scholastic arguments. Further, modern science could be legitimated without conceding to an ultra-radical epistemology, or cultural xenophobia.

Ray clashed with Orientalism on two related fronts. The first is the academic milieu within which Ray's humanist peregrinations are initiated—the tradition that came down from William Jones. The second is through Berthelot. However, Ray soon felt the need to depart from the Orientalist reconstruction of the history of chemistry in India. He noted that 'very vague notions prevail among oriental scholars' on the subject. For the sake of brevity, we will rephrase Ray's main objections to Orientalist construction; and what he proposed instead.

1. Ray observed that the Orientalists painted the history of alchemy in India with a very broad brush. Barth for one insisted that *Rasesvaradarsana* or the 'system of mercury' consisted of a strange amalgamation of Vedantism and alchemy (Ray 1918: 90–91). Ray's own history of alchemy in India identified three periods in the history of alchemy. The first is the Ayurvedic, the second is the tantric and the third is the iatrochemical. In all three stages the place of mercury and its use in medicine is very distinct. These will be discussed later.
2. According to the Orientalists, the use of mercury and its compounds in alchemy in India was introduced by the Arabs. Berthelot was also of the view that from Greece, alchemy travelled with the Syrian Nestorians to the Arab world, and from there to India and China. Ray's reading, in true ecumenical fashion, indicates that there is Arab influence on Indian alchemy, but *Rasayana* or the science of mercury was of Indian origin. The use of mercury in India predates the Arab influence. On the other hand, the works of Charaka and Susruta were translated into Arabic during the reigns of Khalif Mansur and Khalif Harun (Ray 1918: 92).

   There was disagreement between Ray and Berthelot on this count; and that remained unresolved at least during Berthelot's lifetime. However, priority for the use of mercury and heavy metal based compounds in therapy was attributed to India, even though Paracelsus is the founder of the practice in the West (Ray 1918: 92–93).

3. The limitations in the Orientalist account of Indian alchemy were a consequence of two historiographic presuppositions.
   (a) The Orientalists focused on Vedic sources, that were more often than not repositories of Ayurvedic medicine, that involved surgical practices and herbal medicine. However, to decipher the science of mercury (Sanskrit: *rasayana*) and a regime of therapy based on the prescription of metallic preparations, it was necessary to look at the non-Vedic sources that included Tantrism and Mahayana Buddhism (Ray 1918: 98).
   (b) Further, the Orientalists lacked a hermeneutic for interpreting the texts of alchemy. As Ray put it: 'It is clear that the devotional formulae . . . are here only a sort of jargon under which lies hid a radically impious doctrine' (Ray 1918: 91). This is a major departure of Ray from the Orientalists and Berthelot, for in positing the need for a hermeneutic he was liberating himself from the clutches of scientism and the more serious historical defect of presentism.

Ray's recognition of this problematic is evident in his appreciation of alchemical traditions outside India as well. In a popular article, certainly apocryphal by contemporary standards (Ray 1906: 237–38), he divulged, without any reference to his peers, the need for this break. In one breath, he denied a fundamental Orientalist dichotomy (Said 1978) of East and West, and recognised that in case the East is East and the West is West, this self-similarity was not always so (Ray 1906: 237). Second, he distanced himself from those who perceived alchemy merely as vulgar charlatanism that seeks the conversion of base metal to gold; on the contrary the Tantrists in India, the Rosicrucians in Europe, and Paracelsus, the 'sage and seer of Hoenheim' were all seekers after truth (Ray 1906: 238). Patanjali and Nagarjuna in India and Paracelsus were 'dreamers, mystics and naturalists combined in one' (Ray 1906: 238). Clearly, he had departed from the rationalist abuse of his forebear, and dissociated himself from the scientism of the third republic in favour of a more contextualist interpretation.

As a result Ray had proposed a historiographic frame for interpreting the history of alchemy, that brought to bear a new understanding of the alchemy of India. The crux of Ray's historiographic

disidentification with Orientalism was that the exclusion of elements of a heritage was an essential ingredient of the politics of repression. While this dimension was never explicitly stated, Ray's participation in the nationalist struggle, and his unhappiness with the extant historiograhies of alchemy are but manifestations of the politics of knowledge.

The Conjuncture of Science and History

> Dans la proportion même où l'historien des sciences sera instruit dans la modernité de la science, il dégagera des nuances de plus en plus nombreuses, de plus en plus fines, dans l'historicité de la science. La conscience de modernité et la conscience d'historicité sont ici rigoureusement proportionelle (Bachelard 1971: 201).

Scholarship on Ray indicates that between 1895 and 1910 Ray was simultaneously committed to three distinct streams of activity (Chatterjee 1986; J.N. Ray 1961; P. Ray 1966; P.C. Ray 1932; Sen 1986). Chatterjee typifies the quizzical responses of the others as well: 'How he managed to combine the three different streams—the continuous devotion to industrial chemistry, the researches in pure chemistry and the deep studies involved in deciphering the old manuscripts for the book on Hindu chemistry—all demanding full time attention will puzzle anybody' (Chatterjee 1986: 13). An attempt will be made to establish that these apparently independent projects mutually informed each other. To grasp the manner of this informing it would be essential to reopen the black box of 'problem choice' in the 'pure sciences'; for it is likely that within the domain of the cultural studies of science a shift from the epistemic domain would throw up different regimes of interlocking.

Sen, a student of Ray, expresses the uneasiness concerning Ray during these years: 'Why did P.C. Ray confine himself to the investigations on nitrites from 1896 to 1912 particularly when major discoveries were being made in other areas of chemistry and physics during the late nineteenth and twentieth centuries' (Sen 1986: 61). This he considered an indulgence, without explicitly saying so, for he proceeds to explain: 'The reason might have been that Ray was involved in other activities besides research . . . . From 1896 to 1906 or even later he was busy collecting and

studying materials for writing his magnum opus, the History of Hindu Chemistry' (Sen 1986: 61). He then points out that this was probably of 'equal importance' as his work in the laboratory. But despite the qualification, however obliquely judgmental, this is not the point at all. Recognition as a chemist came P.C. Ray's way in 1896, for research undertaken during this decade. The point that Ray's chemical problematic appears quaint from a later day perspective, is a consequence of historical (chemical) presentism, and partly due to the inability of members of the community of chemists to visualise the possible relationship between a scientific research programme and a historical project. This image of the independence of science from a reflection on the past of the discipline must have been a fairly current one in the late nineteenth century. Thus, the history of chemistry was no more than the museumisation of the past of chemistry.

A Summary of Ray's Chemical Researches

In 1877, the University of Edinburgh awarded P.C. Ray a doctorate for a thesis on 'Conjugated Sulphates of the Copper-Magnesium Group: A Study of Isomorphous Mixtures and Molecular Combinations'. Though an inorganic chemist by training, his research problems in the subsequent years necessitated forays into physical and organic chemistry. The second half of the nineteenth century was a period when physical chemists in Germany sought to professionalise and establish their discipline as an autonomous subdomain alongside pharmaceutical, medical and analytical chemistry (Hiebert 1982: 97). During this period, a number of research areas were brought under the jurisdiction of physical chemistry, but the central problematic concerned the study of chemical change, which effectively meant obtaining the position of equilibrium, and calculating the speed of chemical processes (Hiebert 1982: 101).

From 1894 to 1896, Ray undertook analytical investigations of Indian rocks and ores to fill the gap in Mendeleev's periodic table. While pursuing this task, he, as the official account evokes serendipity, synthesised mercurous nitrite in 1895. This is not the place to discuss the sense of 'discovery', but what is worth noting is that a two-faced 'science of mercury', in the alchemical and modern chemical incarnations, occupied Ray during the next decade. During these years he pursued the study of mercury compounds, followed

by studies on nitrites and hyponitrites of other metals, including alkaline earths in the pure states. This decade may be considered the period when Ray, in terms of his chemical repertoire of skills and techniques, switched from purely preparative inorganic chemistry to the measurement of physical parameters and the determination of the physico-chemical properties of compounds (Sen 1986: 41). By 1907, Ray had more or less initiated a tradition of researches into inorganic and physical chemistry, and had moved away from his obsession with what is referred to as his 'science of mercury' years, to the founding of the school of chemistry and the research programme in organic chemistry. We refer to the 1895–1907 period as the 'science of mercury' years because they weave the effort of a decade into a coherent thematic whole, embracing in the process two epistemological projects.

Problematising the Science of Mercury

We will now discuss the close relationship between the actual research done by P.C. Ray on mercury and heavy metals, or the edification of this work through his research on the history of alchemy in India during the mediaeval and ancient periods. This would provide us an instantiation of the conditions under which, Bachelard insists, the history of the sciences can have a positive impact on scientific thought (Bachelard 1971: 202–3). But here we would extend the Bachelardian framework a little further, and suggest that these two activities mutually informed each other. This mutual informing is realised through the conjuncture of three distinct orientations. First, Ray's own predisposition to pharmacological chemistry, and a specific programme initiated by his thesis supervisor at Edinburgh, Crum Brown who along with Thomas Fraser founded the branch of pharmacology dealing with the constitution of drugs and their therapeutical properties (Ray 1932: 60). Second, his investigations revealed that the place of mercury and mercury based compounds in Indian alchemy was unique, and he intended to decipher the nature of its use, its preparation and efficacy. Third, in 1895, Ray commenced his research afresh on the problem of assigning a place to mercury and some of the heavy metals in the periodic table.

The idea is not to suggest a causal relationship of the type where a set of factors precipitates a particular set of actions or a kind of

activity. For even Ray and his students would shy away from such a suggestion—there does not appear to be an insinuation of this nature in any of their published writings. Nevertheless, this reticence was an essential element of the regnant historiographies that see the history of science as offering an imaginative account of already accomplished science, of buttressing the scientific communities' preoccupation with history. The Bachelardian perspective may provide another way of viewing the relationship between the history of science and contemporary scientific practice. The process of the two mutually informing each other, we hope to instantiate in the subsequent subsections, revealing the modality of dialogue between the ancient sciences and the modern—a dialogue whose nature was transformed by the time Ray had retired from professional activity.

The Science of Mercury: The Historian's Account

The first part of this paper described the events that led Ray to the study of Indian alchemy, the commencement of his researches in the area, the presentation of India's unique contribution to alchemy, and the disagreement between him and Berthelot. This agonistic contest, in retrospect, appears to have been settled in Ray's favour. More specifically, Ray was committed to the polygenesis of alchemy, and priority in the use of metallic preparations in therapy: the latter did not amount to asserting that this influenced Paracelsus a couple of centuries later. For Berthelot, the project on the history of alchemy was one in self-congratulation, through the imputation of a cultural unity that was traceable back to the Greeks. The disagreement became most obvious in the second part of the manuscript Ray had mailed to Berthelot (Rosu 1986: 72). Again, in a letter dated 23 June 1898, Ray informed Berthelot that he had consulted some more texts on Indian alchemy and had found in them a process for removing the liquidity of mercury by titrating globules of mercury with a vegetable extract and heating it in a closed retort (Rosu 1986: 74).

The utility of alchemy lay in its connection with medicine. In the history of Western medicine, Paracelsus was credited with the introduction of metallic derivatives in therapy, and the use of mercury for treating syphilis (Knight 1992: 21). This is considered a major revolution in the history of mediaeval medicine. However,

as Knight's history of ideas in chemistry informs us, one of the fundamental problems facing early alchemy was to make base metals appear golden, and mercury and sulphur were seen as the key. Mercury and sulphur, and salt, the third conservative element of the triad, were observed to be the constituents of all metals (Knight 1992: 16). In his first paper on *Rasendra Samgraha*, Ray had reported that the Indian alchemists knew how to prepare black and red compounds of mercury and sulphur, that were used in medication. While Berthelot believed that this naturally confirmed Greek influence, Ray insisted on independent discovery.

There is no reference to the science of mercury in ancient Indian medical literature such as Ayurveda (Ray 1918: 77). Ray not only initiated the modern history of alchemy in India, but also in this history his specific contribution, other than the historiographic one, lies in the disclosure of the evolution of the science of mercury. A separate discussion on this history is warranted. Ray established that there are two important phases in the use of mercury and metallic compounds in Indian alchemy. In the first phase, which corresponds to the tantric period, the discipline was documented in canonical works like *Rasaratnakara* and *Rasarnava* (literally meaning the 'sea of mercury'), mercury based compounds were sought out and prepared to serve as the elixir vitae.

However, during the period which Ray called the iatrochemical period, whose alchemical knowledge is contained in such works as *Rasendrachintamani*, mercury and metallic preparations were used as accessories in medicine, as opposed to surgery and herbal therapies (Ray 1902: lvi). By the thirteenth and fourteenth centuries this knowledge ('the employment of mercury and metals') was exclusively introduced in medicine: and hence Ray ascribed to the term *rasayana* the connotation of the science of mercury (Ray 1918: 78). A century later, inorganic/metallic compounds were elements of a medical practice that 'reacted upon the age in giving fresh impetus to the study of chemistry' (Ray 1918: 86).

The disagreement with Berthelot remained since the Unani tradition as evident in India showed a strong aversion to the utilisation of metallic drugs in medical practice (Ray 1918: 92–93).[13] Further, as pointed out earlier and reiterated by Ray, mercuric/mercurous and other metallic preparations were first pressed into European pharmacopoeia by Paracelsus in the seventeenth century. Thus, India retained for Ray priority in the use of mercury based

drugs in medical practice as the tradition was possibly unique on this count. Though Ray's history appeared in 1902, the textual evidence appeared to have settled the issue for him. Nevertheless, in terms of historical and political consciousness, there remained a challenging epistemic obstacle to overcome, namely, Berthelot's presentism. While Ray was conscious of it, abandoning it willy-nilly would have meant writing away his own legitimatory agenda.

Mercury in the Periodic Classification of Elements: The Chemist's Account

If Berthelot was an important source of inspiration for Ray, the other was the great Mendeleev. In one sense Ray's narratorial range is influenced as much by Mendeleev's *Principles of Chemistry*, a work that exemplified the nineteenth century chemist's mentalité; for Ray considered this work a 'classic in the domain of chemical literature' (Ray 1906: 461). Bensaude-Vincent has highlighted two features of Mendeleev's *Principles of Chemistry*: Chemistry is now projected as a science firmly established on 'principles derived from experiment'; and the facile mobility in discussing problems of physics and chemistry to the problems of economic development of Russia: the inability of separating the 'future of chemistry from the future of Russia' (Bensaude-Vincent 1986: 3). Ray reckoned with the idea that the periodic system was a break with chemistry's past, that rendered chemistry a 'rational and predictive science'. The nineteenth century chemist, in the wake of the new formalism, was propelled into the role of an adventurer seeking out new elements that could fill in the gaps in nature's ordered schema. Ray's autobiography begins with the exclamation: 'I was born on August 2, 1861. This year . . . is memorable in the annals of chemistry for the discovery of thallium by Crookes' (Ray 1932: 1). Wherever he discusses his vision for chemical research in India, he indicates that it would be essential to scout the Indian topography for possibly new elements, compound and ores. By 1894, he had a remarkable collection of mineral specimens obtained through his friend Thomas Holland from the Geological Survey of India (Chatterjee 1986: 13).

After obtaining his doctoral degree, Ray spent sometime overcoming his self-professed inadequacies in 'organic chemistry', as the benefits accruing from the pursuit of research in organic

chemistry would herald the arrival of the millennium (Ray 1932: 71). This was also the time he began contemplating his return to India. He returned to Calcutta in August 1888. He mentions that his research in chemistry began afresh in July 1894. His research started of with the attempt to analyse rare Indian minerals in the hope of discovering *two new elements* that would fill the gap in Mendeleev's periodic table (Ray 1932: 113). Evoking chance, Ray says that in the process they found that mercurous nitrite had been synthesised. This was followed by the synthesis of a large number of mercurous compounds. The first paper was published in the *Journal of the Asiatic Society of Bengal* (Ray 1896a: 1–9) and not in the prestigious *Proceedings of the Chemical Society* or the *Journal of the Chemical Society*. The article was also mentioned in *Nature* (1896), where it was pointed out that a paper of this order had no business to appear in the *Journal of the Asiatic Society of Bengal*. His subsequent work (Ray 1896b: 365; 1896c) was later published in the former two journals which ranked high in the profession. The encomiums came in from his teachers and other renowned chemists of the time such as Roscoe, Divers, Berthelot, Victor Meyer and Volhard (Ray 1932: 114). In the same breadth, Ray mentions something else that was emerging at about this time. He talks of his reading Berthelot's book, and his correspondence with him on *rasayana* (the science of mercury)—a concordance of two mercury related projects; but thematically different spheres of inquiry. Nevertheless, while he chanced upon the synthesis of mercurous nitrite, his investigations on the history of Indian alchemy had revealed to him the centrality of mercury in the mediaeval period. However, it appears that his scientific credentials concerning mercury were legitimating his historical claims about the science of mercury in India.

Ray's papers on mercury and the heavy metals focused on allocating a place to mercury in the periodic table. The problem was that mercuric compounds, or compounds of dyadic mercury bore properties that were closely analogous to those of magnesium, zinc and cadmium; and thus warranted a place in Group II of the periodic table. On the other hand, mercurous compounds bore a closer analogy with silver; mercurous nitrite behaved analogously to silver nitrite and was as stable. The outcome of his researches on heavy metals and the detailed studies on mercury led to the inclusion of monad mercury at the bottom of Group I of the periodic table; while gold moved to Group VIII. Thus, univalent

and bivalent mercury are very different elements, the former being closely related to elements like silver. This duality of properties of mercury makes it 'comparable with thallium' (Ray 1914: 85). Two decades later, Ray summarised his researches of those years in *The Chemical News*, then edited by Crookes; where Ray suggested that the fall out of his work was to allocate a place to mercury in the periodic table. Nowhere, in this account is there a reference to any problem outside the scope of what fell within the purview of discussion of inorganic chemistry.[14] The anguish and joys of those fateful years, the intersection of a plurality of narratives, are totally absent in the account. The professionalised presentation of the scientist is complete. By 1913 nearly forty papers had been published in related areas and a group had been constituted. Other detailed works are available on Ray as the founder of the tradition of synthetic organic chemistry in India (Guay 1986). But then that is the story of the later Ray.

The issues raised above relate to a point made by Bachelard, and later by Canguilhem: that if the role of an epistemological approach to the history of science is to shift the focus of interest from the 'history of science to science as seen in the light of history', then Canguilhem asks ' . . . does this science of the past constitute a past for the science of today' (Canguilhem 1988: 3). It is this inversion of the role of the history of science, whether consciously or otherwise, that constitutes the conjuncture of the allegedly disparate projects of P.C. Ray during the decade and a half, that weaves them together. To call upon Bachelard again, in so interrogating the past in the light of the present, the past of science becomes its, shall we say, present continuous.

In the work of Ray this conjuncture is constituted through the elaboration of two sub-themes: as a chemist assigning mercury a place in the periodic table; and the relationship between chemical properties and physiological properties. His enterprise as a historian of chemistry seeks to elucidate the place of mercury and metallic compounds in therapeutic practice. Here we see the intertwining of two strands in the early Ray's life: on the one hand, he is the modern chemist studying mercury, on the other, in studying *rasayana* (the alchemical science of mercury) as a *rasasiddha* (Sanskrit equivalent of an alchemist), Ray assumes the identity of a *Rasasiddhapradayaka*, a term that Ray translated for his non-Indian audiences as an expert on the science of mercury (Ray 1918: 78).

In this twilight zone, astride two distinct epistemological programmes, the travails of the early Ray cease to be quixotic, and acquire a renewed coherence.

The End of Innocence and the Commencement of 'The School of Chemistry'

By 1907, Ray's 'science of mercury' years were beginning to come to an end (see Figure 1). He reckoned with the fact that in the interim period a whole new world was being instituted by chemists and atomic physicists: the Curies had completed their studies on radium, Rayleigh and Ramsay had discovered the rare gases argon, neon, xenon and krypton; and radioactive properties were being studied by Rutherford and Soddy. By 1905, Ray felt that too much had happened; his historical works were now on the back burner: '. . . I was buried in my researches on the chemical knowledge of the Hindus of old and therefore losing touch with the modern world' (Ray 1932: 122). A phase now begged closure, and efforts were underway towards instituting a full-fledged tradition on synthetic organic chemistry.

In 1930s, on the eve of his retirement, his students remarked that (*a*) Ray's theoretical researches in chemistry led him on to the application of this knowledge to harnessing the material resources of India, and (*b*) his *History of Hindu Chemistry* helped build bridges with the past, so that modern Indian researchers could turn back to Charaka and Nagarjuna with pride (Ray 1932: 189). But by now ensconced within the two cultures divide of the world of science, the underlying unity of Ray's project was lost to its times, and the age thereafter. However, the success of the project lay in that a tradition could turn upon itself without much diffidence. The space for modern chemistry had been gained without the need for foreign intervention or other intrusive strategies. What we have tried to show was during these years, his research in pure chemistry and his investigations on the history of Indian alchemy very closely informed each other. Furthermore, this process of informing lay at the intersection of the deliberations on nationalism and history on the one hand, and a dual project related to the relationship between chemical constitution and physiological response, on the other.

As for Ray himself, the historical project was also political—in as much it countered Orientalist and colonial definitions—and legitimatory: 'Hindu Chemistry . . . waited long and patiently for an interpreter. I thought I owed a debt to that great nation to which I am proud to belong . . .'. Further, 'I implore you to take to its pursuit and I hope that you will justify by your work that your are no unworthy successors of your glorious forefathers in the world of learning' (Ray 1918: 102).

There have been a number of responses to Eurocentrism within the domain of STS studies in India (Raina 1997). Two of these strains have taken recourse either to a radically relativist position, that falls within the current formulation of the 'ethnosciences', and the other from political psychology that essentially dèmonises science as a Western creation (Nandy 1980). Second, Nandy's remarkable study of Ramanujan and J.C. Bose, fails to answer how these otherwise quaint 'scientists' culturally shaped the science that followed them, or how cultural conditions shaped either their choice of research problem or the 'nuts and bolts' of their science. Nevertheless, studies on the cultural appropriation of science in modern India, a field still in its infancy, cannot escape returning to the years 1870–1920, when the conflict between different knowledge systems was at its height. In the present context, Ray's was an important conflict-ridden cultural dialogue, across distinct knowledge systems. Sociological approaches to the history of science have recognised that the history of science, more than any other genre of history writing, has been the most vulnerable to the Whig conception of history (Shapin and Schaffer 1989). The present study has sought not to revive Ray,[15] but to understand a specific cultural response to modern science (Ray's work being one in a larger cultural formation) that was to pave the subsequent trajectory of science in India.

NOTES

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1. However, Gizycki is concerned about the centre and peripheries in Europe, and he is looking largely at institutions, but not science as a cultural form as well.
2. P.C. Ray in an article written with Bidhubhusan Dutta informs us that the 'first chemist of Indian blood was Laurenco, a fellow student of Henry Roscoe and a pupil of Bunsen at Heidelberg in the early fifties of the last century', who for lack of opportunity in India went on to become a professor of chemistry at Lisbon (Ray and Dutta 1911: 460–62).
3. Adas has discussed the emergence of technology as a measure of a nation's development in the age of late colonialism (Adas 1990).
4. Mobilising contributions locally he set up the Bengal Chemicals and Pharmaceuticals, with a research facility to pursue the development of processes for the local manufacture of pharmaceutical products. The establishment of the Bengal Pharmaceuticals is a separate issue that will not be discussed here, suffice it is to say that pharmaceuticals became his new found passion (Ray 1932: 103).
5. On P.C. Ray's 70th birthday, Francis Conan, Professor at the University College of Science, London, was to refer to Ray as one who '. . . never asked much for himself, living always a life of Spartan simplicity and frugality', calling him the 'Saint Francis of Indian Science' (quoted in Ray 1966: 72).
6. Lavoisier in France, opened up a whole new tradition of chemistry that gave rise to the tradition of Gay-Lussac, Dulong, Thenard, Ampère, Arago and Chevreul. In Germany Wöhler and Liebig played the same role by inaugurating the discipline of organic chemistry. England drew its inspiration from Priestley, Cavendish, Dalton and Davy, but was slow in following suit in the wake of Germany and France (Ray 1918: 34–35).
7. Subseqùent histories of the sciences in ancient India have taken off from this observation of Ray. Debiprasad Chattopadhyaya refigures Ray's thesis in a Marxist framework, to point out that of the sciences of the ancient period in India it was medicine that best qualified as a science in the modern sense of the term. Further, Ray pointed out that the tradition fell into decline when the sciences were divorced from the crafts: the divide between theory and the technical crafts (Chattopadhyaya 1979).
8. In 1910, by which time he had already published two volumes on the history of Hindu alchemy, with K.C. Kabiratna he brought out a joint translation of the Sanskrit text, *Rasarnavam* (Chatterjee 1986: 13).
9. Rosu further points out that in retrospect Berthelot has been proved wrong in imputing Greek borrowing in Indian and Chinese alchemy.
10. Ray's letter dated 9 February 1898, thee loongest letter from Ray to Berthelot, states that his historical researches have been interrupted by his scientific work on mercurous nitrite, etc., and that among other things, he desires informing the European scientists of the indigenous origins of Indian alchemy (xerox of the letter reproduced in Rosu 1990).
11. Marxist writings of the 1950s and 1960s are elaborations of these insights; albeit Ray himself was not within the Marxist framework, though he was familiar with the work of the first Marxist history of chemistry authored by Carl Schorlemmer. This familiarity is not coincidental, for as Tucker has pointed out in a more general context, that much of the 'initial theoretical incentive for

the development of economic and social historiography was Marxist' (Tucker 1993: 643).

12. This quotation appears on the cover of the 1897 manuscript.
13. This debate was of a foundational nature, in that the exchange provided the occasion for the founding of French Indological studies on alchemy and Ayurveda, but has been totally ignored by even more recent works, for example, Charles Leslie's *Asian Medical Systems* (Leslie 1976: 357).
14. Between 1895 and 1907 Ray worked on the following: he isolated crystals of mercurous nitrite by the action of dilute nitric acid containing 13.14 per cent N_2O_3 on metallic mercury in the cold. Mercuric hyponitrite was then prepared by the action of potassium cyanide on mercuric nitrite. This was followed by the preparation of nitrites of alkaline earths in a pure state. It was found that magnesium nitrite was fairly unstable, thus linking it with nitrites of zinc, cadmium and the alkaline earths. The preparation of the double nitrites of mercury (II) with barium, calcium and lithium revealed that stability decreased with increasing atomic weight of the metal (P. Ray 1966: 69). This was a key finding in the programme. For details of Ray's later work that is considered relevant see P. Ray (1966: 69–73).
15. Chatterjee writes almost despairingly: 'P.C. Ray remains a class by himself. The utter selflessness with which he served the cause of the common people, the spirit of dedication and the Gandhian simplicity of life-style make him a lone and solitary figure. He has left a school and students but the name has all but disappeared' (Chatterjee 1986: 30).

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