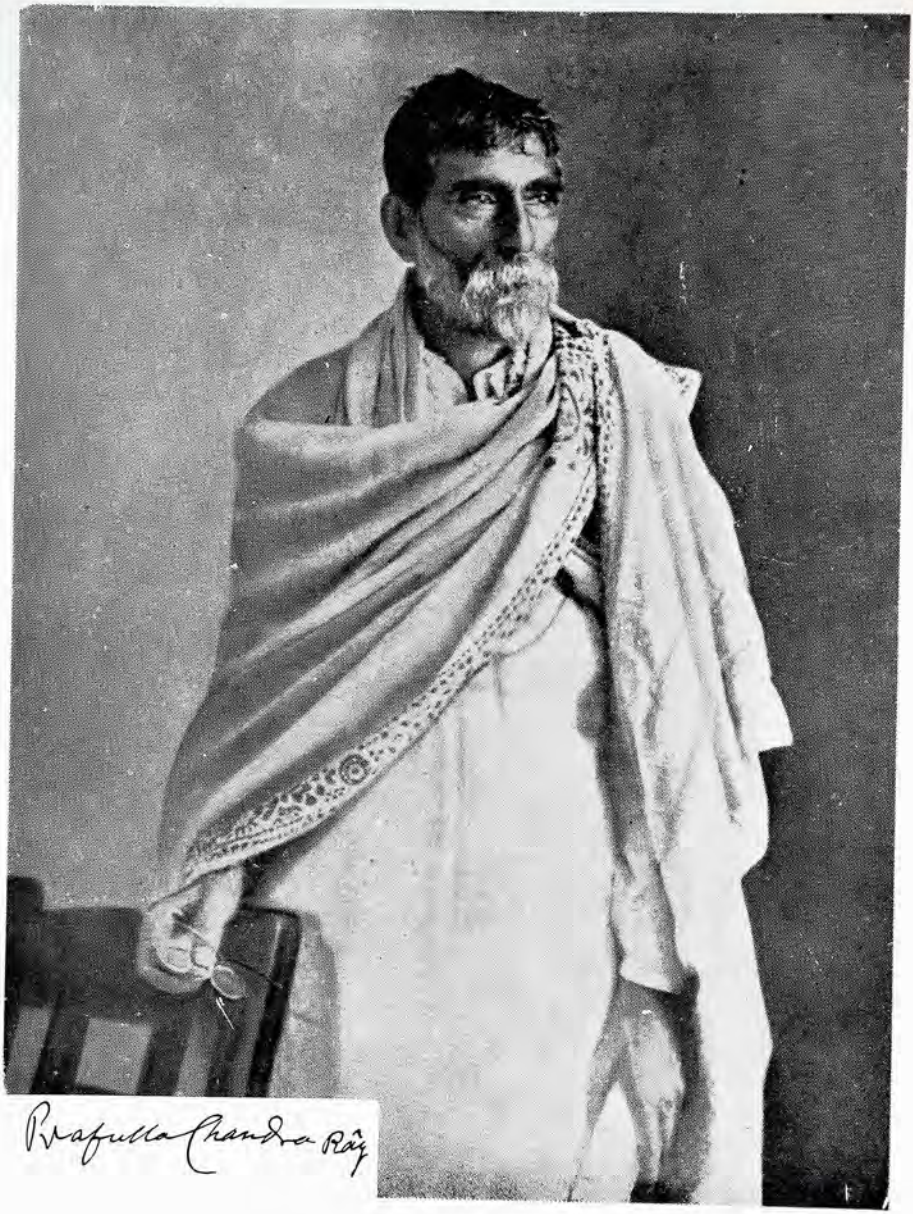

Prafulla Chandra Ray

PRAFULLA CHANDRA RÂY

1861-1944

As PIONEER of chemical education, chemical research and chemical industries in India, and more possibly as a self-denying and dedicated worker for the uplift and emancipation of the country, and last but not least as a man of austere habits and sterling character with dynamic sympathy for the poor and down-trodden, ever alert to the call of humanity, Prafulla Chandra Rây occupied a unique position in India in his days. As a tribute to the memory of his service to the country, his birth centenary was celebrated in August, 1961, by the University of Calcutta, by the Indian Chemical Society, and by many other educational, scientific, industrial, and public organizations in the State of West Bengal, which was the main field of his activity in life. His ideal character, wide range of intellectual interest, and his service and sacrifice for the cause of science and the society earned for him the honorific epithet of Acharya from his countrymen, which in Sanskrit signifies a venerable preceptor of great erudition. In fact, he is better known in India as Acharya Prafulla Chandra Rây.

Early Life and Education

Born on August 2, 1861, in a wealthy cultured family of landed proprietors in a village in the district of Jessore (subsequently of Khulna and now in Pakistan), Bengal, Prafulla Chandra was the third son of Harish Chandra Ray who had five sons and two daughters. Harish Chandra was a man of taste, learning, and liberal views. He was also a lover of music and himself an expert violin player; he had some reputation for his proficiency in Persian and English with a workable knowledge of Sanskrit and Arabic. He came into close contact with the eminent intellectual and cultural leaders of his time, like Iswar Chandra Vidyasagar, Kristo Das Pal, Jatindra Mohan Tagore, Digambar Mitra and others. The signs were then just visible for the emergence of modern Bengal. The habit of free and rational thinking, which constituted a dominating feature in Prafulla Chandra's life, might thus be traced to the influence of his father during his childhood. His mother, Bhubanmohini Devi, also was an accomplished lady of enlightened views, and Prafulla Chandra was deeply attached to her.

Prafulla Chandra first joined the village school for his early education, but could make only little progress as he frequently used to leave, or absent

himself from, the school. In 1870 the family, however, shifted to Calcutta when Prafulla Chandra was admitted to the Hare School, but he had to leave the school after a short time owing to a severe attack of dysentery. This led to an interruption in his regular study for about two years, during which he dived deep into the classics of English literature, and the literary and historical publications in Bengali. He also succeeded in acquainting himself with Latin and Greek, besides acquiring a fair knowledge of the histories of England, Rome, and Spain. His disease, though cured, left a permanent injury to his health in the form of chronic dyspepsia and sleeplessness for the rest of his life. In 1874 Prafulla Chandra resumed his normal academic career and entered the Albert School of Keshab Chandra Sen, the founder of the New Dispensation Order of the Brahmo Samaj. The inspiring ideal and moving eloquence of Keshab Chandra exercised a powerful influence on the student community of Bengal in those days, and Prafulla Chandra readily came under its sway. The teachers of the Albert School were all recruited from among the devoted followers of Keshab Chandra. The liberal views of the Brahmo Samaj and the message of Keshab Chandra did not fail to make a deep and abiding impression on young Prafulla Chandra's mind and to instil the spirit of service and sacrifice which dominated his after-life. After passing the Entrance Examination (equivalent to present School Final) from this school in 1878 Prafulla Chandra joined the Metropolitan Institution (now named Vidyasagar College), established by Pandit Iswar Chandra Vidyasagar. Here he came under the influence of Surendra Nath Banerjee, the father of Indian nationalism, who, as Professor of English literature, used to teach Morley's *Burke* and Burke's *Reflections on the French Revolution*. Surendra Nath was then held in high regard by the students of Bengal as their political idol, and his passionate and patriotic appeal captivated Prafulla Chandra's mind. Service of his fellow men and work for the regeneration of his mother country, which afterwards became the mission of his life, were thus presented to him as objects of high endeavour, and he was not slow to imbibe these noble ideals.

While a student in the Metropolitan Institution Prafulla Chandra used to attend lectures on chemistry in the First Arts Course and on both chemistry and physics in the Bachelor of Arts Course at the Presidency College as an external student. Chemistry was then a compulsory subject of study in the F.A. Course. The lectures of Professor Alexander Pedler, who had a great reputation as an inspiring teacher and a very skilful experimentalist, stirred Prafulla Chandra's imagination and aroused his interest and curiosity in chemistry. So, though an ardent student of literature and history, he took up the B-Course in B.A. with a view to studying chemistry in higher stages. Besides, the pursuit of truth by the experimental method of science and the rational process of scientific thinking, as well as his foresight that the future progress of India was

closely bound up with the development of scientific knowledge in the country, made a strong appeal to his mind. Nevertheless, he did not give up his interest in literature and learnt Latin and French by his own unaided efforts. He had also acquired a fair knowledge of Sanskrit, which was a compulsory subject in his First Arts Course. This encouraged him to appear, while still a student in the B.A. class, at the competitive examination for the Gilchrist Prize, for which a knowledge of at least four different languages was essential. Prafulla Chandra came out successful in the competition, being one of the two winners of the prize. With the stipend provided by the prize he sailed for the United Kingdom in 1882 for further studies.

Education at Edinburgh

In the United Kingdom Prafulla Chandra joined the University of Edinburgh as a student in the B.Sc. Class. Here he came under the influence of Professors Tait and Crum Brown. Crum Brown, then the Head of the Department of Chemistry, was one of the most philosophically minded chemists of the time, and it is no wonder that Prafulla Chandra was naturally attached to him. James Walker was his classmate, who succeeded Crum Brown after the latter's retirement. Alexander Smith and Hugh Marshall, who won considerable reputation in later life by their researches in chemistry, were two of his junior contemporaries in Edinburgh.

In 1885, while a student in the B.Sc. class of the Edinburgh University, Prafulla Chandra competed for the award of a prize by the University to the best writer of an article on *India before and after the Mutiny*. Though not considered the best, Prafulla Chandra's article was assessed by the examiners as the nearest approach to the best. The article was full of diatribes against the British Rule in India, replete with sub-acid humour. Nevertheless, it received unstinted praise from one of the examiners, Sir William Muir, the Principal of the University. A reprint of the article was presented to the great Parliamentarian John Bright, whose sympathetic reply to Prafulla Chandra appeared in all the leading papers of the United Kingdom under the head-line *John Bright's Letter to an Indian Student*. This almost created a stir in the political circle of England at that time, and may be said to have contributed in no small measure to the extreme difficulties and inordinate delays he had to experience later on in securing a suitable employment in the Educational Service of his own country under the British Rule. Encouraged by the result of his excursive effort in the literary field, Prafulla Chandra in 1886 published his *Essay on India* in the form of a booklet, giving warnings about the disastrous consequences that might follow from the reactionary policy of the British rulers. It was a very informative publication and did not fail to attract the notice of some competent critics. These furnish evidence of his

proficiency as a student in the field of literature, history, and economics, in spite of his being a professional student of science.

After obtaining the B.Sc. degree in 1885, Prafulla Chandra started research work in chemistry for his doctoral thesis. In 1887 he was admitted to the D.Sc. degree of the University of Edinburgh in recognition of his work on *Conjugated (gepaarte) Sulphates of the Copper-Magnesium Group: A Study of Isomorphous Mixtures and Molecular Combinations.* He was also awarded the Hope Prize Scholarship of the University, which enabled him to continue his work in the University for another year. He was then elected Vice-President of the Chemical Society of the University.

He managed to stay for about six years in Edinburgh to complete his study, depending solely on his meagre and limited resources provided by the Gilchrist and the Hope Prize Scholarships. This was possible because of his extremely simple and economic habits of living.

Before leaving England Prafulla Chandra, now a D.Sc. of the Edinburgh University, visited some persons of influence with letters of introduction from Professor Crum Brown and Sir William Muir, hoping that their recommendations might persuade the Secretary of State for India to consider about his appointment in the Indian Educational Service. But unfortunately these bore little fruit. For, in those days the Indian Educational Service was practically a close preserve for the Europeans, and the Indians, however qualified, had little chance of being absorbed therein.

At the Presidency College, Calcutta

In 1888 Prafulla Chandra returned to India, but not with any bright prospect for his future. Arriving at Calcutta and being anxious to get an appointment in the Bengal Educational Department he called on Alfred Croft, the then Director of Public Instructions, Bengal, and on Alexander Pedler, the then Professor of Chemistry, Presidency College, Calcutta. He also sought an interview with the Lieutenant Governor of Bengal for the purpose. Financial worries too added to his troubles at the time, his family estate being heavily encumbered owing to his father's debts. During this period he was mostly under the hospitable roof of his friends, Dr. and Mrs. Jagadis Chandra Bose. At last he was offered an appointment as temporary Assistant Professor of Chemistry at the Presidency College, Calcutta, on a salary of Rs. 250/- only per month. He took up his duties at the College in July, 1889. In a short time he acquired a great reputation as a successful and popular teacher. His lectures were made interesting and attractive, not only by demonstration with numerous experiments, but also by interspersion with inspiring anecdotes from the lives of the great masters and pioneers of science, which he would narrate almost dramatically with a view to making a bridge between

the minds of his pupils and those of the masters of modern chemistry, like Priestley, Scheele, Lavoisier, Cavendish, Dalton, Berzelius, Liebig, Wöhler and others. The stories of their struggles and ultimate victory were meant to convey to the impressionable young minds the need for devotion and hard work in the pursuit of science. His animated account of the pilgrimage of Wöhler from Germany on foot to the house of the great Swedish savant Berzelius, where Anna, the kitchen maid, served as the laboratory assistant, still rings in my ears in all its freshness. He also took good care to make his lectures flavoured with apt citations from his favourite authors like Shakespeare, Emerson, Michael, and Rabindranath, as well as from the Sanskrit alchemical treatises like *Rasaratna-kara* by the great Indian alchemist Nāgārjuna and *Rasaratnasamuccaya* by Vāgbhata. Furthermore, he would not forget to weave into his lectures even matters relating to social and political regeneration of the country. For, he realized that the education to be useful and effective must form an integral part of our life, and not serve as a mere appendage or garment for display. He had an aversion to prescribing text-books or syllabuses, and would often humorously advise the students to make a bonfire of their so-called text-books, notes, compendiums, digests, etc., with which the market was flooded to provide for easy means for passing in the examination. He was very critical of university degrees, which under the system of training and examination in vogue, could in his opinion seldom furnish a proper standard for assessing the power of initiative and original thinking acquired by the students. In this connection reference may be made to an interesting incident. At one time when H. R. James was the Principal of the Presidency College, the I.Sc. and the B.Sc. results in chemistry of the college for a few successive years suffered somewhat by comparison with those of some private colleges of the city. On Principal James's enquiring of Dr. Rây about its probable cause in view of the recruitment of better class of students to the Presidency College, he replied "because we teach chemistry and not the syllabus of the Calcutta University". He held the view that the practice of regarding the university degrees as a passport for services and a measure of intellectual ability led to an insane craze for degrees among the Indian youths and a mass production of degree-holders by the universities with their consequent unemployment. He used to allege further that the graduates from the universities, owing to the system of training followed, were seldom better than human parrots or licensed ignoramuses. In his view the whole idea of university education in India was wrongly conceived, making the universities serve more as centres of information and organizations for conferring degrees than of learning.

Ever since he took up science course and adopted chemistry as the special subject of his study, he cherished a desire for the application of chemical knowledge for the welfare of the country through the development of chemical industries. After he had served for about six years in the

Presidency College, he thought of giving a concrete shape to his ideas and ultimately decided to set an example himself. He started preparing common pharmaceutical products in his own house at 91, Upper Circular Road from the locally available raw materials. His resources, however, were very limited, savings from his meagre salary supplying the capital for his enterprise. It was practically a desperate uphill fight; but nothing daunted he persevered in his efforts and was soon joined by a few loyal friends as partners and helpmates. This tiny seed of an industrial enterprise, as if by miracle, sprouted and rapidly grew into a flourishing concern under the name of Bengal Chemical and Pharmaceutical Works Ltd. It now holds a prominent position in the field of chemical industries in Bengal.

While serving in the Presidency College he found opportunities to satisfy his natural predilection for the study of history and literature. History of science, and particularly the history of chemistry, had always a fascination for him. The well-stocked library of the Presidency College provided him with ample materials for his antiquarian researches—researches into the history of chemistry including the lives of the great masters and makers of that science. A study of Berthelot's *L'Alchimistes Grecs* (the Greek alchemy) stimulated his interest, and he started correspondence with the great French Chemist, intimating to the latter that in ancient India also the study and practice of alchemy were zealously pursued. The reply from the illustrious French savant in 1897 asking for detailed information about Indian alchemy stirred him to fresh activity. A paper based on the introductory chapters of *Rasendrasāra Saṃgraha* was soon sent to Berthelot by Prafulla Chandra in response to his appeal. An elaborate and highly appreciative article, based on Prafulla Chandra's investigation on the subject, was published by Berthelot in the *Journal des Savants*. This and a study of Berthelot's encyclopaedic work on Syriac, Arabic and Middle-age alchemy awakened in Prafulla Chandra's mind an idea of writing a history of Hindu chemistry on the model of Berthelot's work. As a result of persistent study and toil of several years, coupled with a vigorous search for Sanskrit manuscripts in various libraries of India and in the India Office, London, the first volume of the *History of Hindu Chemistry* was published in 1902, followed by an enlarged and revised edition in 1904. The second volume of the book came out in 1909, and its second edition in 1925 in an enlarged and revised form. This monumental piece of work, the product of a vast amount of labour and extensive study, has rightly been regarded as a valuable contribution to the history of science. The book has demonstrated by reference to the old Sanskrit texts the antiquity of the knowledge of chemistry in India and of several chemical processes unknown to the rest of the contemporary world.

At the time when Prafulla Chandra joined the Presidency College, there were practically no Indian workers engaged in chemical research. Pedler,

who was then the Professor of Chemistry at the Presidency College, had a great reputation as a very able teacher and a skilful investigator. He trained up some of his Indian assistants in the college in the technique of chemical research. Rây was not slow to follow his example and started with great enthusiasm and devotion to carry out research work in chemistry on his own initiative. His early success in the field of research and his already acquired reputation as teacher, and above all his spirit of dedication to the cause of chemistry and to the service of the country, attracted before long a band of earnest students of talents and parts to his laboratory, which became, as the years rolled on, "the nursery from which issued forth the young chemists of New India".

During the period of his service in the Presidency College, Rây visited Europe on two different occasions; once on study tour in 1904, and again in 1912 as a delegate from the University of Calcutta to the Congress of the Universities of the British Empire, held in London. On this latter occasion, the University of Durham conferred on him the honorary degree of Doctor of Science. In the same year (1912) the British Government honoured him with the title of C.I.E. (Companion of the Indian Empire).

On resuming his duties in the Presidency College after his return from England, Rây continued to pursue his research activities with increased zeal in collaboration with a band of devoted and promising workers, and thus succeeded in creating a nucleus for the formation of an Indian School of Chemistry. In 1916, he retired from his position as Professor and Head of the Department of Chemistry at the Presidency College, a year earlier than the due date, to join the new founded University College of Science as Palit Professor of Chemistry. The students of the Presidency College presented him on this occasion an address, couched in words of profound appreciation of his service to the College and the country for the cause of scientific study and research, of his successful efforts in revealing the glorious achievements of the ancient Indians in the pursuit of chemistry, and above all, of the example of his dedicated and celibate life of high endeavour for the regeneration of India.

At the University College of Science, Calcutta

At the University College of Science, Prafulla Chandra found a more congenial atmosphere and better facilities for research, and he directed his attention to a variety of problems with the recruitment of many new earnest and enthusiastic workers. In a short time the newly started University College of Science became an active centre of chemical research in India. In recognition of his distinguished service as a teacher and investigator in chemistry, as well as of his pioneering work in the development of chemical industries, the British Government honoured him with Knighthood in 1919. In 1920 he was elected General President of the

Indian Science Congress. It was mainly through his encouragement, influence, active support and generous financial assistance that the Indian Chemical Society came into existence in 1924, of which he was elected the first President. In course of his reply to the message of congratulation from the President and the Council of the London Chemical Society on the occasion, Prafulla Chandra made the following notable observation:

"More than forty years ago while a student at Edinburgh, I almost dreamt a dream that, God willing, a time would come when modern India will also be in a position to contribute her quota to the world's stock of scientific knowledge, and it has been my good fortune to see my dream materialize." It reveals his inner urge and solicitude for the intellectual regeneration of India—his mother country.

His research activities in the University College of Science were maintained almost unabated for about twenty years till he retired in 1936 at the age of seventy-five. His pupils and admirers, it might be noted here, are accustomed to look upon him as the 'Father of Indian Chemistry'.

On the completion of his sixtieth year in 1921, Prafulla Chandra made a gift of all his salary from that date onward as long as he would be entitled to it by the retention of his service by the University. It was stipulated that the money accumulated thereby should be spent for the extension and development of the Department of Chemistry in the University College of Science and Technology, as also for the creation of two Research Fellowships. The total value of the gift amounted to Rs. 1,80,000/-, when he retired in 1936. A further endowment of Rs. 10,000/- was made in 1922 for an annual research prize in chemistry, named after the great Indian alchemist Nagarjuna. At the time of his retirement in 1936 he made another endowment of Rs. 10,000/- for a research prize in zoology and botany, named after Sir Asutosh Mookerjee.

Literary Interest and Public Activities

It was stated before that even as a student Prafulla Chandra evinced a great interest in the study of history and literature. He had an early training in the classical languages like Latin and Greek, and picked up French and German at the time. He also acquired a good knowledge of Sanskrit while making preparations for writing the *History of Hindu Chemistry*. Reference has already been made to his article on *India before and after the Mutiny* and his *Essay on India,* which were published while he was a student in the University of Edinburgh. These publications, which received due appreciation from competent critics, furnished ample evidence of his knowledge of history and his command over the English language. His great book, the *History of Hindu Chemistry*, which is recognized as a valuable contribution to the history of chemistry and his

autobiography, *Life and Experiences of a Bengali Chemist,* are other instances of his historical and literary achievements. He was very fond of English and Bengali literature, and had a daily routine of devoting an hour or two for reading some books on those subjects, a habit which he religiously adhered to throughout his life. Shakespeare, Madhusudan, and Rabindranath were his favourite poets, from whose writings he could quote from memory at any time on any particular theme. In prose, Emerson and Carlyle had great fascination for him. It is worthy of note that he published a number of articles on Shakespearean "Puzzle" in the Calcutta Review in 1931, when he was at an advanced age of seventy. This is indeed a rare demonstration of how an Indian (Bengali) chemist could respond to the thoughts of the greatest English poet.

Rây was an ardent advocate for the use of the mother tongue as medium of instructions in schools and colleges. He used to recall in this connection the example of the great Russian chemist Mendeleef, who, after formulating his *Periodic Law of Elements,* a generalization of great significance in the development of science, published it for the first time in his mother tongue—the Russian language. In view of the importance of the work, the leading scientists of all other countries at that time had to learn Russian for obtaining a first hand information on the subject. In recognition of his interest and efforts in the advancement and enrichment of Bengali language, he was elected the General President of the Bengal Literary Conference in 1910 and the President of the Bangiya Sahitya Parishad for the period 1931-34. He was never tired of saying that the "book of knowledge can readily be understood in one's own vernacular".

Though essentially a teacher and investigator in chemistry, Prafulla Chandra lived as much an active life outside the test-tube as that in association with the latter. His activities embraced almost all spheres of human interest: intellectual regeneration, industrial development, social reform, national health, economic freedom and political advancement of the country—all made equally strong appeal to him, as did his scientific research and teaching. In times of national calamities Rây was always the first man to respond to the call of humanity by organizing relief work for the people in distress. His public activities were but the outward expression of his humane personality.

In matters of education Rây used to hold very strong views against the inordinate fascination shown by our young men for university degrees. He, therefore, pleaded for a radical change in our university education. In his view "no one should choose a university career unless he feels that he has an instinctive call in that direction; a university should be a centre of scholarship, research and culture." The undue stress on the literary side, neglecting the vocational aspect, was considered by him as a great defect in our university education.

The poor health of the Bengali students and the problem of their unemployment, which he termed as their 'bread problem', were matters of great concern to him. He would, therefore, never cease to advise them to take to business and industries. He himself set examples for them, as already stated, by organizing the Bengal Chemical and Pharmaceutical Works Ltd., besides participating in the management of a large number of industrial and business concerns in the country, like cotton mills, soap works, pottery and porcelain, etc.

He made social service a mission of his life and was a pioneer of social reform in the country. Caste system among the Hindus was a special target of his attack. As early as 1917 he presided over the Indian National Social Conference in Calcutta, when he made an impassioned appeal for the removal of untouchability from the Hindu Society.

In times of national emergency he did not hesitate to participate in politics, though in a passive manner, with his moral support to the front rankers. He, however, subscribed whole-heartedly to the policy of constructive work, formulated by the Indian National Congress during the Non-Cooperation Movement and became an ardent admirer and follower of Mahatma Gandhi. He, a scientist and an advocate of large-scale industries, thus lost no time in becoming a great exponent and organizer of spinning and weaving by the primitive methods (spinning wheel). In this connection his well-known retort on a memorable occasion, "Science can afford to wait, but Swaraj cannot", is worthy of note.

Researches

The task of making a correct assessment of Sir Prafulla Chandra Rây's contribution as a scientist can be considerably lightened by quoting the following words, which his great friend Professor H. E. Armstrong wrote in the commemoration volume published on the occasion of his seventieth birthday in 1932.

"In type Sir Prafulla Rây is perhaps more like a Frenchman than an Englishman in his receptive habit of mind: the nearest comparison I can make is to contrast him with Berthelot, not only a many-sided chemist but also an agronomist, man of letters and politician. Let me say frankly, Rây is not great as a chemical specialist nor was Berthelot: he has been occupied in too many directions too much kept aloof from the field of chemical discovery and its masters, to have lost himself in the contemplation of the maze of chemical experience to the extent necessary to be entirely overcome by the magic and immensity of its problems. Nonetheless, he is the founder of the Indian Chemical School."

The first notable work of Rây, which brought him recognition, was the isolation of mercurous nitrite in 1896. This was obtained in the form of thin yellow crystals by the action of dilute nitric acid containing 13-14% of N_2O_3 on metallic mercury in the cold. The action of potassium

cyanide on mercuric nitrite led to the preparation of mercuric hyponitrite. Further investigation on the nitrites was concerned with the preparation of the nitrites of alkaline earths in a pure state, and it was observed that the magnesium nitrite was the least stable, thus forming a link between the nitrites of zinc and cadmium and those of the alkaline earths. Some double nitrites of mercury (II) with barium, calcium, and lithium were prepared, which revealed that their stability decreased with the increasing atomic weight of the other metal. Researches on the nitrites continued with the preparation of the compounds of mercury (II) nitrite with alkyl and arylamines. These were found to have the composition: $Hg(NO_2)_2.RNH_2$. Similar composition was also found for the compound with ethylenediamine: $Hg(NO_2)_2$, $C_2H_4(NH_2)_2$. During 1911-13 Rây described the preparations of a number of interesting compounds, such as methylammonium and other alkylammonium nitrites in the pure crystalline state from silver nitrite and alkylamine hydrochloride. Tetramethyl ammonium hyponitrite was also prepared in the same manner. In 1912 Rây and Dhar (N.R.) made a very interesting observation that ammonitrite could be vaporized without any dissociation at 80°C. A solution of nitrous acid was prepared by double decomposition from silver nitrite and dilute hydrochloric acid in the cold. This was concentrated by freezing out the water. Rây and Ghosh (J.C.) determined the velocity of decomposition and the dissociation constant of the acid. The decomposition of nitrous acid was found to follow the equation for a unimolecular reaction. The pure aqueous acid was also found to react very slowly with urea. Rây and his pupils determined the molecular volumes of the alkali and alkaline-earth hyponitrites, and measured the equivalent conductivities of sodium hyponitrite, calcium hyponitrite, and hyponitrous acid.

After joining the University College of Science in 1916, Rây turned his attention to study the compounds of metallic elements with organic sulphur derivatives, particularly the mercaptans and sulphides. The mercury mercaptide nitrites, $RSHgNO_2$ and $RSH.Hg(NO_2)_2$, were prepared and their reaction with alkyl iodides studied. By the action of mercury (II) nitrite on 2,5-dithio-1,3,4-thiodiazole, condensation products of the composition $(C_2N_2S_3)_x.Hg_2O$ (where $x = 2,3,4$ or 6) were obtained, which on interaction with alkyl iodide gave long chain sulphur compounds containing mercury.

The study of these complex mercaptans led him to examine the formation and behaviour of some simple sulphides and mercaptans. It was observed that an attempt to prepare ethylene mercaptan from the interaction of ethylene dibromide and potassium sulphydrate gave a complex mixture of compounds, from which the following could be isolated: $HS(C_2H_4S)_2C_2H_4SH$, $(C_2H_4)_3S_4$, and $(C_2H_4S)_3$. Similarly, the interaction of dithioglycol and benzylidene chloride led to the formation of benzylidenediethylene tetrasulphide and benzylidenediethylene tri-

sulphide with diethylene di- and tetra-sulphides as byproducts. A very interesting series of long chain sulphur compounds of the type $BrC_2H_4(SC_2H_4)_nBr$ was obtained by the interaction of ethylene dibromide and dithioglycol. Ethyl thioacetoacetate and ethyl thioacetone dicarboxylate were prepared from the corresponding oxygenated compounds by the action of H_2S and HCl. The alkyl derivatives of these compounds gave mercaptans on acid hydrolysis, while alkaline hydrolysis led to the formation of mercapto-crotonic acids.

A number of double sulphates of triethyl and trimethyl sulphonium bases with metals of the copper-magnesium group, having the general composition $2M''SO_4.(R_3S)_2SO_4.10H_2O$ (where $M'' = Fe$, Zn, Ni, Co and Cd; $R = CH_3$ or C_2H_5), were prepared and studied. Similar double salts with phosphonium bases were also described.

The preparation and the study of chemical and physical properties of a number of compounds of zinc, cadmium and mercuric iodides, as well as of antimony halides, with alkyl sulphonium iodides were reported by Rây and co-workers in several publications.

Several compounds of some alkyl sulphides with antimony chloride and of alkyl sulphides and disulphides with silver nitrate were prepared and studied in detail.

Hydrated ferric chloride was also found to react with ethyl sulphide, giving the compound $HFeCl_4.(C_2H_5)_2S.H_2O$. Its reaction with organic bases like pyridine, quinoline and *o*-toluidine formed the subject of further investigation.

A series of publications was made from his laboratory on the varying valency of platinum, gold and iridium. The reaction between platinic chloride, or chlorplatinic acid, and organic thiocompounds, mercaptans and sulphides, gave rise to products in which the valency of platinum appeared to vary. The constitution of these compounds was studied by their action on organic bases and by the determination of their ionizability. Six isomeric modifications of $PtCl_2.2(C_2H_5)_2S$ were isolated. Two of these were found to be related as *cis-trans* isomers, the third was represented as $[Pt(Et_2S)_4]PtCl_4$. Gold chloride was also found to give similar compounds with organic sulphides and mercaptanic radicals, in which the valency of gold seemed to vary. Compounds of the composition $2AuCl_2.Et_2S_2$ (crystalline), $2AuCl(C_2H_4S_2)_2$, and $Au_2(C_2H_4S_2)_5$ were described. Complex compounds of iridium with organic sulphides also received his attention. Iridium tetrachloride gave with methyl sulphide, ethyl sulphide, and diethyl sulphide a number of compounds in which iridium appeared to exhibit valencies of 2, 3 and 5. The compound $IrCl_3.3Et_2S$ was obtained in two forms, related possibly as *cis-trans* isomers. Action of ammonia and organic bases on all these complexes of iridium chloride with organic sulphides gave rise to ammonia or amine complexes of iridium chloride, containing in some cases also the organic sulphide.

Most of these complexes can, however, be represented equally well without any such assumption of abnormal valencies of the central metal atoms.

One must not, however, lose sight of the important fact that Rây's real contribution to the development of chemical research in India rests not so much on his own personal research publications as on his inspiring and initiating a generation of young workers, who, dedicating themselves to a scientific career succeeded in building up what is now known as the Indian School of Chemistry.

Views, Values and Ideals

Rây was a bachelor and lived a life of austere self-denial. The simplicity of his living quarters in a single room at the University College of Science, Calcutta, whose only furniture was an iron bedstead, a small table, a smaller chair, and a more or less dilapidated almirah with shelves laden mostly with English classics, could not but strike a casual visitor with awe and reverence, due to a saintly person. A dyspeptic with feeble health, he reduced his diet almost to the minimum necessary for the preservation of life. The same simplicity and naturalness also characterized his dress and manners.

A distinguished Indian scholar and a great admirer of Professor Rây depicted a vivid pen-picture of his personality on the occasion of his seventieth birth-day by demonstrating a close parallelism between him and one of his most favourite writers, Thomas Carlyle, in an article from which the following excerpt is quoted.

"The same bushy eyebrows, shaggy beard, deep-set penetrating eyes, and general appearance of malaise with the ordering of things in general, the sturdy independence, the unbending backbone, the shrewd common-sense, the utter contempt for wealth, the most devastating indifference to manners and appearances, the absolute unconventionality of conduct and behaviour, the missionary zeal and the prophetic ire and the somewhat rough exterior withal, the deep-seated love that flows ever increasingly into suffering humanity—all these mark our great beloved Bengalee as much as they did the great venerated Scot."

Rây was a teacher all his life, though essentially a student throughout. His only love in life was his books, scientific and classics, and the pupils whom he inspired, some of whom always used to constitute his household and manage his daily affairs of life. His relation with his pupils was ever close and cordial as that between father and sons. He served as their friend, philosopher and guide, and mixed freely with them as his equals. Though he remained absolutely oriental in habits and tastes, yet his completeness and breadth of modern outlook was really striking. In him one might recognize an attempt at blending the best of the West with that of the East. Development of scientific research and industries in the country

on the one hand, and the simplicity of life and selfless service on the other, found in him an equally powerful exponent. The rational attitude of his mind, born of his scientific discipline, prompted him to wage a relentless war against numerous social evils in the country, while maintaining a high regard for the ancient Indian ideals of life, based primarily on service and sacrifice. He made the service for the moral, intellectual and material uplift of his countrymen, the mission of his life.

Rây did not earn much in his life, still he could give out plenty in charity to the poor and needy, particularly to those of the student community. In addition he made substantial donations to several educational institutions in Bengal, besides his princely endowment for the University of Calcutta as stated earlier. Many public concerns and humanitarian organizations also received handsome contributions from him. Evidently it is the fewness of his wants that enabled him to spend so much in charity, in spite of his limited income.

His austerities and abstemious personal habits, regarding dress, diet and mode of living, was but an individual aspect in tune with a pattern of life, in which wastage of any kind or form was regarded no better than depriving others of some necessities of life, however small it might appear at the moment. To him it was almost a crime. He was always alert about the economy of time, material and money. Any wastage of chemicals, filter paper, gas, water, or electricity in the laboratory by any body would work him up into a fury. He was equally intolerant of any misuse of time and himself would strictly adhere to a rigid time-table in his everyday life. To him, the waste of time was equivalent to loss of opportunities for work. Any visitor intruding during the morning hours of his study had to be prepared not only for a cold reception, but in the case of younger people, often for a shower of the choicest epithets of admonition from the rich stock of his English and Bengali vocabulary, if not for slaps and blows in a grandfatherly manner. In his dealings with others he was always frank, light-hearted and guileless as a child, and never lacking in good humour.

A passionate regard for the pursuit of truth and a spirit of dedication to the service of his country and suffering humanity constituted the ideal of his life, which he realized in no small measure by his thoughts, words and deeds. This is beautifully expressed in the words of the late Professor F. G. Donnan of the University College of Science, London, which he wrote in 1932 on the occasion of Rây's seventieth birth-day:

"Sir P. C. Rây, however, has been throughout his life no narrow laboratory specialist . . . His ideals have always been hard work and practical good in service of his country. Though devoted to the cause of pure science, he has never been the unpractical dreamer in the clouds. But he has never asked much for himself, living always a life of Spartan simplicity and frugality—Saint Francis of Indian Science. I hope that future ages will cherish his name as one of the band of self-denying and devoted men who

have revived and handed on the flame that once burnt so brightly in India, the search for truth and the hidden mysteries of things."

Retirement and Death

As stated above Rây retired from his service in the University College of Science in 1936, but continued as Emeritus Professor of Chemistry till his death. After retirement he devoted most of his time to literary pursuit and public activities. Within a few years, the World War II broke out and his health began to decline. By the end of 1942 he could not move out of his quarters and was ultimately confined to bed. The end came in 1944 when he passed away on June 16 in the midst of his pupils, friends and admirers at the University College of Science, Calcutta, the field of his activities for more than last 25 years of his life.

A very apt conclusion to this short memoir can be made in the words which Sir Edward Thorpe wrote about Rây in *Nature* as early as in 1919:

"Her (India's) elevation will not come in Sir Prafulla Chandra Rây's time. A small, spare man, in feeble health, and a confirmed dyspeptic, he will be spent in her service. But the memory of these services will survive."

Sir Edward's prediction about India has, however, narrowly escaped falsification. For, India attained her independence only three years after Prafulla Chandra's death.

P. RAY

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