Science India Forum-UAE

Shastra Pratibha Contest 2022

Biography-Indian Scientist

ACHARYA PRAFULLA CHANDRA RAY

Group	Syllabus
Sub-Junior Group (Grade V, VI & VII)	**Complete Book**
Junior Group (Grade VIII, IX & X)	**Complete Book**
Senior Group (Grade XI & XII)	**Complete Book**

Note: - This study material is only indicative of the range of topics that will be covered in the test. This material covers 40% of the SPC syllabus while 40% syllabus is from school curriculum of the respective grade and the general knowledge will cover the balance 20% syllabus. Therefore, the organizers appeal to all the students to explore further reading materials to prepare well for the test.

Wishing you all the best of luck for SPC -2022 !!

Shastra Pratibha Contest 2022

(NATIONAL TALENT SEARCH CONTEST)

Shastra Pratibha Contest (SPC) is a science talent search contest for students studying in UAE organized by Science India Forum, UAE guided by VIBHA (Vijnana Bharti) in collaboration with NCERT – Ministry of Human Resources and Development and Vigyan Prasar, an autonomous organization under the Department of Science and Technology, Government of India.

SPC is a national contest for popularizing Science among school students of grades V to XII studying at CBSE, ICSE & Indian curriculum.

SPC aims to identify and nurture the bright minds among the student community who are willing to pursue science related subjects at higher studies.

Objective of Shastra Pratibha contest (SPC): -

- To acquaint school children about India's contributions to the world of Science and Technology in traditional & modern format.
- To conduct an annual talent search exam at the national level to identify students who have a scientific fervour of mind.
- To enhance science learning experience by imparting hands-on training through workshops and seminars.
- To organize excursion visit for the winners to the various R & D institutions in the country.
- To identify successful students at the national levels and felicitate them with prizes and certificates.
- To mentor students in their progress of higher education in science.

Acknowledgements

SCIENCE INDIA FORUM-UAE gratefully acknowledges the contribution of the individuals and organizations involved in the development of this book -Legendary Indian Scientists.

This in fact solely is the initiative of Vijnana Bharati to introduce literature prepared with material from ancient to modern period specially highlighting the contribution of India in the field of Science & Technology as a reading material for SHASTRA PRATIBHA CONTEST.

SIF UAE is grateful to CBSE- Ex Advisors- Shri Vineet Joshi (Ex-Chairman), Dr. Sadhana Parashar, Ex Director (Academics & Training), Convener Prof. Jagbir Singh, all the members of Material Production Team of K.T.P.I., supporting members (CBSE) and editors Prof. Kapil Kapoor and Prof. Michel Damino.

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THE LEGENDARY ACHARYA PRAFULLA CHANDRA RAY

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THE LEGENDARY ACHARYA PRAFULLA CHANDRA RAY

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From the desk of Editors

It is indeed a great coincidence that this book on Legendary Indian Scientist and revolutionary Acharya Prafulla Chandra Ray is getting released on his 160th birth anniversary!

The life and work of Acharya P. C. Ray has an immense potential to inspire generations of Indian students and people in general to walk on the path of making Atmanirbhar Bharat – the Self-reliant India of 21st century!

While India celebrates 75 years of independence, Vijnana Bharati – the swadeshi science movement of Bharat has launched a yearlong program to celebrate 'Swatantrata ka Amrit Mahotsav' with the theme 'Indian Independence Movement and Science'! VVM – Vidyarthi Vigyan Manthan is a flagship program of Vijnana Bharati which is a unique science talent search activity. This book titled 'Legendary Acharya Prafulla Chandra Ray' is produced as study material for VVM students. Professor of Chemistry Dr. Rajeev Singh, New Delhi, has authored this book with a lot of research and critical selection of content keeping in mind the age-group of readers. We congratulate Dr. Rajeev Singh for successfully narrating the inspiring life and contribution of Acharya P. C. Ray! It was an enriching experience to be associated as the editors of the book.

Acharya P. C. Ray was the first Indian scientist who was deeply involved in studying, analysing, reviewing and connecting the past, the present and the future of SCIENCE IN INDIA! He fathomed the treasure of scientific knowledge created in ancient India, realised how the British were using modern science as a tool to govern and loot the resources and wealth in India and focussed on the future of scientific and industrial development Independent India. His pioneering research in chemistry, revolt against discriminatory attitude of British towards Indian scientists, efforts to impart science education for Indian students and setting up Indian industries in British India were path-breaking actions! He was the torch bearer who paved the path for scientists with nationalist spirit to mobilise the independence movement in their own ways and to voice against the injustice and discrimination to Indian scientists by British.

Vijnana Bharati will continue to strive to bring the lesser known but important facts in the field of science and technology to the forefront; so that every Indian feels proud of the Indian scientific heritage. As the members of the core team of VVM, we wish that this book does not remain mere study material for the students, but gets a larger readership across India.

We are happy to mention that this book is being translated and published simultaneously by Vijnana Bharati in eleven official languages of the country, in addition to English, ensuring a greater outreach to the nooks and corners of India.

Jai Hind! Jay Bharat!

Sangeeta A. Abhyankar

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Contents

1. Introduction

There are occasions that demanded that I should leave the test tube to attend to the call of the country…". - **P. C. Ray (Rowlatt Act, 1919)**

The book will tell you the story of a Scientist who was a Revolutionary, an *Acharya* who was an Industrialist, a Philanthropist who loved his people. These words are too less to define the life of **Acharya Prafull Chandra Ray**, a towering genius of Chemistry. The British feared his revolutionary thoughts but the world respected his scientific discoveries. His modern Chemistry discoveries gave him the title of "*Master of Nitrites*" and his path breaking book, "*The History of Hindu Chemistry*", attracted the whole world towards the scientific works and experiments of ancient Indian Sage-Scientists. He was a patriot who finds mention in government records as "*Revolutionary under the garb of a Scientist*".

We had the privilege and pleasure of listening to-night to that eminent Indian chemist whose name is already familiar to us for his most interesting researches on nitrites, and who unaided has kept the torch burning for years in that ancient land of civilization and learning." - ***Nobel Laureate Sir William Ramsay***

Acharya Prafulla Chandra Ray, a character defined by respect, indomitable courage and patriotism is known as the *Father of Modern Chemistry* in India, who reached a high level of perfection in his times. His commitment to scientific integrity by using the best available local resources is of utmost significance. Ray can easily be regarded as the first Indian who started the integration process of ancient Indian Chemistry with modern sciences, a researcher who led Indians towards modern Chemistry, founder of Indian Chemical Society and a Startup entrepreneur.

Acharya Prafulla Chandra Ray, a nationalist, worked hard to retrieve and strengthen the ancient scientific knowledge of India and amalgamated it with the then emerging modern sciences. Ray writes in his biography (preface): "*While a student at Edinburgh I found to my great regret that every civilized country including Japan was adding to the world's stock of knowledge but unhappy India was lagging behind. I dreamt a dream that, God willing, a time would come when she too would contribute her quota."*

Acharya Ray was unique in his style of working as he dealt with three different fields at the same time which included research in pure chemistry, establishment of industries and interpretation of the ancient scientific manuscripts of chemistry.

2. Early Life

Prafulla Chandra was born on August 02, 1861, in the village of *Raruli-Katipara*, Jessore district, now in present day Bangladesh. His father Harish Chandra Ray was a zamindar who appreciated education, supported learning, had liberal views, and had set up an extensive library at home. He was a regular subscriber to *Tatwabodhini Patrika, Vividhartha Sangraha, Hindu Patrika, Amrita Bazar Patrika* and *Soma Pariksha*. His library was stocked with books like Krishna Mohan Banerjee's *Encyclopedia Bengalensis*, Young's *Night Thoughts*, Lawson's *Paswavali* (Tale of Animals), Bacon's *Novum Organum*, Carey's *Holy Bible*, Mrityunjaya Vidyalankar's *Probodh-chandrika* and *Rajabali*. He strongly believed and supported women education and established the first girls' school in *Raruli and a Middle*

English School. Many times, his father was called 'Mlechha' (foreign heretic) by the fellow villagers. His mother, Bhubanmohini Devi was very well educated with supporting views. This academic atmosphere at home made a lasting impact on Ray and he was captivated towards literature and history. They were six siblings, four brothers; Jnanendra Chandra, Purnachandra, Buddhadev and two sisters Indumati and Belamati. Prafulla Chandra was the third child of his parents and was nicknamed *Fulu*.

3. Education

Prafulla Chandra had his early education in the school founded by his father. In 1870, Ray's family shifted to Calcutta and Prafulla was admitted to Hare School. When he was in IV class (1874), he got a bad attack of dysentery, which took a long period of treatment and forced him to discontinue his studies for some years. This long period impaired his digestive organs and made him a permanent valetudinarian. In 1876, he resumed his regular studies at Albert School, Calcutta, established by Keshab Chandra Sen, the founder of Brahmo Samaj.

After clearing the entrance examination in 1879, Prafulla Chandra took admission at Metropolitan Institution (now Vidyasagar College) founded by Pandit Iswarchandra Vidyasagar. Ray mentions in his autobiography "…This was the first bold experiment in India of making higher education as cheap as secondary education….. In the first place the Metropolitan Institution was a national institution and something we could look upon as our own". Metropolitan College had great teachers like Surendranath Banerjee and Prasannakumar Lahiri, who strongly influenced the nationalist feelings of Prafulla Chandra and inspired him to work for the development and upliftment of the society.

As an external student, his Physics and Chemistry classes were held at Presidency College, Calcutta. Chemistry soon became his dearest subject which was being taught by Prof. Alexender Pedler, whose teaching of the subject influenced Ray to take up the study of Chemistry. Being inquisitive in nature since childhood, he was not merely satisfied by watching classroom experiments. Prafulla Chandra along with one of his close friends, set-up a mini laboratory at home and reconducted the experiments taught to them in the college. Halfway through his BA studies, he won the Gilchrist scholarship of Edinburgh University (1882). Only two students were selected from India, Prafulla Chandra Ray and a Parsee student Bahadurji. Ray completed his B. Sc. in 1885 and at the age of 26, was awarded a D. Sc. in Inorganic Chemistry (1887) for his thesis, '*Conjugated Sulphates of Copper Magnesium Group: A study of Isomorphous Mixtures and Molecular Combination*.' His thesis was judged the best thesis and got 'Hope Prize' which allowed him to carry on research for one more year. He was elected the Vice-President of the Edinburgh University

Chemical Society in 1887, as his colleagues and teachers held him in high esteem because of his disciplined life, work ethics and simplicity.

Before returning to India, Ray was given testimonials and recommendations which mentioned highly of his attainments in the field of Chemistry. Professor Cum Brown, Sir William Muir and Prof. C. H. Tawney (Principal, Presidency College) wrote impressive letters of introduction, mentioning him to be an invaluable asset to any institution. He returned to India in 1888, and applied for a job at Indian Educational Services (IES) and despite his impressive letters of recommendations and introductions, he had to remain jobless for a year. At that time, letters of recommendations were mandatory to get a job under the education system implemented by British. There were two classes in the education services: Imperial and Provincial. The Imperial service was mostly reserved for Europeans and had more pay and privileges. Such was the extent of racial discrimination of British, that P. C. Ray was appointed as a temporary Assistant Professor in Chemistry under the Provincial Services, with an absurdly low salary of Rs. 250 per month, for a person with such high qualifications. He went to Darjeeling to talk to British Officer Sir Alfred Croft, the Director of Public Instruction to discuss the injustice being meted out to him. As Ray mentions in his autobiography, "***Croft almost got into a temper and exclaimed: There are other walks of life open to you. Nobody compels you to take this appointment.***" Ray protested against this humiliation but accepted the job due to his passion for research and teaching in July 1889. In 1916, the then Vice-Chancellor of Calcutta University, Ashutosh Mukherjee invited P. C. Ray and C. V. Raman as Palit* Professor of Chemistry and Physics respectively, to join the newly opened University College of Sciences, Rajabazar, Calcutta. Here, he was able to carry out his research work along with his students in a much better manner. P. C. Ray is credited for shaping the Science College into a centre of excellence. It was during this time that his students started calling him by the title of 'Acharya'.

** The Palit Chair of Chemistry is a Chemistry professorship in the University of Calcutta, India. The post was named after Sir Taraknath Palit who donated Rs. 1.5 million to the university in 1912.*

4. Contribution to chemical research

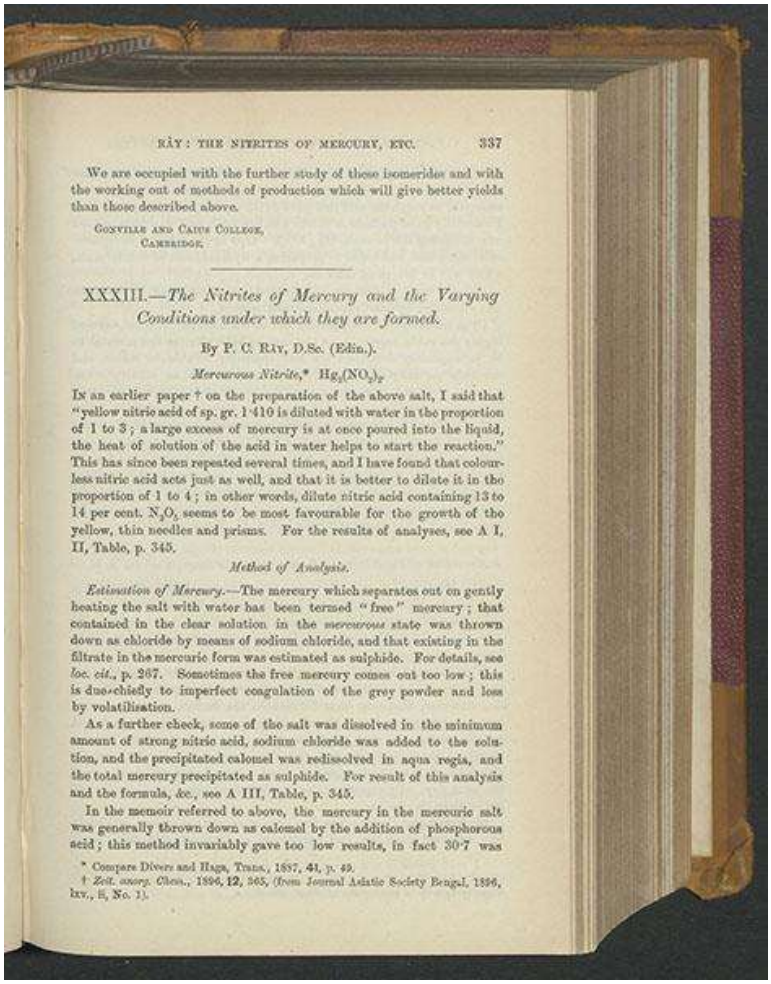
P. C. Ray mentions in the second sentence of his autobiography that he was born (1861) in a very historical year for the field of Chemistry, the year when Crookes discovered the element Thallium. From 1894, in the course of the next 40 years, he produced wonderful research results. A highly enthusiastic researcher himself, Ray's mission was to kindle the flame of eagerness, inquisitiveness and hunger for research among his students. Many of his research productions have been carried out along with his research students.

Praful Chandra Ray began his research in India in the field of detection of adulteration of edible fats and food items. He was very worried about the regular deterioration in quality of food items available in Bengal. He conducted chemical examinations of adulterants in fats, oils and ghees available in the market and published his findings in the Journal of Asiatic Society of Bengal in 1894. His aim was to create standards for food items and put the identified adulterants being used in Bengal in public domain.

P. C. Ray began analysis of certain rare Indian minerals in his quest to discover some new elements to fill the gaps in Mendeleev's Periodic table. He travelled far and wide all through India collecting samples of compounds and mineral ores. By 1894, he had built up an extensive library of samples with the aid of his friend Thomas Holland of Geological Survey of India. He soon reported the first ever synthesis of the *previously unknown compound of Mercurous Nitrite* $Hg_2(NO_2)_2$. He narrates in his autobiography, "the discovery of mercurous nitrite opened a new chapter in my life". This compound of mercury was a fascinating example of two relatively unstable ions combining to form a stable substance. He received congratulatory messages from eminent chemists like Victor Meyer, Volhard, Berthelot and his teachers. On his discovery, Alexander Pedler, his former teacher said, "Dr. P. C. Ray, by

his discovery of the method of preparation of this compound, has filled up a blank in our knowledge of the mercury series".

P. C. Ray's Laboratory, University College of Science and Technology, Calcutta, Telegraph file picture



RAY: THE NITRITES OF MERCURY, ETC. 337

We are occupied with the further study of these isomerides and with the working out of methods of production which will give better yields than those described above.

GONVILLE AND CAIUS COLLEGE,
CAMBRIDGE.

XXXIII.—*The Nitrites of Mercury and the Varying Conditions under which they are formed.*

By P. C. RAY, D.Sc. (Edin.).

*Mercurous Nitrite,** $Hg_2(NO_2)_2$.

IN an earlier paper † on the preparation of the above salt, I said that "yellow nitric acid of sp. gr. 1·410 is diluted with water in the proportion of 1 to 3; a large excess of mercury is at once poured into the liquid, the heat of solution of the acid in water helps to start the reaction." This has since been repeated several times, and I have found that colourless nitric acid acts just as well, and that it is better to dilute it in the proportion of 1 to 4; in other words, dilute nitric acid containing 13 to 14 per cent. N_2O_5 seems to be most favourable for the growth of the yellow, thin needles and prisms. For the results of analyses, see A I, II, Table, p. 345.

Method of Analysis.

Estimation of Mercury.—The mercury which separates out on gently heating the salt with water has been termed "free" mercury; that contained in the clear solution in the *mercurous* state was thrown down as chloride by means of sodium chloride, and that existing in the filtrate in the mercuric form was estimated as sulphide. For details, see *loc. cit.*, p. 267. Sometimes the free mercury comes out too low; this is due chiefly to imperfect coagulation of the grey powder and loss by volatilisation.

As a further check, some of the salt was dissolved in the minimum amount of strong nitric acid, sodium chloride was added to the solution, and the precipitated calomel was redissolved in aqua regia, and the total mercury precipitated as sulphide. For result of this analysis and the formula, &c., see A III, Table, p. 345.

In the memoir referred to above, the mercury in the mercuric salt was generally thrown down as calomel by the addition of phosphorous acid; this method invariably gave too low results, in fact 30·7 was

* Compare Divers and Haga, Trans., 1897, **41**, p. 49.

† Zeit. anorg. Chem., 1896, **12**, 365, (from Journal Asiatic Society Bengal, 1896, lxv., II, No. 1).

First page of Prafulla Chandra Ray's paper on nitrites of mercury, in which he announced his discovery of mercurous nitrite, Journal of the Chemical Society of London, 1897 (Linda Hall Library)

Prafulla Chandra was a synthetic inorganic chemist with active interest in organic molecules and reactions; especially into the chemistry of thio-organic compounds. His initial work which made him famous was based on the chemistry of inorganic and organic nitrites. He was regarded as '*Master of Nitrites*'. British Chemist, Henry H. Armstrong stated: 'The way in which you have gradually made yourself 'master of nitrites', is very interesting and the fact that you have established that as a class they are far from being the unstable bodies, chemists had supposed, is an important addition to our knowledge.' He continued his work on related compounds and thereon shifted to organic thio-compounds and their metal complexes. The metal which particularly fascinated him was mercury, maybe because it has an extensively important role in Indian medicine system of Ayurveda.

The formation of mercurous nitrite, $Hg_2(NO_2)_2$ was an accidental discovery, while he was trying to react excess mercury with cold dilute nitric acid to synthesize mercurous and mercuric nitrates, $Hg_2(NO_3)_2$ and $Hg(NO_3)_2$. During the course of reaction, he noticed the appearance of a yellow crystalline solid on the sides which on analysis revealed to be the unknown mercurous nitrite. The nitrite ion probably was the result of initial reduction of nitric acid by mercury. The pertinent point to be noted here is that stable mercury(I) complexes are very few in existence, even today, owing to the instability of mercury(I) towards disproportionation to mercury(II) and metallic mercury in solution.

$$Hg\ (excess) + dil.\ HNO_3 \longrightarrow Hg_2(NO_2)_2$$

This discovery was first published in the *Journal of Asiatic Society of Bengal* (1896), and immediately noticed by *Nature* magazine, which mentioned the work in its issue of May28, 1896, "A paper by Dr. P. C. Ray….. on mercurous nitrite, that is worthy of note…". Eminent chemists of the time like Volhard, Victor Meyer, Berthelot sent him congratulatory letters on the discovery.

Subsequent series of work by Ray and his students, led to establishing the foundation of the first research school of modern Chemistry in India. He published numerous significant research papers on nitrites and its related derivatives. Now with advances in analysis techniques, the compound has now been structurally analyzed using X-ray crystallography techniques (1985, 1986, 2011).

As can be seen from the figure, the molecule is planar and centrosymmetric. The Hg atom is unsymmetrically bonded to nitrite ion through the two oxygen atoms, thereby forming a four membered chelate ring. The Hg-Hg bond length is 2.54 Å and the shorter and longer Hg-O distances are 2.20 Å and 2.61 Å respectively .

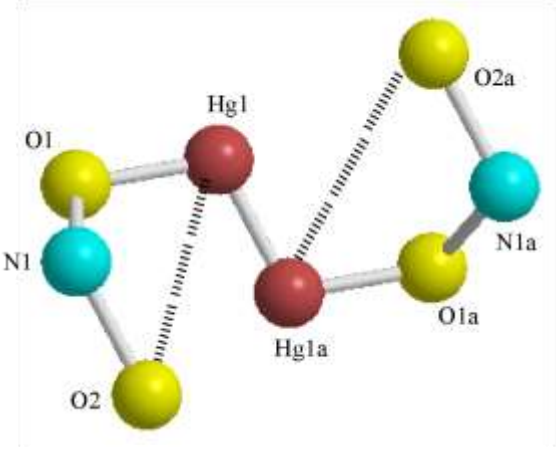


Figure: Molecular view of $Hg_2(NO_2)_2$

Another of his major contributions was the synthesis of *ammonium nitrite* in pure form via double displacement between ammonium chloride and silver nitrite.

$$NH_4Cl + AgNO_2 \longrightarrow NH_4NO_2 + AgCl$$

He also reported that on careful heating to 70 ^oC in moderate vacuum, a part of the ammonium nitrite goes through the process of *sublimation* via vaporization.

$$\underset{\text{(solid)}}{NH_4NO_2} \xrightarrow{\Delta} NH_4NO_2\ \text{(vapour)}$$

He further worked upon it to determine the vapour density of ammonium nitrite and observed that his experimental density value agreed very well with the calculated figure, thereby showing that the salt existed in ion-pair form. In those times, only ammonium chloride salt was known to exhibit this property.

In 1912, he presented this work at Chemical Society, United Kingdom before a distinguished audience including Noble Laureate William Ramsay. In its issue, the Nature magazine mentioned the work as, "…*a further accomplishment in determining the vapour density of this very fugitive compound."*

His major work contributions has been in the field of coordination chemistry, specially metal nitrites, ammonium nitrites and their derivatives, organic thio- compounds and their complexes. Almost seventy percent of his research publications from Presidency College in major journals belonged to the field of nitrite chemistry. P. C. Ray had published 158 research papers. 60% of his papers were published in famous journals like Nature (8 papers) and the Journal of the Chemical Society (65 papers). He was also greatly appreciative of research being carried out in Germany and published many papers in German language, many of them in Zeitschrift fuer anorganische Chemie. He was equally dedicated towards his contribution in Indian journals (nearly 50 papers) like Journal of the Asiatic Society of Bengal (12 papers) and Journal of the Indian Chemical Society.

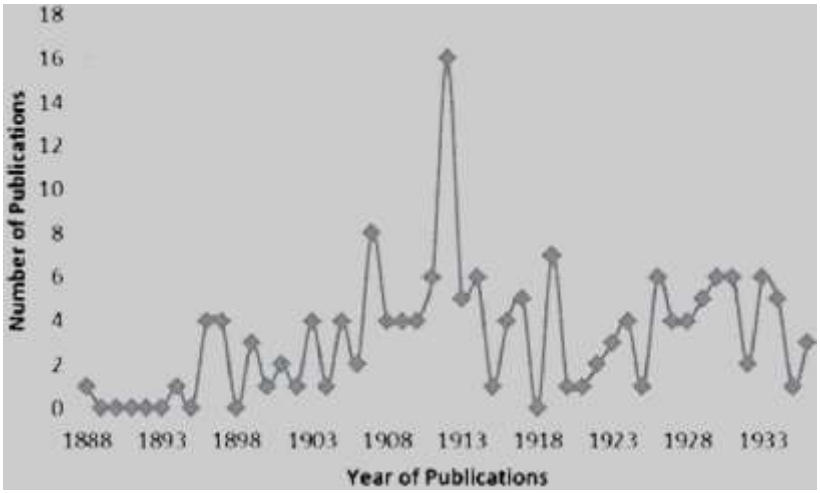


Figure: The number of papers by P. C. Ray published in different years.

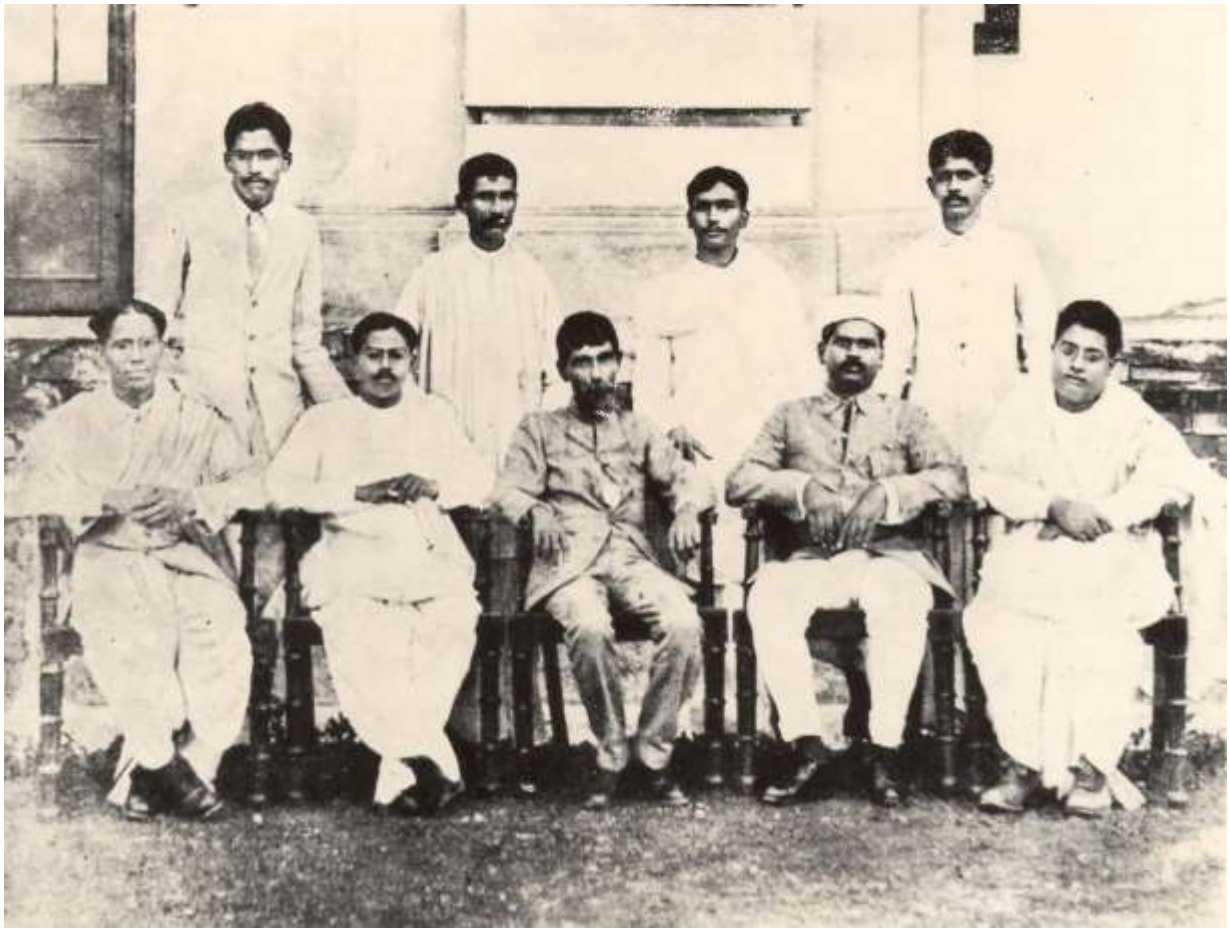
5. Passionate and Innovative Teacher

As a teacher, Acharya Ray was an ideal person who was loved by his students. He believed in the philosophy of Sanskrit shloka, which he usually quoted: "*Wish for victory everywhere except from your son and from your disciple*." He writes in his autobiography, "*Although as yet scientists in posse, there was something indescribable in their character, which drew me to them. The bonds existing between them and me were as subtle as those of chemical affinity. I used to visit them often in their hostel rooms and they were my constant companions in my maidan walk in the evenings*." The *maidan* (ground) referred to here is the famous ***Garer Maath****',* the vast *maidan* adjoining Fort William. He used to take a walk daily evening along with his students discussing studies, social problems, swadeshi movement and other issues.

Throughout his twenty-seven years at Presidency College, he always preferred taking the classes of Junior students. He said that the boys coming from high school were fresh and teachable just like a potter's mud that can be moulded into desirable shape. A very interesting way of teaching and experimental learning, he mentions in his autobiography, is to teach the concept that everything comes from nature and it is the thought that binds us. He would bring pieces of bones to the class, heat and burn them on a burner, then put the burnt bone in his mouth, chew it and swallow it. The aim was to show that the bone was almost a pure chemical compound, free from organic impurities – for a chemist, it was *phosphate of Calcium*, prescribed in powdered form as a nerve tonic. He would also ask his student to attempt the same.

P. C. Ray's student, the great astrophysicist Meghnad Saha, once narrated an incident about him, "Sir P. C. Ray was once invited to Lahore to deliver a course of lectures on Hindu Chemistry, after the publishing of his path breaking book, the *History of Hindu Chemistry*. While he was addressing, among his audience, a young Englishman who was a professor in one of the local colleges was apparently not very much impressed. Sir Ray was explaining the chemical processes practised by the ancient Hindu s*age-scientists*, and exhibiting those processes with the aid of diagrams, the young Englishman could hardly suppress his sneers. Ray had noticed it and was apparently annoyed. After the apparatus had been described, he took in his hand a lump of *Makaradhwaja*, which is resublimed mercuric sulphide and used as a medicine, sometimes even by European physicians. Sir Purdy Lukis, who was Surgeon-General with the Government of Bengal, would often prescribe it to his patients as a stimulant. Sir P. C. Ray took the lump in his hand and said: "Look here, my friends, with such crude apparatus, the Indians, two thousand years ago used to prepare such a fine chemical and used it to alleviate human sufferings and this at a time when the ancestors of our friend over there were eating raw berries and wearing raw hides". The Englishman was left red-faced and he rushed out of the hall. Later on, the Englishman became a great follower of Prafulla Chandra Ray.

Some of the luminaries who learned the art of scientific investigation and undertook research with him and spread across the country in different universities were: Jnan Chandra Ghosh (Director of IISc, Bangalore and founding Director of IIT, Kharagpur), Panchana Niyogi (founding Principal of Raja Monindra Chandra College in Calcutta), Nil Ratan Dhar (Allahabad University), Priyada Ranjan Ray (Calcutta University), Biresh Chandra Guha (founder of Biochemistry Research in India), prominent scientist Shanti Swarup Bhatnagar was a student of Prof. Atul Chandra Ghosh, who was in turn a student of P. C. Ray. Eminent Indian scientists like Satyendra Nath Bose (Bose–Einstein statistics) and Meghnad Saha, (Saha equation) were also part of his extended group.



P. C. Ray, S. N. Bose, Meghnad Saha and other prominent scientists of India

6. Establishment of Indian Chemical Society

P. C. Ray took the initiative to create Indian Chemical Society (1924). He along with Shanti Swarup Bhatnagar (student), J. N. Mukherjee and J. C. Ghosh had always felt the strong need of a chemistry society of India and the Indian Chemical Society was founded and registered on 9 May, 1924. P. C. Ray consented to be the Founder-President for the first two terms. The establishment of the new chemical society and its journal was well received in academic circles in India and abroad. The London Chemical Society sent this message, "*Hearty congratulations and warm wishes to the newly formed Indian Chemical Society*".

In the initial days, the society didn't have its own office and functioned from the office of Dr. J N Mukherjee (Secretary). Prafulla Chandra Ray felt that proper accommodation was needed and so he gifted ten thousand Rupees to Calcutta University requesting space for the society. Thus, in 1933, the construction of three large rooms started on the second floor of the Sir Taraknath Palit Building of the University College of Science and Technology, Calcutta. The address 92, Acharya Prafulla Chandra Road, Kolkata- 700009 remains its registered office still.

This society published the first research journal of India, The Journal of Indian Chemical Society, under his leadership in November, 1924. **Nature magazine welcomed it with a congratulatory note,** "*The great work in chemistry which has occurred in the Indian Empire during the past ten years, had led to the establishment of an Indian Chemical Society, the first number of the quarterly journal of the Society has now appeared. There are thirteen papers, and only one of these is published under the English names. The remaining papers are published by Indians and come from all parts of the Indian Empire. Four of these emanate from the College of Science, Calcutta, and this is as it should be, because for many years past, this Institution has been the back-bone of chemical research in India.*"

He believed that problems being faced by a common Indian can best be understood by an Indian and there was a need for national regeneration using science. To achieve this, he, along with Meghnad Saha, established Indian Science News Association (ISNA), with the purpose of spreading and informing achievements in the scientific domain and initiating the young scientists to devise solutions for the problems present in the society. P. C. Ray was the founder President of ISNA and he guided in starting the journal – *Science and Culture* in 1935.

7. Revolutionary Scientist of Independence Movement

P. C. Ray was a nationalist scientist with a fire raging inside him since his childhood to see India in its former glory. He mentions many times in his autobiography that India was glorious but the present Indians need to adapt and compete with the changing times.

During the late 19th century, nations had started looking up towards establishing scientific institutions of research and technology, it was viewed that the wealth of a nation was dependent upon how it promotes and develops scientific thoughts in its society. The patriot Surendra Nath Banerjee (father of Indian nationalism), who taught English to Ray in College, instilled in him a sense of nationalism.

In 1885, he took part in the essay competition announced by Sir Stafford Northcote, Lord Rector of the University of Edinburgh, on the subject "*India Before and After the Mutiny*" He did not get a prize in this competition. In his biography, he wrote- *"The prize was awarded to a rival competitor, but my essay as well as another's was bracketed together as proxime accesserunt (nearest approach to the best)."* He described with a lot of courage and conviction how the British are perpetuating colonial exploitation in India neglecting the development and education of its people. Ray distributed copies of his printed essay among the university students and general public with the appeal to take steps to free India from colonial bondage. He sent one copy to Sir John Bright, an open minded and progressive

Parliamentarian for his comments. Bright wrote a letter commending the article and permitted him to use the letter to publicize the contents of the essay. Prafulla's letter to newspapers to expose the nature of colonial exploitation before the general public of Britain is quite noteworthy. Scottish Newspaper, *The Scotsman* remarked "It contains information in reference to India which will not be found elsewhere, and is deserving of the utmost notice."

From the 1880 to 1925, Bengal was going through a rough transition period. On one hand, the partition of Bengal occurred in 1905 and on the other hand, young Indians were establishing themselves in all spheres from science to business. The basic Bengali community was following two different paths, one was awakening to the concept of Swadeshi and the other following the path of militant struggle to achieve independence. Swadeshi or self-reliance was an attempt to create awareness among Indian masses to create opportunities in every societal sector based upon indigenous enterprise. Ray was part of the Swadeshi community who believed in self-reliance of India, modernising education, ushering in the industrial revolution of Indian products, teaching skills to students so that they can participate and compete with the fast changes occurring in the world.

Indian scientists were constantly feeling the requirement for a system of scientific self-reliance to be created in India, which will be managed and run by Indians. He established the first research laboratory at Presidency College from scratch and that became the cradle of chemistry research for the whole country. He realized that our country needs a hand of highly educated and capable researchers dedicated to the service of sciences.

P. C. Ray was always irked by the absence of research studies in the academics of Calcutta University and therefore, he was fully supportive of a teaching system gaining roots in Bengal at that time. He closely affiliated himself with National Council of Education (NCE), a pedagogic organization based upon the swadeshi spirit with science, technology and industrialization as its foundation. NCE was founded by Satish Chandra Mukherjee along with Sri Aurobindo. In the year 1921, the council planned expansion in the syllabus of engineering studies. Under the chairmanship of P. C. Ray, a syllabus revision committee was set up to introduce new streams. The new curriculum introduced Chemical Engineering besides Mechanical and Electrical. Later on, Ray was made the President of National Council of Education, Bengal. He was of the opinion that Indian students should learn new skills and techniques and mere getting degrees will not suffice the modern era dawning upon the world. He inspired students to become self-reliant entrepreneurs and not keep running for academic degrees to get a comfortable government job.

He believed in the principles of Gandhi and was a practising Gandhian in daily life. When Mahatma Gandhi visited Calcutta in 1901, on the invitation of Gopal Krishna Gokhale, Prafulla Ray actively participated in making arrangements for Gandhi's first public appearance in Calcutta. In the book *My Experiments with Truth (*Part 3, Chapter 17), Gandhiji writes, "*Of these the one who stands foremost in my memory is Dr. (now Sir) P. C. Ray. He lived practically next door and was a very frequent visitor. This is how he introduced Dr. Ray: 'This is Prof. Ray, who having a monthly salary of Rs. 800, keeps just Rs. 40 for himself and devotes the balance to public purposes. He is not, and does not want to get, married.*' During the decade of 1920's, Ray participated in the freedom movement and was attached with political fronts. Although he did not take part in active politics, he could not keep himself aloof from the freedom struggle sweeping through the nation at that time.

In the 1920's, during the peak of the Non-cooperation Movement, he delivered the famous inspiring quote, "*Science can afford to wait but Swaraj cannot…*" -
The anecdote below has been reproduced word to word from P C Ray's autobiography *"Life and Experiences of a Bengali Chemist".*

"*A mass meeting was held at the Town Hall- the principal speaker being C. R. Das, who was just then coming to the fore. My friend Satyananda Bose called on me one afternoon and suggested to me that I might go a little earlier to my usual maidan constitutional walk so as to be present at the meeting. It was thus only by an accident that I happened to be one of the audience. The ground floor of the Town Hall where the meeting was held was packed to suffocation and a large crowd had also gathered on the southern flight of steps as also on the broad street. C. R. Das in order to be audible to the vast seething mass of humanity took his stand on the front of the steps. Naturally I was at the back of the audience and occupied a very inconspicuous place. Somehow or other I was recognised and pushed forward by those about me and placed alongside of Das. Everyone was anxious that I should have my say; what then happened is thus described by a local daily:*

"*Mr. C. R. Das then asked Dr. Sir P. C. Ray to speak on the resolution. Dr. Ray rose to speak and then was witnessed a scene which I shall never forget. For a few minutes Dr. Ray could not utter a single syllable as ovation after ovation, -cheers after cheers, shouts of "Bande Mataram" greeted the venerable Doctor. Dr. Ray began by saying that he had not the remotest idea that he would have to address the meeting even for a single moment. He came as a mere spectator. He was a man of the laboratory but he felt that there are occasions – the rest of the sentence was drowned in deafening cheers. Dr. Ray repeated that he felt that there are occasions which demanded that he should leave his test-tube to attend to the call of*

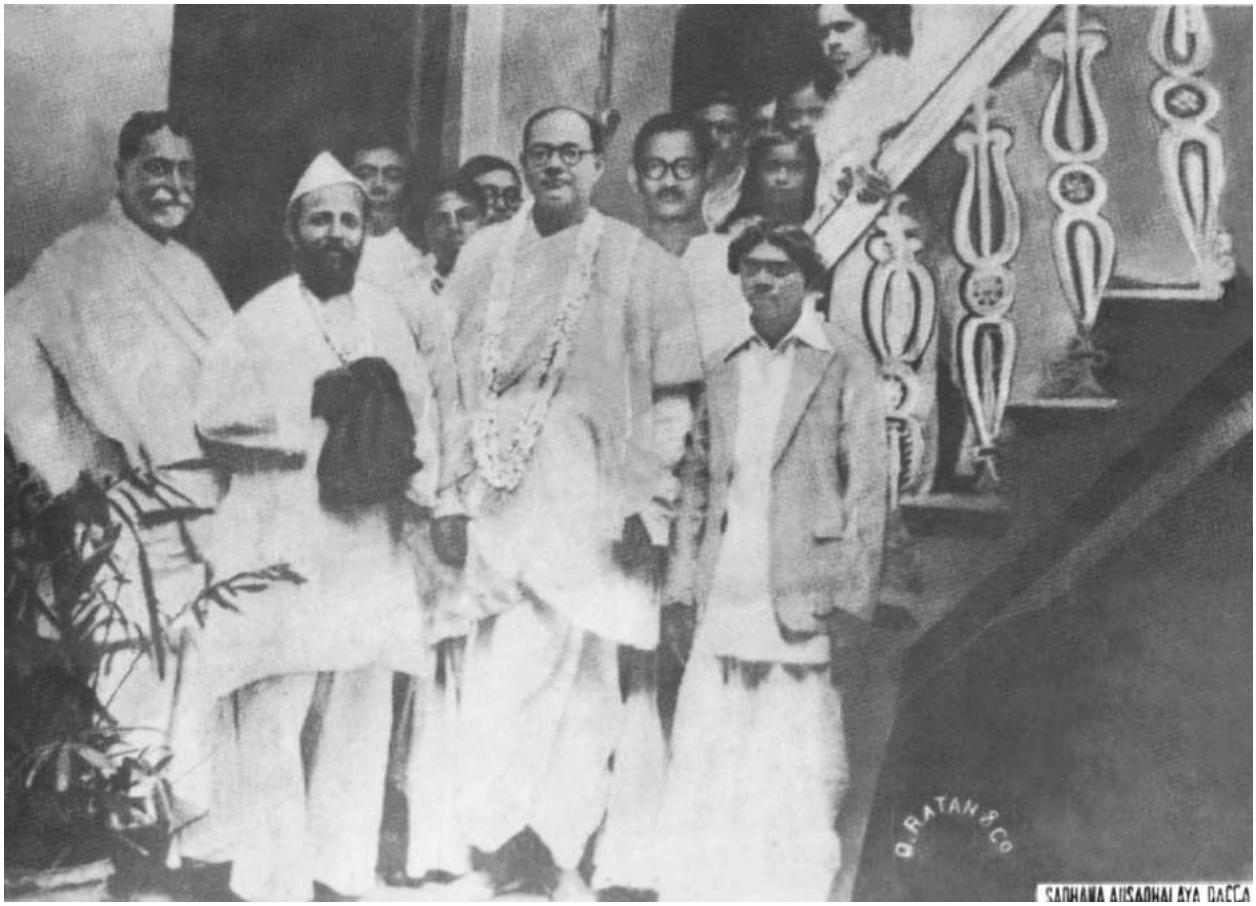
the country. ***So grave was the danger to our national life that even Dr. P. C. Ray left his work in the laboratory and joined the meeting to raise his voice of protest against the obnoxious Bill*****". [The Amrita Bazar Patrika, February 1919]**

When British rulers introduced the norm of separate election of Hindus and Muslims (*Indian Councils Act, 1909 or Minto-Morley Reforms*) to the legislative forms, Congress remained indifferent to it but Prafulla Chandra opposed nationalism on the basis of religion. He criticized the opportunist policy of then Congress leadership which he believed could lead to communal divide.

Being a righteous person and despite being a practising Gandhian, he severely criticized Gandhiji for his blunder in Khilafat Movement (1919), "*We must not allow our loyalty to the mother country to be swamped by the wave of extra-territorial patriotism. India must not be a spoke in the Khilafat gyrated from Istanbul. The Swaraj of India must be our one all-compelling goal…*".Ray was vociferous in his support for Subhash Chandra Bose, when the Congress was divided on the election of Netaji to the President's post the second time in 1938.

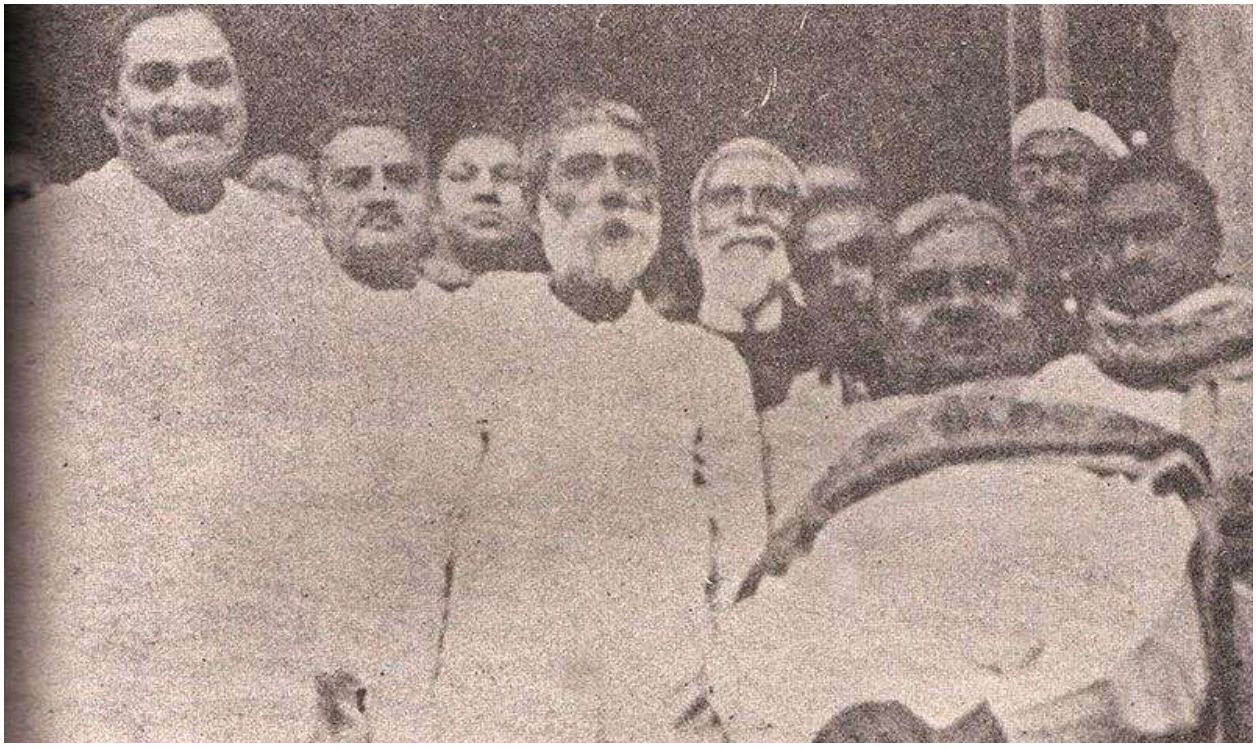
During World War II, when Nazi Germany attacked Russia in 1941, Acharya Prafulla Chandra Ray along with prominent Indians, issued a manifesto urging Indians to express full "*Sympathy and solidarity with USSR*". Acharya P C Ray was the first signatory to the statement.

He was also sympathetic towards the revolutionaries and would make arrangements for their shelter and food at his factories. After his death, many revolutionaries and his colleagues mentioned his indirect support and help in manufacturing explosives. The Government records of that time mention him as a "*Revolutionary in the garb of a Scientist.*"



Prafulla Chandra Ray, Netaji Subhas Bose at Sadhana Aushadhalaya (1924)

In later decades, Ray heavily criticised British for their failure to understand the nationalist feelings of Indians, the progressive needs of young Indians and cautioned the British that this would lead to inevitable anger against their administration. The political and economical mayhem that they have created will cost them dearly. He was right in his observation as can be seen from the fact that India gained independence within the next 10 years.



Civic Reception to Acharya Prafulla Chandra Roy December 10, 1932

P C Ray inaugurating Gujarat Vidyapeeth University established by Mahatma Gandhi

8. Visionary Startup Industrialist

'In Europe, industry and scientific pursuits have gone hand in hand … one helping the other… The gigantic progress in industry achieved in Europe and America is a history of the triumph of research in the laboratory. These thoughts were weighing heavy on me at the very threshold of my career at Presidency college. How to utilize the thousand and one raw products which nature in her bounty has scattered in Bengal? How to bring bread to the mouth of the ill fed…' - P. C. Ray

Since childhood, Prafulla Ray had observed the frequent famines and poverty in the country. Due to his knowledge of ancient Indian history, he was aware of the highly developed Indian industries existing before the arrival of British, who deliberately destroyed and crushed the native manufacturers to promote the British interest. Under an outsider and aggressive rule, gradually Indians had lost the inspiration and endeavor to set up any new venture.

During his stay in England, Ray had observed the social and scientific changes in the English society. On his return from England, he had set up his plans to locally manufacture some of the chemicals which were being imported in bulk from England and Europe. This dependency on imports made the existing local industry slow with no growth and innovation. With increasing unemployment levels in Bengal, he took up to himself to revive the industrial economy using the latest scientific knowledge and putting it to industrial use. With an initial investment of Rs. 700, in the year 1893, he set up India's first pharmaceutical company, **Bengal Chemicals**, now known as the **Bengal Chemicals and Pharmaceutical Works Ltd (BCPWL).** The company is now in prominence during the Covid-19 situation, as it has been licensed by Government of India to produce the much-needed hydroxychloroquine (HCQ).

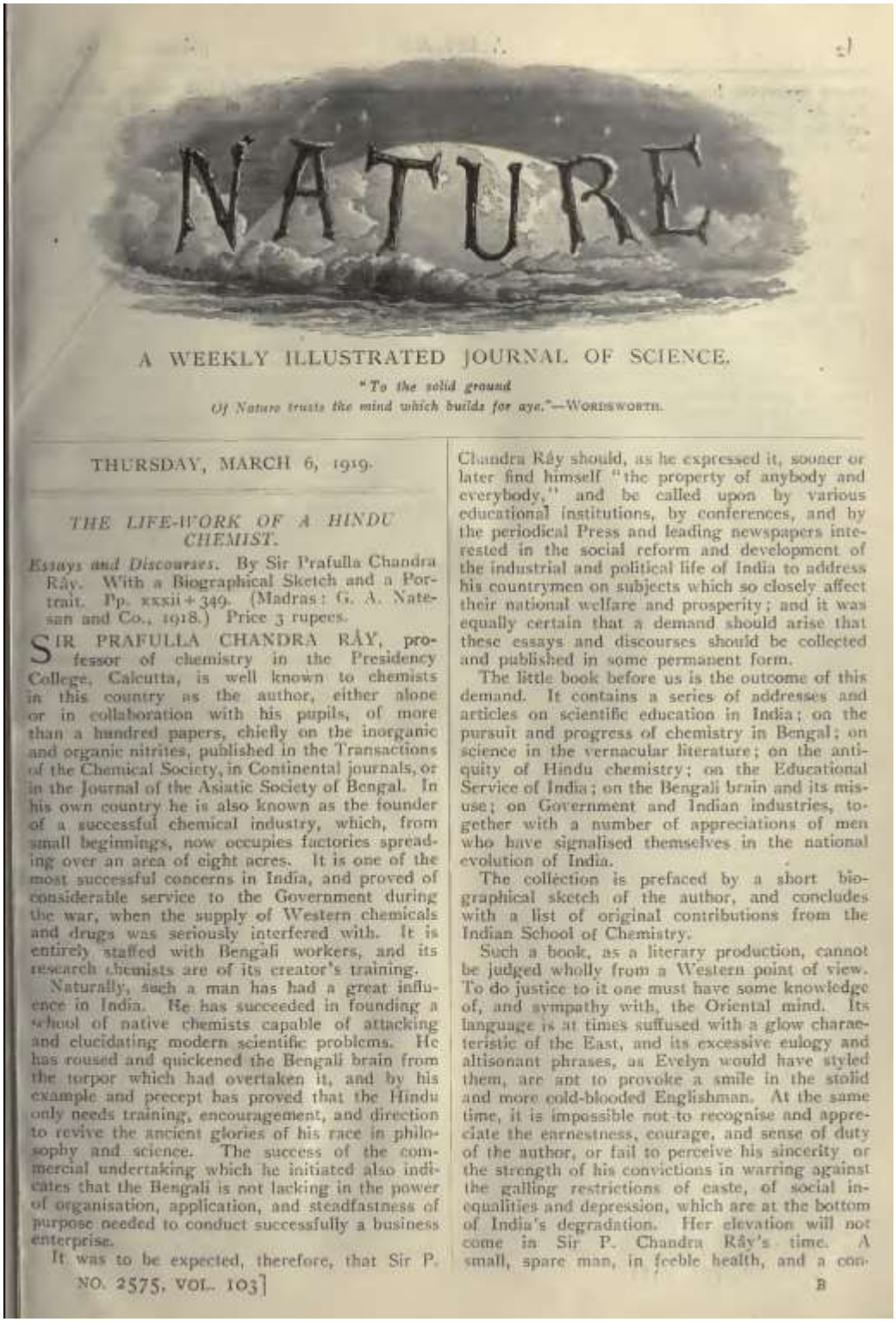
With establishment of this industry, he was able to achieve his dream definition of Swadeshi, self-reliance in research leading to the development of swadeshi industries. BCPWL. was set up with an in-house research facility for development of alternate and cost-efficient processes for production of imported chemicals like Tincture of Nux Vomica, Spirit of Nitric Ether, Syrup Ferri Iodidi. The products manufactured at Bengal Chemicals were displayed at the Indian Medical Congress, Calcutta held in 1898, which impressed the doctors attending the Congress. Many of them at a later stage, started recommending these drugs as prescriptions. Being from an inorganic and analytical background, it was a little easy for

Prafulla Ray to impart training skills to his industry workers and very soon he was able to achieve his target. His excitement and dedication can be gaged from the fact that after his academic work, he used to work in the Bengal Chemical factory daily from 7 to 8 PM. In his autobiography, Ray pens this excitement as, "*...the very idea of locally manufacturing pharmaceutical preparations, which hitherto had to be imported, acted like a tonic".* Sir John Cumming in 1903 noted, '*BCPWL. is one of the most go-ahead young enterprises in Bengal.'*

His industry also started manufacturing basic necessary reagents like sulphuric acid, which were a necessary part of the chemical processing industry. Gradually his industry moved towards manufacturing of various other products like soaps, paper pulp, fertilizers and oils. P. C. Ray along with his students established many other industries like Acharya Prafulla Chandra Cotton Mills, Bengal Salt Manufacturing Company, Bengal Potteries, Bengal Enamel Works, Bengal Steam Navigation, Bengal Paper, Bengal Canning and Condiment, National Tanneries, Chuckervertty, Chatterjee & Company Ltd (Publishing House) and Bharati Scales and Engineering Company. Even today many of us are using the products of industrial legacy established by Ray in the form of common sanitization products like naphthalene and phenyl bottles.

Many Indians from various walks of life like Leaders, Scientist and Doctors gradually started supporting him in his endeavours. People like Subhash Chandra Bose, Chitranjan Das, Dr. Amulya Charan Basu, Radha Gobinda Kar, Kulbhusan Bhaduri, Chandra Bhusan Bhaduri, Suresh Prasad Sarbadhikari stepped in to help his initiatives achieve success.

Prominent British Chemist of the time, Sir Thomas Thorpe, wrote a two-page front article in Nature titled, 'The life-work of a Hindu Chemist'. He said, "Sir Prafulla Chandra Ray, professor of chemistry in the Presidency College, is well known to chemists in this country as the author, either alone or in collaboration with his pupils, of more than a hundred papers, chiefly on the inorganic and organic nitrites, published in the Transactions of the Chemical Society, in Continental journals, or in the Journal of the Asiatic Society of Bengal. Thorpe also mentions that Ray has contributed 'as the founder of a successful chemical industry', which 'proved of considerable service to the Government during the war, when the supply of Western chemicals and drugs was seriously interfered with'.



NATURE

A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE.

"To the solid ground
Of Nature trusts the mind which builds for aye."—WORDSWORTH.

THURSDAY, MARCH 6, 1919.

THE LIFE-WORK OF A HINDU CHEMIST.

Essays and Discourses. By Sir Prafulla Chandra Rây. With a Biographical Sketch and a Portrait. Pp. xxxii + 349. (Madras: G. A. Natesan and Co., 1918.) Price 3 rupees.

SIR PRAFULLA CHANDRA RÂY, professor of chemistry in the Presidency College, Calcutta, is well known to chemists in this country as the author, either alone or in collaboration with his pupils, of more than a hundred papers, chiefly on the inorganic and organic nitrites, published in the Transactions of the Chemical Society, in Continental journals, or in the Journal of the Asiatic Society of Bengal. In his own country he is also known as the founder of a successful chemical industry, which, from small beginnings, now occupies factories spreading over an area of eight acres. It is one of the most successful concerns in India, and proved of considerable service to the Government during the war, when the supply of Western chemicals and drugs was seriously interfered with. It is entirely staffed with Bengali workers, and its research chemists are of its creator's training.

Naturally, such a man has had a great influence in India. He has succeeded in founding a school of native chemists capable of attacking and elucidating modern scientific problems. He has roused and quickened the Bengali brain from the torpor which had overtaken it, and by his example and precept has proved that the Hindu only needs training, encouragement, and direction to revive the ancient glories of his race in philosophy and science. The success of the commercial undertaking which he initiated also indicates that the Bengali is not lacking in the power of organisation, application, and steadfastness of purpose needed to conduct successfully a business enterprise.

It was to be expected, therefore, that Sir P. Chandra Rây should, as he expressed it, sooner or later find himself "the property of anybody and everybody," and be called upon by various educational institutions, by conferences, and by the periodical Press and leading newspapers interested in the social reform and development of the industrial and political life of India to address his countrymen on subjects which so closely affect their national welfare and prosperity; and it was equally certain that a demand should arise that these essays and discourses should be collected and published in some permanent form.

The little book before us is the outcome of this demand. It contains a series of addresses and articles on scientific education in India; on the pursuit and progress of chemistry in Bengal; on science in the vernacular literature; on the antiquity of Hindu chemistry; on the Educational Service of India; on the Bengali brain and its misuse; on Government and Indian industries, together with a number of appreciations of men who have signalised themselves in the national evolution of India.

The collection is prefaced by a short biographical sketch of the author, and concludes with a list of original contributions from the Indian School of Chemistry.

Such a book, as a literary production, cannot be judged wholly from a Western point of view. To do justice to it one must have some knowledge of, and sympathy with, the Oriental mind. Its language is at times suffused with a glow characteristic of the East, and its excessive eulogy and altisonant phrases, as Evelyn would have styled them, are apt to provoke a smile in the stolid and more cold-blooded Englishman. At the same time, it is impossible not to recognise and appreciate the earnestness, courage, and sense of duty of the author, or fail to perceive his sincerity or the strength of his convictions in warring against the galling restrictions of caste, of social inequalities and depression, which are at the bottom of India's degradation. Her elevation will not come in Sir P. Chandra Rây's time. A small, spare man, in feeble health, and a con-

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Prominent British Chemist of the time, Sir Thomas Edward Thorpe, wrote a two-page front article in Nature titled, "The life-work of a Hindu Chemist". Thursday, March 6, 1919

9. Humble Philanthropist

Being from a humble background, Ray always had that spirit to contribute to society. He never missed an opportunity wherein the welfare of citizens was priority. Even as owner of the various industries, he never took any salary and distributed all his part among the workers.

A simple incident will give you an example of the humbleness of P. C. Ray. It was a tradition in colleges that before the Professor came to take the class, a clerk would come in and clean the blackboard, table and put in all teaching materials. One day a clerk came in wearing a coat and did all the chores. After some time, Professor Ray entered the room to take the class and to everyone's surprise, he was also wearing the same coat as was the clerk. After the class was over, the students in their eagerness tried to get the reason and it was revealed that Prof Ray had gone to purchase woollen clothes for himself but during the purchase, he realized that the clerk from the college would also need it and so he bought two sets of cloth and got two suits stitched for both of them.

In 1916, he joined as Palit Professor in Calcutta University and from 1921 onwards, he stopped accepting salary and requested the University to spend the money on development of the Chemistry Department. For the last 20 years of his life, he lived in a room of the university building. He even considered ceiling fans as an element of luxury. This room now houses the P. C. Ray Museum. Many students, mainly the poor, lived with him. In 1922, he made an endowment of Rs. 10000 for an annual prize in Chemistry named after the great Indian Chemist Nagarjuna. In 1936, he made another endowment named after Prof. Ashutosh Mukherjee. He donated Rs. 1,80,000 to Calcutta University for extension and development of chemistry at the time of his retirement.

In 1921, during the famine of Khulna, he created Khulna Relief Committee to feed the poor people of the famine affected district for months. In 1922, P. C. Ray motivated scientists and students to come out to help flood affected North Bengal (collected Rs.3 lakh in one month). He along with Subhash Chandra Bose rushed to affected areas and set-up the Bengal Relief Committee, he being the President of the committee. On his call, many of his students and colleagues like Prof. P. C. Mitter, Meghnad Saha, Prof. Niren Chowdhury worked twenty-four hours helping out the citizens.

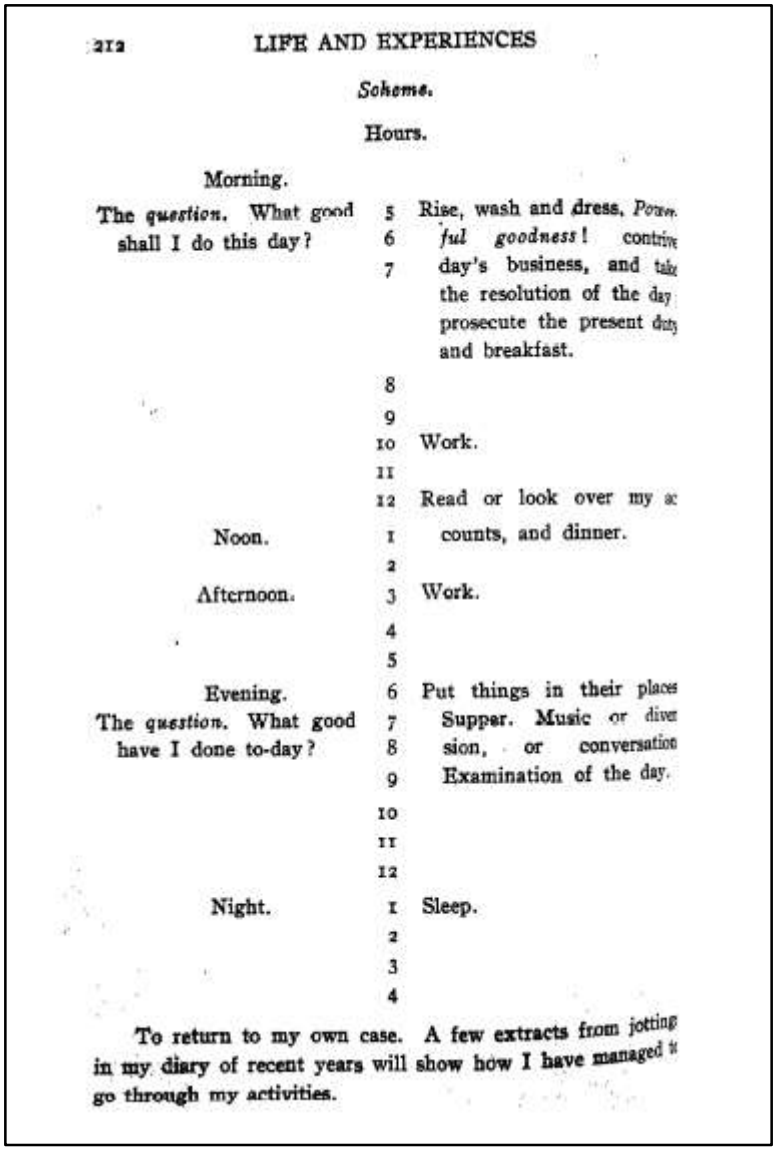
[From his autobiography: The Special Correspondent of the Manchester Guardian writes from the flooded area of Northern Bengal, Nov 11. —

"In these circumstances a professor of chemistry. Sir P. C. Ray stepped forward and called upon his countrymen to make good the Government's omissions. His call was answered with enthusiasm. The public of Bengal in one month contributed three lakhs of

rupees; rich women giving their silks and ornaments, and the poor giving their spare garments. Hundreds of young men volunteered to go down and carry out the distribution of relief to the villagers, a task which involved a considerable amount of hard work and bodily discomfort in a malarious country.

What greatly aggravated the public's dissatisfaction with the Government's attitude was the fact that the disaster is generally attributed to the faulty design of the railways which is believed to make very inadequate provision for the passage of flood water. There is much evidence to support this view, but it was only after a month and a half that the Government promised an inquiry into the question."]

Again in 1923, the Bengal Relief Committee collected Rs. 2.5 million in cash for millions of people made homeless by flood that year. In 1931, flood struck again North Bengal, Prafulla at the age of 70, made *Sankat Taran Samity* to provide relief to the affected people. This time he devised a new way and formed cooperative committees in which there was direct participation of his students and the public in general.



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Scheme.

	Hours.	
Morning.		
The *question*. What good shall I do this day?	5	Rise, wash and dress. *Powerful goodness!* contrive day's business, and take the resolution of the day prosecute the present duty and breakfast.
	6	
	7	
	8	
	9	
	10	Work.
	11	
	12	Read or look over my accounts, and dinner.
Noon.	1	
	2	
Afternoon.	3	Work.
	4	
	5	
Evening.	6	Put things in their places
The *question*. What good have I done to-day?	7	Supper. Music or diversion, or conversation
	8	
	9	Examination of the day.
	10	
	11	
	12	
Night.	1	Sleep.
	2	
	3	
	4	

To return to my own case. A few extracts from jottings in my diary of recent years will show how I have managed to go through my activities.

Page of Daily Diary of P C Ray

10. The Book that taught Ancient Indian Chemistry to World: THE HISTORY OF HINDU CHEMISTRY

As a student at the University of Edinburgh, Ray was impressed by the scientific knowledge of ancients in the western world. This generated immense curiosity in him to explore the contribution of ancient India in the field of science and technology. He was of the view that a Nation's success and strength depends upon what its citizens achieve independently in the fields of science, technology, pedagogy and methodology. He observed that Hindu traditions had a strong scientific basis that formed a knowledge bank, which was followed in daily life but taken for granted as it was their way of life. The importance of maintaining and nurturing this tradition and past knowledge was important for the success of India. Ray says in his autobiography,

"The Hindu nation with its glorious past and vast, latent potentialities may yet look forward to a still more glorious future, and, if the perusal of these pages will have the effect of stimulating my countrymen to strive to regain their old position in the intellectual hierarchy of nations, I shall not have laboured in vain."

Prafulla Chandra Ray was a visionary ahead of his times, who understood the importance of amalgamation of ancient scientific experimentation and modern emerging sciences. He had observed that the scientific knowledge was vast and highly advanced of its time but scattered all over. Parts of it were present in Royal libraries, some in temple libraries, European museums, some with individuals, various of them in regional languages, many of them in Sanskrit and Pali. With the passage of time and the impact of Mughal and British system, people had stopped reading them. Hence, the knowledge was not transferred to the next generation. He decided to take up this herculean task of compiling this scientific knowledge at one place.

He had always been interested in reading and exploring the history of science, especially his own subject, Chemistry. While at Edinburgh University, he read *Geschichte der Chemie* (History of Chemistry) by German Chemist Hermann Franz Moritz Kopp which influenced his understanding about the topic. In 1894, at Presidency College, he read the Collection *des anciens alchimistes grecs* by Bertholet. He was greatly impressed by the book of Berthelot, *Les Origines de l'alchimie* (1885), which detailed the work of ancient Greeks in alchemy. Prafull Ray sent letters to Berthelot on discussions about the topic and explaining the work done by ancient Indians in Chemistry through the ages. To his utter dismay, he found that at international level, scientists were not aware of the work of Indians, as the work had never been translated in any international language and neither was it communicated in the modern sense. Whatever was available at that time, had either been translated by Europeans or kept at their museums as a rare transcript, with no understanding of the work.

For many years, he continued studying various Indian texts of *Susruta*, *Charaka* and explored the world of Indian science developed hundreds of years ago. He learnt the languages like Sanskrit and Pali from eminent scholars like Pandit Nabakanta Kavibhusana and Acharya Brajendranath Sil. Pundit Nabakanta Kavibhusan worked with him in searching

ancient manuscripts in various temple libraries of Benares (present Varanasi). They collected many volumes and texts of books in Sanskrit language which contained processes, techniques, methodology, characteristics and other details about use of chemical knowledge and involvement of concepts of Chemistry in ancient India. He studied ancient Indian medical and chemical encyclopaedia like '*Materia Medica of the Hindus*' by Udoychand Dutt, '*Indian Materia Medica and Indigenous Drugs of India*' by Kannai Lal Dey. He took guidance and help from Kavirajs, the traditional scholars of Indian system. He carried out many of the experiments to prove and verify their exactness like preparations with Kurchi (*Holarrhena antidysenterica*), Kalmegh (*Andrographis paniculata*), Vasaka syrup (*Adhatoda vasica*) etc.

Ray took it as a mission to disprove the misconception that the ancient Indian science was based only on mythology and had no proof. He stated that experimental learning was part of Indian system and mentioned important works of thirteenth and fourteenth century Yasodhara's *'Rasaprakasa Sudhakara'* and Ramchandra's *'Rasendrachintamani'*. Many of the manuscripts were in pieces and one that he found complete was *'Rasarnava'*, from Raghunath Temple Library, Kashmir and another copy of it at Oriental M. S. S. Library, Chennai (now known as Government Oriental Manuscripts Library and Research Centre, Chennai). The book highlighted and mentioned the existence of knowledge of chemistry among the Hindus in the twelfth century.

Acharya Prafulla Chandra Ray's book, *The History of Hindu Chemistry* is a critically acclaimed treatise on *Rasashastra* and *Ayurveda*. The first volume of the book was published in 1902, and the second in 1909. The book was strong enough to attract the attention of western world towards Indian alchemy and lead to the globalization of the fundamentals of *Rasashastra.*

In his book he proves and emphasizes the fact that alchemy and scientific and medical principles based on metal mercury purely originated from India. He accepts in his book that with the advent of outsiders in India, there was indeed influence of Arab and European knowledge on Indian alchemy but the use of many medicinal and chemical compositions predates the Arabic-European impact. He found that it was during the reign (700 AD) of Khalif Harun and Khalif Mansur that the works of *Charaka* and *Susruta* were translated into Arabic language. Ray's work on bringing up the ancient knowledge helped him in applying it in terms of emerging modern science of that time. The book history of Hindu Chemistry

proudly presents to the world the great work done by Indian sage-scientists like *Nagarjuna* and *Charaka*. He quotes an example to show the timeline, when he details the preparations of various mild alkalis and caustics mentioned in the book of *Susruta* whereas the evidence of this knowledge in Europe is found just around 1755 AD. Another example that he mentions is of the process of Zinc extraction as mentioned in the ancient book, *Rasarnava*, the process of which is exactly what the modern chemists follow.

The book asserted that Indian knowledge was far more superior than Europeans. P. C. Ray mentions in his book '***The History of Hindu Chemistry***' that Indians developed the concepts and experimental knowledge of Chemistry much before the Europeans.

The book clearly mentions that, *"In the European histories of chemistry, the credit of being the first to press chemical knowledge into the service of medicine and introduce the use of the internal administration of mercurial preparations, is given to Paracelsus… The Nāgarjunas and Patānjalis of India, however, had the merit of anticipating Paracelsus and his followers by several centuries… We have indeed reasons to suspect that Paracelsus got his ideas from the East, and in Chapter on Arabian indebtedness to India we have pointed out the media through which Indian sciences filtered into Europe"*

As Ray said, '*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'*

His other important books are '*Rasayanika Paribhasha'* (Vernacular Terminology in Chemistry) (1919), *'Khadyabijna'* (Food Chemistry) (1936), '*Saral Bijnana*' (Simple Science) (1902), '*Desi Rang*' (1922). He wrote many articles in prominent journals – '*Pravasfi*', '*Prakriti*', '*Bangavani*' and so on.

11. What others said about him

"He is also a real organiser and a real teacher. I heard a European saying, "If Mr. Gandhi had only been able to create two more Sir P. C. Ray, he would have succeeded in getting Swaraj within this year." - **Correspondent, Manchester Guardian**

"A more remarkable career than that of P.C. Ray could not well be chronicled…" - **British Chemist H E Armstrong while reviewing P C Ray's autobiography, Natur**e, 131, 672-674 (1933) (https://doi.org/10.1038/131672a0)

Famous Geographer and also his class fellow, **Hugh Robert Mill** remembered him as "*the most enlightened Hindu I ever met, speaking and writing English with grace and fluency, and singularly at home in European modes of thought*."

Frederick G. Donnan, a professor of chemistry at University College, London, was highly impressed by Indian students who joined him and were students of P C Ray. In a letter to Ray, he says, "*[Y]ou have, by your constant devotion to teaching and research, created a school of chemistry in India which will be of the greatest importance for the prosperity of that land. I feel certain that you have done work in India of which any man might feel proud in any country*."

On his 70th birth anniversary in 1932, a reception was organized by the Corporation of Calcutta in his honour. In his presidential address, **Rabindranath Tagore** said, "*It says in the Upanishads that the Supreme one wanted to be many. The urge of self-disposal is at the root of creation. It was through this kind of creative urge that Prafulla Chandra became many in the minds of pupils by diffusing and thereby reactivating himself in many younger minds. But this would hardly be possible unless he had the capacity to give himself fully to others.*"

Mahatma Gandhi said, "*Great he undoubtedly is: But goodness from Indian stand point is greater than greatness and Acharya Ray is even more good then he is great. And it is his goodness—his childlike simplicity, his suavity of manners, his ready accessibility, his unblemished purity, unostentatious charity, his voluntary poverty with plain living and high thinking, his enthusiasm and optimism, his innate spirit of self-denial, his incurable habit of always taking a back seat, his sturdy independence, his inflexible incorruptibility…in a word, his nobility of nature made him idol of the people. Service and sacrifice were his watch-word…*"

"*It is difficult to believe that the man in simple Indian dress wearing simple manners could possibly be the great scientist and Professor*." - **Mahatma Gandhi**

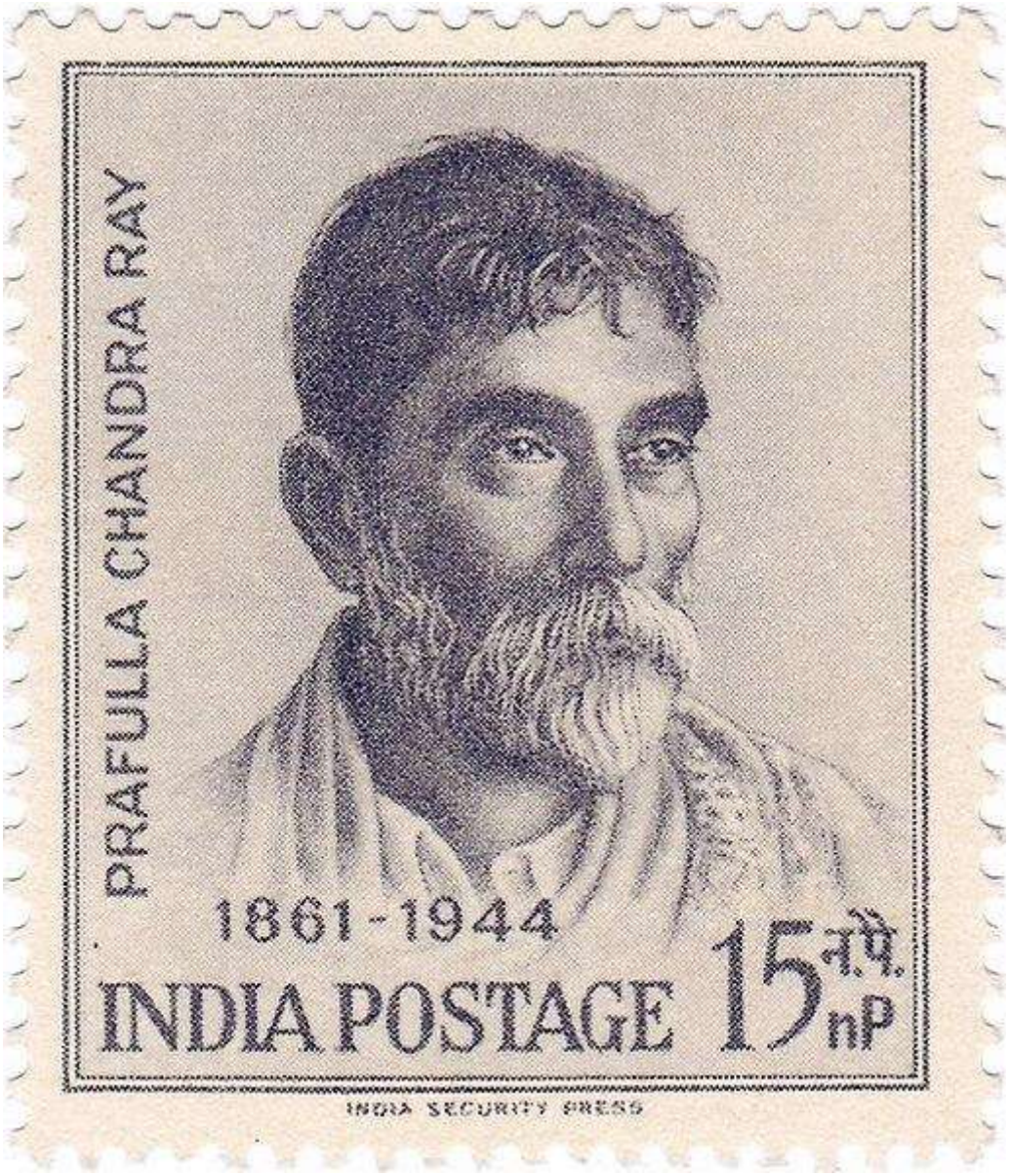
In 1912, Ray was honored with an honorary **D. Sc.** degree by the University of Durham. He was awarded with the **Companion of the Order of Indian Empire** (CIE) in 1912 and a title of **Knight Bachelor** in 1919.

"…. Prof. P.C. Ray had added to his success in preparing ammonium nitrite in a tangible form, a further accomplishment in determining the vapour density of this very fugitive compound."

Nature (London), August 15, 1912

The 'Makers of Modern Chemistry' is beautifully and entertainingly written, and deserves a place in the library of all who are interested in the history and development of the science of chemistry. It is very valuable to get the viewpoint of an eminent teacher and scholar who is thoroughly familiar with the past and present intellectual life of India.. - Book review of 'Makers of Modern Chemistry', by eminent chemist **William Foster**.

In the year 2011, which was also the International Year of Chemistry, the **Royal Society, UK,** honoured his work with the Chemical **Landmark Plaque** - *'To commemorate the life and achievements of Acharya P. C. Ray, father of Indian Chemistry, philanthropist and entrepreneur who founded modern Chemistry teaching and research in India*.' This was the first-ever Landmark Plaque awarded outside Europe. The plaque was installed on 31 January 2012 at his alma mater, Presidency College, Kolkata.



Postage stamp honoring Prafulla Chandra Ray on the 100th anniversary of his birth, India Post, 1961 (Wikimedia commons)

	Life-Sketch : A Chronology
1861	Born on August 2, in Raruli-Katipara village, Ditrict Jessore district (Now in Bangaldesh) to Harischandra Roychowdhuary (*father*) and Bhuvanmohini Devi (*mother*).
1866-1870	Studied at the village school founded by his father.
1870	The family shifted to 132, Amherst Street, Calcutta
1871	Took admission in Hare School.
1872-1873	Suffered chronic dysentery and sleeplessness and returned to native village.

1874	Returned to Calcutta and took admission to Albert School (Established by Kashab Chandra Sen.)
1875	Again returned to his village.
1876	Came back again to Calcutta and took re-admission in Albert School.
1879	After clearing the entrance examination in 1879, Prafulla Chandra took admission at Metropolitan Institution (now Vidyasagar College) founded by Pandit Iswarchandra Vidyasagar.
1881	Passed First Arts (FA) examination in Second Division. Admitted to B.A. Class (B-Course) with chemistry as the main subject.
1882	Obtained Gilchrist Scholarship to Edinburgh University, moved to England.
1885	Completed his B. Sc. Participated in an Essay Competition. Adjudged *proxime accesserunt* (nearest approach to the best). "India before and after Mutiny" (His essay topic)
1886	Published a critically acclaimed booklet titled "Essays on India"
1887	At the age of 26, was awarded D.Sc. in Inorganic Chemistry from Edinburgh University. His thesis was judged the best and awarded Hope Prize and Faraday Gold Medal. Elected as Vice-President of Edinburgh Chemical Society.
1888	Returned to India. Took hospitality of Dr. Amulyacharan Basu first and then of Acharya Jagadish Bose.
August 1888-June1889	He remained jobless due to the discriminatory attitude of British in Indian Educational Services
1889	● His first research paper published in *Proceedings of the Royal Society of Edinburgh*, "On the Conjugated Sulphates of the Copper Magnesium Group." Volume 15, 1889 , pp. 267 - 283 (DOI: https://doi.org/10.1017/S0370164600005502) Appointed as temporary Assistant Professor in Provincial Services at Presidency College, Calcutta. (July 1889)
1890-91	Founded "Nature Club". Started experiments to understand the effect and working of snake bites of Cobras.
1893	● Established "Bengal Chemical and Pharmaceutical Works (BCPW) at 91, Upper Circular Road, Calcutta. ● Death of his father—Harischandra Roychowdhury.

	• First trip to Europe after joining service.
1894	First research paper in India: On the Chemical Examination of Certain Indian Food Stuffs; Part-I— Fats and Oils, *Journal of the Asiatic Society of Bengal*, 1894, Vol-I, pp. 59-80. (http://www.southasiaarchive.com/Content/sarf.120250/221679/003)
1895	Synthesizes the previously unknown compound Mercurous Nitrites'.
1896	His first research student—Jatindranath Sen started working under his supervision
1897	Declined the offer of Principalship of Rajsahi College, Bengal (Now part of Bangladesh)
1899	P.C.Ray, 'The Problem of Scientific Education in India'. The Calcutta Review, CVIII, (April 1899): 347-395 (http://www.southasiaarchive.com/Content/sarf.120137/211188/010)
1901	Met Gopal Krishna Gokhale and Mahatma Gandhi. 1902
1902	Published the famous book "History of Hindu Chemistry" Vol I
1904	Visited institutions across England and Europe.
1906	First Book on Chemistry in Bengali language, "*Nabya Rasayanividya O Tahar Utsa*.", published by Bangiya Sahitya Parishad
1907	Elected President of 'National Education Society."
1908	Awarded honorary degree by University of Calcutta.
1909	• Published "History of Hindu Chemistry" Vol-II. • Promoted as Full Professor in Presidency College. • Published a textbook for college students: "*Elementary Inorganic Chemistry*".
1910	• Elected President of Bengal Literary Conference held at Rajsahi. • "*Bengali Brain and its Misuse*." (Book published in English and Bengali) • Published book "*Rasarnava*" Edited by P C Ray & Harischandra Kavyaratna.
1911	Founded "Maidan Club" during his evening walks to discuss social issues. Joined by G C Basu, Satyananda Basu, Devaprasa Ghosh and Prankishna Acharya as members.
1912	• Travelled third time to England along with Devaprasad Sarbadhikary. • Honoured with the title C.I.E. (Companion of the Order of Indian Empire) by the British Crown.
1913	Initiated the setting up of the industry, Calcutta Pottery Works.
1914-1915	Delivered talk at Punjab University. Prof. Armstrong gives him the title of "***Master of Nitrites***".

1916	● Retires from Presidency College. ● Joins as Palit Professor of Chemistry in the University of Calcutta on the request of Vice-Chancellor, Sir Ashutosh Mookherjee,
1917	Established Co-operative for his employees of Bengal Chemicals.
1918	"*Essays and Discourses by Dr. Prafulla Chandra Ray – with a Biographical sketch and a Portrait*" published by G A Natesan & Co., Madras.
1919	● "Knighted" for his contribution in chemistry. ● Sir Thoma Thorpe, writes front page article in Nature titled, "The life-work of a Hindu Chemist". ● Calcutta Pottery Works was converted into a limited liability company "Bengal Potteries Ltd., with a sum of Rs. 10,00,000/ and Ray being the Director. ● Lectured against the Rowlatt Act at the Town Hall. ● Honorary member of the Deutsch Akademic of Munich, Germany
1920	● Delivered the Presidential address "Dawn of Science in Modern India." at the 7th Indian Science Congress Association held at Nagpur: ● Awarded Honorary D.Sc. by Dacca University and Benaras Hindu University.
1921	● Announced donation of his monthly salary for development of Chemistry Department, University of Calcutta. ● Initiated a monthly research scholarship of Rs. 200/- for students. ● President, First conference of All Bengal Teachers' Association (ABTA). ● Relief Committee for Khulna Famine.
1922	● Made arrangement for relief work in North Bengal Flood. ● Established Nagarjuna Prize, University of Calcutta with a Donation of Rs. 10,000/- ● Vociferously participated in the protest against deliberate interference by British administration in the independent working of the University of Calcutta (Senate Hall, Dec., 8, 1922).
1923	● Address at the inauguration of Handloom (Khadi) Exhibition, Kokonad. ● Malaria Prevention Co-operative Committee.
1924	● Founded Indian Chemical Society. ● Elected President, Primary Education Special Committee, Calcutta. ● Presidential address at the 8th Conference of Hindu Mahashaba, Faridpur district.

1925	• Book: "*Makers of Modern Chemistry*" published by Chuckervertty, Chatterjee and Co. Ltd., Calcutta
1926	• Addressed Convocation of Mysore University on invite of Acharya Brajendranath Sil. • "The discovery of Oxygen", *Journal of Indian Chemical Society (JICS)*, 3, 1-22 • Addressed the First conference of Rural Welfare Association as President.
1927	Financial donation to Jenana, Society of Jessore to advance womens' education.
1928	Discussed about the faults of Secondary Education. Appealed for propagation of education in mother-tongue.
1929	• Travelled to England on his fifth visit as representative of University of Calcutta to the Congress of the Universities of the Empire, University of Cambridge. In his speech in the section "State and University", he was heavily critical of the workings of the British Government and their interference in higher education institutions. • Inaugurated the exhibition in Lahore organized by Indian National Congress.
1930 :	• Addressed the Classified Trades Exhibition, Bombay (27 August 1930). • Convocation Address of Benaras Hindu University.
1931 :	• "Bengal Flood Relief Committee" for North and East Bengal. • Inaugurated the All India Industrial Fair held at Karachi. • Operated the new factory of Bengal Chemical at Panihati.
1932 :	• Autobiography: *Life and Experiences of A Bengali Chemist* (Volume I)" Published. • Published "The Shakespearean Puzzle—Endea-Vours After Its Solution" in *The Calcutta Review*", pp 247-256 (http://www.southasiaarchive.com/Content/sarf.120137/211422/002) • Honoured by Corporation of Calcutta and other eminent citizens on his 70th birthday under the Chairmanship of Rabindranath Tagore (1932).
1933	• Donated Rs. 10,000/ - to Calcutta University for building the office for Indian Chemical Society. • Presidential Address at the State Youth Conference held at Travancore. • Took active part in the movement for allowing entry of Harijans to Hindu temples at Midnapore. • Inaugurated industrial fair and co-operative Bank in Karachi. Felicitated by the Corporation of Karachi.

1934 :	● Nomination for Fellow of the London Chemical Society. ● Established Bengal Salt Corporation & Cotton Mill, Khulna. ● First President of Indian Science News Association, Calcutta. ● Opposed nationalism on the basis of religion. When British rulers started the norm of separate election of Hindus and Muslims to the legislative forms, Indian National Congress remained indifferent to it.
1935	Second part of his autobiography, "*Life Experiences of Bengali Chemist*" - II
1936	● At age 75, retires as Palit Professor of Chemistry from Calcutta University ● Incorporates "Sir Ashutosh Mukhopadya Memorial Prize." at Calcutta University. ● Honoured with the title of "Jnanabaridi" by Karatia College (Now **Government Saadat College, Bangladesh)** ● Inaugurated Chittaranjan Cotton Mills at Narayanganj. ● Signed the manifesto of World Peace Conference, Brussels (September 3, 1936)
1937	Published autobiography in Bengali "*Atmacharita*".
1938	Established "Indian Chemical Manufacturers Association" (now known as Indian Chemical Council) along with Rajmitra B D Amin. Ray being its first President from 1938-1940.
1940	● Protested against Secondary Education Bill. ● Resigned as Chairman of Bengal Chemicals and Pharmaceuticals Ltd..
1941	First to sign the proposal against invasion by Nazi Germany of Soviet Union.
1943	● Felicitated by the people of Khulna Town and Raruli village. ● Last lecture of his life on April, 24.
June 16, 1944	End at 6.27 PM in his room at Calcutta University.

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