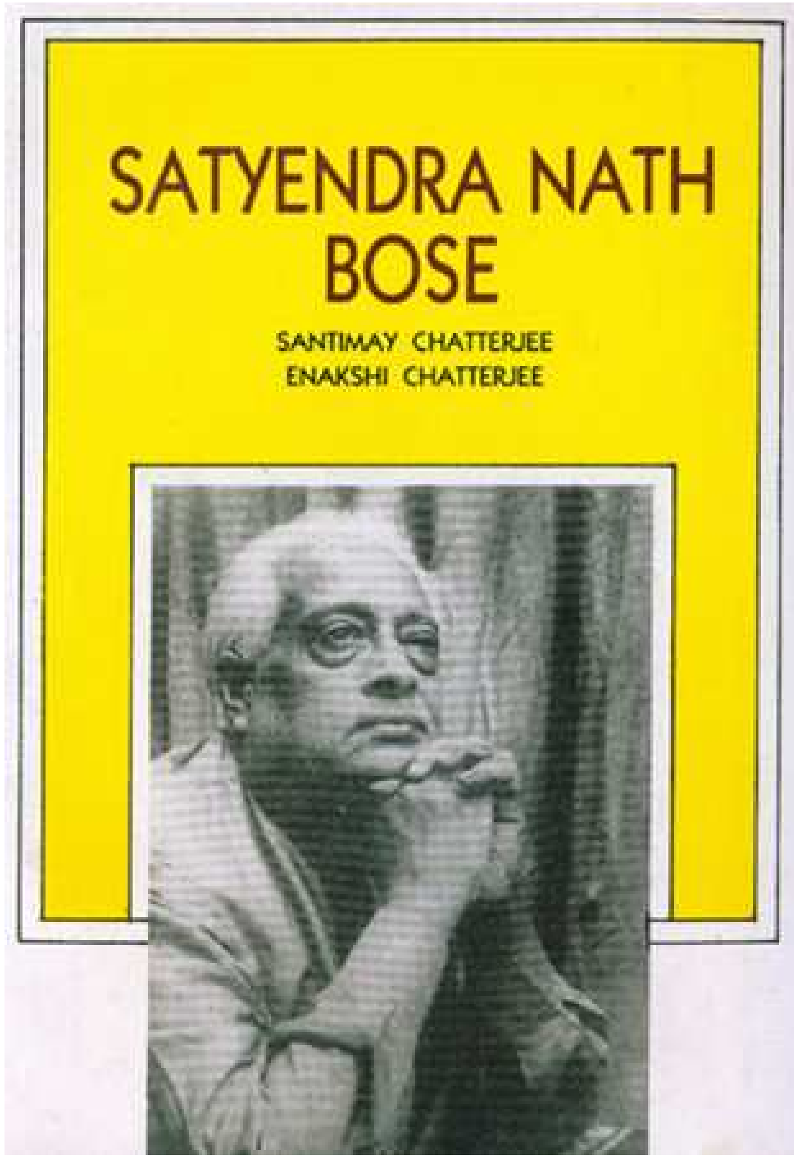

SATYENDRA NATH BOSE

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Preface

The role of a father figure of Indian science was more or less thrust upon Professor Bose, yet he was grossly misunderstood by many. The image of the idle genius who wasted his powers in intellectual small talk has persisted. It is the task of the biographer to find out if such an image was based on justifiable assumptions. Between the admirers and the detractors, the legend has grown, and the man has been somewhat cast in the background. Bose is perhaps still too close to us historically for a proper perspective. We have made an attempt to show him against the changing times when science was making rapid strides in India, and white doing so other personalities have been drawn into the canvas. We realise, however, the inadequacy of our attempt for Bose was a very complex personality. It would have taken years of research and labour to collect and sort all the materials which, however, are not easily obtainable. Bose's habit of not keeping any record, letters or diary has further handicapped us; hence some of the information could not be verified.

We are grateful to so many people for their willing cooperation in the writing of this book that it is impossible to express our thanks for all the help received. However, we are particularly grateful to Mrs Ushabati Bose, Bose's nephew Sri Bhakta Prasad Mitra and other members of the Bose family, to Sri Girijapati Bhattacharyya who had been his life-long friend, to professor Tarini Charan Bhadra of the Bose Institute, and Dr Sibabrata Bhattacharyya of the Calcutta University. We specially acknowledge the help of Sri Rabin Banerjee who H the author of Bose's biography in Bengali.

Our sincere thanks are due to Professor Syamadas Chatterjee who had very kindly gone through the entire manuscript. We have also benefited from the comments and criticisms of friends and colleagues on some of the chapters.

SANTIMAY CHATTERJEE
ENAKSHI CHATTERJEE

Preface to the Second Edition

We are happy that the biography of Satyendra Nath Bose is being reprinted at long last. During the last twelve years a number of articles and monographs have come out on Professor Bose. For the benefit of interested readers they have been listed after the references. We cannot, however, claim the list to be exhaustive.

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1. THE BACKGROUND

The first thirty years of this century saw a conceptual revolution in physics. One of the fundamental discoveries associated with the new developments came from an unknown Indian—one Satyendra Nath Bose, a young physicist from Dacca University. Working in a country remote from the active centres of learning, he was dearly a man of extraordinary intellectual ability.

Just how outstanding was the work done by Bose? It was so important that it went into the physics text-books almost immediately. Professor P.K. Kabir writes:

Bose's paper not only had an immediate and far-reaching impact on several basic problems in physics but it also provides the fundamental explanation of phenomena whose elucidation and elaboration has been the subject of at least three Nobel Prizes. It is a great pity that this token of honour was not accorded to S.N. Bose, whose work is undoubtedly the most important contribution to science made by any Indian so far. Professor M.G.K. Menon comments:

I have never understood personally why Satyen Bose was never awarded a Nobel Prize nor have the many very distinguished scientists with whom I have conversed on this subject. The question that we should ask, in terms of the decades and centuries ahead, is not whether a scientist has received a Nobel Prize, but whether his name will survive in the pages of science that all will read, discuss and constantly use. In the latter category will come Satyen Bose. Bose-Einstein Statistics and the use of the word Bosons will live on a permanent basis in the history of science.

For anybody working in any branch of science in India today it is difficult to imagine the primitive conditions in which Bose and his contemporaries had to do research. It was the formative period of modern science in India and, paradoxically enough, one of the most spectacular. Apart from Bose this was also the age which produced Saha, Raman, Mahalanobis and a host of other celebrities with substantial contributions to their credit.

In order to evaluate the performance of these pioneers one must set them against the background of past traditions and the conditions in which modern science and technology evolved on Indian soil.

Ancient Indians had a distinct role to play in the history of science and technology. Some of their observations about the origin and composition of matter as expounded by Kapil, Kanad and, later, by the Jain and Buddhist philosophers are surprisingly close to modern theories. It is all the more remarkable when we think that science in those days was more a part of philosophy and these scientific thinkers had no methods at their disposal to carry on experimental verifications of their theories. Even in the West, science became modern only after Galileo, who like a true scientist distrusted authority, particularly Aristotleian authority, and laid stress on observation and experiment.

Ancient India saw the flourishing of some applied sciences, like astronomy, surgery and metallurgy. But due to various factors, such as political instability and foreign invasion, science suffered a total eclipse. After the 12th century, intellectual stagnation began in India. Some have attributed this to the decline of Buddhism, a system which encouraged science and education. The renaissance in Europe had no effect here, and the Dark Age continued till the coming of the British and the introduction of English education. The I9th century renaissance marks the real beginning of modern science in India.

Many thinkers are of the opinion that progress in science is linked with happenings in history. The influence of history on science has been particularly effective in the case of India, because the birth of modern science in this country may be traced directly to certain historical developments.

Modern science came to India under very peculiar circumstances. The British who came with the East India Company had superior technical skill and it did not take them long to realise that India had vast natural resources. It was under their initiative that experts from England were brought to explore and measure the extent of that wealth. They brought with them modern scientific methods and modern scientific ideas. Through their efforts the Trigonometric Survey of India, the Agricultural and Botanical Survey, the Mining Federation, the Geographical Survey, Planters Association, Chamber of Commerce, etc. came into being. The English traders-turned-rulers had their own interests in mind, but whatever be the motive it was through their effort that coal was discovered and extracted from Raniganj, petroleum from Assam and Burma and gold from Mysore. They started the railways even though it was for their own benefit. Eminent scientists like Lambton, Everest, Voysey came to India in this connection, but their work did not take root in Indian soil. Indian involvement in science was yet to begin.

The Board of Directors or the officers of the East India Company had no intention of introducing any system of education in this country. There was no planning for improvement and the local people were deliberately kept away— this along with the absence of any initiative on the part of the Indians delayed the advent of modern science in India.

The single individual to play the biggest role in deciding the future course of Indian science was Raja Ram Mohun Roy. A man of remarkable foresight, he was the first to realise that the only way India could save herself was through Western education. It must be kept in mind that the Raja and the members of the Tagore family had started educating themselves in English through their own efforts. The British government was still reluctant to introduce English education among the Indians. Ram Mohun Roy tried to convince the then Governor-General of the need for introducing such branches of science as mathematics, physics, chemistry and physiology in the curriculum. In 1781 Warren Hastings had started a *madrasa* in Calcutta and a college was established at Banaras in 1792 by Jonathan Duncan. Lutheran missionaries in south India and William Carey and other Baptist missionaries in Serampore also started maintained schools. Western learning in a wider sense was introduced by David Hare and Ram Mohun Roy who in 1816 established a college in Calcutta which later changed its name to Hindu College and, finally, in 1855 to Presidency College. The Christian missionaries founded a missionary college at Serampore in 1818, the Wilson School at Bombay in 1834 and the Madras Christian College at Madras in 1837. But the formation of the universities had to wait till the middle of the 19th century. By the famous Woods' Despatch the three universities at Calcutta, Bombay and Madras came into being in 1857. Thus the dream of Raja Ram Mohun Roy found fulfilment at last.

But the education of the century was not science-oriented. It was confined to philosophy, literature, logic, history, etc. Again it was the new awakening among the Indians, the realisation that modern science must be a part of the curriculum, which forced the authorities to introduce the teaching of science. The first modern research institution, however, was founded without any government patronage—it was the Indian Association for the Cultivation of Science started in 1876 by Dr Mahendra Lal Sircar. The Association was started with the following objective:

We want an institution which will combine the character, the scope and objects of the Royal Institution of London and of the British Association for the Advancement of Science. We want an institution which shall be the institution for the masses where lectures on scientific subjects will be systematically delivered and not only illustrative experiments performed by the lecturers, but the audience should be invited and taught to perform them themselves. And we wish that the institution be entirely under native management and control.

At that time all scientific work worth mention was carried out in the various scientific services of the Government of India. The oldest of these was the Trigonometric Survey of India, founded in 1818. Worthwhile researches were also carried out by the Geological Survey of India, founded in 1850 and the Meteorological Office founded in 1864. But all these efforts were geared to help the foreign government and were not in any way related to the interests of the Indian people.

In those days when political and social movements engaged the attention of most Indians, Dr Sircar, though in active touch with these movements, could realise that his countrymen must not lag behind in the race for progress. He was a renowned medical practitioner and had a fairly large income. But that was not enough; he collected funds from the Indian princes and Maharajas. The Maharaja of Vizianagaram was a patient of his and contributed towards the building of a laboratory as a mark of gratitude. Against this background emerged the three great stalwarts of Indian science—J.C. Bose, P. C. Ray and Ramanujan. It was the combined efforts of these three, late in the 19th century, which laid the foundations of modern science in India. Two of them were contemporaries: Jagadish Chandra Bose was born in 1859, P.C. Ray was born two years later, Ramanujan was born twenty-six years later in 1887. Both J.C. Bose and P.C. Ray received their higher education in England, then came back and taught in Presidency College, Calcutta. J.C. Bose, a physicist by profession, laid the foundations of experimental science in this country. Before him there was hardly any tradition of experimental science in India. He can very justifiably be called the Galileo of modern India.

P.C. Ray, a noted chemist, provided a splendid example of the scientist with a social conscience. He had no family; all his life was devoted to the twin cause of science and the people. His *History of Hindu Chemistry* is an indication of India gradually discovering her scientific past. Srinivas Ramanujan came from an uneducated family in an obscure village in the south. But his inborn genius in mathematics puzzled the best mathematicians of that time. It is difficult to explain this except by the fact that a man is always a product of the moment. Otherwise how does one explain this village boy having a clear idea of the latest mathematical theories? Unfortunately, he died too early to leave any lasting legacy/ like J.C. Rose or P.O. Ray did.

Indian science was well on its way towards development early in the 20th century. This marked the renaissance of learning in India, though a belated renaissance. The ground was being prepared, while certain historic factors hastened the process. There can be no doubt that the British, though unwillingly, are to a great extent responsible for this happening. Postgraduate courses in science were started at the Calcutta University in 1913, mainly through the efforts of Sir Asutosh Mookerjee, but since the ground was ready, it did not take long to bear fruit. Within the first quarter of the present century three remarkable discoveries came out of India—thermal ionisation of Saha, Bose Statistics and Raman Effect. Apart from Saha, S.N. Bose and Raman, others who established themselves in their respective fields were J.C. Ghosh J. N. Mukherjee, Shanti Swarup Bhatnagar and Birbal Sahani, to name a few. When Raman received the Nobel Prize in 1930, it lifted Indian science to an equal level with world science. But the time coincided with India’s struggle for freedom. The best brain and intellect of the country were drawn towards the freedom movement. So science had to wait till 1947 for a more expansive phase.

Let us at this point digress a little to take account of the recent trends in world science. The pattern of growth which science in the West has been taking in recent years can be classified according to Bernal into three distinct phases. The first can be called the romantic phase. In this period science progressed and flourished round eminent personalities, such as Roentgen, Becquerel, the Curies, Rutherford, Einstein— names which became almost household words. However scientists in those days worked with very crude instruments. They could hope for no material benefit except the spiritual pleasure of getting at the truth. Science as a profession was rarely a paying one. In most cases ideas came to them in a flash and showed the way to a great discovery. The stage did not continue for a long time. The First World War intervened. It had a profound effect on the nature of scientific research in general, in view of the fact that the governments soon realised that the immense potentialities of science could be used very effectively in defence. A great deal of effort and patronage from the government changed the direction of science. From individual efforts it was suddenly transformed into government-financed projects. Along with defence research/ other theoretical branches of research were also given equal patronage. Obviously no applied research is possible without a good theoretical background. The two World Wars, in spite of their disastrous consequences, advanced the pace of scientific research to a point which would have taken many years to reach under ordinary circumstances.

The third and the present phase is a logical development from the second. Science and technology is now being oriented more and more towards the benefit of mankind. But the nature and extent of research has undergone a virtual change. The instruments are infinitely more complex and sophisticated than they ever have been; besides, they have become as expensive as to be beyond the buying capacity of individuals. Modern research is more organised team-work, the success of which depends on the effective co-ordination of individual efforts. This is indeed a long way from the romantic era when the scientist had only himself to fall back on. Now every theoretical scientist needs very expensive and giant computers. So instruments have come .to occupy a position of very great importance. However, the scientist of today enjoys greater prestige and he can hope for better material rewards than ever before.

Let us now turn to the post-Independence scene in India. The first phase of scientific research, which has been called the romantic phase, continued in India up to the forties of the present century. Whatever our scientists had achieved so far were mainly through individual efforts. There was no State patronage or backing by industry. After Independence, however, a very ambitious plan was chalked out and a national science policy was formulated. Science was given its due priority. Since modernisation began very late in this country, it was necessary to take quick steps to catch up with the advanced countries of the world. But these phases can sometimes overlap. As we shall presently see from a study of the life and works of Satyen Bose, he belonged very much to what has been termed the romantic phase of scientific research.

The National Planning Committee formed in 1940 under the chairmanship of Pandit Nehru had prepared a draft plan. Based on this plan the new national government set out to achieve its objectives. A thorough revision of the old education system was made at all levels—primary, secondary, higher secondary, graduate and postgraduate. A number of new universities were set up, and were given government grants for research. A number of national laboratories and institutions for research were also founded.

A quarter of a century has passed since then. There are certain noticeable, trends. These are:

• that we have plunged into several large-scale scientific efforts;

• that these projects are enormously expensive, hence they are government-sponsored;

• the number of research institutes has increased along with the number of universities.

All these are very hopeful signs, but the greatest hurdle which stands before us is the lag in technology. The progress of technology in India has not been in keeping with the progress in science but these two are so interdependent these days that one just cannot do without the other. Our planning in technology in the last twenty-two years again shows three distinct phases:

• setting up of industry with imported machinery arid know-how, teaching of technology, sending students abroad to receive technological training;

• the production of machinery in India with the help of imported tools;

• a total stoppage of import of foreign tools and machine tools followed by the production of indigenous tools and machinery.

Actually these stages are not very well-defined. Broadly speaking, we have just reached the starting point of the third phase. But all these details of science policy and planning were non-existent at the turn of the century when Satyendra Nath Bose was born.

2. THE FORMATIVE YEARS (1894-1914)

Satyendra Nath was born in Calcutta on the first of January, 1894, in a high caste Kayastha family with two generations of English education behind him. Both his grandfather and father held government jobs for which they had to leave their ancestral village Bara Jajuli, in the district of Nadia, about 48 km from Calcutta.

Before the emergence of Calcutta as a metropolitan city in the late 18th century, Nadia used to be the centre for cultural and intellectual activities in Bengal. The scholars of this region were well known all over India. Nadia has a tradition of good manners and chaste diction. The dialect of Nadia has come to be accepted as standard Bengali. In the 19th century Bara Jajuli was a fairly prosperous village. It still has relics of old temples and ancient buildings.

The British administrative machinery had created new job opportunities which prompted a regular influx of the so-called ‘Bhadralok’ (respectable, white-collar workers) class towards the metropolis. The Bose family clearly fell into this pattern. The Kayasthas took to English education more readily than other castes and naturally they filled up all the important services and professions. Satyendra Nath’s grandfather Ambika Charan was on a government job which took him to remote places. When he was working as an accountant in Meerut (UP), he fell seriously ill. News was sent to his family. But when his son Surendra Nath (Satyendra Nath’s father) reached Meerut it was a day too late. Ambika Charan was dead.

Ambika Charan’s family now moved from the village home to Calcutta, because Surendra Nath who had not yet finished his school had to work for a living. It was a hard time for the family, as the two sons, Surendra Nath and his younger brother, were still too young to take charge. Even though they owned a house at Calcutta in Ishwar Mill Lane, they had to live in a rented house in Jorabagan because their house had tenants who could not be persuaded to vacate. The house, incidentally, was built by Ambika Charan’s father. Even when Satyendra Nath was born, the family was still struggling to overcome the financial crisis.

Surendra Nath, a young man with ambition and initiative, soon qualified himself for the post of an accountant and joined the executive engineering department of the East India Railway. His work took him all over Assam and north Bengal. He was also connected with the Sarah Bridge construction. He married Amodini Devi, the daughter of a renowned lawyer of Alipore, Motilal Roy Choudhury. The Roy Choudhurys were *zamindars* of Gaihati and were connoisseurs of art and culture. Motilal was personally acquainted with writers like Bankim Chandra Chatterjee and Dinabandhu Mitra. One of the grandsons, Sri Anil Roy Choudhury, happens to be a reputed *sitar* player.

To understand Surendra Nath it is necessary to have some idea of the spirit of the time which moulded his personality. The 19th century witnessed a new awakening in Bengal and in India. Politically and socially a nation was making its entrance into the modern age. Various forces were responsible for this change, such as the impact of British rule, the introduction of Western education, and the growth of a new economy, which together led to the creation of a middle-class intelligentsia, sensitive to the new winds of change. The new awareness brought about its inevitable consequence—an upsurge of nationalist movement.

A significant feature of the nationalist movement in Bengal towards the end of the 19th century was the growth of what was known as the New Spirit. The spirit of self-help and emphasis on the necessity of building up Indian industries, art and culture were first evident in the annual sessions of the Hindu Mela. The trend had been developing and it reached a new stage with the Industrial Exhibition of 1896. *Swadeshi* stores were opened and campaign for *swadeshi* goods started. Surendra Nath was one of the founders of the Indian Chemical and Pharmaceutical Works which began on a very modest scale. It went into production at about the same time as Sir P.C. Ray's Bengal Chemical and Pharmaceutical Works did. Surendra Nath was a very well-read man. His readings included the works of Marx and Engels. He was open to new ideas, was a man of strong moral principles and had a generous heart. He was in every way representative of his time.

Meanwhile, a metropolitan society was slowly evolving and with it a new metropolitan culture. A new generation educated in town schools was slowly coming up with an outlook and attitude which were definitely urban. Satyendra Nath belonged to this generation.

His metropolitan upbringing shaped his character to a great extent. Particularly those special qualities which go to the making of a typical Calcuttan were strikingly evident in his case.

Bose's was an inborn talent and would have flourished under any circumstances, but it was a happy coincidence that it found a congenial atmosphere to develop. He was a gifted child. Whenever his father went out, he gave his son sums on the cemented floor of a room which was used as a store. Here young Satyen would go on writing numbers to his heart's content. It was a kind of game which kept the child out of mischief. But Satyen was also the centre of attention in the family, being the only son in a family of six daughters. Surendra Nath lived with his brother and his family, as was usual in those days. He also had four sisters.

Satyen's schooling began at the age of five. At first he was put in Normal School which was close to their Jorabagan home. It was the same Normal School where Tagore was a student for some time. Later, when the family moved to their own house at Goabagan, he had to be put in the neighbouring New Indian School. It was a good school whose principal, Khudiram Bose was noted for his radical ideas in the field of education. In the course of time, Surendra Nath became anxious to put his son into an even better school where his talents would be sharpened by keener competition. And so in the final year of school, Satyen was admitted to the famous Hindu School, the school with a tradition behind it.

The history of this school goes back to 1817, to the efforts of David Hare and Raja Ram Mohun Roy who spearheaded the movement which led to the foundation of the Hindu College, the oldest college established in India for imparting English education.

It was the success of the Hindu college which proved the strength and extent of the popular demand for English education and helped in moulding the educational policy of the government which till then had done little to encourage modern education in India. In 1953 the government decided to take over the Hindu College under its direct management and the senior department of the college was then renamed the Presidency College. The junior department survived in the Hindu School.[6]

During the first decade of the present century, Hindu School and Hare School were two schools of distinction. When Satyendra Nath was a student, the rival Hare School had Ishan Ghose, the famous Pali scholar as its headmaster, of whom the Hare boys were justly proud. Hindu School had Rasamaya Mitra, who was not as great a scholar as Ghose, but an able headmaster and a devoted teacher. He had written a book on English composition, grammar and translation for the students. Hindu School had not only an excellent headmaster but other equally inspiring teachers. The Bengali teacher Sara t Chandra Shastri was primarily responsible for creating in the students a passion for Bengali language and literature. In the first class (which was the final class in school) the boys had to study English, Bengali, history, geography, mathematics and Sanskrit. The prescribed text-books were Gauri Sankar Dey's *Arithmetic* and *Algebra, Geometry* by Hall and Stevens, *World Geography* by Dudley Stamp, Adhar Mukherjee's *History of India* (the first chapter opened with the observation: 'India is the epitome of the world'), and Row and Webb's *Grammar.* In languages the prescribed books were university selections. As supplementary books they read Kipling's *Jungle Stories* and in Bengali *Sitar Vanabas* by Vidyasagar, *Kadambari and* Jogen Bose's life of Michael Madhusudan,

Satyendra Nath, in spite of weak eyes since childhood, was a voracious reader. His favourite poets were Tennyson and Tagore. His school friend, Girijapati Bhattacharya tells us that he was particularly fond of *In Memoriam* and could recite the entire poem. He also knew Kalidasa's *Meghdoot* by heart.

The mathematics teacher, Upendranath Bakshi was a legend of the Hindu School. He was quick to recognise the signs of genius in the boy. Once he gave Satyen 110 marks out of 100 in a test examination, his argument being that Satyen did not skip any of the alternatives. Bakshi used to boast that one day Satyen would be a great mathematician, like Laplace or Cauchy.

It is the mark of a good teacher to recognise talent and Bakshi was convinced that this boy, as far as his mathematical talent was concerned, was quite out of the ordinary. Apart from working out all the sums from prescribed textbooks, Satyen would solve similar sums from subsidiary text-books. Moreover, it was his practice to try them by diverse methods. The genius which later manifested itself as a wizard in numbers was blossoming during this period. Satyendra Nath was due to sit for his entrance examination in 1908. But unfortunately he was down with an attack of chicken-pox just two days before the examination. As a result he lost one year. He had to remain in Hindu School for one more year. But he took this opportunity to study advanced mathematics and Sanskrit classics.

In the entrance examination of 1909 Satyen stood fifth in order of merit. The boy who stood first was Chandidas Bhattacharya of Hindu School, who unfortunately died the following year. Satyen had also done very well in Sanskrit, history and geography, but he opted for the science course. He joined the intermediate science classes at the Presidency College, Calcutta.

1909 was a significant year in the scientific history of Bengal, both in physics and in chemistry. As Acharya P.C Ray was to remark in his autobiography:

In that memorable year some members of the brilliant group of students who were afterwards destined to play a conspicuous part in notable research took their admission in the Presidency College.

The brightest among them was S.N. Bose. Then there were others like Jnan Chandra Ghosh, Jnanendra Nath Mukherjee, Nikhil Ranjan Sen, Pulin Behari Sarkar, Manik Lal Dey, Sailendra Nath Ghose and Amaresh Chakraborty. Meghnad Saha joined the Presidency College two years later. It was one of the most brilliant groups at the Presidency College, whose combined academic record remains unparalleled in the history of the Calcutta University. It may also be noted that P.C. Mahalanobis, Nilratan Dhar and S.K. Mitra were a few years senior to this group. Apart from setting the norm of scientific research, these people have been chiefly responsible for moulding the shape of future science policy and scientific research in India.

Apart from their individual academic brilliance, this group was united by some common ideals. They were all nationalists at heart, some of them were indirectly connected with the freedom fighters; a few had closer links.

1905, the year of Einstein's special theory of relativity, was also a crucial year in the political history of India. Satyen was then a boy of eleven, still in school, when Lord Curzon announced the partition of Bengal. Political thought and movement had reached a stage in Bengal which could no longer be tolerated by a reactionary imperialist like Lord Curzon. So he now planned to play his trump card and break the backbone of the movement. His first plan of operation was to crush the nationalist solidarity in Bengal. For some time a partition of Bengal on grounds of administrative necessity was being considered. Curzon equated the Congress with the Calcutta leaders and viewed the metropolis as 'the centre of successful intrigue'. By dividing the Bengali-speaking population he expected to weaken their influence on the national movement. The divisions of Dacca, Chittagong and Rajshahi were to be taken out and joined to Assam. A new province called East Bengal and Assam would thus be formed with Dacca as capital. Contrary to the wishes of the people, he decided to split the province of Bengal in half, thus sparking off an already smouldering discontent. The educated Bengali rose up in protest, a wave of new patriotism swept over Bengal. Satyen and his generation grew into manhood in this atmosphere of inspired idealism.

The most potent influence in the formative years of young Satyen's life was the *swadeshi* movement, wrote his boyhood friend, Nirendranath Roy. The movement was given the semblance of a ritual by Tagore and the Tagore family. The day of Rakshabandhan (Rakhi-Bandhan) was chosen as a day of purification when every home would go without cooking. As a token of protest, a bonfire of British mil 1-made cloth would be made on every street corner. Every family would contribute its share of British goods, especially clothes and the young boys would have a merry time going from house to house pouring water "on the cooking stoves and collecting clothes for burning. This became a yearly ritual. The idea was that people were not doing it to spite the British but doing it as part of their duty—a part of *dharma.* Boycott of British goods was also in full swing. At the same time, there were secret societies formed with the objective of training the youth of the country physically and morally for Independence. Anusilan Samity was one of these societies which gave lessons in handling weapons and physical culture. Satyen along with his friend Jivantara Halder was involved to some extent in these secret activities. However, Satyen took a more active part in running the night school for the children of working class people. This was known as the Working Men's Institute. The Institute held classes in the Keshab Academy in Maniktola Street. It was founded by an associate of Sri Aurobindo Ghosh and Barin Ghosh. D.N. Mallik, the famous professor of mathematics of the Presidency College, was the president of this school, even though he had no direct contact with the revolutionaries. The young students who conducted the classes were Nirendranath Roy, Satyen Bose, Girijapati Bhattacharyya, Pashupati Bhattacharyya and Harish Sinha. These classes continued till they passed their B.Sc. examinations.

However, Satyen was not as directly affected by the 1905 movement as his future friend, Meghnad. Meghnad had come to Dacca Collegiate School from his village school, depending on a stipend, when the movement swept through Bengal. The Governor, Sir Bamfylde Fuller, was visiting their school. The senior students staged a boycott. All those who participated in the boycott were expelled, including Meghnad Saha and Nikhil Ranjan Sen. Meghnad lost his stipend and free studentship and was finally taken by another private school. The *swadeshi* movement affected the lives of every student in some way or the other. It left a deep and long-lasting influence so that very few of thecontemporaries went for government service. Instead they took a vow to devote their lives to the cause of science through which they would serve the country.

Presidency College in those years could also boast of a galaxy of stars on its teaching staff. Apart from Sir P.C. Ray in chemistry, Sir J.C. Bose and Surendranath Maitra in physics, there were also men like D.N. Mallick, Shyamadas Mukherjee and C.E. Cullis in the Mathematics Department. In the English Department were Manmohan Ghosh (the younger brother of Sri Aurobindo), Mr Percival and P.C. Ghose, son of the famous headmaster, Ishan Ghose.

Satyen had physiology as fourth subject in the I.Sc. class. The subject was taught by Professor Subodh Mahalanobis, the uncle of P.C. Mahalanobis. In the final examination Satyen got 100 marks out of 100 in this subject. Since school, Satyen was a very mischievous child. Contrary to the popular image of the serious student he was notorious for teasing the teachers in class. But none of them seemed to mind his innocent pranks because they were hardly ever offensive. Sir P.C. Ray did not fail to notice this as he took their first chemistry class. During his next lecture Satyen was asked to come down from the gallery and sit on a stool, right beside his table.

In his English paper in the intermediate test Satyen got the highest marks. Professor Percival who was due to retire that year had added an extra ten marks on his answer paper, remarking, "This boy has originality." He was so impressed with Satyen that he called for him to give his blessings before he left for England.

Satyen had weak eyes since his childhood, which prevented his becoming actively involved in any kind of game. He rarely displayed any interest in sports.

In the intermediate science examination in 1911, Satyendra Nath stood first in order of merit. Meghnad Saha who appeared from Dacca College secured the second position and

Nikhil Ranjan Sen, the third. Meghnad Saha came to Calcutta and joined the B.Sc. classes in the Presidency College in 1911.

In the B.Sc. class Satyen, Nikhil Ranjan and Meghnad opted for mixed mathematics, while Jna'n Chosh and Jnan Mukherjee opted for chemistry. Sailendra Dutta studied physics. In the B.Sc. (Hons.) examination in 1913 Satyendra Math stood first, Meghnad second and Nikhil Ranjan third, all in the first class. The same result was repeated in the M.Sc. mixed mathematics examination in 1915. Satyendra Nath stood first and Meghnad Saha stood second; Nikhil Ranjan did not appear for the examination in 1915. In the university the 'boy with the-14 spectacles' was already a legend, the boy who had never stood second in any university examination. But unlike many good students, he devoted a good deal of his own time in coaching his classmates and junior friends. They met regularly at the home of Harish Sinha. The friends who benefited most from his help were Nirendranath Roy and Dilip Kumar Ray (of Pondicherry). During this time he had also became actively associated with the *Sabuj Patra* group who met in the house of Pramatha Chaudhury. The details about this association have been given in a separate chapter.

One incident which happened during Satyen's Presidency College days is worth mentioning. In 1914, just before the First World War, a student of the second year class was insulted by the physics teacher, Professor Harrison. As the news spread, the students abstained from their classes. Satyen spoke in a students' meeting, asking fellow-students not to bear with such insults. At the end of the day Professor Harrison had to apologise and thus the matter ended. But this was a prelude to the famous Subhas Bose-Oaten episode which took place in 1919. Satyen was out of college by then. "Professor Bose is my junior by about four years," wrote Suniti Kumar Chatterji in 1964. "It had been my great privilege to know him rather intimately from his college days. I had just taken my M.A. degree in 1913, and I was at that time attending German classes in our university. As far as I can remember I had in those classes, as fellow-students both Meghnad Saha and Satyendra Math Bose. I knew them as brilliant students of science and as a mere student of literature and linguistics, I had a very wholesome respect for those of our fellow-students, senior or junior, and who were passing through an exacting discipline of physical science." Satyen had a natural aptitude for languages. He started taking lessons in French from a French lady as early as in 1908. In 1914 at the age of twenty, while still a student of the M.Sc. class, Satyen was married to Ushabati, the only child of Jogindra Nath Ghosh, a renowned medical practitioner of Kombulia tola near Shyambazar, Calcutta. According to the social ethics of those days, Satyen had no say in the choice of bride. 'It was left entirely to his mother, as his father's work kept himaway fromCalcuttamost of the time. Young Satyen in spite of his reading of Ibsen did not raise a voice of protest against this procedure because he was much too devoted to his parents. He did however object to the one social evil which was the burning problem in those days—the dowry system. Satyen agreed to marry the girl of his mother's choice on the condition that they would not demand any cash or dowry from the girl's family. This was agreed to. As a matter of fact Satyendra Nath laid another condition. He wanted the bride's father to be told that two hundred of his close friends would accompany the groom and necessary arrangements for their reception should be made. This only shows how popular Satyen was among his friends.

It was just a coincidence, but even before the marriage negotiations started, Dr Jogindra Nath Ghosh had visited the Bose household to treat a member of the family. This was related to the biographers by Mrs Bose herself. The handsome young man who showed him the way by holding the light and to whom he took an instant liking was to be his future son-in-law.

Ushabati was eleven when she was married. She had gone to school, first at the Nivedita School, then at the Ma-hakali Pathshala. The enthusiastic husband started giving her lessons in English. Later on, when it came to the marriage of his own daughters, Satyendra Nath saw to it that they passed their Bachelor's degree before they got married.

3. EARLY CAREER (1915-1920)

Satyendra Nath, a bright star of the Calcutta University, was now ready for a career. But what were the prospects open before him? In those days jobs were difficult to get. While looking for a job, Satyendra Nath gave private tuition to a young prince of the Gauripur estate, Pramathesh Barua, who later became the renowned film-director and actor. Earlier he had applied for two jobs but was not selected on grounds of being overqualified.

About this time the opportunity he was looking for presented itself. It came from Sir Asutosh Mookerjee, who integrated teaching and research at the university level for the first time in India. The *swadeshi* movement had already created in the people an urge for economic self-reliance, for new industries, trade and commerce. So far, the system of education did not provide the necessary training for scientific and technical personnel needed for the purpose.

But things changed with Asutosh. Before 1908 just a few colleges had science in their curriculum. In 1916 Asutosh made a plan for converting the university from an affiliating body to a teaching organisation. He also introduced postgraduate teaching. So he immediately needed a band of teachers to set up the laboratories and to start classes. The donations of Sir Tarak Nath Palit and Sir Rash Behari Ghose enabled him to lay the foundations of the University College of Science at 92 Upper Circular Road. The road was later named after Acharya Prafulla Chandra Ray. However, the biological sciences were housed at the residential building of Sir Tarak Nath Palit at Ballygunj Circular Road.

Satyendra Nath and Meghnad were both appointed lecturers in the Applied Mathematics Department in 1916. But neither of them could get on well with the then Ghosh professor of applied mathematics, Dr Ganesh Prasad. With Sir Asutosh's permission both of them were transferred to the Department of Physics, even though their formal training in physics was up to the B.Sc. level.

The Physics Department was already facing a crisis. While Sir P.C. Ray was himself organising the Chemistry Department, the Department of Physics was virtually without a head. Dr D.M. Bose, who was appointed the Ghosh professor of physics, was sent to Germany for advanced training. But the World War intervened and he was interned there. The task of organising the department was therefore left to young people like Satyen Bose, Meghnad Saha, S.K. Mitra, Sailendra Nath Ghose (who later had to leave the country for his extreme political affiliations), Phanindra Nath Ghosh and others. The young men did such a good job that when C.V. Raman joined as Palit professor of physics, the department was running itself.

Saha and Bose began to study modern physics on their own. They took German language lessons (where their classmate was Suniti Chatterjee) and discussed the new concepts in the subject which were undergoing swift changes. The quantum theory, the theory of relativity, and Bohr's theory of the hydrogen spectrum heralded a new age in physics. The older teachers of physics in Calcutta had not kept pace with these revolutionary trends, but confined themselves to classical physics as embodied in the M.Sc. syllabus. The team selected by Sir Asutosh broke the old Barriers and made the M.Sc. course a really progressive one.

It must be remembered that Saha and Bose were entirely self-taught in physics. The hurdles which they had to overcome were formidable. For one thing, they had no access to modern books. In those days Indian participation in international conferences and seminars was unthinkable. World War I was raging. While the young scientists were frantically looking for books and periodicals, they came upon an unexpected source.

In the Bengal Engineering College at Sibpur, Howrah, there was a German professor, named P. J. Bruhl, who had an interesting career. He did his doctorate in botany, but for health reasons he was forbidden to expose himself to out-door activities. So he switched over to physics. The reason for which he came to India was its warm climate, which he needed. It was a stroke of good luck for Bose and Saha that Bruhl was an inspiring and sympathetic friend. Bruhl supplied them all the advanced text-books in physics, but they were in German. Some of these books were written by Max Planck. Saha had already learnt German and Bose had started taking lessons in German. For convenience the two friends divided the subjects. Saha was to specialise in thermodynamics and statistical mechanics and Bose on the theories of electromagnetism and relativity. Both of them were destined to make fundamental contributions in the respective fields of their choice—Saha in his theory of thermal ionisation which explained the physical conditions in stellar bodies and which is considered one of the ten major discoveries in astrophysics, and Bose for his Bose Statistics which is still playing a very vital role in the study of modern physics, in the field of elementary particles and in the field of super conductivity.

Bose's first research paper on The Influence of the Finite Volume of Molecules on the Equation of State' was written jointly with Meghnad Saha. The physical behaviour of actual gases differs from the ideal gases which are so named because some ideal properties are hypothetically assigned to them for the sake of simplicity. This paper was published in the *Philosophical Magazine* of London in 1918.

His next two papers were published in the *'Bulletin* of the Calcutta Mathematical Society in 1919 and 1920. They were on 'The Stress Equations of Equilibrium' and 'The Horpol Hode'. Both these papers were based purely on mathematical problems. In 1920 Bose's paper on 'The deduction of Rydberg's Law from the Quantum Theory of Spectral Emission' was published in the *Philosophical Magazine.* It becomes evident from these papers that his command over mathematics was not only extraordinary but also that he wanted to probe the fundamentals.

Around that time Bose, in collaboration with Saha, had translated Einstein's papers on the theory of relativity from the original German. The book was published by the

Calcutta University. Incidentally, it happens to be the first English version of those celebrated German papers.

Things turned out more favourably for Saha, who submitted his Premchand Roychand studentship in 1919, his D.Sc. thesis in the same year and left for Europe in the middle of 1920 on the support of the Ghose Travelling fellowship. Bose could not establish a rapport with Sir Asutosh. On several occasions he differed with him, once concerning a particular mathematics question paper set by Sir Asutosh himself. In 1918 the war was over and D.M. Bose returned from Germany. Meanwhile Sir Asutosh had picked up another talent, C.V. Raman, from the Finance Department of the Government of India, who was conducting research on an honorary basis at the Indian Association for the Cultivation of Science, and appointed him the Palit professor of physics in 1914. Prof. Raman joined the post in 1917. Meanwhile, Bose was looking for a better opportunity elsewhere. At that time a new university was being formed at Dacca and the authorities were looking for suitable teachers. Bose was offered a readership. When Asutosh came to know of this, he expressed his willingness to increase Bose's salary. But Bose had already given his word to accept the appointment at Dacca. He did not go back on his word. To quote Dr D.M. Bose:

During 1920s the situation in Physics Department of the Science College was becoming rather uncomfortable; there were too many able scientists crowding together who were provided with inadequate laboratory accommodations, technical resources and apparatus; consequently a certain amount of heat was generated. The situation became somewhat eased by the migration of some of the physicists to other universities, by the gradual expansion of accommodation and resources. The first physicist to migrate was Satyendra Nath Bose.

4. THE YOUNG INTELLECTUALS

Satyendra Nath did most of his studying at night, by the light of an earthen lamp. During the day he was seldom alone, for he adored the company of good friends. The friends he chose were certainly the pick of his generation.

By 1911 the house of the Bhattacharjee brothers, Pashupati and Girija, at Hiralal Mitra Street had become almost like a second home to him. The Bhattacharjees were a cultured family, had a fairly large collection of books and were music-lovers. It was here that Satyendra Nath received his first training in music and his first musical instrument was an *esraj*. Pashupati could sing very well. On the *esraj* Satyendra Nath would compose various *ragas* by permutation and combination of notes, Pashupati supplying the words; thus they had a very creative time. The evening progressed; they sat on the terrace discussing books, while the mother sent them refreshments, *puri* and *halva.*

As a matter of fact Satyendra Nath spent more time in this house than in his own home, and there is reason to believe that the cultural atmosphere of this household influenced his mental make-up to a great extent. With his characteristic flair for acquiring gifted friends, he soon collected around him men like Niren Roy, Harish Singha, Harit Krishna Deb and Haripada Maiti. Jamini Ray was a friend of Pashupati and lived in the neighbourhood of Bagbazar. He too was a regular visitor. Then there were others, like Puma Chandra Sen, one of Satyendra Nath's class-fellows who became a deputy magistrate later. In this house was another interesting man of their age, Bhupal Bhusan Bhattacharjee.

Though not directly related to the Bhattacharjees, he was almost like a member of the family. Bhupal Bhusan had a natural gift for rhythm and he made various experiments with rhyme. In those days Tagore was ma king revolutionary experiments in poetic rhythm. So far the Bengali verse rhythm did not follow the Sanskrit method of double stress for combined letters *(yukta varna).* In Bengali verse a *yukta varna* was considered as one *maim.* Tagore was the first to break it up and his efforts were being enthusiastically welcomed by the young versifiers. Lines such as *'Pancha sharey bhasma koray koracho eki sanyashi visma maye diyecho tare charaye* were very popular. Pashupati, who later became a close friend of Tagore, also tried his hand at writing. He wrote an appreciation of one of Tagore's short stories called *Megh O Roudra* (Cloud and Sun). He gave it to Satyendra Nath. It must have inspired the young Satyen considerably, for within a couple of days he proposed that they bring out a hand-written journal. Satyen was to be the editor. It was to be called *Manisha* (Intellect). It came out when he was in the third year. One of the stories written by the editor was about his experiences in the jungles of Assam where his father lived, and which he used to visit during his holidays. The treatment showed considerable skill, but the account remained incomplete as the journal died after several issues. Unfortunately none of the copies are available now, but from the written account of some of the contributors; it seems there was nothing amateurish about the venture.

Another of their favourite meeting grounds was Cornwal-lis Square, popularly known as 'Hedua'. It has now been renamed Azad Hind Bagh. After class they used to spend hours here. Harit Krishna sang to them oneTagoresong after another. Cornwallis Square in those days did not have a swimming club. The place was much less crowded. Sixty years later, on the eightieth birthday of Satyendra Nath, All India Radio, Calcutta, presented a programme in his honour which included as a surprise his favourite songs by which Harit Krishna Deb used to entertain the young Bose in their student days.

The Bengali's inordinate love for small talk is well-known and Satyendra Nath had cultivated this habit to perfection. To people not used to this way of life it may seem an exercise in futility/ but in proper perspective it can also be intellectually stimulating. The open-air meetings after class hours were not enough. The young people also met in the house of Harit Krishna, whose father Asim Krishna was a generous host. He bought his son an organ because his friends were keen on hearing him sing. To this haunt came many gifted people like Pramatha Chaudhury, Amritlal Basu and others.

Pramatha Chaudhury, who wrote under the pen name of Birbal, had married into the Tagore family. His wife was Indira Devi Chaudhurani, a remarkably gifted woman, and the favourite niece of Tagore. A lawyer by training, Chaudhury was a well-read man, and a connoisseur of music and French literature. He brought out a journal called *Sabuj Patra* (Green Leaves) and a powerful group of writers with a cosmopolitan outlook grew round it. It was the age of chaste Bengali; the spoken language was not considered a suitable medium for literary expression. To Chaudhury goes the credit of elevating the status of the spoken language. His style was witty, intelligent and sophisticated; it was altogether a novel thing in Bengali. Even Tagore was to a certain extent influenced by his style of writing.

From the informal friendly meetings which were more or less like family gatherings/ Satyen Bose was inevitably attracted to these more purposeful gatherings. For the *Sabuj Patra* group he was a valuable acquisition. But even though Bose participated in all their discussions, he refrained from writing a single line. It was one of the enigmas which has baffled his admirers all along. Meaningfully Pramatha Chaudhury commented on his self-imposed reticence: “Perhaps he feels more at home in front of a blackboard/’

The *Sabuj Patra* group met at Pramatha Chaudhury’s residence in Bright Street. The group included Sudhir Chandra Singh, Somenath iVIaitra, Atul Chandra Cupta, Kiransankar Ray, Dhurjati Prasad Mukhopadhyay, Dilip Kumar Ray, Manik Lal Dey, Barada Charan Gupta, Amiya Chnkraborty,SunitiKumarChatterji, NirendranathRoyand others.

It was only superficially a literary group. They discussed not only literature but philosophy, economics, history, sociology, science, politics, philology—in fact, everything under the sun. It was an assembly of the most cultured people of that generation. They talked about new publications and would get hold of outstanding new books. The biggest buyer was Pramatha Chaudhury himself. The books were circulated among the members. In a letter” to Satyendra Nath Bose, Pramatha Chaudhury had made their purpose clear:

I believe in exchange of ideas. It not only gives pleasure but can be highly illuminating. Though we all derive our ideas more or less from books, yet when the ideas are passed on they undergo some transformation, the lifeless world throbs with a new life. Written words cannot give one the pleasure one gets from conversation. That is why I am so fond of chattering myself and hearing others speaks. Besides, I wish to make the well-read among us commit themselves in writing. Our literature is sadly lacking in criticism and scholarly writing. For everything one cannot and should not depend on stalwarts like Rabindranath and Bankimchandra; besides, great minds like them are always rare. We have to manage with the second best. That is where we come in. I consider it the duty of educated people like us to make our fellow-countrymen share in our knowledge.

Bose kept up his active association with this group till he migrated to Dacca. But his long sojourn did not put an end to the relationship. Satyendra Nath was also a frequent visitor to the literary meetings known as ‘Bichitra’ which Tagore conducted, but here his role was more of a silent listener than that of an active participant.

Later, a quarterly called *Parichay* was more successful in getting Bose involved in writing. This journal was in the direct tradition of *Sabuj Patra*—modern, liberal and intellectual. *Sabuj Patra* was somewhat traditional in its outlook; *Parichay* was more European in spirit. In the very first issue Bose wrote an article on ‘Crisis in Science’; his second article was on Einstein. *Parichay* came out as a quarterly for five years, and then it became a monthly. Like the earlier journal, the *Parichay* group met every week in the home of the editor Sudhindra Nath Dutta, who was a good friend of Bose. When he was in Calcutta on holidays, Bose would come and join the group and would not mind walking from one end of the city to the other to be present at these meetings.

It seems that Satyendra Nath took to these cultural exchanges as a fish takes to water. Wherever he went he seemed to collect a group of talented people around him. In Dacca they had formed a club ‘Baro Jana’—’The Twelve’. The twelve members were Ramesh

Chandra Majumdar, Charu Bandopadhyay, Mahmood Hussain, Arthur Hughes, Punyendranath Majumdar, Satish Ranjan Khastgir, Lalitmohan Chottopadhyay, Artanda Sankar Ray, Sarbanisahay Guha Sarkar, and Hirendra Lal Dey. The historian Sushobhan Sarkar, who was Bose's next-door neighbour and friend, had left Dacca when the club was formed.

5. FIRST VISIT TO EUROPE (1921-1926)

The Dacca University was founded in 1921 with Philip Hartog as the first Vice-Chancellor. Bose was one of the young and brilliant men Hartog brought to Dacca to work in the Physics Department. The professor of physics was one Dr W. A. Jenkins, 'a sound but not so brilliant Englishman'.[12] Jenkins however could recognise brilliance and encouraged it. Earlier, Sir Philip had met Dr J.C. Ghosh in London, was impressed by his work and persuaded him to come and join Dacca University as the professor of chemistry.

A month after joining Dacca University, Bose in a letter written to his friend Saha commented on the state of affairs there:

...It has been well over a month since I moved to your part of the country. Work has not yet started. Your Dacca College had quite a few things but due to utter neglect they are in a bad way. Perhaps I need not elaborate. On the table of the *sahibs* are scattered lots of Nicol prisms, lens and eye-pieces. It would require a lot of research to determine which one belongs to which apparatus. We do suffer from lack of journals here, but the authorities of the new university have promised to place order for some of them along with their back numbers. Talk is going on about having a separate science library.

Into this young centre of learning, where libraries were yet to be furnished with the latest journals, came the alert and agile Satyendra Nath with his mind full of the latest discoveries in modern physics. The news of such happenings had already reached Calcutta. D.M. Bose had returned from Germany in 1919 after long internment during World War I. It was he who presented Satyendra Nath a copy of Max Planck's *Thermodynamik und Warmestrahlung.* Max Planck, the German physicist, was the main architect who-ushered in the age of modern physics. He founded his quantum theory in 1900 which states that energy is released in the form of *quanta,* that is, in packets rather than in a continuous manner. He introduced his famous formula E = hv. Bose had read Planck's work on the distribution of energy from a black body based on this new theory. Satyendra Nath had always been a perfectionist and would not accept any ad hoc assumption while working out a theory. So he was not happy with Planck's derivation which had such ad hoc assumptions.

Three years later, in 1924, the paper which won him fame overnight, 'Planck's Law and Light Quantum Hypothesis' was published in the German scientific journal *Zeitschrift fur Physik.* Actually Professor Bose had communicated this paper to the *Philosophical Magazine* for publication. He had also sent a copy of it to Einstein asking for his comment. Here is what Bose wrote in his first letter to Einstein:

Physics Department

Dacca University

Dated the 4th June, 1924

Respected Sir,

I have ventured to send you the accompanying article for your perusal and opinion. I am anxious to know what you think of it. You will see that I have tried to deduce the coefficient piv^2/c^3 in Planck's laws, independent of the classical electrodynamics, only assuming that the ultimate elementary regions in the phase space had the content h^3. I do not know sufficient German to translate the paper. If you think the paper worth publication, I shall be grateful if you arrange for its publication in *Zeitschrift fur Physik.* Though a complete stranger to you, I do not feel any hesitation in making such a request. Because we are all your pupils though profiting only by your teachings through your writings. I do not know whether you still remember that somebody from Calcutta asked your permission to translate your papers on relativity in English. You acceded to the request. The book has since been published. I was the one who translated your paper 'Generalised Relativity'.

Yours faithfully,

S.N. Bose

Very soon the paper was published, translated by Einstein, and with the following translator's remark:

In my opinion Bose's derivation of the Planck formula signifies an important development. The method considered here yields also the quantum theory of ideal gases which I shall discuss elsewhere.

All this is part of history now. Ever since then, the name of Einstein has been linked with this work and his role magnified to the extent that the real nature of the contribution made by a young scientist making his first entry into international science is somewhat cast in the shadow. It may be relevant at this point to examine the salient features of the paper which made it a work of fundamental importance. The following is a brief and simplified account of the work. In the latter half of the 19th century, the spectral distribution of radiation emerging from a small aperture in the wall of an enclosure maintained at thermal equilibrium was measured, but the nature of the distribution could not be explained by any existing theory. At last Planck was able to provide one. Einstein further interpreted Planck's hypothesis. He suggested that the radiant energy emerges in packets or quanta. Even then Planck's formula was not entirely satisfying because he had combined classical electrodynamics with an ad hoc hypothesis. Attempts were made by others to improve upon this. It was the unsatisfactory nature of Planck's formula which prompted Bose to work on it on his own, and he finally succeeded in providing an entirely self-contained derivation of the Planck formula. But what Bose actually did was more than derive a formula. He introduced new concepts in physics, later named as Bose Statistics. Einstein understood the significance of it and immediately applied it to the case of ideal gas and found a new relation known as Bose-Einstein Statistics.

Purnansu Kumar Roy, a student and close associate of Professor Bose, gives a detailed account of how that paper came to be written:

When Bose left for Dacca his acquaintance with statistical mechanics and gas theories was rather superficial compared to his familiarity with the theories of electro-magnetism and relativity? It was sometime after March 1924 that Bose had a meeting with Saha when, during the course of the discussion, Saha referred to the papers by Pauli (1923) and Einstein and Ehrenfest (1923) published in the recent issues of *Zeitschrift fur Physik.* (In fact Saha is supposed to have left the papers with Bose.) He complained about some strange relation in the Pauli paper and asked Bose to examine it. What is the 'strange' relation that Saha had talked about? In the first half of 1923 the works of Compton and Debye on the X-ray scattering of an electron considerably agitated the minds of the then leading physicists. It was, however, young Pauli who took up the problem of finding a quantum theoretical mechanism for the interaction of radiation with free electrons. He subjected the interaction to the requirement that electrons with the Maxwellian distribution of velocities were in equilibrium with radiation; it was, of course, assumed that the spectral distribution of radiation obeyed Planck's law. Pauli thus obtained an expression for the probability of a Compton interaction between photon and an electron. The expression, however, consisted of two parts. One part depended on the radiation density of the primary frequency alone, while the other depended also on the radiation density of the frequency which arose through the Compton process. It was this second term which was intriguing and puzzling from the philosophical point of view: the existence of this term sought to imply that the probability of something happening depended on something that had yet to happen! The paper by Einstein and Ehrenfest was a generalisation of Pauli's work.

It is to this 'crazy idea'—is how Bose often referred to the work of Pauli—that Saha drew the attention of Bose. It is thus young Bose was inducted into the brilliant papers of Debye (1916) and Einstein (1917). It is thus he was led into the evergreen wonderland of radiation and statistical physics.

In his derivation of the Planck's radiation formula from quantum statistics, Professor Bose treated the photon quantum as a particle and obtained an expression for the number cells in phase space occupied by the radiation which was one-half of that obtained by Planck. He introduced a factor 2 to take care of the polarisation of the photon. In the paper he did not discuss in detail how the factor 2 arises. Polarisation was usually attributed to the wave nature of light radiation and not to particles. However, a few years later in 1931, C.V. Raman and S. Vagavantam in their paper, 'Experimental Determination of the Spin of the Photon' wrote:

We understand from a personal communication by Prof. Bose that he envisaged the possibility of the quantum possessing energy hv and linear momentum hv/C, also an intrinsic spin or angular momentum $\pm h/2\lambda$ round an axis parallel to the direction of motion. The weight factor 2 thus arises from the possibility of the spin of the quantum being either right-handed or left-handed, corresponding to the two alternative signs of the angular momentum.

Within a very short time Bose was ready with another paper named 'Thermal Equilibrium in Radiation Field in Presence of Matter'. Like the previous paper, he sent it to Einstein. This paper was also translated by Einstein and published in *Zeitschrift fur Physik* in 1924, but here, at the end of the paper, Einstein remarked that he did not agree with Bose's hypothesis and gave his reasons for doing so.

It is very surprising that these papers were first published in English translation in 1974 simultaneously in the April issue of the *Physics Teacher* (journal of the Indian Physical Society) and the June issue of *Physics News* (bulletin of the Indian Physics Association).

Meanwhile, Bose had applied for study leave to go abroad. The Dacca University was passing through a financial crisis at that time. They offered a better salary grade to the teaching staff than other universities. But in the first few years the university funds got depleted in constructing buildings. And so the governing body proposed to reduce the scales of pay. Satyendra Nath and others did not agree. Finally a compromise was reached. The revised pay scale was accepted on the condition that the university would bear his expenses of travel and stay in Europe for two years.

Einstein's comments on his paper provided him the final passport to go to Europe for a period of two years. It was a handwritten letter, a postcard in which Einstein had expressed his admiration for the paper, adding that he considered it to be a major contribution. So if the authorities were reluctant to grant study leave earlier, they could not refuse now. The postcard also helped him in securing a visa very promptly from the German consulate in Calcutta.

He sailed from Bombay and arrived in Paris sometime in October 1924. He was a lit tie apprehensive about where he was going to stay or how he would adjust himself to his new surroundings. But as soon as he reached Paris, all such uncertainties were removed, for he met Probodh Chandra Bagchi who was doing his research under Professor Sylvain Levi, the famous French indologist.

Bagchi was then in his mid-twenties, Bose was about twenty-nine. To find someone of his own age and from his own country was reassuring. Bagchi turned out to be more than helpful. He took Bose to Levi, introduced him to the famous French physicist Paul Langevin. Langevin was a student of Pierre Curie and also the head of the Municipal School where radium was discovered.

In Paris Bose stayed at 17 Rue-du-Sommerand, a building which housed the Indian Students' Association of which Bagchi was the secretary. This association gave refuge to the students involved in the nationalist movement. The association had branches in various European cities, but its headquarters was Paris.

Even though indology was not Bose's field of interest, he was greatly attracted towards Bagchi, and it was the beginning of a lifelong friendship. Incidentally, Bose succeeded Bagchi as the Vice-Chancellor of Viswabharati in 1956, after the letter's death.

Bose's old friend, Girijapati Bhattacharya was already in Paris, a few weeks before Bose arrived. He had accompanied Rabindranath Tagore to Paris. The meeting was a pleasant surprise for both friends.

Bose was anxious to meet Einstein. He wrote to him from Paris. Quoted below is part of the text of that letter:

Dear Master,

My heartfelt gratitude for taking the trouble of translating the paper yourself and publishing it. I just saw it in print before I left India. I have sent you about the middle of

June a second paper entitled ‘Thermal Equilibrium in Radiation Field in Presence of Matter’.

I am rather anxious to know your opinion about it as I think it to be rather important. I don’t know whether it will be possible to have this paper published in *Zeitschrift fur Physik.*

I have been granted study leave by my university for two years. I have arrived just a week ago in Paris. I don’t know whether it will be possible for me to work under you in Germany. I shall be glad if you grant me the permission to work under you, for it will mean for me the realisation of a long cherished hope...

The paper was published later that year, but Einstein differed with the author’s conclusions this time.

While in Paris, Bose explored the possibility of working at the laboratory of Madame Curie: the idea was suggested to him by Langevin. He met Madame Curie with a letter of introduction from Langevin. Doors opened easily wherever he went. Madame Curie was more than pleased to receive him. Bose’s work had already been noticed; moreover, Langevin’s letter was a double passport. Madame Curie agreed to have Bose work with her, but since she had faced some difficulty with foreign students before, she spoke at some length about the necessity of learning the French language. She suggested that Bose should learn French first and come to her in about four months’ time, when he would be able to communicate in French. She took it for granted that this young Indian did not know French, She did not give him a chance to say that his knowledge of French was more than adequate. In fact Bose had spent years in learning French but for some reason he kept quiet. After five months, Bose went back to Paris and worked in the Radium Institute for some time. But it was characteristic of Bose that his interest dispersed over a wide variety of subjects. In Paris he was drawn towards X-ray crystal structure analysis. In France, Bose was introduced to the famous de Broglie brothers who were doing original researches in X-ray crystallography. He was also invited to stay at the de Broglie estate in the country, where his friendly behaviour endeared him to his hosts. Bose made friends easily and during his first visit to Europe established lasting friendships with many European scientists.

Bose’s experience in X-ray crystallography later was put to good use when he went back to Dacca in 1926. He developed a well equipped X-ray crystallographic laboratory at the Dacca University.

After spending one year in France a networking with the luminaries of modern physics, Bose left for Berlin. On October 8, 1925, he sent a message to Einstein seeking an appointment. They could not meet immediately afterwards, for Einstein had been away from Berlin. When he returned, Bose had a meeting with him. He spent one year attending seminars, colloquiums, studying and meeting people.

During his stay in Berlin, Bose came in contact with such towering figures of the new science as Fritz Haber, Otto Hahn, Lise Meitner, Walter Bothe, Hans Geiger, Peter Debye, von Laue, Wolfgang Pauli, Werner Heisenberg, etc., many of whom were to receive the Nobel Prize. They were the people who gave a new meaning to the German tradition of scientific scholarship. Germany, or, more correctly, Berlin was the centre of learning—which attracted scientists from all over the world. In a letter written in 1921 to

Saha and J.G Ghosh who were then in Europe, P.C. Ray advised them to spend as much time in Berlin as they could manage. “Never in your life will you get such a chance of meeting great men of science. England has only mediocre people, barring a few. Moreover they are incapable of appreciating our work because we belong to a subject race.”

In the summer of 1926, Bose returned to Dacca. From Europe he wrote every week to his family, particularly to his mother, to whom he was extremely devoted.

When he moved to Dacca in 1921, his parents stayed on in Calcutta. The house at Goabagan had at that time his uncle, aunt, their children and his widowed aunt (his father’s sister), besides the parents. Satyendra Nath’s mother often went to Dacca” for short visits, his father went less often, for he had to take care of the India Chemicals. The father and mother never went together; one of them had to stay back to look after the household.

Satyendra Nath’s first child, a daughter, Nilima was born in 1916 at Kambuliatola, in the home of Mrs Bose’s parents. With the exception of Rama, his youngest son, all his nine children were born there. Unfortunately, two of his children died very early. His second child, a son died of pneumonia at the age of one in Banaras, while his third child, a daughter, died in Dacca as the result of a domestic accident when she was only one-year old. His fourth child, a daughter, Purnima, known at home as Pacha, was born in 1922; then came Jaya in 1925.

6. STAY AT DACCA (1927-45)

When Satyendra Nath returned to Dacca from Europe in 1926, the post of the professor of physics at the Dacca University was vacant. The selection committee recommended the name of D.M. Bose as its first choice and that of S.N. Bose as its alternative choice. D.M. Bose was then the Ghose professor of physics at Calcutta. He was comfortably settled in his research work and was also in close touch with his uncle, Sir J.C Bose and his research laboratory, the Bose Institute, adjacent to the University College of Science and Technology. Since D.M. Bose did not accept the position offered to him by the Dacca University, Satyendra Nath became the professor of physics at Dacca University, where he continued till 1945.

After the sophisticated laboratories of France and Germany, his own laboratory at Dacca must have appeared to him to be quite a change. But Satyendra Nath was ready to start from scratch. Most of his time in Europe was spent visiting various laboratories to study, so that similar experiments could be done in his own country. The task he set before himself was to organise a modern laboratory, an up-to-date workshop and a suitable library—facilities essential for research work and training. He did not confine himself merely to the subject of his own specialisation, mathematical physics, but encouraged his colleagues and students to undertake experimental work also and helped them with new ideas, both in theory and in experiment. During his stay at Dacca, the Physics Department had developed special facilities for research work in X-ray spectroscopy, X-ray diffraction, magnetic properties of matter, optical spectroscopy including Raman spectra, wireless, etc. The scientists who came to Dacca University to work as colleagues were to make very important contributions later. The one name which stands out among the rest is that of K. S. Krishnan.

Dr K.S. Krishnan started his research career at the Indian Association for the Cultivation of Science, Calcutta, under Sir C.V. Raman. He collaborated with Raman in his celebrated work on the new scattering of light, later named 'Raman Scattering'. After that famous work Krishnan joined Dacca University in 1929 as a Reader in physics and stayed there till 1933. While he was at the Indian Association, Raman and Krishnan's theory of magnetic birefringence led to a method of determining the molecular magnetic anisotropy and Krishnan's interest in the subject grew. At Dacca, Krishnan got the full benefit of Satyendra Nath's encyclopaedic knowledge and had a very congenial atmosphere for developing his own line of research. He developed very accurate methods of measuring magnetic anisotropies in crystals. He and his students, B.C. Guha, S. Banerjee, N.C. Chakraborty, A. Mukherjee, A. Bose and others published a number of papers on the subject. Krishnan left in 1933 when he became the Mahendra Lal Sircar professor at the Indian Association for the Cultivation of Science. In 1942 he moved to Allahabad as the professor and head of the Physics Department there. After Independence he was the first Director of the newly established National Physical Laboratory. Krishnan was elected a fellow of the Royal Society of London in 1940. He died in 1961 at the age of 63.

Among the other physicists at Dacca was Dr Kedereswar Banerjee who joined the university as a Reader in physics in 1933 and stayed on till 1943. Dr Banerjee was a student of the Calcutta University, and had his early research training under C.V. Raman. His original work on the diffraction of X-rays by liquids was useful in the analysis of crystal structures. He visited renowned European laboratories in 1931. His stay at Dacca was beneficial both to him and to Professor S.N. Bose. The X-ray laboratory of Dacca soon became one of the finest of its kind in India. There were many research scholars in the department who made important contributions. They were R.K. Sen, Abdul Matin Chaudhuri, S. Sen, S.B. Bhattacharyya and C.R. Bose. Dr K. Banerjee later became Mahendralal Sircar professor of the Indian Association for the Cultivation of Science in 1943, professor of physics at Allahabad University in 1948, Director, Indian Association in 1959, and retired in 1965. He died in 1975 at the age of 74; Dr Banerjee has left a school of students wherever he went.

Dr Satish Ranjan Khastgir was Professor Bose's colleague at Dacca as Reader in physics from 1931 to 1945. Dr Khastgir's original interests were studies in X-rays. After coming to Dacca he chose a new line of research and started working on atmospherics, i.e. radio disturbances caused by natural causes such as lightnings, magnetic storms, etc. by means of electromagnetic wave propagation. In his memoirs, Khastgir recalls the incident which excited Satyendra Nath to publish a paper in 1938 on The Total Reflection of Electromagnetic Waves in Ionosphere. In the words of Khastgir:

Prof, Saha had once come to Dacca from Allahabad. He gave a lecture in the Physics Department. He addressed a huge gathering at the Curzon Hall. Saha spoke on those problems relating to the reflection of radio waves from the ionosphere on which he was then working. He asked his friend Bose to work out a solution for an intricate problem like this. Appleton had given three conditions for the reflection of radio waves; Saha introduced a fourth one, based on the hypotheses that there is no absorption of radio waves in the ionosphere. But Saha knew himself that the assumption was arbitrary. So he requested Prof. Bose in the open meeting to give a general solution to the reflection problem. After this lecture Satyendra Nath concentrated on the problem and finally succeeded in finding a general solution.

Dr Khastgir was to succeed Professor Bose as the professor of physics when Bose came to Calcutta. In 1948 Khastgir joined the Banaras Hindu University and in 1958 succeeded Professor Bose as Khaira professor of physics at Calcutta. After retirement from that position in 1963 he joined the Physics Department of the Bose Institute and worked for a period of five years. Professor Khastgir died in 1973 at the age of 75.

Bose used to invite eminent scientists like C.V, Raman, D.M. Bose, Meghnad Saha, Sisir Kumar Mitra and B.B. Roy as external examiners for the M.Sc. practical and viva-voce examinations. It used to be followed by long tea sessions and discussions in Bose's room. Later in the evening there would be lectures. All these helped to create an atmosphere of learning and scientific attitude. They were immensely helpful to the students.

In 1929 he delivered the presidential address of the physics and mathematics section of the Indian Science Congress. He spoke on 'Tendencies in Modern Theoretical Physics'.

In 1944 Bose became the General President of the Indian Science Congress. His presidential address on 'The Classical Determinism and the Quantum Theory' is still as thought-provoking today as it was then. He introduced the subject by saying:

Fifty years ago the belief in causality and determinism was absolute. Today physicists have gained knowledge but lost their faith.

He concluded with these words:

In spite of the striking successes of the new theory, its provisional character is often frankly admitted. The field theory is as yet in an unsatisfactory state. In spite of strong optimism, difficulties do not gradually dissolve and disappear. They are relegated to a lumber room, whence the menace of an ultimate divergence of all solutions neutralises much of the convincing force of imposing mathematical symbols. Nor is the problem of matter and radiation solved by the theory of complementary characters. Also we hear already of the limitations of the new theory encountered in its application to nuclear problems.

The quantum theory is frankly utilitarian in its outlook, but is the ideal of a universal theory completely overthrown by the penetrating criticism of the nature of physical measurements.

Bohr has stressed the unique character of all physical measurements. We try to synthesise their results and we get probabilities to reckon with, instead of certainties. But how does the formalism

$$\frac{h}{2\pi i}\frac{\partial\Psi}{\partial t} = H\Psi$$

emerges as a certain law? The wider the generalisation, the less becomes the content. A universal law would be totally devoid of it. It may nevertheless unfold unsuspected harmonies in the realm of concept. More than ever now, physics does need such a generalisation to bring order in its domain of ideas. It was a coincidence that on the same occasion D.S. Kothari was the president of the physics section and delivered an address on the 'Cold Dense Matter'. In describing the properties of dense matter and their astrophysical applications, Dr Kothari based his arguments amongst others on Saha's theory of thermal ionisation and Bose Statistics.

The Physics Department of the Dacca University had never been very big. The department conducted courses for both undergraduate B.Sc (Hons.) and postgraduate classes leading to the M.Sc. degree. The number of students in the M.Sc. classes was never very large—nine or ten students at the most. Thus the classes were very informal. Professor Bose's classes were held in his office. When all the chairs were occupied, the arm-chair served as an additional seat which Bose was fond of calling the royal seat. The class hours were never well defined; it could continue for the whole day. Around 1943 the department had two Readers, S.R. Khastgir and K. Banerjee. There were eight lecturers—Haraprased Mukherjee, Sasanka Sekhar Mukherjee, Surya Kumar Mukherjee, Kaji Motaher Hossain, Sachin Mitra, Bhabani Guha, Phani Mitra and Sushil Biswas. Students of those days recall that Satyen Bose used to be a chain-smoker. A sandal-wood cigarette box, a gift from his mother-in-law, was usually kept on his desk. The smarter students freely helped themselves to cigarettes from that box and he did not mind as long as there were a few left for him.

The question which is commonly asked is what had Bose been doing with himself all these years while teaching at Dacca? That he existed and functioned purely for the sake of his students and did not think of himself may sound like a feeble excuse, but that is precisely what he did. He had admitted that his one purpose of visiting the laboratories of Paris and Berlin was to find out what new ideas were being tried out there, and to see how hp could learn something for the benefit of his students. A teacher so genuinely concerned about the intellectual well-being of his students was something of a rarity even in those days, even among the students of Sir P.C. Ray. It was common knowledge that any student could approach him to solve a difficult problem or ask him to explain a topic which he found incomprehensible. Even the mathematics teacher, N.M. Bose did not mind telling his students to go to Bose for Bose's superiority was unchallenged. It was unfortunate for Bose that he did not get many good research scholars at Dacca. The really good students were either offered such lucrative jobs after their M.Sc. that nobody stayed on for research or they left Dacca for better opportunities elsewhere. During this entire period only two students completed their doctorate thesis under him: Sachin Mitra and Paritosh Dutta.

Perhaps his involvement with the students explains why the papers published during this period were just a handful. They were on such widely divergent subjects as 'D2 Statistics', Total Reflection of Electromagnetic Waves in the Ionosphere', 'On Lorentz Group' (concerning relativity), 'On an Integral Equation of the Hydrogen Atom Problem', etc.

But he never wrote on radiation theory again. There is a school of opinion that a scientist of Einstein's stature whom Bose had looked upon as 'master' had not been very fair to him in this case. On his 80th birthday when a formal reception was given to Bose by an All-India Committee/ Bose was heard to speak nostalgically of his second paper.

He could not get over the fact that his second paper did not receive the notice it deserved. In his article on ‘A World of Bose Particles’, E.C.G. Sudarshan comments:

Bose had continued to inspire and foster creativity and class amongst us all who are his students and followers. Thus most of us in remembering this giant amongst us rarely ever think of the courage and dignity of one who must have felt such keen disappointment in the lack of generosity and appreciation from him whom he considered his master. Neither Gupta’s crowning formulation of electrodynamics nor the work on quantum optics (by Sudarshan) has failed to find a secure place in theoretical physics. Nor have great men been too generous with appreciation of the work of a man who did not complete even thirty years when his finest work was announced. In a nation where intellectuals are not often eager to recognise and honour originality, it requires a courageous man to be ahead of his peers. To such a person Bose is an inspiring example in dignity and courage. But whatever regrets he may have had later, Bose seemed to be perfectly happy in his work, in the company of friends and students in the campus and outside and at home, taking care of his spacious and well laid out garden. As Dean of the science faculty and the Provost of the Dacca Hall he wielded considerable power. It was only to be expected that he should succeed R.C. Majumdar as the Vice-Chancellor, but local politics intervened. Things took such an undignified turn that it was no longer possible for him to stay on there any longer. He accepted the position offered by the University of Calcutta at this time. But his closest associates admit that the Dacca period was the happiest in his career.

Four of his younger children were born during this period—a daughter Sobha in 1924, a son Rathindra Nath in 1933, a daughter Aparna in 1939 and the youngest, a son, Ramendranath in 1941.

Nilima was married in 1937 to a doctor of Howrah, Barindra Nath Mitra, who was a very good sportsman; Purnima was married in 1945 to Dr Arun Roy, the medical officer in charge of the Indian Iron and Steel Co. at Kulti, near Burdwan. A very cheerful sort of person and fond of music, Dr Roy was Satyen Bose’s special favourite. On one of his subsequent trips to Paris he brought him a mandolin.

Satyendra Nath’s house at Dacca had a beautiful garden. He spent a lot of time in the garden; sometimes he was seen lying on the grass with a book. There were musical evenings with Dilip Kumar Ray as the principal singer, whenever he came down to Dacca. The cultural life of the campus and the stimulating company of friends made equal claims on his leisure. It was on the whole a way of life which Bose enjoyed to the fullest extent.

7. BOSE AT CALCUTTA (1945-1956)

The Second World War was drawing to a close. Political and social changes were evident everywhere. The political atmosphere at Dacca was beginning to affect the academic environment. The situation was getting worse with rising communal tensions—a state of affairs which pained and disturbed Satyendra Nath considerably. Moreover, he did not find the atmosphere congenial for scholarly pursuits. Fortunately the offer of the Khaira professorship from the Calcutta University came just at this opportune moment.

Due to the sudden death of Professor Bidhu Bhusan Ray, the Khaira chair was lying vacant. Bose accepted the offer.

So after almost a quarter of a century he was back to his alma mater. The Physics Department meanwhile had established a tradition of fundamental research. The recipient of the highest scientific honour, Sir C.V. Raman had formed a school of research workers in the field of optical scattering and allied branches, though all his work was carried out at the Indian Association for the Cultivation of Science. Dr D.M. Bose's work on magnetism and atomic physics, Dr S.K. Mitra's pioneering work on radio and wireless had already brought the department glory and fame. There had been some inevitable changes during the period Bose was away at Dacca. C.V. Raman had left for Bangalore, Dr D.M. Bose had taken over charge of the Bose Institute next-door, and Saha was back from Allahabad. Professor B.B. Ray in the meantime had set up an X-ray laboratory and trained a band of research workers in the field of studies with X-rays, and had-built X-ray equipments with indigenous materials. The work on Raman spectra was continued in the Palit laboratory through the efforts of Dr. S.C. Sirkar. Professor Saha changed his line of research and concentrated on nuclear physics. B.D. Nag Chaudhuri was setting up the cyclotron and Dr N.N. Dasgupta was laying the foundations of biophysical studies. When Bose returned to the Calcutta University, the Physics Department was not large by any standard—there were three professors in all Bose himself, Meghnad Saha, the Palit professor, and S.K. Mitra, the Ghose professor. There were four lecturers—J.C. Mukherjee, B.N. Chuckerbutti, D. Banerjee, and S.G Sircar. Shri S.K. Acharya, another very old colleague of Professor Bose, was then special officer for the Council of Postgraduate Teaching in Science and Technology. The other important physicists in the Pure Physics Department at that time were Dr B.D. Nag Chaudhuri, Dr J.N. Bhar, Dr N.N. Dasgupta, Shri D.N. Kundu, Shri H.N. Bose, Shri P.C. Bhattacharyya, Shri S.S. Baral, Dr. Ajit Kumar Saha and Shri B.K. Banerjee. The annual research grant was a meagre Rs 2,500 for each professor and Rs 1,000 for lecturers. Any additional support for research had to be channelled through the different schemes financed by the Board of Scientific and Industrial Research and other bodies.

In 1945 the faculty of the University College of Science and Technology could boast of celebrities in almost all departments. The Pure Chemistry Department had Professor Prafulla Chandra Mitter, the first lieutenant of Acharya P.C. Ray, as Palit professor; the famous Professor Jnanendra Nath Mukherjee as Ghose professor; Priyadaranjan Ray as Khaira professor and other distinguished chemists like Dr P.B. Sarkar, Dr J.C. Bardhan and Dr B.N. Ghosh as lecturers.

Some of the contemporary research workers in chemistry later headed the Chemistry Departments of many universities in India. Professor P.C. Mukherjee, the present Vice-Chancellor of the Kalyani University, was then a research scholar in chemistry. Professor A.N. Bose, the present Vice-Chancellor of the Jadavpur University, was also a re- search scholar in the Applied Chemistry Department, where Dr Biresh Chandra Guha was the Ghose professor and head. The Applied Mathematics Department was headed by Dr Nikhil Ranjan Sen, Ghose professor of applied mathematics, the famous mathematician and an old classmate of Satyendra Nath. Dr P.N. Ghose was the head of the Applied Physics Department.

It was a happy home-coming and the faculty and the students of the University College of Science and Technology gave Satyendra Nath a very hearty welcome. The Khaira laboratory at that time had two senior research students, Harsha Narayan Bose and Kamalakshya Dasgupta. H.N. Bose later joined the Physics Department of the I.I.T., Khar-agpur, and established his school of research in solid state physics; Kamalakshya Dasgupta was to become internationally famous for his experiments on X-ray scattering and is now a professor at the University of Austin, Texas. Sibabrata Bhattacharyya who had been a student of Professor Bose at Dacca came and joined the Khaira laboratory in 1945. The laboratory soon filled up with promising students like Jadugopal Dutta, Apresh Chatterjee, Jagadish Sharma, Purnima Sengupta, Biren Dutta, Amal Ghosh, Leela Roy and many others. The names mentioned are only those who joined as formal research students after their M.Sc. degree. Asoke Bose of the Chemistry Department, Parimalkanti Ghosh, Mahadev Dutta, Gagan Behari Banerjee, Purnansu Roy, Tapan Roy who were originally students of the Applied Mathematics Department also joined the band of research workers under Satyendra Nath. But there were other members of the faculty and research students of other departments and institutes who used to come to Satyendra Nath for advice, consultation and discussion.

Hardly had Satyendra Nath settled down in Calcutta when the entire country was shaken by the fiercest political upheaval of the century. The great Calcutta killing of August 1946 snapped the academic life for some time and work came to a standstill. The University College of Science and Technology at Raja Bazaar, a predominantly Muslim area, *was* very heavily affected. Students of the university who lived in hostels nearby were brutally murdered. There were very few families in the student and teacher community either in East or West Bengal who were not affected in some way or the other. British army personnel were housed within the precincts of the Science College campus. The academic atmosphere was shattered for almost a year.

This was followed by the long-awaited Independence in August 1947. For Bengal it was a mixed blessing because a part of it was taken away to form East Pakistan. Emergence of Pakistan caused added problems of refugee influx which immediately affected the system of educational environment.

But other long-cherished dreams were soon on their way to be fulfilled. Our forward-looking Prime Minister Nehru lost no time in setting up an infrastructure for scientific research and development on a large scale throughout the country. The Council of Scientific and Industrial Research headed by S.S. Bhatnagar was formed. All the important scientists of the country were invited to participate and act as advisers. The Calcutta school participated in a big way. M.N. Saha, S.K. Mitra, S.N. Bose, B.C. Guha, J.N. Mukherjee, D.M. Bose and many others contributed their share in shaping the future of science in India.

Brisk activity went on in the University College of Science. Dr M.N. Saha's ambition to start a separate Institute of Nuclear Physics was fulfilled. The foundation stone of the institute was laid by Shyamaprasad Mookerjee in 1948. Meghnad Saha became the Honorary Life Director while the Palit laboratory of the Pure Physics Department with its research grant was separated from the Physics Department and given to the Institute of Nuclear Physics, which was run by an independent autonomous governing body. The post of the Sur readership was then occupied by Dr B.D. Nag Chaudhuri who was also transferred to the new institute.

Almost on a similar footing the Chose (wireless) laboratory of the Pure Physics Department and the electrical communication laboratory of the Applied Physics Department were integrated from the Institute of Radio physics and Electronics, which became one of the departments of the Technology Faculty of the Calcutta University. Professor S.K. Mitra, Ghose professor of pure physics, became the head of the Institute of Radio physics and Electronics. Thus the Pure Physics Department was left only with the Khaira professor of physics. This situation continued for quite a long time. After Professor Saha relinquished the Palit professorship to become the Director of the newly reformed Indian Association for the Cultivation of Science, Dr B.D. Nag Chaudhuri became the Palit professor. After Saha's death in February 1956, Dr Nag Chaudhuri became the Acting Director of the Saha Institute of Nuclear Physics. Later, Dr Nag Chaudhuri became the full-time Director and the post of Palit professorship was retuned to the Physics Department in 1958. In 1957 during the centenary of the Calcutta University, a post of professor of chemical physics was created and was held by Dr S.N. Bagchi for a few years. After Dr Bagchi left for the USA, the post was abolished.

While all these changes were taking place, the work at the Khaira laboratory progressed. It had already established its reputation in the field of X-ray crystallography studies. Harsha Narayan Bose and his students did pioneering work on thermo-luminescence which now flourished under the guidance of S.N. Bose. The fields of research work quickly expanded in many directions including many applied aspects like studies in minerals and clays.

The first few years were very active in many senses. Professor Bose became the president of the Indian Physical Society for the period 1945-48. In 1948 the Bangiya Bignan Parishad was formed, reference to which will be made in a separate chapter. Bose became the president of the National Institute of Science for the period 1948-50. During the period 1947-55, a large number of foreign scientists visited the Physics Department, including P.A.M. Dirac and J.D. Bernal.

Although basically a theoretical physicist, Professor Bose had taken keen interest in experiments all his life. In 1954 at the Crystallographic Conference in Paris, Bose presented a paper describing a new and very significant thermo-luminescence analyser developed by his pupils under his guidance. From 1951 Bose had been visiting Europe almost every year and the time became very ripe for his genius to strike again.

It was well known that an attempt was being made to set up a unified field theory which could explain both the electromagnetic theory and the general theory of relativity. Such an attempt was originally started by Einstein himself. Other top men like Herman Weyl, Eddington, Schroedinger and Kaluza had tried their hand at this. This matter was being discussed by a group of scientists attending the Science Congress at Calcutta, in Professor Bose's office on the ground floor of the Science College main building. It aroused his interest. This particular problem which had been bothering scientists and was not nearing any solution intrigued him. In a short time the solution came out in a series of papers in quick succession between 1953 and 1955. His papers were considered a very important step forward and had the unmistakable stamp or Bose's originality and lucidity on them.

In 1952 Professor Meghnad Saha was elected a member to the Lok Sabha of the Indian Parliament from a Calcutta constituency. This caused quite a sensation in the scientific and political circles in the country. The same year Professor Bose was nominated a member of the Rajya Sabha and he continued there till 1958. In 1954 the Government of India honoured him with the title of Padma Vibhushan.

In 1956 at the age of 62, Satyendra Nath retired from the post of the Khaira professor, and became the Vice-Chancellor of Viswabharati. As that time the Physics Department had only four full-time staff members—Dr S.D. Chatterjee, Dr P.C. Bhattacharyya, Dr K. Dasgupta and Dr S. Dutta Majumdar. The teaching of the M.Sc students was, however, carried out with the help of a large number of honorary-lecturers drawn from the Saha Institute of Nuclear Physics and the Presidency College.

Professor Bose revisited Europe after an' interval of almost twenty-six years. Earlier he missed an invitation to Europe in 1927 due to a misunderstanding. The Italian government was celebrating the centenary of the death of AlessandroVolta. Among their Indian invitees were Dr Saha from Allahabad and Professor Bose from Calcutta. The telegram did not specifically mention which Bose they meant and Professor D.M. Bose attended the centenary celebrations since he was the Professor Bose of Calcutta. Later on it transpired that the invitation was for Professor S. N. Bose and was wrongly addressed to the Calcutta University.

In 1953 Bose was asked to attend the World Congress for General Disarmament and Peace at Budapest. Invitations came from Soviet Russia, Denmark and Czechoslovakia. Bose took this opportunity to visit Geneva, Paris, Copenhagen, Zurich and Prague. He met Professor Pauli in Zurich and Niels Bohr in Copenhagen.

The following year Bose attended the International Crystallography Conference in Paris as a representative from India. Apart from scientific interests he had a special liking for France and the French way of life. The year 1955 saw him in Paris again, this time on an invitation from the Council of National Scientific Research of France. It was the 50th year of Einstein's formulation of the theory of relativity. It was in Bern that Einstein had promulgated the theory of Brownian movement, the photon theory and the special theory of relativity. Naturally Bern was the most suitable place to celebrate the golden jubilee of a discovery which changed the basic physical concepts. The conference was to be held in July, and Einstein himself was supposed to attend. Bose was eager to have a discussion with Einstein about the unified field theory, a fundamental and unsolved problem on which he too had been working. But unfortunately Einstein's death prevented such a meeting.

Bose's next trip was to England in 1956 to attend the Annual Meeting of the British Association for the Cultivation of Science. Two years later he was back in London to attend the Royal Society meeting where he was nominated a fellow.

In 1962 he went to Sweden and from there to Moscow to attend the Peace Conference. In August 1962 he was invited to Japan to attend a seminar on science and philosophy. This was organised in memory of the atomic explosion over Hiroshima and Nagasaki.

He never visited China, though he came close to going there once. In 1952 a delegation of teachers from India was going to visit China. Bose was requested to join them. He agreed at first. But later when he was told that it was going to be a seven-day whirlwind trip with the condition that after their return home, they were supposed to speak about their Chinese experience, Bose withdrew. He said since he did not know neither their language nor their temperament, all he could achieve to do was to meet a few people in meetings. How could one call that a fruitful experience?

Another country which he never visited was the United States. An American interviewer in India once asked him if there was any reason, Bose answered jokingly, “Your Senator, Joseph McCarthy might have objected because of the fact that I had visited Russia first.”

After his return from Dacca in 1945, Bose lived for some time in his ancestral house at 22 Ishwar Mill Lane. Later he moved to a rented house at the junction of Gursaday Datta Road and Pramathesh Barua Sarani. Later he moved to another house at New Alipore.

Bose had never been a dominating father—he left the running of the household to his wife and his father. Surendranath, who lived to see the 70th birthday celebrations of his illustrious son, was unusually active for his age. Bose maintained a tender relationship with his father. During his stay at Calcutta in this period, every morning before going out, he visited his father in his room, asking him how he was feeling that day. He left a tin of cigarettes for the old man. He smoked before his father, which is proof of the informal relationship they enjoyed. In fact one of the nephews of Bose recalls having seen the father and son in a relaxed mood, reclining on cushions, with a tin of cigarettes before them. Informality was the keynote of the style of living in the family. The children grew up unrestricted and free. There was no fixed time for meals. In 1949 his third daughter, Jaya was married to Shri Debprasad Chaudhuri who is an advocate of the Calcutta High Court. The Chaudhuris live in their own house at Park Circus.

8. AT SANTINIKETAN (1956-1958)

In 1951 Viswabharati became a central university with the Prime Minister as Chancellor or Acharya. In January 1956 when the Upacharya, Dr Probodh Chandra Bagchi, died, Bose was offered the post. Bose meanwhile had retired from the Calcutta University. He joined Viswabharati on July 1956. During the interim period Shrimati Indira Devi Chaudhurani acted as the Upacharya. Mrs Bose stayed back in Calcutta for some months for reasons of health. She joined her husband later. Two of the daughters were already married. Rathin, his elder son was working and Ramen, the younger son was in a hostel in Belur near Calcutta, studying for his intermediate.

Welcoming the new Upacharya, the *Visivabharti News* wrote: “In him we shall find the most wanted leadership for the growth of this institution.”

Bose lost no time in getting down to work. Before the end of the week he met the heads of departments and other officials. He met the Karmi Mandali and the senior students. “It has been very gratifying to hear him reiterate every time that the ideals and the special features of this institution should continue to be integrated into a co-operative and harmonious fold for the fulfilment of the object of this institution as a meeting ground of the East and the West,” wrote the *Viswabharati News.* One of the many ideals on which Viswabharati was founded was a close relationship between the teacher and the student. In Dacca as well as in Calcutta, Bose was well known for his informality. His lectures often extended beyond the scheduled hours; he addressed his students in the familiar form *tui* instead of the impersonal *tumi*—there was absolutely nothing awe-inspiring about this professor. Naturally, during his brief stay at Santiniketan, Bose endeared himself to everybody, but some of his attempts at administrative reforms met with stiff opposition.

He had many new ideas but what he did not realise was that no matter how noble the purpose, they might go against the set and rigid way of life which was often almost a ritual in Santiniketan. It seemed to him a waste that the glass enclosed *mandir* (temple) should be used for prayer only one day of the week. "How about converting it into a reading room?" he asked a senior staff member once. "That would be sacrilege, Sir," answered the professor. Bose was disappointed, but the idea was dropped all the same. The truth of the matter was that the set-up at Viswabharati did not take kindly to outsiders or to such changes which Bose proposed to bring about.

Bose had drawn up a plan for re-organising the existing set-up and to introduce a science course. Viswabharati offered a science course only up to the intermediate level. His scheme outlined three stages in the teaching programme: the first stage (age-group 6 to 11) earmarked for primary school leaving certificate examination, the second stage (age-group 11 to 17) for higher school leaving certificate examination equivalent to the present intermediate standard, and the third stage (age-group 17 to 22) for higher studies and researches leading to the three-year B.A. Honours and M.A. degrees. It recommended the abolition of the present system of matriculation and B.A. (Pass) examination. It also provided for training in almost all the important Indian, Asian and European languages, both modern and classical.

Another important feature of this scheme was the establishment of a science institute. This institute which would be better known as Bignan Bhavan would provide for teaching and research in some of the important branches of physics and biology. Six post-doctorate research fellowships in sciences and humanities were also provided for in the scheme.

"Professor Bose's scheme is expected to be implemented after it is considered and approved by the Karma Samiti (Executive Council) and the *samsad* (court) of the university," wrote *Viswabharati News.*

The need for introducing science studies of a higher level in Viswabharati was emphasised in his convocation address of January 1957. He said that a certain amount of essential scientific knowledge helped to build up a modem man of culture. He often spoke to students about the role of science in everyday life and as an experimental measure proposed the setting up of a small plant which would use kitchen garbage as fuel. It would have to serve a twofold function: to produce manure and to provide the school laboratories with the methane gas they needed for their classroom experiments. The proposal was approved by the Karma Samiti and a sum of Rs 2,000 was sanctioned for it. However, there were hurdles to be crossed and opposing forces to be reckoned with. By the end of the year he grew disillusioned. When the members of the staff gave him a reception at the Amra-Kunja on March 28, 1958, on his election as a Fellow of the Royal Society, Bose replied, "I remember my teacher, the late Jagadish Chandra Bose, who was the pioneer in scientific research in our country. All my bits of endeavour in life have been in that direction of scientific research ... Now at the fag end of my life I wish I could be useful to you in our recently sponsored general science classes, although here at

Viswabharati we could not afford to have much of science as yet/' It was almost the acceptance of defeat, expressed with the characteristic humility of a man who could dream dreams but was prevented partly by circumstances and partly by his own limitations to give it a concrete shape.

It is an unfortunate fact that Bose was not much of a success in Santiniketan, which is more of a pity because his mental affinity and good relations with Tagore made him eminently suitable for the work. He shared with Tagore the theory that basic education should be imparted through the mother tongue. In fact it was one of Bose's grievances against Sir Asutosh Mookerjee that for all his farsightedness he did not give the Bengali language its due place. Incidentally, Tagore had dedicated his first book on a scientific topic, *Visva Parichay,* to Satyendra Nath Bose.

Bose had already been the Chairman of the National Institute of Science, India, and a nominated Member of Parliament. In 1954 he was awarded the Padma Vibhushan. During this period other honours and academic distinctions came his way. In 1957 three universities—Calcutta, Jadavpur and Allahabad—gave him honorary doctorate degrees; Calcutta on the occasion of its centenary celebrations. Honours which were long overdue followed one another in quick succession. In 1958, belatedly, he was elected a fellow of the Royal Society of London along with Professor S.K. Mitra. In 1959 he was appointed a national professor, the highest honour which the nation could confer upon a scholar. In 1961 after he had left the place, Viswabharati conferred upon him the title of 'Desikattama'.

His brief interlude at Viswabharati was soon over. He was back to Calcutta and the scientific world in 1959, to the great delight of his friends and students. In a letter to his friend Dilip Kumar Ray, Bose too expressed satisfaction at being relieved from duties which were becoming a burden. Perhaps the last years of his life could be spent free from worries of administration.

9. THE UNCONVENTIONAL SCIENTIST

Satyendra Nath was an early riser. It was his habit to be up by five in the morning, make two cups of tea himself and settle down to read for about two hours. When the household activities began he would have his bath and get ready for the day. By eight o'clock he was on his way, carrying his lunch with him. Another round of tea in his room and his day's work began. He worked hard, though erratically; when he was on the verge of a new result he just shut himself up and would refuse to see anyone.

It was easily done. All he had to do was to ask his lifelong personal assistant, Nagen Kali to shut the door. Nagen Kali, incidentally, was the famous goalkeeper of the Mohun Bagan Club in the twenties. Mr Kali took good care of his moody boss and was extremely proud of him. But such phases of furious concentration were over as soon as he was satisfied with his results, and he worked and chatted, received visitors, offered them snacks and tea, helped students with their academic problems and was available to friends who happened to drop in.

He returned home late, but no matter what the hour was, he had his meal almost immediately, and then lay down to rest. Around nine he would be up again and settle down to study; it could be a problem in mathematics or something vastly different from physics. The theory of numbers had him engrossed for a long time. He got the idea while teaching his fourth daughter. Fatal, her sums, and he had been working on this in his last years. In fact, the unfinished jottings found on his table after his death were on the theory of numbers.

For some reason the image of Bose which has persisted in the public mind is that of a genius who disliked hard work and wasted his energy in small talk. The real Bose was far from this popular image. His casual exterior was very deceptive.

Much of the work done by Bose were on loose sheets of paper which he never bothered to preserve. On very special occasions he would keep record in a bound exercise book and complete his observations. After the paper was published he washed his hands clean and cared the least about the handwritten manuscript. Thus the intriguing problems concerning the theory of numbers on which he had been thinking for about twenty years never got published.

But there were other facets of his personality which have helped build up the legend that was Bose.

One afternoon in 1947, Saha walked into Bose's office room in the University College of Science to remind him of a meeting they were both supposed to attend. Some of the research scholars working in the adjacent rooms overheard them. Here is an approximate reproduction of the conversation.

Saha: "Satyen, aren't you coming to the meeting?" Bose had completely forgotten about it. "Come in and hear some music," he said. "I have got a man here, he is going to play the *raga Behaga* on the flute."

Saha merely looked at his colleague and walked out. The flute player began his recital and all thoughts of attending the meeting were forgotten. Bose had a tremendous zest for enjoying the finer things of life—good food, music, good company, and books and any time was good enough for these.

Instances of Bose's unconventional ways are legion. Some of these have already been elevated to the status of a legend. Bose heard of a student who played the *sitar.* He was immediately summoned.

"You must play to me some day."

"Do you want me to come to your house, Sir?" asked the boy, elated at the unexpected honour.

"Bring it right here," ordered Bose.

So the instrument was brought, the accompanist on the *tabla* called and both of them climbed on to the large laboratory table to play, as most of the floor space was taken up by that table.

Often in informal musical circles Satyen Bose, the connoisseur of classical music, would close his eyes and seem to fall asleep, to everybody's dismay. But in the end he would open his eyes and put extremely pertinent questions to the performer.

On the occasion of his 80th birthday, the Director of the Calcutta station of All India Radio went over to his house to record an interview with him.

“What is all this paraphernalia for?’’ asked the amused Bose. “Does this mean I am supposed to say nice things about you? Let me tell you something. The songs you broadcast in the name of old Bengali songs, well...” he did not finish the sentence. Evidently his ear for music was no less critical in his declining years.

The fact that he played the *esraj* himself is well known. What is not so known is that he played the flute too. Music was one of his early loves and his interests ranged from folk music to classical as well from Indian to Western. When Professor Dhurjati Prasad Mukhopadhyay was writing his book on Indian music, he received a number of helpful suggestions from his friend Bose. Dhurjati Prasad used to say that if Bose had not been a scientist he might have become a master musicologist.

Bose had crashed into the international scientific arena with his paper of 1924. What had he been doing in the meantime? Was his genius taking a rest? As a matter of fact, his total output in terms of publication of papers is so small— numbering about twenty-five entries in all—that the question is often asked, sometimes to disparage him. But for a complex and many-sided genius like Bose, the conventional yardstick which tends to assess a scientist in terms of his published papers seems hopelessly inadequate.

He seemed to care the least about the publication of scientific papers, which any other scientist would have thought to be the most important object, if not the only objective of Ms life, It is useful to remember that Bose did not submit a doctoral thesis on his own and did not think much of a doctorate degree. To many of his students doing research under him this may have seemed like an enigma. To them submission of a doctoral thesis was a matter of professional survival, but they received no encouragement from their guide who thought knowledge was much more important than getting a doctorate degree. It was perhaps for this reason that the number of doctorates under him was hardly a dozen.

Even though the total number of papers published by him was small, this does not mean that his range of knowledge was in any way limited. On the contrary, he had a more brilliant mind than most of his contemporaries and his range of interests was unlimited.

He was a physicist and a mathematician but when he returned to Calcutta in 1945 as the Khaira professor, he setup a laboratory of organic chemistry in the Department of Pure Physics at the University College of Science. Even at Dacca he had set up an organic chemistry laboratory and worked with a group of chemists. Dr Paritosh Dutta who completed his doctorate degree working under him at Dacca was a chemist. Dr (Mrs) Asima Chatterjee, the noted chemist worked with him since 1946 on the structure and stereo-chemistry of several alkaloids and others in organic substances. In the words of Mrs Chatterjee:

Work on inorganic complex salts and clay minerals were another major contribution of Professor Bose. A large number of samples of clays, shale and soil from different parts of India were studied. X-ray diffraction methods and the differential thermal analysis were employed in order to understand the atomic structure of common clay minerals and the effect of the layer thickness upon *cation* exchange. Since clays are poor reflectors of X-rays, there is a tendency to choose small diameter cameras, but in general with small cameras important details of the power diagram may not be resolved. As such, an adjustable flat-plate camera was designed and used in this investigation. The differential thermal analyser used in the present investigation was constructed after the design of

Berkelheimer. Very little work was done in India at the time when this project was undertaken by Professor Bose and his students. As clays are formed under widely varying environmental conditions, the study of minerals from regions still unexplored is important both for the purpose of verification and for new information. With this object in view a differential thermal analyser and a micro-focus X-ray tube were designed at this laboratory for the study of a number of Indian clays obtained from a wide variety of sources and isolated from different types of soils.

His long silence after the work of 1924 has been variously interpreted. To quote B.M. Udgaonkar:

For smaller minds he had become a drop-out. However, his keen, perspicuous and versatile mind, trained in the method of physics and mathematics, was allowing itself to range over a variety of fields, including chemistry and biology, soil science and mineralogy, philosophy and archaeology, fine arts, literature and music. Then after thirty years, during 1953-55, at the age of sixty, he performed a *tour de force* and published some important papers in unified field theory, showing that his mathematical powers were still as keen as ever. B.D. Nag Chaudhury has this to say about him:

Bose's ability to tackle entirely new problems is legendary. He took keen interest in life sciences in later life. In chemistry his work ranged widely. Apart from advising in these fields, he actually worked on the structure of Sulphonazide molecule.

Perhaps Satyen Bose's greatest charm lies in his ability to look at life in a total manner. The minor pleasure of leisure and pleasant company were to him a par^-of a bigger universe of the pleasures of the mind and the intellect. Ina sense this was also his strongest limitation. Bose was a man who tried to see the world around him in its entirety, in its complexity and in which his own particular science and himself were very small parts. When Ananda Sankar Ray, the writer, visited him in Santiniketan, he found him one evening in bed, under the mosquito net. Was he sick? No, the mosquitoes would not let him concentrate. Ray discovered that the subject which had engrossed the scientist was the newly discovered Aramic scripts of Asoka, just found in Afghanistan. Ray, an extremely well-read man himself, had not heard of them yet. On another visit Ray found him reading *Charu Datta* in the original Sanskrit.

One of his students, Banerjee, has the following to say in his defence:

The path can be called wayward only if it is on without a definite attitude or a definite aim. Professor Bose had a definite attitude and definite sense of direction. He was totally oblivious of the techniques or habits needed to enhance one's scientific reputation, a habit which even many reputed persons are compelled to cultivate. These techniques and habits are by no means undesirable; only they need effort. Professor Bose's temperament did not permit such efforts.

Adds Samarendra Nath Sen:

Those who have had the privilege of either working with him or watching him at close quarters affirm that once his interest in a problem challenging enough was aroused, he would not rest until it was solved or at least a solution of it was within sight. This done, he would cease to take further interest in it and would not even bother to organise his notes and rough working sheets in the form of a communicable paper, as scientific workers in general are accustomed to do. He established his reputation as a teacher both at Dacca and Calcutta but he never kept notes on the subject matter of his teachings. Likewise, his speeches and conversations always characterised by great lucidity, wit and thought-provoking capacity mostly went unrecorded with the result that the personality of this great man is perhaps in danger of being irretrievably lost to posterity.

Professor P. A.M. Dirac had come to Calcutta along with his wife in the mid-fifties. They were sharing the same car with Bose. Bose let them have the back seat. The front seat, which Bose occupied along with the driver, did not have much room. Nevertheless Bose asked some of his students to get in. Dirac, a little surprised, asked if it wasn't too crowded. Bose looked back and said in his disarming fashion, "We believe in Bose Statistics." Dirac explained to his wife, "In Bose Statistics things crowd together." But surprisingly enough, Bose preferred not to talk of his work except by way of a joke.

His door was always open to anybody who cared to drop in. He did not believe in any formality. At his Calcutta home he received visitors in his bedroom which also served as his study. People streamed in; he never refused an audience. No appointments were needed. When Professor Bose was Khaira professor in Science College, Calcutta, to meet him all that one needed was 'to push the swing door and enter his room'.

He had been strikingly handsome in his youth. Even though his hair turned grey prematurely, he retained his good looks. The slightly bent figure, heavy with age, with a shock of white hair, sitting on a dais with pyjamas and a long coat or a *kyrta,* was a familiar sight in Calcutta in the fifties and sixties. Yet, surprisingly enough, very few in the audience perhaps knew what was his contribution in physics; may be a good majority were not even acquainted with the name 'Bose Statistics'. To them the man was a symbol of faith and knowledge and his very presence was reassuring. Bose displayed a fondness for good clothes. His collection of walking sticks and caps drew the attention of every visitor who stepped into his room. His taste was often bizarre. Sometimes in an international gathering, his unconventional clothing would be a source of embarrassment, but those who knew him did not mind his terrible clothes; they were a part of his unique personality.

Some of the members of the Tagore family were known for their eccentricities in dress; one of them had even tried to design a national costume which would combine the grace of a *dhoti* with the utility of a pair of trousers—and the effect, needles to say, was too ridiculous to be acceptable. Satyen Bose's fantastic dress consciousness was merely a projection of his personality; it was prompted by no social motive. In a sense he was the conventional Bengali, who detests formal attire of any sort. His lack of concern for formal clothes went to such lengths that he even thought nothing of attending international conferences wearing a *lungi* around him and going about in it without a trace of self-consciousness, as he did in Japan.

At home he preferred *lungi* and undershirt; he changed to pyjama and *churidar-kurta* for going out. A long coat, the kind Tagore wore, along with a woollen cap completed the winter uniform. In summer he often wore a *merjai,* a kind of loose shirt with knots instead of buttons—the traditional Bengali dress worn some time ago.

Einstein's disregard for dress has been interpreted by his biographers as a desire to restrict his outward needs and to increase his freedom. Long hair minimises the need for a haircut. Socks are not really necessary. Einstein used a leather jacket because it solved the coat problem for a long time.

The desire to simplify and restrict his requirements was evident in Bose too, though not so much in his dress as in his style of living. He confined himself to one room in his house where he studied, worked, met people and slept.

10. SCIENCE THROUGH THE MOTHER TONGUE

The dedicated batch of students who had their training under Acharya Prafulla Chandra Ray were all scientists with a social consciousness, aware that science has a major role to play in the service of the nation. How this was going to be achieved was a question which troubled the minds of Satyendra Nath Bose and his equally illustrious contemporary, Meghnad Saha. Unlike some of the dreamy political idealists, they had no hesitation in calling a spade a spade. Saha, tired of the misguided superiority evident everywhere, was impatient with the 'but-we-have-everything-in-the-Vedas' attitude, and Bose, in his own way, was as unsparing of humbug as Saha's direct blasts. He often referred to this 'we-have-everything-in-the-Vedas' attitude as our main psychological block. "We must be told some very unpleasant truths plainly," he used to say, and through his public speeches and writings he, with the unambiguous precision of a scientist, analysed the weakness and pointed the way out. It was clear to him, but unfortunately it took him years to convince those in authority that the reason why science in our country has failed to make headway is the barrier of the language through which it is taught.

It was his firm conviction that this factor is responsible for our slow rate of progress in our education. A foreign language not only encourages cramming among students, it also prevents the expression of original ideas and acts as a barrier to creativity. No other country in the world imparts education through a language not its own. There is no reason why they should. Bose was deeply concerned with the wasteful education in our universities. The trouble, he believed, was not in our students, but in the method of guidance and training. Given proper chance and training, Indian students were capable of a high degree of efficiency. In his 1963 convocation address at the University of Ranchi he stressed this point, analysing the malady and pointing the direction where the solution lay. As a teacher he came in contact with hundreds of students and from frank discussions with them, he came to the conclusion that students needed free discussion with their teachers. No barrier of a foreign language should stand in the way. It was high time that we introduced vernacular as the medium of instruction at all levels, including the graduate and the postgraduate. If the student had to express himself in English it might come in the way of making himself properly understood. Even the teacher, if he teaches in English, is never sure of how much he has conveyed to the students. These practical difficulties had been there ever since the introduction of English education but no educationist had been as vocal and insistent about this as Bose.

Later, during his visits to Japan, Bose had the opportunity to study the Japanese system at first hand. He had gone to Tokyo to participate in a seminar on The Role of Science in Modern Life'. It was an international seminar and Bose had naturally expected that the deliberations would be carried out in English. But he was told that in spite of the fact that most Japanese scientists understood English and a few other languages, the entire education in the country was conducted in Japanese. So he must be prepared to listen to a great deal of Japanese in the seminar. Of course, there would be interpreters who would translate his speech into Japanese. Bose was greatly impressed by the effectiveness of this method. A most technical, abstract and complicated exchange was carried on in Japanese and the audience had no difficulty in catching the gist of what the foreigners had to say, which was evident from the sharp criticisms that followed.

Bose went to their universities to enquire about the details. He saw that the Japanese always discussed the latest scientific notions in their mother tongue. To quote Bose: They used plenty of loan words, but they were not apologetic about it. I heard that the Japanese translation of an English book by two Indian scientists on the effects of a nuclear explosion had sold about three thousand copies in six months. The common people in Japan, who can only read in their mother tongue, are very anxious to learn about the consequences of a nuclear explosion. Probably they trust the Indian opinion in this matter for being impartial, yet in our country those two scientists have kept on writing in English and keeping eighty per cent of their countrymen in the dark about the consequences of the radioactive fall-out. It is often said as an excuse that lack of Indian synonyms may act as a handicap. I am not a purist. I welcome the idea of using English technical terms. If our boys understand these terms they will survive as loan words and enrich our vocabulary. We have a lot of such words of foreign origin which have now been absorbed in the regional languages.

In many cases translation of scientific terms would be futile. Everybody understands what is meant by railway, restaurant, telegram, centimetre, wheel, lathe, thermometer, bacteria, fungus, differential, co-efficient, integration, etc. Tables and chairs are part of our life now. There is no need to lengthen the list. After his return to Calcutta this idea of a vernacular-based science education became a mission. He spoke endlessly on the subject to students, teachers, to the general public. It was the theme of his convocation address in 1962. Everybody listened out of polite respect, but nobody took his ideas seriously.

Actually it was a very old issue. It went back to the beginning of this century. In 1905 when the National Council of Education was founded, a resolution was adopted to establish a national university. Consequently on August 15, 1906, a college was started with Sri Aurobindo as the principal. This later grew into the present Jadavpur University. The money came from Raja Subodh Mallick, the Ma haraja of Mymensing, and Brajendra Kishore Ray Chaudhury of Gouripur. It is a little known fact that in 1891 Bankim Chandra Chatterjee had brought a. proposal in the Senate to introduce Bengali as the medium of instruction in schools and colleges, but it was turned down.

Earlier, the Indian Association for the Cultivation of Science was established in 1876, with the object of promoting scientific interest among the Indian people at a time when scientific investigation Tacked initiative among the people. About sixty years later, when modern science had struck its roots among the English educated section, the need was felt to make our science education more broad based. Among the pioneers who realised the need long before the State government did anything about it was Satyendra Nath. In a meeting held in the University College of Science on October 18, 1947 a resolution was passed to establish a society with the sole objective of promoting and popularising science through the vernacular. The meeting was presided over by Satyendra Nath. The meeting resolved to adopt the name ‘Bangiya Bijnan Parishad’ and decided to formally inaugurate the Parishad on the January 25, 1948. The circular printed in Bengali for the occasion ran as follows:

'Bangiya Bijnan Parishad

92 Upper Circular Road, Calcutta-9

We need science at very step, but our system of education does not prepare us for it, so that we are not able to utilise science in our everyday life. The main obstacle so far was a foreign language through which education was being imparted. Today the ties have changed. New hopes and aspirations are emerging. Now it is the duty and the responsibility of our scientists to popularise science through the medium of vernacular and thus help to create a healthy scientific attitude among the people.

As a first step to this effort it has been resolved to form a 'Bangiya Bijnan Parishad'. It was mainly through the inspired leadership of Professor Satyendra Nath Bose. The primary objective of the Parishad would be: (i) the creation of a scientific outlook among the people, (ii) to publish school and college texts in an easy manner, yet keeping the scientific content, (iii) to publish and provide texts of available books on science, (iv) to enrich popular and children's literature with scientific knowledge, (v) to help popularise science in Bengali, the Parishad would conduct conferences and seminars and arrange exhibitions and popular lectures.

We know we have a limited capacity; still we have come forward to take up this responsible job. We consider this a national duty and we count on the co-operation and active support of our learned friends. We believe we shall not lack help or goodwill. We particularly bank on the support of the universities of Dacca and Calcutta because all of us are connected to these two glorious institutions either as student or as teacher. We hope the Bangiya Sahitya Parishad will help us. We also hope for the cooperation of the Viswabharati because Rabindranath had dedicated his first book on science, *VisvaParichay*, toSatyendraNath Bose who is one of us. We have decided to formally inaugurate the Parishad on January 25, 1948. May we request our patrons to kindly send their subscriptions and be members and attend the session. Please send your membership fee along with name and address to:

Dr Subodh Nath Bagchi,

Secretary, Bangiya Bijnan Parishad,

92 Upper Circular Road, Calcutta-9

The signatories were: Satyendra Nath Bose, Subodh Nath Bagchi, Jagannath Gupta, Jnanendra Lal Bhaduri, Sarbanisahay Guha Sarkar, Sukumar Bandopadhyay, Devi Prasad Roy Choudhury, Gopal Chandra Bhattacharya, Parimal Goswami, Amiya Kumar Ghose, Sudhamay Mukhopadhyay, Dwijendra Lal Bhaduri, and Birendra Nath Mukhopadhyay.

Before the formal inauguration they used to have weekly meetings every Friday. After January 25, 1948, they met again on the 30th at the Science College, when someone rushed in excitedly, declaring Gandhiji was shot.

The Bangiya Bijnan Parishad published a monthly periodical in Bengali, called *Jnan O Bijnan* which has played an important role in fulfilling the object of the Parishad, though its circulation was limited more or less to the academic circle. The association has also been publishing books in Bengali. Money from donors like Niren Roy and a grant from the State government had enabled it to construct a building of its own.

Bose's passion for developing science and scientific writing in Bengali extended even to abstruse subjects like hydrodynamics and physics. The students of 1946still recall his lecture in the M.Sc. classes in Bengali. His effort to achieve this end was ridiculed in some quarters by people who were not convinced that the Bengali language was a suitable medium for the expression of highly technical ideas. Bose effectively silenced his critics when he delivered the Saha Memorial lecture in Bengali on recent developments in cosmology. He was so devoted to the cause that he readily went to out-of-the-way places and to little known institutions to talk in Bengali on popular and semi-popular topics.

Satyendra Nath's first published article in Bengali on a scientific topic was 'Crisis in Science' which appeared in the first issue of *Parichay* in 1931. He wrote rarely, but the few pieces he wrote are remarkable for their lucidity and grace. It is interesting to compare the Bengali prose style of Sir J.C Bose, Saha and Satyen Bose. J.C. Bose could express himself in beautiful prose on highly technical and philosophical subjects. Some of these pieces have gone into Bengali text-books as models of style. Meghnad Saha was undoubtedly the most prolific writer of the three. But his articles on popular and semi-popular scientific topics were prompted more from an urge to educate the people than from any other literary consideration. The language was not so important to him as the ideas and in fact as the editor of *Science and Culture,* his English articles far outnumber his Bengali writings. In whatever language he wrote, Saha's style was direct and terse, S.N. Bose's was more casual and colloquial; he wrote exactly as he talked. It is unfortunate that most of his speeches have not been recorded. He never spoke from a prepared text and hardly ever kept notes.

11. THE LAST YEARS (1959-1974)

The Calcutta University had appointed Satyendra Nath Bose as Emeritus Professor in 1957 and allowed him to retain his office for holding seminars and discussions at the main building of the University College of Science and Technology, the office he was occupying as Khaira professor of physics. In fact many of Professor Bose's books and journals were left in this room during his stay at Santiniketan. Many of the books are still there and the room serves as the office of S.N. Bose Institute of Advanced Physical Studies. When Satyendra Nath was appointed the national professor, he was also the Emeritus Professor of the Indian Association for the Cultivation of Science at Jadavpur. He finally decided to establish his office and laboratory as the national professor at the Indian Association. The Department of Science and Technology of the Government of India which disburses the grants for the national professor and his research group was instructed to send the grants to IACS.

Professor Bose's intention was to make an intensive study of theoretical developments in nuclear physics in order to obtain greater insight into the nature of the fundamental particles and the laws of interaction. He also wished to complete his earlier investigations in organic chemistry. Those who worked with him during this period were a batch of devoted workers, the most productive of whom was undoubtedly Nripendra Nath Ghose who worked on the unified field theory. There was the senior research officer, Dr Pumanshu Kumar Roy, who worked in particle physics. Dr Roy later joined the Pure Physics Department of the Calcutta University as Reader in 1964. Professor N.R. Sen, after he retired from the Ghose professorship of applied mathematics, also joined Professor Hose's research group but died within a year. Two younger people got their doctorate degrees working under him; they were Parthasarathi Ghose and Salil Roy.

Professor Syamadas Chatterjee joined him in 1971 after retiring from the University of Jadavpur. Bose himself was rather keen to have him. Chatterjee had been working on a helium extraction scheme from the hot springs of Bakreswar since 1954. He was the first to detect radioactivity in the water there and later analysis by him showed traces of helium which is a rare gas and of strategic importance. Bose sponsored the scheme for making a systematic analysis of the spring water. He supervised the construction of a field laboratory at Bakreswar. The scheme has now almost reached the production stage.

One unfortunate incident in his family was the death of his eldest son-in-law, B.N. Mitra in 1958. Mitra had been unwell for some time and Bose was constantly worrying about him. At last when he died in Vellore, the shock was too much for the ageing father-in-law.

Six years later, Bose's youngest daughter Khuku was married. She went abroad with her husband, first to Africa and then to the USA where they are now settled. It was also the year of Bose's 70th birthday and his students and admirers, with generous help from the State government, arranged for a fitting celebration. The Science Congress held that year in Calcutta had a seminar on Bose Statistics and unified field theory in his honour.

The Delhi University observed his 70th birthday with a seminar on 'Forty Years of Bose Statistics' and presented him a collection of articles on Bosons, edited by R.C. Mazumdar. This volume contained a number of papers illustrating the great impact which Bose's work of 1924 has made on contemporary physics.

Acknowledging the good wishes of the people, Bose addressing a gathering at Mahajati Sadan, Calcutta, spoke of the duties and responsibilities which Independence had thrust upon all. The fruits of freedom had to be shared by all and should not be confined to the educated minority, he insisted.

All through his later years Bose was becoming increasingly involved with the activities of the Bangiya Bijnan Parishad in all their efforts to make science accessible to the common people.

He was the national professor for three consecutive terms, each of five years' duration. In 1974, when he completed eighty, celebrations were organised on a nationwide scale. The year coincided with the golden jubilee of Bose Statistics. An international seminar was held at Calcutta. It was attended by scientific celebrities from all over the world. Bose spoke about his long years of struggle and the satisfaction at having seen his life's work appreciated at long last. "Now I feel I do not need to live any longer," his words ended with a ring of prophecy.

The month of January was a hectic one for a man of his age. He had to attend so many receptions, seminars and exhibitions that he was worn out completely. He knew that the end was near. After an attack of bronchial pneumonia, he died on the 4th of February.

12. THE COMPLETE MAN

Satyendra Nath died in the early hours of February 4, 1974. By afternoon the Goabagan boys' library had badges printed and pinned on the shirts of all the members with these words in Bengali: 'Our homage to the undying lamp'. Children and adults poured in to have a last glimpse of the body kept in the portico of the Science College. Even Dr D.M. Bose, now almost ninety, was carried all the way from his home in the premises of the Bose Institute to the street to have a last look. Though Bose was well advanced in years and his death was by no means unexpected, the public expression of sorrow was spontaneous and overwhelming. Clearly the common people had no idea of the scientific miracle which had made Bose a name; still less did they care about the complications of modern physics. But they were proud of him, proud of the legend that was Satyen Bose and fond of the man behind the legend.

What kind of a man was Bose and how could he transcend the limitation of his profession and win a place straight in the hearts of his country men? For an answer one must take an analytical look into the various traits which went into the making of his personality.

It is one of the prices of greatness that a great man tends to get isolated, his enemies multiply, and friends diminish. Bose was one exception to the rule. His leap into fame came early enough to create enemies, but they could never outnumber his friends.

From school days Bose displayed a curious power to attract kindred souls. He was loving and sociable. His friendships are legendary. The few of his old friends who are still living grow wistful while talking of him. He was loyal and devoted to friends to such an extent that these relationships provided him the greatest emotional sustenance through difficult times. His letters to his very old friends written at the fag end of his life show a tender concern not only for his friends but also for all the members of their families.

In school he was fond of Tennyson's long poem *In Memoriam.* Prompted by the death of a very dear friend, this poem must have produced identical emotions in the young boy. This ability to love was one predominant quality in him which advancing years and the experiences of life could do nothing to abate.

Another endearing trait which naturally followed from this was his trusting nature. From the early days of teaching in Dacca, he had never turned away any needy person, particularly a student who asked for help. Thus he would stand them a meal, pay their examination fees, and recommend a student for a free ship without a moment's thought. His numerous other acts of private charity are known only to the people intimately connected with such affairs. It was typical of him that the thought of his own financial commitments never kept him back. Needless to say, his generosity and trust were occasionally misused—the idea never occurred to him that they might. During the communal riots in 1946, he was approached by a certain person for a large sum. The man explained that he would employ the money in the building of wireless sets to get news from the newly formed State, East Pakistan. Partition and lack of any means of communication had upset Bose greatly, especially because he had left friends on the other side. The money which Bose offered out of his provident fund was promptly used up and never accounted for. He could be easily taken in, because by nature he was vulnerable. Even though the pay of a professor was princely in those days and he had been a university professor since 1922, when he died he left practically nothing. After his death one of the leading newspapers commented:

Some may regret that he did not apply himself more to a fuller development of his own ideas. Had he done so, he could have established himself as a scientist of much greater stature. But he was content with the somewhat wayward exploration of his brilliant mind. One cannot imagine Bose doing anything in a calculated fashion in order to gain professional prestige or to add to his stature. He had accepted fame when it came to him with an easy grace; silenced critics when they teased him about not getting the Nobel Prize by saying, "I have got my due." To do anything else would have been contrary to his nature, but whether by being so he was doing an injustice to' himself is an altogether different question.

His unhurried and casual approach to everything, even things which interested him professionally, is well brought out by an incident in his early life. When D. M. Bose returned to Calcutta after his long internment in Europe, both Saha and Satyendra Nath came to see him. Saha, as was his custom, at once plunged into a detailed discussion of research plans. Satyendra Nath, after taking a look around? commented, "I see, you are going to do some research here/' That was all he had to say about the subject.

This could occasionally be very misleading. The historic example of such a misunderstanding was his encounter with Madame Curie in Paris. William A. Blampied, the American physicist, unfamiliar with the nature of Bose, was led into a mistaken conclusion that 'Bose was terribly intimidated by most Europeans'. He quoted two instances on which his belief was based:

Although he (Bose) was in Paris with Langevin while the latter was communicating with Einstein on de Broglie's thesis, there is no evidence that Bose ever tried to impress upon Langevin his dream of working with Einstein. Presumably Madame Curie would have accepted him as research assistant had he been able to convince her that he knew sufficient French. Yet he was either too polite or too frightened to interrupt her

English monologue by replying in French and thus (perhaps) convincing her.

Perhaps the interviewer was not aware of the fact that Bose was withdrawn by temperament and would have been the last person to draw attention to himself. Even while in school he displayed a total lack of exhibitionism which is so common a feature in young boys. The boy Satyen would wait patiently by the gate of a friend's house, he would not cross the ground and walk up to the front door, let alone shout from the gate. He would wait till someone came out of the house and then ask him to send a message in. It is still more difficult to imagine the young scientist interrupting the great lady of science to tell her that she was mistaken in her assumption.

Even after, the publication of his famous paper, Bose remained just as unconcerned about the consequent publicity as before. Vanity and pride had absolutely no place in his temperament. His friend Girijapati, who happened to be in Paris in 1924, dropped in one morning in Bose's room. Bose was looking at some German reprints which had just arrived. When Girijapati asked him about them, Bose answered casually that they were from Einstein—a hundred reprints of his paper on the Planck Laws. To his friend this was wonderful news. But to his utter surprise Bose put away the offprint, got up and said, “Now let us go out and get something to eat.” Of course, Girijapati stood him the lunch.

But for all his passivity there was a hard core of iron will and determination which showed up on rare occasions. Bose’s nephew, Bhakta Prasad Mitra recalls how on the death-bed of a relative, Bose at once took command of the situation, ordering and directing the confused family members. Again, during his brief stay at Santiniketan as Upacharyya, he showed how firm and fearless a stand he was capable of taking. If he had more tact he may have been a better administrator. But Bose was not the kind to yield before pressure; in fact, he had kept his head up before no series of articles challenging this statement. For many years afterwards this was a common joke among the friends, and in some of his speeches much later, Bose refers to this attitude of complacency as the root of all our ills.

It is interesting to compare the reactions of these two class-fellows, Saha and Bose, when faced with the same challenge. During one of the meetings of the *Parichay* group in September 1932, Probodh Bagchi, while comparing the European mystics with Indian *yogis,* mentioned in passing that Einstein’s theory of relativity was no new idea to the Indian *rishis.* Satyendra Nath was present in the company, but he merely smiled and kept quiet; it was his friend, Girijapati who gave a spirited reply. For all his social nature, Bose was a romantic par excellence: the scientist who relied more on the flash of inspiration than on any organised or collective effort. The name which naturally comes to mind as a vivid contrast is that of H. J. Bhabha, the first Indian scientist of the modern century. Earlier mention has been made about the evolution of scientific research, how it has moved on from the individualistic to the collective pattern. Temperamentally Bose belonged to the earlier generation, when science developed round men with ideas who struggled despite odds. But the days of the Curies are gone. Technology has quickened the pace of research and the shape of science has to be adjusted accordingly. To Bhabha, who was fifteen years younger than Bose, goes the credit of shaping and planning the nuclear energy programme of the country. Such large-scale planning and organisation was beyond Bose’s scope; he was primarily a scholar scientist. This was his greatness as well as his limitation.”

In the first few decades of this century when Tagore was at the height of his glory, it was natural among aspiring young men to be seen in his company, to have their names somehow linked with the great presence. Satyendra Nath, who went to the literary meetings known as ‘Bichitra’ conducted by Tagore, always kept to the background, so that Tagore had no opportunity of knowing him. In 1925-26 when Tagore met Einstein in Germany, the German enquired about the young scientist Bose. Tagore did not know who Bose was. Some biographers have expressed surprise at this, especially because some of Bose’s close friends and colleagues being very close to Tagore, could have introduced Bose, or at least spoken of him to the poet. This throws an interesting light on the nature of Satyendra Nath.

Hiran Kumar Sanyal wrote about the contemporary intellectual scene, in which Satyendra Nath had a major though unobtrusive role:

In the later years of his life when he could not walk out of the house, his home had become a meeting place of friends. It could very well be called a literary get-together; as a matter of fact, the topics discussed were also science, history, philosophy. From the way Satyen Bose talked it seemed he was an expert on every subject except his own. There was hardly ever any argument about any scientific subject.

One wonders if Bose's reluctance to discuss his own subject was really something more than modesty, if it did have something to do with the contemporary attitudes, which if not directly hostile were at least apathetic to science. The history of modern science in India was not even a century old. Patronage, honour and prestige went to art, to literature and poetry. In spite of J.C. Bose or P.C. Ray, it is common knowledge that the 19th century Bengal renaissance cared least for science. Yet those were exciting years for Indian science: Saha's theory of thermal ionisation was being treated as one of the ten major discoveries in astrophysics, J.C. Bose had just missed a Nobel Prize, Bose's first important paper was a breakthrough, C.V. Raman had already won the most coveted award, yet the written records or diaries of that period show little enthusiasm or awareness of such magnificent achievements. Typical reactions like 'we have everything in the Vedas', starting from the composition of celestial bodies down to the very recent theory of relativity, tended to attribute everything to our sacred authorities. Clearly science had made no impact on the more receptive minds; it had failed to stimulate their imagination.

Bose is a man who defies classification, and can be partly understood as the embodied synthesis of his time. Through him we can understand his time—but his age does not explain him fully. His versatile mind could be properly understood only by the highly gifted. When Suniti Chatterji showed him the file copies of his huge book on *The Origin and Development of Bengali Language,* Bose had a few useful suggestions which Chatterji incorporated in the book. Bose was capable, with equal ease, to talk about research on edible mushrooms with a botanist or discuss the pre-revolution conditions in France, or read the history of the French Revolution in the original. Even at the age of seventy-eight he could surprise people be publishing beautiful Bengali renderings of French stories. Indeed, he had helped so many with new ideas that the exact extent of these indirect contributions will perhaps never be known or assessed. Only the grateful students and colleagues will ruefully realise that such types of men are perhaps gone for ever; a scholar who would not mind spending hours working out the problems of others, a labour which will not bring any recognition for himself. A true scholar will always be on a level high above the merely successful scientist who is busy with his own publications and publicity.

Honour which was his due came to him at the end of his life. He was made an F.R.S. only in 1958; the various national awards and honours naturally had to wait till Independence. After his departure a new generation of scientists could justifiably wonder why he was denied a Nobel Prize. But Bose had received the affection of the vast majority who are not at all bothered about scientific discoveries and, like his reply to his early detractors, he would have said, "I have received my due."

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APPENDIX-I

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AFPENDIX-II

The Classical Determinism and the Quantum Theory

(Delivered on Jan. 3, 1944)

Thirty-first Indian Science Congress, Delhi, 1944

PRESIDENTIAL ADDRESS

Congress President: Professor S.N. Bose

I wish to express sincere thanks for the great honour you have done me. The president ship of the Science Congress is a great distinction, and I confess, I have my own misgivings about the wisdom of your choice. Your first decision had raised high hopes. Many of us expected that a deliberate programme of the future scientific activities of the country would probably be a feature of the opening speech of this Congress. Pandit Jawaharlal had studied the needs of the country. Many of our front-rank scientists and industrialists had met under his leadership, not long ago, and given to questions of future reconstruction much time and anxious thought. The result of this deliberation would have been invaluable at the present moment. My regret is that chance has deprived us of the benefits of a sustained and careful study of the problems of the day. I would have liked to present here the results, if they were available. Unfortunately they are not, as most of the reports are inaccessible to me.

One of your former presidents had remarked that "a scientist is apt to become a man that knows more and more about less and less, so that his opinion upon subjects outside his field of special study is not necessarily of special value." I realise the wisdom of this warning and hope to have your indulgence, if I seem to be more at home with doubts and criticism than with useful knowledge.

I would like to present before you certain aspects of modern physics and draw your attention to the profound changes in the principle of scientific explanation of natural phenomena brought about by the quantum theory. The last fifty years record remarkable discoveries. I need only mention the electron and the neutron. X-rays and radioactivity to remind you of the increase of our knowledge. Our equipment has gained in power, range and accuracy. We possess powerful telescopes to scan the farthest corners of the universe, also precise and delicate instruments to probe into the interior of the atoms and molecules. The alchemist's dream of transmutation has become a reality. Atoms are now disintegrated and synthesised. X-rays reveal invisible worlds and wireless links upon the furthest ends of the earth with possibility of immediate intercommunication. These discoveries have their repercussions in the realm of ideas. Fifty years ago the belief in causality and 4etermination was absolute. Today physicists have gained knowledge but lost their faith. To understand properly the significance of such a profound change it will be necessary to discuss-briefly how it all came about. Classical physics had begun with the study of astronomy. With his laws of gravitation and his dynamics, Newton had explained planetary motion. Subsequent study has shown astronomical prediction to be possible and sure. Physicists had taken the equations of celestial mechanics as their model of a universal law. The atomic theory had in the meantime gained universal acceptance; since matter had resolved into a conglomeration of particles, the ideal scheme was to explain all phenomena in terms of their motions and interactions. It was only necessary to set up a proper set of equations, and to take account of all possible mutual interactions. If the mass, position, and velocity of all the particles were known at any instant, these equations would theoretically enable the physicist to predict the position and motion of every particle at any other subsequent moment

The phenomena of light did not at first fit into this simple scheme. To regard i t as a stream of particles was impossible due to the discovery of interference. Accordingly the wave theory of light was originated by Huyghens and perfected by Maxwell. With the discovery of the electron as a universal constituent of matter, the electromagnetic theory of Maxwell was converted into an electronic theory by Lorentz. To the dynamical laws were added the electromagnetic equations and the two together apparently gave an exact and ideal formulation of the laws of causality. In the forces *of* interaction henceforth, were to be included not only the gravitational forces but also those interactions which depended on the charge and the motion of the particles. These interactions were brought about by influences which spread out as waves with the velocity of light. They superimposed, interfered and constituted the field of force in the neighbourhood of the particles, modified their motion and were in turn modified by them. The motions of all particles throughout the universe were thus interlocked. These out-going influences also constituted light, invisible radiation, X-rays and wireless waves. Thus a set of universal laws was supposed to have been discovered and we had only to apply them suitably to find explanations of all conceivable natural phenomena. In physical science we do not however always proceed in the above way and turn to the 'microscopic' equations whenever we have to explain events. We often study materials *en masse,* consisting of an enormous number of corpuscles, and we use either the principle of the conservation of energy or the laws of thermodynamics to explain their behaviour. These laws were however regarded either as simple consequences of the fundamental equations or as statistical laws derivable from them by a suitable averaging. Though in the latter cases we talk about probabilities and fluctuations, it was more or less a matter of faith to maintain that if it were possible for us to obtain all the necessary data by delicate observations, universal laws would enable us to follow each individual molecule in this intricate labyrinth and we should find in each case an exact fulfilment of the laws and agreement with observation. The above in brief form an expression of faith of a classical physicist. We see that it involves as necessary consequences, belief in continuity, in the possibility of space-time description of all changes and in the existence of universal laws independent of observers which inexorably determine the course of future events and the fate of the material world for all times.

A few remarks about the general equations will perhaps enable us to follow better the criticisms that have been levelled against the system. The structure of the mechanical equations of particles is different from the field equations of Maxwell and Lorentz. The principles of conservation of energy and momentum were first discovered as consequences of the mechanical equations. Mass and velocity of the corpuscle furnish means to measure its momentum, and its energy, if we leave aside the potential energy which resides in the field. To maintain the integrity of the principle of conservation, the field must also be considered capable of possessing energy and momentum, which, however, being associated with wave-motion, must spread out in all directions with the waves. The transfer of energy from the field to the particles must thus be a continuous process, whereby a finite change should come about only in a finite interval and the process should theoretically be capable of an exact description in space and time.

Physics being essentially concerned with relations between quantities, these should all be capable of exact measurement. We measure always intervals of time or inter-distance between points; hence the specification of the reference frame is just as important as the units of measure. Newton had not analysed closely the conception of mass and time. This vagueness persisted in the dynamical equations for the particles. The field-equations which form the basis of the wave theory of light have a different origin. With the discovery of the principle of the least action, a common derivation of both has been attempted. But a difference in the choice of reference frame in the two apparently subsisted. The wave-equations assumed fixed ether whereas the material laws contemplated a Galilean inertial-frame. An immediate deduction from this distinction was the possibility of measuring the relative velocity of the observer with reference to ether. The experiment of Michelson and Morley showed it to be unrealisable in practice and formed the starting point of the celebrated relativity theory. Einstein had subjected the conception of time-measurement to a searching examination and showed the impossibility of conceiving a time independent of an observer, or an absolute simultaneity of events happening at two different places. The same space-lime reference should be chosen for dynamical equations as well as the equations of the field, this being supplied by the observer. In spite of this apparent limitation, Einstein demonstrated the possibility of formula lion of natural laws independent of all axes of reference and pointed out that the necessary auxiliaries existed already in the invariant theory and the tensor calculus of mathematicians. In spite of its apparently revolutionary character, the theory of relativity upheld the ideal of causality and determinism. Einstein himself has continued to seek with great earnestness a unifying field theory which will combine gravitation and electromagnetism and render unnecessary a separate formulation of the dynamical equations. No such theory as yet exists.

II

The development of the quantum theory has raised fundamental issues. Facts have been discovered which demonstrate the breakdown of the fundamental equations which justified our belief in determinism. A critical examination of the way in which physical measurements are made has shown the impossibility of measuring accurately all the quantities necessary for a space-time description of the motion of the corpuscles.

Experiments reveal either the corpuscular or the wave nature for the photon or the electron according to the circumstances of the case, and present us with an apparently impossible task of fusing two contradictory characters into one sensible image. The only solution suggested has been a renunciation of space-time representation of atomic phenomenon and with it our belief in causality and determinism.

Let me briefly recapitulate the facts. In 1900 Planck discovered the quantum of action while studying the conditions of equilibrium between matter and the radiation field. Apparently interchange of energy took place in discrete units whose magnitude depended on 'h' and the frequency of the radiation emitted or absorbed by matter. Photo-electric emission had similar disquieting features. Einstein therefore suggested a discrete structure of the radiation field in which energy existed in quanta instead of being continuously distributed in space as required by the wave theory. The light-quantum however is not the old light-corpuscle of Newton. The rich experimental materials supporting the wave theory preclude that possibility altogether. Moreover the fundamental relation, $E=hv$, and $p=hk$, connecting energy and momentum of the photon with the frequency v and the vector wave number k, makes a direct reference to idealised plane wave so foreign to the old idea of a corpuscle. Soon afterwards, Bohr postulated the existence of radiation-less stationary states of atoms and showed how it led to a simple explanation of the atomic spectra. The extreme simplicity of the proposed structure and its striking success in correlating a multitude of experimental facts at once revealed the inadequacy of the ordinary laws of mechanics and electro-dynamics in explaining the remarkable stability of the atoms.

The new ideas found application in different branches of physics. Discontinuous quantum processes furnished solutions to many puzzles. Suitably modified, the theory furnished a reasonable explanation of the periodic classification of elements and thermal behaviour of substances at low temperature. There was however one striking feature. It was apparently impossible to characterise the details of the actual transition processes from one stationary state to another, that is, to visualise it as a continuous sequence of changes determined by any law as yet undiscovered. It became clear that the dynamical laws as well as the laws of electromagnetism failed to account for atomic processes. New laws had to be sought out, compatible with the quantum theory, capable at the same time of explaining the rich experimental materials of classical physics. Bohr and his pupils utilised for a time a correspondence principle, guessing correct laws for atomic processes from analogy with the results of the classical theory. In every case these appeared as statistical laws concerned with the probabilities of transition between the various atomic states. Einstein tackled the problem of the equilibrium of matter and radiation on the basis of certain hypotheses regarding the probabilities of transition between the various states by absorption and emission. A derivation of the Planck Law was obtained by Bose by a suitable modification of the methods of classical statistics. Heisenberg finally arrived at a satisfactory solution and discovered his matrix-mechanics and a general method for all atomic problems. Dirac and Schroedinger also published simultaneously their independent solutions. Though clothed in apparently dissimilar mathematical symbols, the three theories gave identical results and have now come to be looked upon as different formalisms expressing the same statistical laws.

I have mentioned that the photon gave a simple explanation of many of the properties of radiation and thereby presented its corpuscular aspect while the well-known properties of interference and super possibility brought out its wave character. That the same dual nature may exist in all material corpuscles was first imagined by de Broglie. His phase-waves found quick experimental verification, and raised a similar problem of the real nature of the corpuscle. The formulation wave-mechanics by Schroedinger, once raised a hope that by a radical modification of our usual ideas about the corpuscle, it might be possible to re-establish the law of causality and classical determinism. Subsequent developments have shown such hopes to be illusory. His waves are mathematical fictions utilising the multidimensional representation of a phase-space and are just as incapable of explaining the individuality of the electron, as the photon is incapable of explaining the super possibility of the field. The true meaning of his equations appears in their statistical interpretation.

III

The adherents of the quantum theory interpret the equations in a peculiar way. They maintain that these equations make statements about the behaviour of a simple atom and nothing more than a calculation of the probabilities of transition between its different states is ever possible. There is nothing incomprehensible about such a statistical law even if it relates to the behaviour of a single particle. But a follower of determinism will interpret such statements as betraying imperfect knowledge, either of the attendant circumstances or of the elementary laws. We may record the throws when a certain die is cast large number of times and arrive at a statistical law which will tell us how many times out of a thousand it will fall on a certain side. But if we can take into account the exact location of its centre of gravity, all the circumstances of the throw, the initial velocity, the resistance of the table and the air and every other peculiarity that may affect it, there can be no question of chance because each time we can reckon where the die will stop and know in what position it will rest. It is the assertion of the impossibility of even conceiving such elementary determining laws for the atomic system that is disconcerting to the classical physicist.

Von Neumann has analysed the statistical interpretation of the quantum mechanical laws and claims to have demonstrated that the results of the quantum theory cannot be regarded as obtainable from exact causal laws by a process of averaging. He asserts definitely that a causal explanation of quantum mechanics is not possible without an essential modification or sacrifice of some parts of the existing theory.

Bohr has recently analysed the situation and asserted that we cannot hope any future development of the theory will ever allow a return to a description of the atomic phenomena more conformable to the ideal of causality. He points out the importance of the searching analysis of the theory of observation made by Heisenberg, whereby he has arrived at his famous principle of indeterminacy. According to it, it is never possible for us to determine the simultaneous values of momentum, and positional co-ordinates of any system with an accuracy greater than what is compatible with the inequality

$$\Delta (p) (\Delta) q > h / (4\pi)$$

This natural limitation does not affect the physics of bodies of finite size but makes space-time descriptions of corpuscles and photons impossible. When we proceed to study the behaviour of the elementary particles, our instruments of measurement have an essential influence on the final results. We have also to concede that the contributions of the instrument and the object are not separately computable from the results as they are interpreted in a classical way with the usual ideas of co-ordinate and momentum, accepting thereby a lack of control of all action and reaction of object and instrument due to quantum effects.

It is in this imperative necessity of describing all our knowledge with the usual classical ideas, that Bohr seeks an explanation of the apparently irreconcilable behaviour of corpuscles and radiation in different experiments. For example, if we set our experiments in such a fashion as to determine accurately the space-time co-ordinates, the same arrangement cannot be simultaneously used to calculate the energy momentum relations accurately; when our arrangements have pushed the accuracy of determining the positional coordinates to its utmost limit, the results evidently will be capable only of a corpuscular representation. If, on the other hand, our aim is to determine momentum and energy with the utmost accuracy, the necessary apparatus will not allow us any determination of positional co-ordinates and the results we obtain can be understood only in terms of the imagery of wave-motion. The apparently contradictory nature of our conclusions is to be explained by the fact that every measurement has an individual character of its own. The quantum theory does not allow us to separate rigorously the contribution of the object and the instrument and as such the sum total of our knowledge gained in individual cases cannot be synthesised to give a consistent picture of the object of our study which enables us to predict with certainty its behaviour in any particular situation. We are thus doomed to have only statistical laws for these elementary particles and any further development is not likely to affect these general conclusions.

It is clear that a complete acceptance of all the above conclusions would mean a complete break with the ancient accepted principles of scientific explanation. Causality and the universal laws are to be thrown simultaneously overboard. These assertions are so revolutionary that, no wonder; they have forced physicists to opposing camps. There are some who look upon causality as an indispensable postulate for all scientific activities. The inability to apply it consistently because of the limitations of the present state of human knowledge would not justify a total denial of its existence. Granted that physics has outgrown the stage of a mechanistic formulation of the principle, they assert that it is now the task of the scientists to seek for a better formulation. Others of the opposing camp look upon the old determinism as an inhuman conception, not only because it sets up an impossible ideal, but also as it forces man to a fatalistic attitude which regards ^humanity as inanimate automation in the hands of an iron law of causation. For them the new theory has humanised physics. The quantum statistical conception of determinism nestles closer to reality and substitutes a graspable truth for an inaccessible ideal. The theory has brought hope and inspired activity. It constitutes a tremendous step towards the understanding of nature. The features of the present theory may not at all be familiar but use will remove the initial prejudice. We are not to impose our reason and philosophy on nature. Our philosophy and our logic evolve and adjust themselves more and more to reality.

In spite of the striking successes of the new theory, its provisional character is often frankly admitted. The field theory is as yet in an unsatisfactory state. In spite of strong optimism, difficulties do not gradually dissolve and disappear. They are relegated to a lumber room, whence the menace of an ultimate divergence of all solutions neutralises much of the convincing force of imposing mathematical symbols. Nor is the problem of matter and radiation solved by the theory of complementary characters. Also we hear already of the limitations of the new theory encountered in its application to nuclear problems.

The quantum theory is frankly utilitarian in its outlook; but is the ideal of a universal theory completely overthrown by the penetrating criticism of the nature of physical measurements?

Bohr has stressed the unique character of all physical measurements. We try to synthesise their results and we get probabilities to reckon with instead of certainties. But how does the formalism

$$\frac{h}{2\pi i}\frac{\partial\Psi}{\partial t} = H\Psi$$

emerges as a certain law? The wider the generalisation, the less becomes the content. A universal law would be totally devoid of it. It may nevertheless unfold unsuspected harmonies in the realm of concept. More than ever now, physics does need such a generalisation to bring order in its domain of ideas.

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