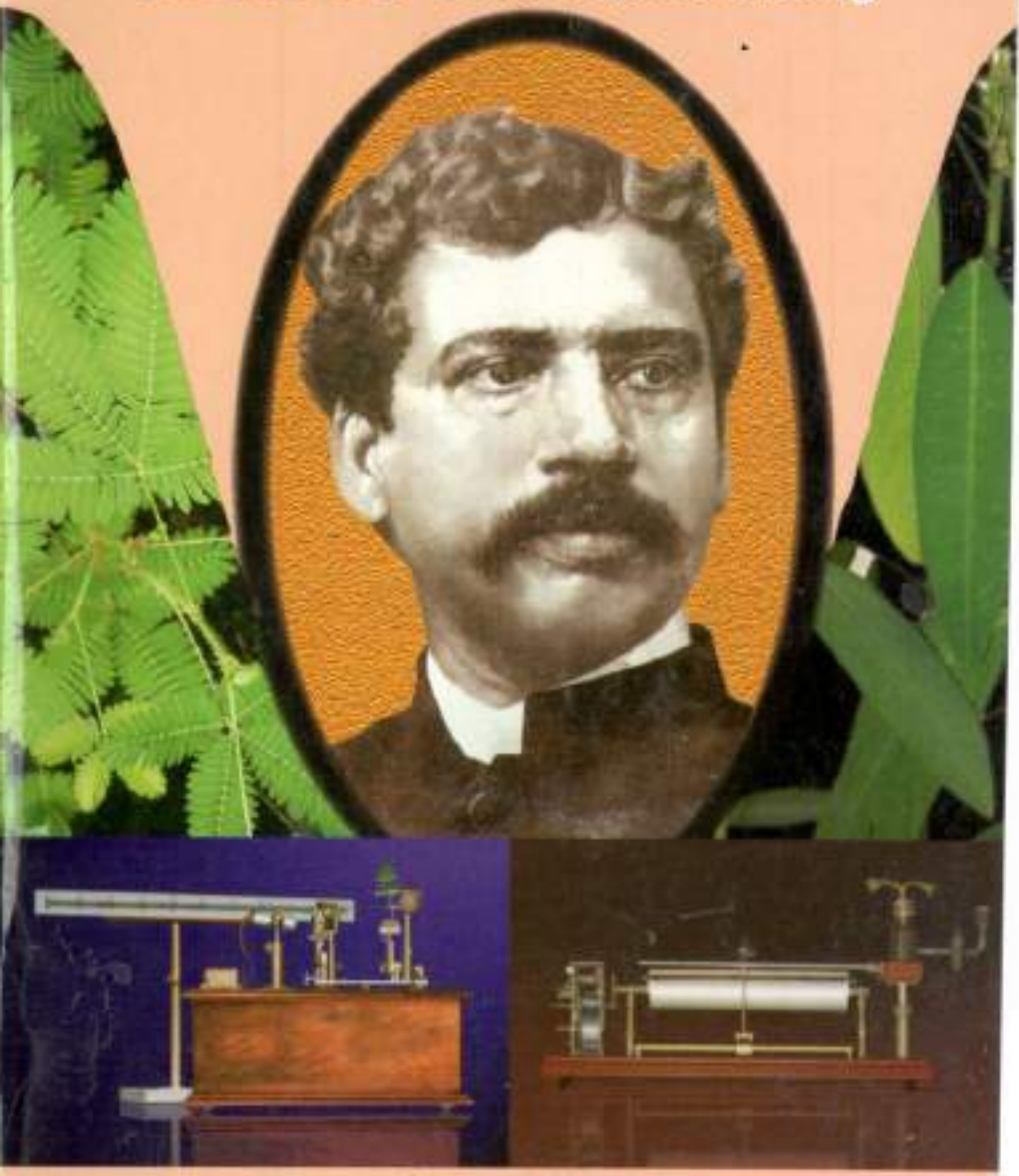
Acharya Jagadish Chandra Basu:
A Tribute
on His 150th Birth Anniversary



Bose Institute

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St. Xavier's College.

LECTURE BY

Father Lafont,

ASSISTED BY PROFESSOR J. C. BOSE.

On Telegraphy without Wires.

On Thursday, 17th instant, at 5-30 p. m.

Tickets may be had at St. Xavier's College,

at Rs. 2 per seat.

THE INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE.

(210, Lower Circular Road.)

(SESSION 1865 to 1866.)

LECTURES by Dr. Mahendra Lal Sircar, on Tuesday, the 13th instant, at 7 P.M.

Subject: Thermo-Electricity.

PRACTICAL CLASS in Physics under Babu Jagadish Chandra Bose, A. M., on Wednesday, the 17th instant, at 5-30 P.M.

LECTURE by the Rev. Father Lafont, S.J., on Thursday, the 22nd instant, at 7 P.M.

Subject: Optical Study of Musical Sounds.

LECTURE by Dr. Rajendr Lala Mitra, on Friday, the 23rd instant, at 7 P. M.

Subject: Iron Class of Metals.

PRACTICAL CLASS in Chemistry under Babu Ram Chandra Datta, M.A., on Saturday, the 24th instant, at 3 P.M.

Subject: Metals of the 4th Group and their separation.

ADMISSION *Fee*, in advance, for all the courses of lectures to be delivered during the session, Rs. 6; for 12 consecutive lectures, viz. 1-6; for a single lecture, annas 4.

The fee for the Practical Class from regular students is annas 4; from casual students, annas 8.

MAHENDRA LAL SIRCAR, M. D.,

February 15th, 1866. *Honorary Secretary.*

Acharya Jagadish Chandra Basu: A Tribute on His 150th Birth Anniversary*

Nitai Chandra Mandal

Acharya Jagadish Chandra Bose
150th Birth Anniversary Celebration Committee, Kolkata
Bijnan Bharati and Bose Institute

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*This Book is an English version of the Bengali Book, *'Acharya Jagadish Chandra Basu: 150th Janmabarshikite Shraddhanjali'* by the same author (Nitai Chandra Mandal) earlier published by the Acharya Jagadish Chandra Bose 150th Birth Anniversary Celebration Committee, Kolkata.

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Ms. Mridula Banerjee : Sections 1, 3, 4, 5, 7 and 8;
Dr. Ramdas Chattopadhyay : Sections 2, 11, 12 and 13; and
Prof. Nitai Chandra Mandal : Sections 6, 9, 10, 14, 15 and 16.

Acharya Jagadish Chandra Basu : A Tribute on His 150th Birth Anniversary

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"As a compassionate you've felt with sympathy the life of plant,
Mine's iron vibrates and animal's blood throbs by your touch.
Sorceress you're, enchanter you're, what a magic of you!
The forest plant Ban Chnaral performs dance by the command of you!"

Satyendra Nath Dutta

DEDICATION

"We are new, we are buds in the entire forest garden,
With smile on lips our lives awake with pulsation.
Lakhs of hopes are sleeping
In the depth of our minds,
Sleeping our language of hearts in the bondage of petal leaves.

We'll bloom, we'll blossom ignoring the thorns,
We'll capture the morning golden sun by our hands.
Novel prides everyday,
We'll spread like fragrances,
We'll lift our heads to sky-high, shattering all obstructions."

Golam Mostafa*

'Dedicated to the Youth Communities of India'

* Translated into English by Prof. Nitai Chandra Mandal

PREFACE

This faultless attempt of Prof. Nitai Chandra Mandal to write on the life and activities of Jagadish Chandra in clear and lucid language for the youths on the occasion of 150th Birth Anniversary Celebration is praiseworthy. Today, the life and the scientific activities of the greatest scientist of India of all the times, its relevance to the present time or the scale of his recognition, are not properly evaluated yet. Most of the youngsters of the present generation feel that Jagadish Chandra is famous for discovering life in plants. That such simplifications lead to erroneous concepts often escape us.

I was delighted to read this book written by Prof. Mandal. His pen neither got tired, slowed down, nor stopped by the burden of documents and opinions. He has presented a lot of yet unknown information to us. Books with a proper evaluation of Jagadhish Chandra are still very limited or lacking; almost none which would appeal to the young generation. I have no doubt that this book by Prof. Mandal will get special appreciation by all. I express my regards and gratitude for this work.

Prof. Sibaji Raha
Director, Bose Institute
and
Chairman
Acharya Jagadish Chandra Bose 150th
Birth Anniversary Celebration Committee

AUTHOR'S NOTE FOR THE BENGALI EDITION

It is not an easy job to write an account of the life-time multidirectional activities of a towering personality. With a view to celebrate 150th Birth Anniversary of Acharya Jagadish Chandra Basu, a meeting was held on 26th September, 2008 with a joint effort of Vijnana Bharati and the Bose Institute. In that meeting, among the various programmes and activities decided to be undertaken, one was to percolate his life's philosophy and the accounts of research activities among the present student community to inspire them in nationalism and in basic scientific research. The responsibility of compiling such a document in the form of a book was given to me. A huge number of various documents about his personal life and the accounts of his research work are already available in writings. Many writers including Historians and Scientists have compiled in various forms on Acharya Bose. So, to write something new within a short time is not an easy task. Also, it is not possible to avoid this responsibility. Under this circumstance, I have tried my best to include various anecdotes and events related to the national and scientific activities of Sir J. C. Bose. In this venture, I have consulted literatures, which were available to me. Any unintentional omissions may be excused. I do not have enough capability to evaluate the research works of Acharya Bose all of which were highly accepted by the top scientists of the world. I have tried to explain the value of J C Bose's philosophy and scientific researches keeping in view the youth communities for whom I have planned to write this book. Keeping in mind the vastness of his professional activities, I have tried to analyze them. If the young minds, who are directed in the path of fulfillment of success, can properly analyze them, they will be able to understand as to what they will have to learn from the life and activities of Acharya J. C. Bose. It has not been possible to include all the important events/documents in this short space. I shall feel rewarded if this book is well appreciated by all for whom this has been written.

Nitai Chandra Mandal

December 1, 2008,
E-5, Digantika, AH Block, Sector-2, Salt Lake, Kolkata-700 091
Email : mandalnc2003@yahoo.com

AUTHOR'S NOTE FOR THE ENGLISH EDITION

Soon after the book, 'Acharya Jagadish Chandra Basu : 150tama Janma Barshikite Shraddhanjali' written in Bengali by me was published by the 'Acharya Jagadish Chandra Bose 150th Birth Anniversary Celebration Committee' in December, 2008, the same committee decided that this book should be translated into English for the English speaking peoples including student and youth communities of India. No single person can complete this job within a short time. Two persons came forward voluntarily to share this responsibility. They are: Dr. Ramdas Chattopadhyay and Ms. Mridula Banerjee. Thus, Dr. Chattopadhyay translated the Sections 2, 11, 12 and 13; Ms. Banerjee, Sections 1, 3, 4, 5, 7 and 8; and I myself, Sections 6, 9, 10, 14, 15 and 16. At the final stage, Dr. Pataki Charan Banerjee and Dr. Pradeep Parrack assisted me in editing certain selected Sections. I would like to point out that some Sections have been enriched with additional information in the English Edition of the book. I shall feel gratified if the English Edition of this book ('Acharya Jagadish Chandra Basu : A Tribute on His 150th Birth Anniversary') is appreciated by all for whom it has been translated into English.

Nitai Chandra Mandal

July 20, 2009
E-5, Digantika, AH Block, Sector 2, Salt Lake, Kolkata 700 091
Email: mandalnc2003@yahoo.com

N.B. : Note added in the second (revised) edition : In this edition certain errors have been rectified. November 20, 2009.

ACKNOWLEDGEMENTS

During the compilation of this book (Bengali Edition), Prof. Sibaji Raha, Director, Bose Institute, all the staffs of the Library and Publication Department of Bose Institute extended help and co-operation by providing various information including pictures and other related documents. I acknowledge my gratitude to all of them. I also collected various information from the web-sites of Presidency College, St. Xavier's College, Royal Society, Royal Institution and J. C. Bose. I shall remain grateful to all these websites. I also thankfully acknowledge the help extended to me by many others by way of critical review of the manuscript, reading proof and providing various suggestions to improve the text matters and presentation format. I would like to thank the 'Acharya Jagadish Chandra Bose 150th Birth Anniversary Celebration Committee' for entrusting me with the responsibility of writing this book. Also the 'Vivekananda Vijnan Mission' (the West Bengal unit of Vijnana Bharati) actively participated in 150th Birth Anniversary of Acharya J. C. Bose and extended co-operation & help in various ways during the compilation of this book. I express my grattitude to 'Vivekananda Vijnan Mission'. Dr. Ramdas Chattopadhyay and Ms. Mridula Banerjee were involved directly in translating certain Sections of the Bengali Edition of the book into English. My sincere thanks are due to them. Also, I express my gratitude to Dr. Pataki Charan Banerjee and Dr. Pradeep Parrack for helping me in editing some of the Sections of the English Edition of the book.

Nitai Chandra Mandal

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This bust, made by Sri Biman B. Das (Ex-principal, Government Art College, Kolkata, WB), has been installed in the premises of Christ's Collage, Cambridge and unveiled by Sri Shiv Sankar Mukherjee (India's present High Commissioner in London) on December 6th, 2008. Photograph : By the courtesy of Sri Biman Bihari Das.

*This signature (original) was put by Acharya J. C. Bose in the Register of Christ's College at the time of his first entry as a student.

Acharya Jagadish Chandra Basu: A Tribute on His 150th Birth Anniversary

1. Science Education in the Pre-Jagadish Chandra Era in India

In ancient period since the time of Atharva Veda, the 'Study of Chimea' (mixture of Metallurgy and Chemistry) started and Pundit Nagarjuna had great expertise in this area of science. In the 'Charak–Sushruta' era, medicine and surgery had undergone great developments. India was also very advanced in Astronomy as well as in Arithmetic. In these areas, the contributions of Aryabhatta, Barahamihir, Brahmagupta and Bhaskaracharya were very significant. But in later periods, the continuity of the study of sciences in all these areas was not maintained properly. It so happened that when William Jones, after coming to India, looked for an expert to acquaint him with the numerous stars seen in the night sky and was even ready to pay remuneration, could not find any such deserving person. Towards the end of 12th century, the study of science went in the downward direction. Possibly, the scientific methods were developed by personal efforts, but could not be transmitted through generations. As a result, the continuity was gradually lost. On the other hand, from that time onwards, the study of science and scientific research gradually progressed in Europe in a better and advanced direction. Since the time of Galileo, the very life-style of people changed as a result of various scientific discoveries. Many industrial developments such as the use of glass, compass, mechanical clock, gunpowder, paper, printing machine, water-power, steam

engine etc also took place during the European Renaissance. The use of all these materials was quite unknown to India at that time. The recording of knowledge in descriptive form, the progress of printing technology and the shipping trade were considered the three main causes of European Renaissance.

Being tempted by India's natural resources, the East India Company came to India as a representative of the ruling British. Since that time they identified the weak points of the Indian natives and established their business market in exchange of the natural wealth of India. After that the British came to India directly and established the British Empire by successively defeating Sirajuddoula in 1757, and Mirkashim, Sujuddoula and the Mogul Emperor Shah Alam in 1764. Calcutta (now Kolkata) became the capital of the British Raj in 1774, and the 'Supreme Court' was set up in that very year for conducting all administrative works. The Bengali language got importance as Kolkata became the capital of Bengal, and education, culture, industry etc. also gradually developed around Kolkata. Thus, the printing machine was imported, Bengali type-sets for printing were made, the *Impe Code* was translated into Bengali, and also the Anglo-Bengali Dictionary was prepared for the foreigner. However, it was rather difficult and troublesome to run the administration and education systems by importing experienced teachers or the so called resource persons from England. So, the training school for preparing clerks was established. The role of Bengalees in the educational renaissance was significant, but education in science and technical subjects did not start. It is also true that Bengalees were not mentally prepared to accept science education, since the possibility of getting into Government service was far better if one studied literature and was remote if one studied science. Therefore, the elite society of that time was more inclined towards the study of English rather than that of science. The British also did not bring or introduce modern science in the curriculum at first, as they knew that if the natives were taught everything fast, it might turn to be

suicidal to their plan. Medical science was indeed introduced in the syllabus in order to look after the Britishers' health. But a few Bengalees could make different types of machines just by imitating the imported ones, as they lacked proper training.

Sir William Jones came to India in 1783 as the Justice of the Supreme Court. He set up the Asiatic Society of Bengal in 1784, just 15 years before the Royal Institution was started in England. Though the Asiatic Society of Bengal was set up in the style of Royal Society (London), but it was not conceived as a Scientific Society. There was no effort of nurturing contemporary science. Its only link to science was that Jones applied scientific methods in studying history, science and arts related to Indian culture and classifying taxonomically the flora and fauna, insects, animals, birds etc. In 1790, Michael Topping set up an Astronomical Observatory in Madras, and William Lambton introduced 'Trigonometrical Survey' in India. The 'Survey of India' was also established in 1767 to facilitate the administrative work and the Atlas of Bengal was scientifically prepared in 1779. After that, the map of Hindustan (India) was drawn in 1782. In 1787, the 'Botanical Garden' was set up on the bank of Ganges at Sibpur solely with a financial purpose, but there was no plan or project for nurturing natural science, especially Botany.

William Carey came to Kolkata in 1793. He undertook various concrete steps to develop the learning and teaching of the Bengali language and literature. So, there was a better atmosphere of Bengali learning/education. He composed a Bengali Grammar book in Bengali language in 1801. The famous Fort William College was set up in 1800 to train the ministerial officers. In 1804, the Bengali version of the essence of the knowledge of Chimia (Chimia Vidyar Sar) of John Mackey was published. Reverend May built a Christian school at Chinsura in 1814. Also, Raja Ram Mohan Roy set up a school in 1816 to teach English to the Hindu students. Ram Mohan Roy realized that the society could not be freed of blind prejudices and superstitions

unless and until they would accept Western science and scientific education. He also realized that English was very much essential for the study of science. Later, Pundit Iswar Chandra Vidyasagar tried his level best to implement Ram Mohan's endeavour for social reforms. After that, Hindu College was set up in 1817 with the financial assistance and enthusiastic approach of the Bengalees but in the beginning, science courses were not started. In 1855, Hindu College was divided into two branches – school and college; the college branch was named the Presidency College and the school branch, the Hindu School. In 1821, Reverend Mac started teaching science in Sreerampur College. In 1829, Captain James de Herbert published a science magazine named 'Gleanings in Science'. In the same year, Indians were granted eligibility for the membership of the Asiatic Society of Bengal. In 1832, the Journal of Asiatic Society was published. In spite of so many ventures, any environment suitable for the study of science was yet to be developed.

In 1826, Henry Louis Vivian Derozio joined the Hindu College at the age of 17 only. He influenced the students to a great extent by his qualitative teaching of English literature, history and philosophy; unfortunately he died of cholera in 1831. A student named Radha Nath Sikdar took admission in the Presidency College in 1824. This year was also marked by the fact that science teaching started in this College. Radha Nath learned science and mathematics with great interest and was considered to be the most brilliant mathematician of that time. He was very much influenced by Derozio. After passing out from college, he joined the 'Trigonometrical Survey of India'. He was an expert in three-dimensional land surveys and as a first Indian, used science in land surveying with great success.

The Calcutta Medical College was established in 1835. Subsequently, the Grant Medical College was set up in Bombay in 1845-46. These medical colleges were the main centres of science education for a long time. The first Engineering College was started in 1846 at Roorkee. In the

first year, only Civil Engineering was taught in English model in this college and Nilmani Mitra was the first Bengalee who received the Engineering degree. Many colleges were established by that time in several states of India.

In order to critically examine the education system and various other social and administrative affairs in India, a Select Committee was constituted in the British Parliament in 1852. As per the recommendation of this committee, detailed discussions were carried out and a concrete proposal was suggested as a new step for the improvement of the education system by setting up Universities in India following the British system of education. Accordingly, in 1857, three Universities named after Calcutta (in January), Bombay (in July) and Madras (in September) were set up. There was no provision of teaching in the Universities, which were conducted in the University-affiliated colleges like Presidency, St. Xavier's and Scottish Church Colleges in Kolkata, Elfinston and Wilson Colleges in Bombay and Christian College in Madras. The Universities were entrusted only with the responsibilities of holding examinations and awarding the degrees. The first graduate of the Calcutta University, Sahitya Samrat Bankim Chandra Chattopadhyay wrote many essays on science subjects in the Bengali language. Rajendralal Mitra also wrote many essays and articles on science subjects in Bengali at that time. Many books on science suitable for use in teaching science at the school level were also written.

'Thakur Bari' of Jorasanko was an important centre of science and culture. Prince Dwaraka Nath Thakur had a great contribution towards the introduction of English education in Bengal. Rabindra Nath went through the books like 'Padarthavidya Path' by Akshoy Kumar Dutta, and 'Prani Brittanta' and 'Asthividya' by Satkari Dutta. The subject matters of 'Padarthavidya Path' contained various topics of physical science. Sitanath Ghosh, the private tutor of Rabindra Nath, used to teach him science showing various experiments using different instruments. Seeing these experiments, Rabindra Nath became overwhelmed with

astonishment.

The St. Xavier's College was set up in Kolkata in 1860 by the initiative of the Belgium Christian Society. Though the college started in the style of Oxford and Cambridge, the foundation of science teaching was not very good, although Father Inesius Karboneli himself taught Physics, Chemistry, Mathematics and Mechanics. On 7th December, 1865, Father Eugene Lafont, another member of the Belgian Christian Society, joined the St. Xavier's College and thereafter science-teaching started in full swing. Actually, Father Lafont is considered as the father of science education in Bengal. He used to teach science, preach science and practise science. Though he belonged to a particular religious group, he made a synthesis of science and religion. In 1867 when the B.A. course started in the college, he moved to the college section. At that time, the Asiatic Society of Bengal put forward a proposal for introducing science courses in the University curriculum right from the entrance level. Even the print media started a movement in favour of science education. In fact, such a movement was started by the initiative of Father Lafont and Dr. Mahenndra Lal Sircar. It is surprising that even in the midst of such a movement, physical science was deleted from the B.A. syllabus in 1867. That very year, Father Lafont further improved the teaching of science. With a view to preach science among the common peoples, he started delivering popular lectures with practical demonstrations. As a result, the youth community started getting attracted towards science education. From that time onwards, students from other colleges, even from the Presidency College, used to attend his lectures on physical science and meteorology. Later, Lafont also started studying astronomy and set up a telescope in the college premises. In 1871, a subcommittee recommended for giving more stress on the teaching of science in the University education. In 1872, two separate streams, 'a' and 'b', were introduced in the F. A. and B. A. courses in which the students of the 'b' stream got the opportunity of studying science. During the next decade, this

science stream became very popular.

Dr. Mahendralal Sircar was a very brilliant student of the Calcutta Medical College. Even in his student life, like Raja Ram Mohan Roy, he realized that without science education, superstitions and prejudices could not be wiped out from the national life of India. So, he took up a plan to establish an institution in Kolkata in the model of the Royal Institution of London. With the collaboration of Father Lafont, he established the 'Indian Association for the Cultivation of Sciences' (this will be called IACS later) in 1876 at 210 Bowbazar Street. But in this institution, there was no provision for research work. However, various science-based lectures were arranged for the public. In 1879, when Father Lafont returned from his tour of Europe, he brought with him several new instruments to be used for science teaching in Kolkata. He started delivering scientific lectures on new subjects with practical demonstrations using those instruments at both IACS and St. Xavier's College. On listening to these lectures of Lafont, many students were very much inspired and influenced to take up science education and scientific research as their future profession.

Just a few years before Father Lafont joined the St. Xavier's College, Jagadish Chandra Bose was born on November 30, 1858 in the district of Mymensingh (now in Bangladesh) in the then unpartitioned India (in undivided Bengal, at his maternal uncle's residence) in a Brahmo family. In 1868, Jagadish Chandra took admission in the St. Xavier's School, where Father Lafont had started teaching science with practical demonstrations, just the previous year, i.e., 1867. So, Jagadish Chandra was born in a historical cross point. The Sepoy Mutiny started in 1857. Many men of genius were born in Bengal within a few years just before and after his birth. They were : Dr. Sundari Mohan Das (1857), Rabindra Nath Tagore (1861), Acharya Prafulla Chandra Ray (1861), Dr. Nil Ratan Sircar (1861), Upendra Kishor Roy Chowdhury (1863), Swami Vivekananda (1863), Ramendra Sundar Trivedi (1864), Dinesh Chandra Sen (1866), Jagadananda Roy (1869), Dr. Upendra Nath

Brahmachari (1873), to name a few. All these intellectuals created an environment of scientific research and study of literature, based on which several famous scientists such as Meghnad Saha, Satyendra Nath Basu, Prasanta Chandra Mahalanabis, Sir C. V. Raman and several other persons helped take the systems of science education and research to higher levels. Now, keeping aside the above historical background of education and research in basic science, we shall discuss how Jagadish Chandra set a rare example by carrying out research in modern science in the absence of any suitable infrastructure and established both himself and his motherland in the world of science.

"An aimless experimentation can lead to no result, while an unstrained imagination will lead to the widest speculation, which is subversive to intellectual sanity. A true inquirer has, therefore, to guard against being self-deceived; he has at every step to compare his own thought with the external fact; he has remorselessly to abandon all in which these are not agreed. Thus what he slowly gathers is certain forming a sure foundation of what is to come."

ACHARYA JAGADISH CHANDRA BASU

2. Jagadish Chandra's Childhood and Education: in Village

While narrating the achievements of Bengalees, the poet Satyendra Nath Dutta called Acharya Jagadish Chandra Bose a Devotee and also adorned him with the adjectives like 'Mayabi' and 'Kuhaki'. Sir Jagadish Chandra Bose discovered 'Microwave' in the first phase of his research career, and later in the second phase, he discovered a direct link between living and non-living objects. In the third phase, he discovered the existence of sensibility in plants. He has been recognized as the 'Father of Microwaves and Semi-conductor' for his researches in those areas in the first phase. Through the second and third phases of his research, he developed a new branch of science – 'Biophysics' or 'Electrophysiology' in India. All these works created an unprecedented sensation in world science. His father Bhagaban Chandra and mother Bamasundari Debi had six daughters and two sons. The younger son died at the age of ten when Jagadish Chandra was seventeen. When Jagadish Chandra was born, that time Bhagaban Chandra was a Deputy magistrate at Faridpur. Although Bhagaban Chandra was serving the British government, yet he was a true Bengalee by heart and a strong nationalist. His mind was firm like a thunderbolt but softer than flowers. As a judge, he used to pronounce severe punishments for the thieves and dacoits, and he also used to extend help to the needy peoples. Once, he sentenced a notorious dacoit for a long time behind the bar. When the jail term was over, the dacoit failed to get a job to live a normal life even after approaching many peoples. Then he approached Bhagaban Chandra for a job who appointed him to escort Jagadish Chandra to school. Riding on the shoulder of that former dacoit leader, Jagadish Chandra used to go to school

everyday and hear the thrilling stories of his past dacoit life. All these stories helped the boy Jagadish Chandra develop a brave and firm mind. Jagadish Chandra was very much surprised to see the signs of wounds on his body that were inflicted, while he used to commit dacoity.

Bhagaban Chandra realized that the country could be progressed by developing education, industry, business, and agriculture. Being guided by such idea, he used to take up projects of various kinds that brought different types of job opportunities to the villagers. These projects included establishing cloth weaving machine, opening loan office at Faridpur for the convenience of villagers, arranging agricultural and industrial fares, making an indigenous tea garden at Assam and establishing technical school. This list also included the opening of Bengali-medium school for the children. Bhagaban Chandra used to spend his own savings for launching and carrying out these projects. But many of these projects did not succeed. Consequently, he ran into financial trouble. Even then, he was not cowed down as he knew that failure and success stay side by side. He used to think that in most cases failures bring the message of future success.

Although Jagadish Chandra was born in Mymensingh, he spent his childhood at Faridpur. He started his education at the age of five in a Bengali-medium school established by his father at Faridpur. Bhagaban Chandra did not like class-difference. Though he had well-to-do condition and the then elite families were inclined more towards educating their children in English-medium schools, he sent Jagadish to a Bengali-medium school. He wished that his son should learn mother tongue well before learning to speak in English and being accustomed to other etiquettes. He also wished that Jagadish Chandra should become well-acquainted with the Indian customs and culture, and above all, the peoples from all walks of life. In the class, the son of his father's Muslim peon used to sit at his right-hand side and the son of fisherman at his left. He used to mingle with the boys from fisherman, cultivator and labor class families with open

mind and learnt about the lifestyles of those peoples. Those friends showed him the magic of dancing (movement) of the leaves of 'Lajjabati' (*Mimosa pudica)* and 'Ban Chnaral' (*Desmodium gyrans*). Those magical events aroused in the curious mind of Jagadish Chandra various questions regarding the movement of these plants. Those friends influenced him to accompany them to the village fairs. He was inspired to read the great epics, Ramayana and Mahabharata from association with those friends. He liked the character (neglected) of Karna (in Mahabharata), who had a great influence on his future life. He used to rear animals at home and take care of them. Bamasundari Debi also disliked caste-system. Whenever those friends (from fisherman, cultivator and labor class families) of Jagadish Chandra came to his house, Bamasundari Debi used to feed those boys with personal care herself sitting by their side.

"The more difficult is the task, the greater is the challenge. When you have gained the vision of a purpose to which you can and must dedicate yourself wholly, then the closed doors will be opened, and the seemingly impossible will become fully attainable."

From the collection of ACHARYA JAGADISH CHANDRA BASU

3. Education of Jagadish Chandra in Kolkata Schools and College

When Bhagaban Chandra was transferred to Burdwan in 1868, he admitted his son Jagadish Chandra to school in Kolkata, at first to the Hare School and then after three months to the St. Xavier's School, an English-medium European School. During this school life, he had to stay in a hostel where the other residents were the students of different colleges, and there was none of his age among them. His father arranged a European private tutor who used to teach him in the hostel. His all classmates were European; so, Jagadish Chandra, fresh from village Bengali-medium school, felt like fish out of water in respect of communicating with them in English and adapting with their manners and gestures. In such an environment, his class-mates used to barrack and tease him often. Jagadish Chandra heard many stories of heroism and velour from his ex-dacoit friend-cum-caretaker in his childhood. So, he made use of the morals and feelings of those stories to vanquish his class-mates as and when needed. One day, when his class-mates were annoying him harshly, which ultimately turned into hand-to-hand fight, Jagadish Chandra paid the leader of the group in his (leader's) own coin by giving him a great blow. After this incident, the relationship with his class-mates became cordial. He passed the Entrance Examination in 1875 from this school. Then he got himself admitted in the college section of this institution for higher education and passed the F.A. Examination affiliated to the Calcutta University in 1877. Then he took admission into B.A. course with Physical Science as one of his study subjects in the same college. From that time, he stayed in the hostel of St. Xavier's College. During the study of B.A., Jagadish Chandra had a great inclination for Botany. In spite

of that, he developed deep interest in Physics due to the excellent teaching through illuminating lectures (with practical demonstrations) of Professor Father Eugene Lafont. In 1879, Jagadish Chandra passed the B.A. Examination in Physical Science stream with Physics. During the period of his study in this college, Father Lafont once took Jagadish Chandra along with other boys to Botanical Garden at Sibpur. Jagadish Chandra was very much excited to see such a natural environment enriched with various plants similar to those of his native village, and out of curiosity, he asked Father Lafont varieties of questions about those plants. The quality of those questions reflected his deep inquisitiveness, and Prof. Lafont predicted that Jagadish Chandra would be a very famous scientist in future. Without exception, everyone is now convinced that Prof. Lafont's prediction has been proved to be true.

"In order to discover the life mechanism of the interior of the tree, one has to become the tree and feel the throbbing of its beating heart".

ACHARYA JAGADISH CHANDRA BASU

4. Jagadish Chandra's Education at Cambridge

There was a great famine in the province of Bengal in 1880. During that period of calamity, Bhagaban Chandra used to go out very often riding on his horse to help the famine-stricken peoples with various types of relief materials like food, clothes etc. He hardly cared for his own health and timely meals. As a result, his health deteriorated to a great extent. In order to recover from his broken health, he took a leave of absence from his official duty for two years. Consequently, his regular income reduced. Moreover, most of the projects he launched did not turn out successful. As a result, he ran into a large amount of debt. So, after passing B. A., Jagadish Chandra wanted to choose a line in respect of his next educational step which would enable him to get a job within a short period by which he would be able to assist his father directly to get rid of his monetary stringency. Therefore, he resolved to join the Indian Civil Service. But his father did not agree to this proposal. He argued that, If Jagadish would join that service, he would lose contact with the common peoples; moreover, by becoming a Civil Servant and flattering the British Government obsequiously, he would not be able to render proper service directly to the general public at large. With this view in mind, Bhagaban Chandra resolved to make his son study Medicine in England. At this proposal, Bamasundari Debi initially reacted strongly, and she did not agree to let her only son go out of India, because, their youngest son died at the age of ten just five years ago. Also, Jagadish Chandra gave importance to his father's bad financial status as well as to his mother's mental condition. So, a family council was held, and it was decided that Jagadish must not go. Therefore, Jagadish Chandra dropped the plan of going to England and settled down to do his best staying in the homeland. But considering her son's higher education-

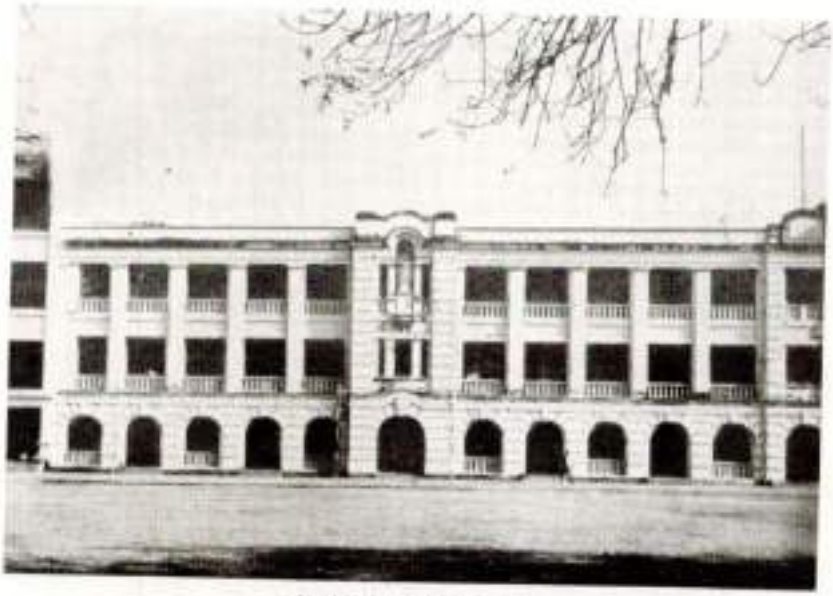
Bhagaban Chandra Basu

Bamasundari Basu

Parental House of J. C. Bose at the Rarikhal Village.
At present it is used as School, College and Museum.

Figure 1

St. Xavier's School



St. Xavier's College

Figure 2

Father Eugene Lafont

Lord John William Strutt Rayleigh

Christ's College (Cambridge)

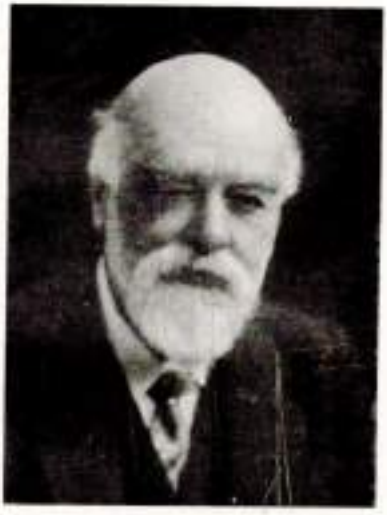
Jagadish Chandra receiving
B.A. Degree from Christ's College

Figure 3

Michael Faraday

James Clerk Maxwell

Heinrich Rudolf Hertz



Sir Oliver Lodge

Figure 4

based future, after a few days, Bamasundari Debi not only agreed to the proposal for his studying medicine abroad, but also wanted to give away all her savings and ornaments (including costly jewelries) to render financial help to her son going abroad. But, at that very juncture, Bhagaban Chandra recovered fully from bad health and resumed his service. Consequently, Bamasundari Debi did not have to sell her ornaments. Jagadish Chandra got a great relief and set out for London in 1880. After reaching London, he took admission in the Medical School there. During his sea-voyage on the way to England, Jagadish Chandra was attacked with 'Black–fever' ('Kala-azar'). A few days after he had joined the Medical School, the Black-fever relapsed. As a result, his health deteriorated, and he could hardly bear with the excessive strain of medical study. Subsequently, his Professors suggested him to give up medical study and to take up a different course. He wrote a letter to his father requesting his permission for the change of course. His father entrusted Jagadish Chandra to take the final decision himself. Then he left London giving up the medical course and came to Cambridge. Here, he passed the entrance examination conducted by the Christ's College, got a Scholarship and started studying Natural Science. He passed the Natural Science 'Tripos' Examination with Physics, Chemistry and Biology in 1884; in the same year, he also obtained the B.Sc. Degree from the London University. Despite his interest and brilliant result in Physiology and Embryology during the first year of study in the Christ's College, he continued with Physics, Chemistry and Botany from the second year. At that time, renowned scientists and Professors like Lord John William Strutt Rayleigh used to teach Physics, Michael Foster – Physiology, Sidney Vine and Francis Darwin - Botany and Prof. Liveing - Chemistry. He enjoyed the teaching of Lord Rayleigh as he taught every lesson through practical demonstrations like Father Lafont of the St. Xavier's College. Naturally, he was more inclined towards Physics and got himself trained in performing various experiments of Physics with special credibility and perfection.

5. Jagadish Chandra's Teaching in Presidency College

After returning to India at the end of 1884, Jagadish Chandra served IACS in Kolkata for a few months and then he joined the Presidency College in Kolkata in 1885 as a Professor of Physics. He also continued to take practical classes in IACS for sometime after joining the Presidency College. At the time of his appointment in the Presidency College, he faced a lot of troubles created by the Education Department. In those days, hardly any Indian would get an appointment in the higher posts of the Education Department in spite of having eligibility and bright academic career. Appointments in these posts were under Imperial Service where only the Europeans were considered. The Indians with similar eligibility and qualifications were appointed in the Provincial Services (Indians were sent to colleges elsewhere within the Province). It may be mentioned here that Jagadish Chandra was the first Indian, who was selected and appointed as the Professor of Physics in Presidency College, which was under Imperial Service. The trouble he faced at the time of considering him for appointment in the Presidency College is described briefly as follows: When Jagadish Chandra came to Cambridge, Ananda Mohan Basu (who later married Jagadish Chandra's elder sister) was studying in Christ's College. Ananda Mohan also passed the B.A. Examination from this college with 'Tripos' in Mathematics and became the first Indian Wrangler by virtue of getting first division in all three Tripos subjects. He had an intimate friendship with Professor Fawcett, the Economist and then Postmaster-General of Britain. By virtue of his acquaintance with Ananda Mohan, Jagadish Chandra came in close contact with Fawcett who later developed great affection for him. For such a good relationship with him, Fawcett gave a letter of introduction

for Jagadish Chandra to his good friend Lord Ripon, the then Viceroy of India. Before reaching Kolkata on his way from London, Jagadish Chandra met Lord Ripon at Simla and handed over the introductory letter of Fawcett to him. Lord Ripon was highly satisfied after a brief conversation with him, and he promised to nominate Jagadish Chandra for the Educational (Imperial) Service. During conversation with Jagadish Chandra, Lord Ripon broke out in full bitterness of disappointment and said, "My life here has been a failure; I wanted to serve India and to give Indians more responsibilities. At first all seemed promising, but there came the Illbert affairs. I never thought our English liberal tradition could be abandoned." Any way, after Jagadish Chandra left Simla, Lord Ripon sent a letter to the D.P.I. through the Bengal Government recommending Jagadish Chandra for an appointment under Imperial Service. On reaching Kolkata, Jagadish Chandra met the D.P.I. Sir Alfred Croft who already received the letter from Lord Ripon. Croft was not at all pleased at this and said, "I am usually approached from below, not from above. There is no higher-class appointment at present available in the Imperial Educational Service. I can only offer you a place in the Provincial Service from which you may be promoted to Imperial Service later." Jagadish Chandra declined this offer. Lord Ripon used to look into the Gazette regularly. When he did not find the name of Jagadish Chandra in the Gazette within an expected period, he wrote to the Government of Bengal for an explanation from the D.P.I. as to why the appointment of Jagadish Chandra was not made effective by that time. As a result of this, Sir Croft was compelled to release the letter of appointment to Jagadish Chandra, but with a clause that his appointment was only on temporary basis (as an Officiating appointment) with one third of the actual salary. If Jagadish Chandra could satisfy the test of service, he would then consider the question of making him permanent." The British Government biasedly believed that Indians were intellectually more oriented towards Metaphysics and Languages, but had no aptitude for the exact methods

of science. So, when Jagadish Chandra was appointed Officiating Professor of Physics at the Presidency College, its Principal Charles H. Tawney protested against this appointment on the above ground, though without success. In protest against such discrimination in respect of pay and position, Jagadish Chandra boldly refused the salary for long three years, but continued teaching with full responsibility. Soon he established himself as a very popular teacher among the students by his excellent method of teaching. In the class, he used to deliver his lecture showing various experiments and practical demonstrations following the methods of Father Lafont and Lord Rayleigh. As a result, after three years, the British Government actually surrendered to Jagadish Chandra and granted full salary along with the arrears with retrospective effect. With the arrear money, he cleared his father's debt. After a long period of service for 30 years in the same college, Jagadish Chandra retired in 1915. Thereafter, he continued teaching in the same college as an 'Emeritus Professor' for a few years.

"The whole world is a living laboratory in which the most wonderful experiments are constantly being performed. We should indeed be fascinated if only we had eyes to see them".

6. Research Life of Jagadish Chandra

6.1 Research in Physics

Though three Universities named after Calcutta, Madras and Bombay were set up in 1857, yet during the long period from 1857 to 1890, no environment and infrastructures conducive for carrying out basic researches in science were developed. But many academic-minded peoples were thinking about the necessity of basic research in different areas of science along with science teaching at the University level. In this background, Jagadish Chandra started developing infrastructure facilities suitable for carrying out basic research without affecting his teaching assignment. This took a long 8-9 years. It has been mentioned above that the British Government was holding the biased and insulting opinion that Indians had no aptitude for pursuing researches in basic science because of their mental orientation towards Metaphysics and Languages. This actually compelled Jagadish Chandra to develop a strong mentality and attitude to face, accept and answer properly any type of challenge that might come in his later life.

After joining the Presidency College, he used to spend spare times by pursuing various hobbies. On holidays, he often went out to take photographs of various objects from the natural surroundings and processed to develop them. Occasionally, he invited his students to his residence and spent time by gossiping with them. He used to record songs using a phonogram he brought from abroad and to play back those songs in presence of invited guests. Later after acquaintance with Rabindra Nath, he recorded many songs sung by him. Besides these activities, he had a great fascination for constructing various machines using the scraps or rejected materials. During the first few years in teaching profession, he did not think about scientific research;

probably he was preparing himself for research in future through making of those machines (instruments) from scraps. This conclusion was evident from the following facts. He had been delivering scientific lectures in IACS for a few years. But in 1888, he suddenly discontinued such activity on the ground that he was busy with Electric Waves. After his marriage in 1887, his wife Abala Debi very often encouraged him for initiating research. It may be inferred from these facts that from that time onwards, he had been preparing himself for starting research. On his 37th birthday in 1894, he, all on a sudden, declared the decision that he would initiate research. At that time, he had been teaching Electric Waves.

In 1820, Hans Christian Oersted showed that when electric current was passing through a conducting wire, the magnetic needle kept around that conductor was deflected. In 1821, Michael Faraday forwarded the Oersted's observation one step ahead and showed that in the magnetic environment thus created by the passage of current through the conducting wire, the magnetic force travelled in circular path. He also showed the reverse phenomenon, i.e., he demonstrated that when a magnetic bar was pushed inside a coil of conducting wire, a current was generated in the coil. He was the first to generate the concept of magnetic lines of force. After a long time, James Clerk Maxwell, a Professor of Physics at Cambridge, showed in 1864 from mathematical calculations that a change in electric current flowing through a conducting wire would generate an electromagnetic effect at a distance from the conducting wire. He also predicted that such electromagnetic waves (hereafter will be called EMWs) would travel from the source of its generation at the speed of light and would possess all the properties of light. Maxwell died at the age of 48 years before he could experimentally establish his proposition. In 1887, Heinrich Rudolf Hertz proved experimentally the Maxwell's theory; he showed that this theory did work at least within a short distance. Hertz constructed an instrument by which he could generate EMWs having wave-length

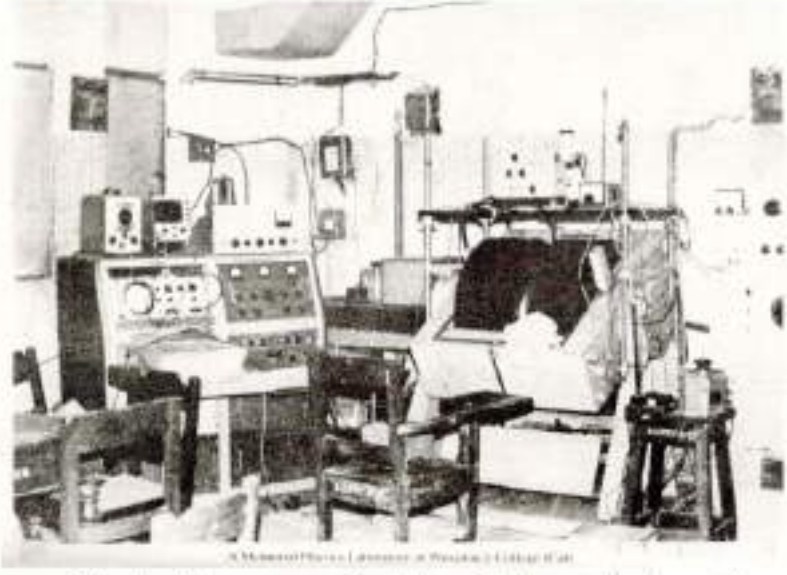
longer than that of light. By that time, several properties of visible light were established. These were as follows: The visible light (1) travels in a straight line, (2) when falls on an opaque object, it is reflected and forms a shadow of the object, (3) when travels from one transparent medium to another, it takes a detour path i.e., it is refracted (also in a straight line), (4) it is unorganized due to its vibrations in all directions, and it spreads in all directions around the source; but, when it passes through certain crystals, its vibrations become unidirectional, and such light is said to be polarised; and (5) visible light possesses diffraction property. The EMWs created by Hertz were not visible, yet these were shown to have some of the above properties like reflection and refraction of the visible light. But such determinations were not accurate enough. Hertz also constructed instruments suitable for detecting (receiving) those EMWs. He could generate EMWs of varying wavelengths, and the waves having shortest wave length he could generate were of 66 cm.

In 1890, Edouard Branly developed a receiver suitable for detecting the above EMWs. He made this apparatus by filling a glass tube with iron dusts. Prof. Oliver Lodge made improved receiver starting with the one made by Branly. After absorbing EMWs, these iron dusts came in mutual contact (cohere among themselves) thereby reducing the resistance among them and causing an increased flow of current. So Lodge named this receiver as 'Coherer'. Lodge was able to detect EMWs of different wavelengths each with a different such improved coherer. He also made different types of instruments by each of which EMWs of different wavelengths could be generated separately. Actually, these inventions of Lodge could be regarded as the first step of radio-tuning, although the radio was not discovered by that time. Besides Branly and Lodge, several other scientists also worked on coherer around that time. Prof. Lodge wrote a book entitled "Heinrich Hertz and his Successors" in which he discussed in details about various information on the Hertzian waves known around that time.

Many peoples thought that Jagadish Chandra was induced to initiate research on Hertzian waves after reading this book. This was surely a bold step he took, because there were no infrastructure facilities in this country that could help him in his research on Hertzian waves.

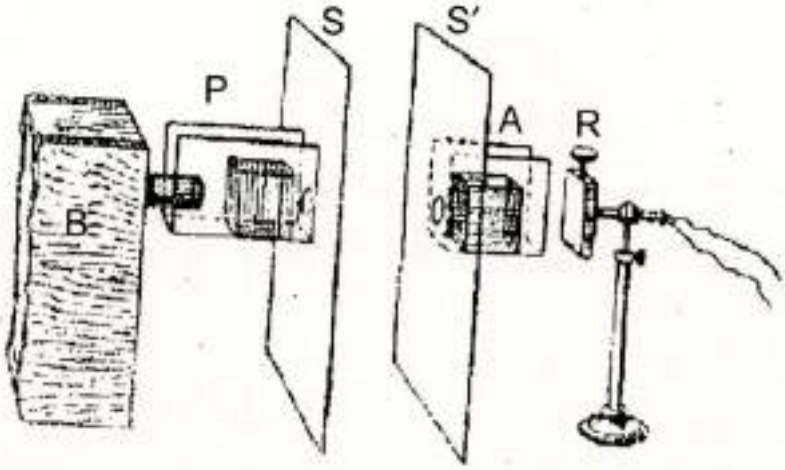
Around the end of 1894, Jagadish Chandra started full-fledged research on EMWs in a small room in Presidency College. He had realized that there were several drawbacks in working with long wavelength EMWs. Firstly, the Hertz-made apparatus for generating EMWs was so large in size that it would occupy the entire space of his laboratory room. Secondly, the study of the long wavelength EMWs in relation to the properties of visible light could not be made error-free. So, he decided to make (i) small-sized instrument by which EMWs with shorter wavelengths could be generated and (ii) high capacity detector suitable for identifying (receiving) those short wavelength EMWs. To fulfill these objectives, he constructed better quality generating apparatus by which he was able to produce EMWs having wavelengths as short as 5 mm. He also made much improved coherer by which he could detect those short wavelength EMWs. Earlier, the coherer discovered by Oliver Lodge was used to detect EMWs; but that coherer had certain disadvantages; it lost detector function after its use even for a short time. As mentioned earlier, Lodge's coherer was prepared by packing iron dusts in a glass tube. On being hit by EMWs, the iron dusts came in contact with one another and could activate the conductivity; but when they were free again from EMWs, those contacted iron dusts did not separate, which caused them to remain in inactive state. Jagadish Chandra felt that the EMWs could activate only the dusts which were in direct touch with the surface of the inner wall of the glass tube, and those staying at the inner side (towards the centre) of the tube were ineffective in the process. So, he thought that the mutual contact among the iron dusts had definitely certain role in creating conducting environment. With this idea in mind, he prepared receiver apparatus with short length thin iron springs in place of iron dusts in a

Presidency College (Kolkata)

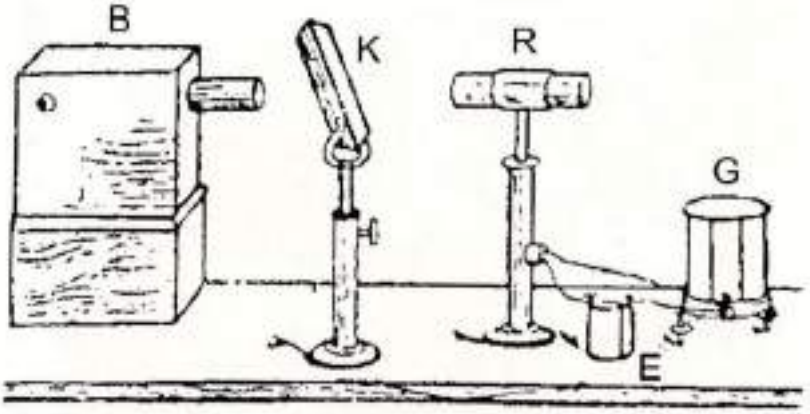


Physics Laboratory at Presidency College at the time of Sir. J. C. Bose

Figure 5



Polarisation Apparatus
B, Radiating Box; P, Polariser; A, Analyser;
R, Receiver; SS′, Screw



Remote Control used in Millimeter Wave Communication.
R, Receiver; B, Metal Box (contains Rumkorf Coil and Radiator);
G, Galvanometer; E, Voltaic Cell; K, Crystal.

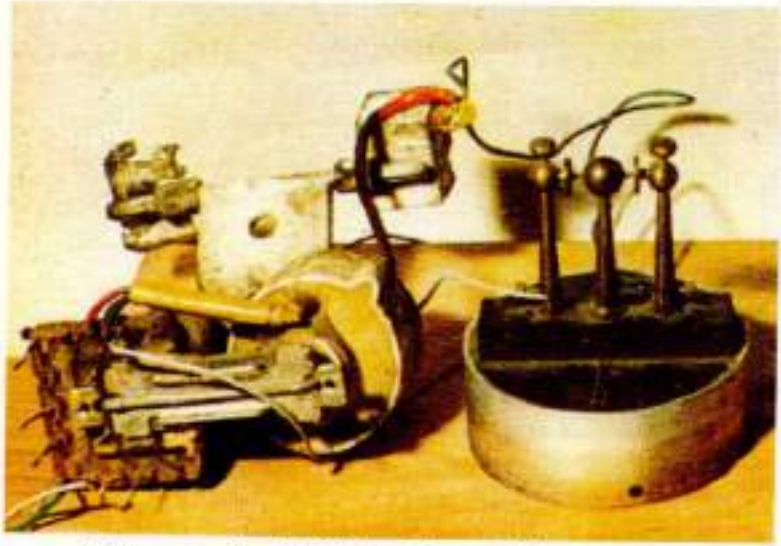
Figure 6

The room where J. C. Bose used to design and construct instruments for his work

J. C. Bose is demonstrating the historical experiment on production of Microwaves (this is a picture of the model preserved in the Bose Institute Museum) in the left room, J. C. Bose is generating Microwaves, Acharya P. C. Ray (sitting) and Father Lafont (standing) are watching the experiment. In the right side room: Prof. Pedler (sitting), the gun to be fired by microwaves is placed on his left side.

Figure 7

Microwave Apparatus



Microwave Spark Wireless Transmitting Apparatus

Figure 8

Royal Society Premises (Estd. 1660, London)

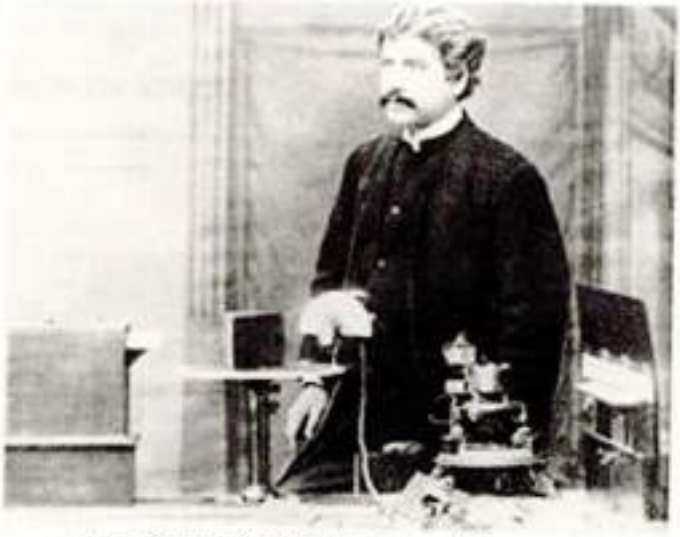
Royal Institution (Estd. 1799; London)

Figure 9

Bose Institute (Old Campus; Estd. 1917;
Situated near Rajabazar, Kolkata)

Bose Institute (Centenary Building Campus,
Estd. 1983; near E.S.I. Hospital, Kankurgachhi, Kolkata)

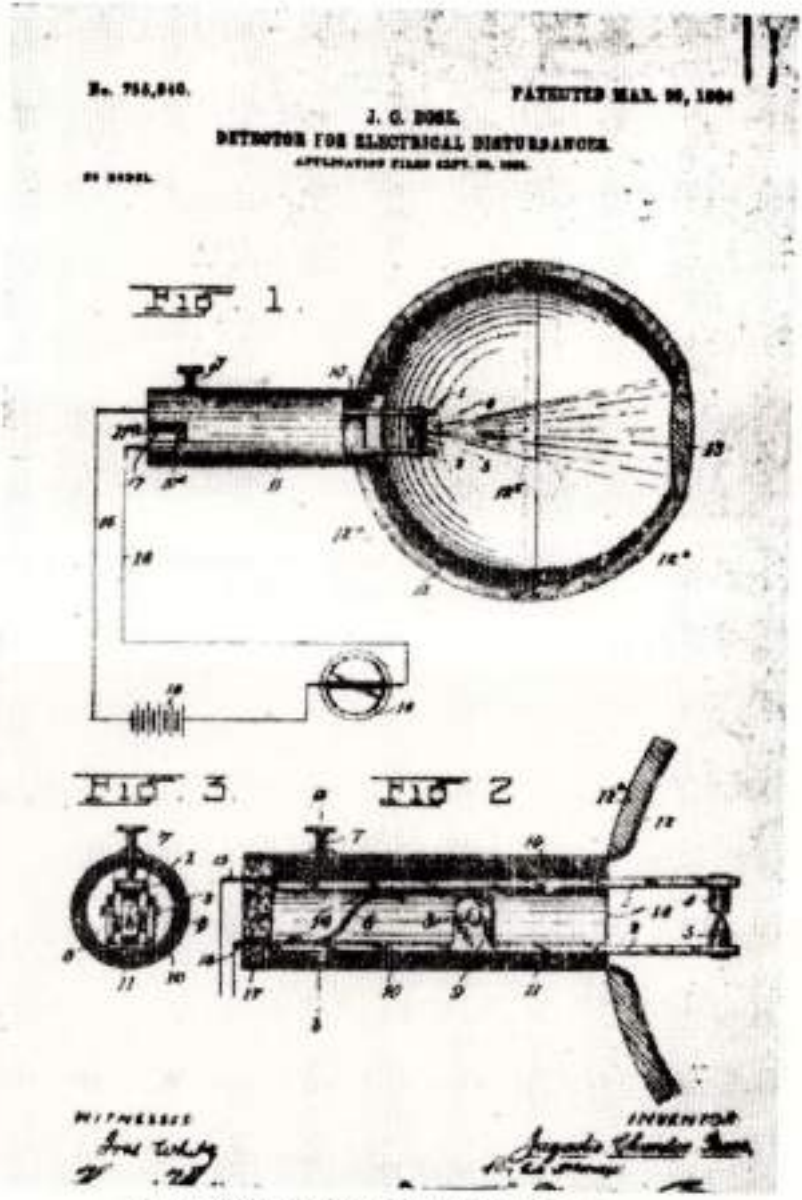
Figure 10



J. C. Bose delivering lecture on Microwave
at Royal Institution (1897)

Guglielmo Marconi with his Wireless Apparatus

Figure 11



Application for Patent on Galena Coherer (Artificial Eye) discovered by J. C. Bose.

Figure 12

glass tube and tied the two ends of the tube to the two terminals of a galvanometer. When exposed to EMWs, the springs came in contact with one another through their curved surface which ultimately resulted in reduction of resistance. When there were no EMWs, the springs came back to their original (noncontacted) state by their elastic property and hence, once again, they got back the capacity of receiving another batch of EMWs. So, this coherer was automatically rejuvenated. Making of this type of coherer was his fundamental contribution in microwave research. He made another improved coherer using a piece of galena (lead sulphide), which could also be rejuvenated automatically. He showed that when this coherer was tagged to a galvanometer and then EMWs were made to hit on it, the galvanometer needle deflected. With the help of this newly made coherer, Jagadish Chandra was able to detect EMWs of varying wavelengths. In November 1894, he demonstrated a historic experiment in Presidency College. He generated EMWs in the room of P. C. Ray (he was sitting on a chair in his room). In the adjacent room, separated by a brick wall, Prof. Pedler was sitting, and in this (second) room a gun was kept at the other end (away from the wall separating the room of P. C. Ray). As soon as the EMWs were generated in the P. C. Ray's room, in no time the gun in the adjacent room was fired automatically indicating that those rays passed through the brick wall and human obstruction (Prof. Pedler sitting on the way) and reached the gun and switched it on (See Fig. 7).

On May 1, 1895, he read a paper entitled 'On the Polarisation of Electric Rays by Double-Refracting Crystals' before the Asiatic Society of Bengal. This work was later published in the Journal of the Asiatic Society (Vol. 64: pp. 291-96, 1895). Also in the same year, he demonstrated the production of EMWs in presence of the then Governor of Bengal, Sir William MacKenzie in the Town Hall in Kolkata. These waves generated in the lecture room were shown to pass through the huge body of the Governor and travel

about 75 ft distance from the radiator crossing three brick walls on the way through an intervening room and a passage. The transmitted signals activated a receiver, which in turn caused a bell to ring, fired a pistol and exploded a miniature mine (small amount of gun powder). By this discovery, he actually opened the possible path of wireless news transmission. It is to mention in this connection that the coherer he used in this experiment was built using mercury as one of the components. His second paper on this novel type of work was published in the October 1895 issue of the Science Journal of the Royal Society (of London). This paper was communicated by Lord Rayleigh. His third paper in series on this work was published in the December 1895 issue of 'The Electrician' journal. During his first scientific mission to Europe (1896-97), he delivered lectures on these works with experimental demonstrations using the instruments (constructed by him) in presence of the stalwart Western scientists of the time. All the works and the instruments received valued appreciation.

In the next phase of his research, Jagadish Chandra designed and constructed various types of coherers using certain metals, nonmetals or metalloids and showed that those coherers could be reactivated with the variation of pressure and the amount of current. The metals, which he used to make these coherers, were classified by him into two distinct groups. The coherers in one group were electropositive, while those in the other were electronegative. When the coherers were connected to a galvanometer and exposed to EMWs, the flow of current increased with the coherers of the first group and decreased with the coherers of the second group. Moreover, the galena-based coherer in the positive group was capable of efficiently detecting invisible waves of short wavelength as well as the visible light waves. For having this property, this coherer was called by Jagadish Chandra as an "Artificial Eye" (Fig. 13). As the discoverer of galena receiver (coherer), he is recognized as the 'Father of Semiconductor'. Actually, the concept of P-type and N-type semiconductors originated from his

electropositive and electronegative coherers. Besides these, he also showed the polarisation of EMWs using jute fibres as the polariser. While delivering lecture in the Royal Society during his second scientific tour to Europe in 1900-1901, he could show polarisation of EMWs even using a railway Bradshaw (Fig. 17). While he was delivering lectures at different Institutions in Europe during the same tour, he was succeeded in polarising EMWs using rejected hairs collected from barbers' shop. He did all these second phase works during 1899-1902.

There were certain difficulties in verifying the then known properties of visible light (reflection, refraction, total internal reflection etc.) with the EMWs in an error-free manner using the same methods and instruments as used for the visible light. The visible light does not pass through an opaque object, but can pass through a transparent and translucent object (medium), while microwaves could pass successfully through all the above types of objects excepting water or any liquid (utilizing this liquid-impassable property of microwaves, microwave oven has been developed). So, the methods and instruments, which were being used for the visible light, could not be used for the study of those properties of microwaves. But neither any method nor any instrument, suitable for the study of those properties of microwaves, was then available either in India or abroad. Jagadish Chandra possessed a great mental strength and determination. By his own effort, he could design and make the instruments needed for the completion of the job he intended to do. He did never surrender to any obstacles that might come in his way. Even he used to consider the obstacles as the booster to take those as challenges, and he had the determination to accept and answer those challenges with great courage. He designed and constructed many quasi-optical instruments which were used to study the above properties of microwaves. These instruments were as follows. (1) Di-electric lens (this instrument was used to focus the microwaves; he used a pair of di-electric lens made of sulphur and the microwave transmitter

apparatus to determine the refractive index of some di-electric substances). (2) A spark-transmitter with the help of which he could produce sharp polarised microwaves. (3) Automatic activating coherer and metal-contact receiver (using these instruments and spark transmitter, he was able to generate microwaves by which he could switch on a gun kept at a long distance separated by brick wall). (4) Galena receiver, which could detect microwaves, visible and infrared light (functions of these instruments have been stated earlier). (5) Polarisation apparatuses made from wire grids and jute fibres (with these instruments he polarised microwaves). (6) Horn antennae (this is a kind of aerial receiver). (7) Curved diffraction grating (this instrument looks like a hemisphere; he determined the wavelength of microwaves with the help of this apparatus). Some of the above-noted instruments are shown in Figs. 6, 8, 13 and 17.

He received the D. Sc. Degree from the London University in 1896 by submitting a thesis based on various results obtained from the experimental determination of wavelengths of microwaves using curved diffraction grating instrument.

At present, it has been possible to explain the mechanism of functioning of these instruments, and their working principles are being used in modern science and technologies. Though Jagadish Chandra invented all these instruments, he never tried to patent them. He was not at all interested in money-making business out of these inventions. He was of the opinion that the information about the scientific and technological methods should be freely available to all. However, by the request of Mrs. Ole Bull (also known as Sara Chapman Bull) and Sister Nivedita, he patented the galena receiver (see Fig. 12), but he did not renew it later. These instruments have been preserved in the museum located on the right side at the entrance of the Bose Institute (main campus). In 1901, when Jagadish Chandra was in London, a company representative, interested in manufacturing wireless instruments, came to him with a proposal of signing a financial contract on his

newly discovered wireless receiver. But he did not agree. It may be mentioned in this connection that long before this (in 1897), Jagadish Chandra thought (though casually) of a plan for setting up of a good laboratory in India where Indians could carry out research independently. Even under the background of such thought, he did not feel any urge to earn money through patenting his instruments that could be helpful in the establishment of a good laboratory in future. He did not want to commercialize the products of his research. He could have done this for the generation of a fund, that might be used for setting up of a laboratory he thought of.

Impact of the discovery of microwaves: When Jagadish Chandra discovered microwaves in 1890s, the impact of these waves on the society was felt not at that time, but at much later period. Utilizing certain properties of microwaves, these waves have been used in later years to develop various technologies. A few examples of these technologies are cited below.

1. With the help of RADAR system, the location, height, velocity and direction of a flying aeroplane are determined.
2. The height of the ionosphere above the surface of the earth is determined.
3. In dark and foggy atmosphere and cloudy sky, the velocity of movement of ships on sea and that of aeroplane in air are determined.
4. The flying aeroplane is directed to a definite destination.
5. The location and velocity of a flying supersonic aeroplane are determined.
6. Television and mobile phones are based on microwave technologies.
7. Weather and climatic conditions are predicted (forecasted).
8. Details of the surface conditions of the earth's neighbouring bodies like sun and moon are determined.
9. Microwave is used to generate heat as in a microwave oven.

10. In the safe landing of aeroplane, microwave-based technology is applied.
11. In any kind of remote control devices, microwave is used.

6.2 Unity between living and nonliving

It has been mentioned earlier that Jagadish Chandra made certain coherers which not only had good working (reception) capacity, but also those were revitalized automatically after use in microwave reception. He could alter the reception capacity and sensitivity of those coherers by changing the pressure and the amount of current flow. But in doing so, he observed the appearance of several new ailments. He noticed that when the coherer was used in an experiment for a longer period, its reception power gradually decreased with time, and it became completely fatigued at the end. When such fatigued coherer was kept at rest for a few hours, it could regain its capacity to work. Again, if such fatigued coherer was left at rest for several days, then it lost the receptor capacity permanently and could not be reactivated at all; it became completely idle. But, when the idle instrument was given an electric shock, it could get back the receptor capacity (get back the work habit). To uncover the mysteries behind this type of phenomenon, Jagadish Chandra oriented his research in a new direction. First, he classified all the coherers, he made, into two distinct groups which responded by being influenced by (1) electric contact and (2) metal contact. He had shown that when a nonresponsive metal (like copper) was very thinly coated with a well-responsive metal (like cobalt), the overall response increased several-fold. On the other hand, when a good responsive metal like iron was very thinly coated with a non-responsive metal like copper, the overall response was either reduced or totally lost. Being influenced by these observations, he started investigating this type of contact-induced response in different metals, nonmetals, and metalloids. He found that the metallic substances showed a periodic change in their coherer property with the increasing

order of their atomic weights, and the positive and negative responses of the metals were dependent on their chemical nature. So, he called this characteristic as a kind of molecular/atomic property. The change of electric stress-induced resistance in certain metals was not permanent, but those metals could return to normal state completely. From all these observations, he arrived at a definite conclusion. He inferred that the molecules/atoms of these metals are subjected to strain by the applied stress. Certain metals showed flexibility towards the alteration of current; those metals could revert back to the normal state. Under similar conditions of change in current, other metals were less flexible; the strain condition in those metals remained in the stress-induced state and those could revert to normal state very slowly. In the International Physicists' Congress held in Paris in 1900, Jagadish Chandra delivered a lecture on the above findings. When Jagadish Chandra delivered the Friday Evening Discourse, he put his reasoning in his introduction as follows: According to Waller's view, electrical response is the distinguishing factor between nonliving and living. So, he reasoned that if Waller's theory were correct, and if inorganic matter could be shown to respond to electrical stimulus, then the latter would be considered to show the sign of life. He himself observed that nonliving object like the one forming coherer shows certain property like fatigueness, which is similar to that of certain living tissue like muscle. In the case of nonliving object, a change of conductivity is a manifestation of response. Again, the changes of conductivity in nonliving and living objects in response to different stimuli are similar. Therefore, he concluded that there is no discontinuity between the nonliving and living.

Based on this property of metals (nonliving objects), he was the first to explain the '*similarity in such responses in nonliving and living objects*' and to bring about a conceptual change in the scientific world by putting forward this new hypothesis. Actually, from that time onwards, he initiated to collect experimental evidences in favour of his new theory.

(The experiment with pure tin wire described in Section 6.3 support the above theory.)

6.3 Living and nonliving objects show similar response to any external stimuli

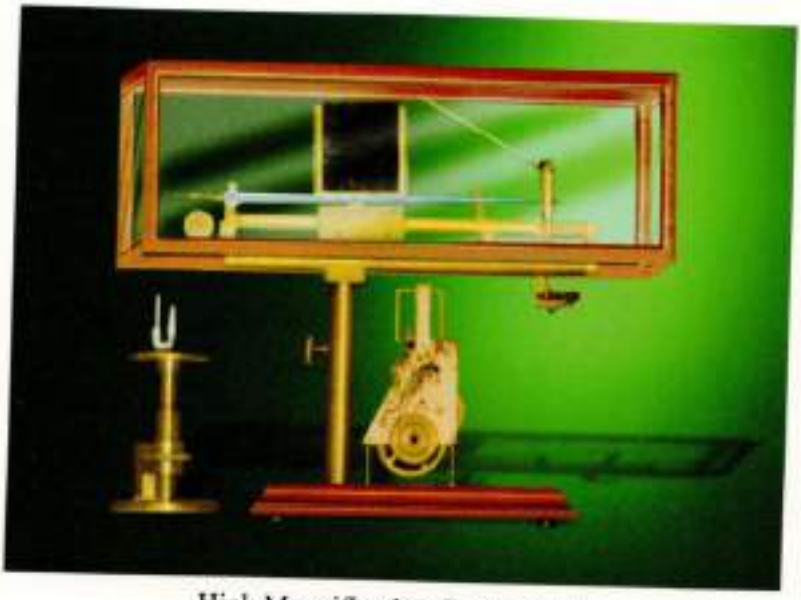
Jagadish Chandra made a logical guess that the nonliving and living objects might behave similarly in response to an exposure to EMWs. Being influenced by this idea, he initiated research in 1901 on the effect of bioelectric potential on the transmission of response in plants. He showed for the first time that the electric signals have definite roles in coordinating the responses in plants against stimuli from environment. He also showed that the nonliving objects have also this property. Not only this, he showed also that if a nonliving object was given any external stimulus for a longer time, then this object lost for a moment its capacity to generate response. If the object was left in that nonresponsive state in absence of stimulus, it recovered and regained this property. On the other hand, if the object was exposed to any strong chemical or a poisonous substance, it lost its capacity to respond. He hypothesized that when the nonliving objects are exposed to heat, light, gravitational or chemical stimuli, those generate a flow of electrons within the object. If a metal wire is given a twist, flow of electrons probably occurs within the wire. To prove such an effect in a tin wire, he performed an experiment in the presence of the stalwart scientists in the Royal Institution. The experiment was as follows:

Two pieces of pure tin wire were taken and their one ends were separately tied to a piece of ebonite; the free ends of the wires were passed through two separate holes of an ebonite disc and were finally tied to the two terminals of a galvanometer. The ebonite-tied terminals of the wires were then dipped into distilled water in a glass vessel. When one of the two wires was twisted, immediately there was a flow of current through the galvanometer circuit deflecting the needle. When a pinch of sodium bicarbonate was added to the water and a twist was applied to the

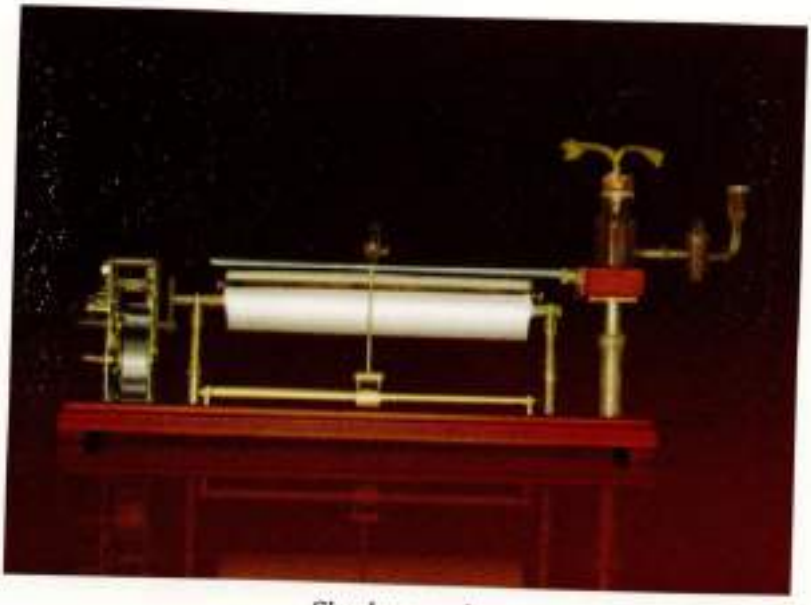
Galena Coherer (Artificial Eye)

Lady with the Lamp (at the entrance on the left side within Bose Institute Old Campus)

Figure 13



High Magnification Crescograph



Shushungraph

Figure 14

Optical Sphygmograph

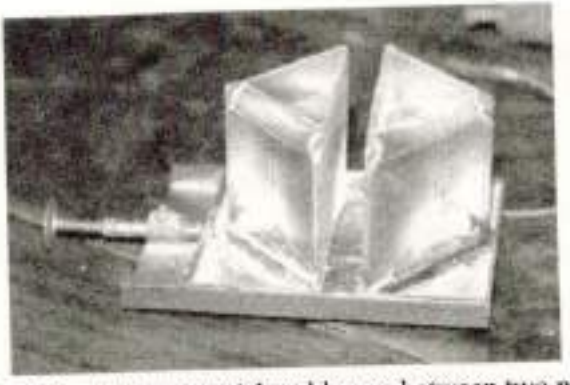
Lajjabati (*Mimosa pudica*)

Figure 15

Ban chnaral (*Desmodium gyrans*)

Figure 16

Polariser made of jute fibres.



Double-Prism Attenuator (alterable gap between two prisms)

Railway Bradshaw used as Polariser.

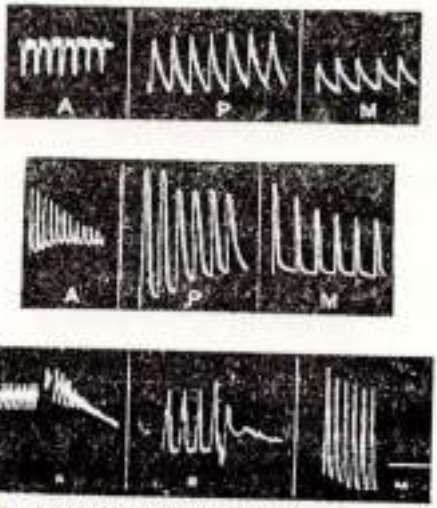
Figure 17

ভারতের গৌরব ও জগতের
কল্যাণ কামনায়
এই বিজ্ঞান মন্দির
দেব চরণে নিবেদন করিলাম।

শ্রীজগদীশ চন্দ্র বসু

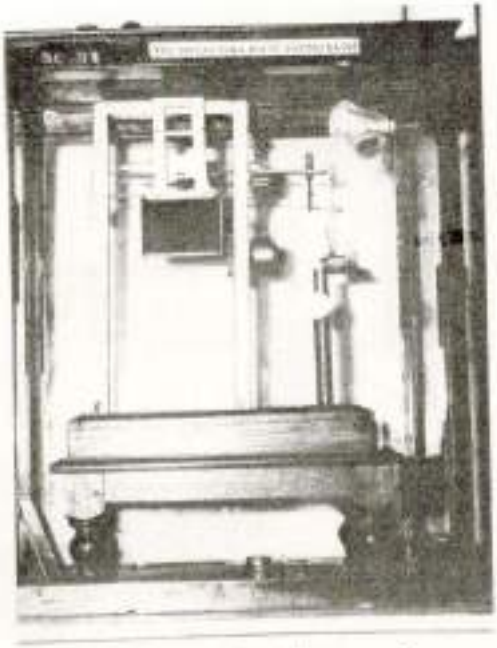
১৪ই অগ্রহায়ণ, সংবৎ ১৯৭৪।

Dedication message hand-written by J. C. Bose on the occasion of inauguration of Bose Institute (Message translated in English: "I dedicate this Bijnan Mandir to the God for the Glory of India and Welfare of the World").
- Sd/ Sri Jagadish Chandra Basu
14th Agrahayan, Sangbat 1974.

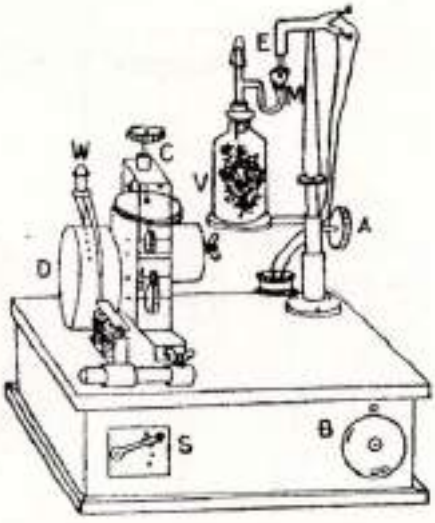


Response of animal (left), plant (middle) and metal (right) against stimulus. From top to bottom : different stages of response

Figure 18

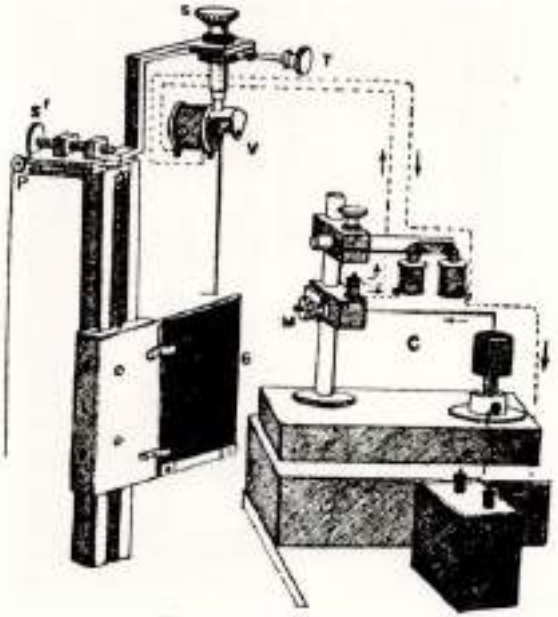


Oscillating Plate Phytograph

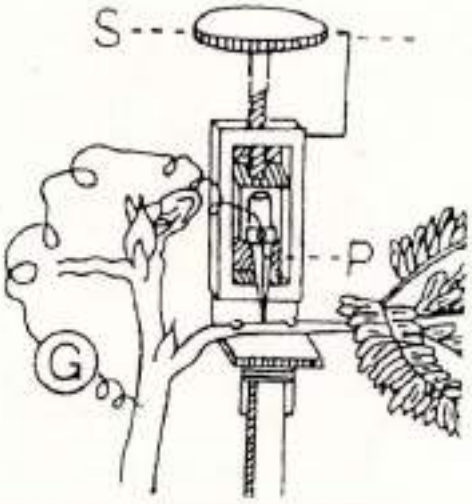


Photosynthetic Bubbler

Figure 19



Resonant Recorder



Electric Probe

Figure 20

same wire, the flow of current was found to increase. But, when oxalic acid was added to the water in a different experiment, then under identical condition of twist in the same wire, there was no flow of current at all (flow of current was inhibited by acidic condition). After seeing this phenomenon, the audience was very much excited. In an analogous experiment, he showed that when visible light was projected on a metal rod, a flow of current was generated. This phenomenon appeared to be identical with the one that occurs when light falls on animal eye which generates electric impulse on retina and the conducting nerves. He showed further that certain chemical substances could increase this effect, while certain others could cause an opposite effect. So, in the wider range of livingness and non-livingness, the responses to external stimuli were similar. The various symptoms, which were detectable after throwing a nonliving object with force from above to the ground, were almost similar to those produced in living objects under identical condition of throwing to the ground. This phenomenon was not known previously, and Jagadish Chandra proved it by demonstrating proper experiments using various instruments made by him.

He also observed similar effects in both plants and animals by analogous experiments. When an animal tissue was subjected to a pinching action, electrical pulse was produced and the shape of the tissue changed. If a living muscular tissue was subjected to scratch, twist or pressure, then it shortened in length and widened in breadth. When the action was removed, the tissue regained its normal state (shape etc.). If such action was applied repeatedly, then the tissue came to a fatigued state and lost its capacity to respond to a stimulus (action). In order to explain these facts, Jagadish Chandra said that whenever a stimulus (action) is applied to any substance (living or nonliving), then a kind of reaction is generated within the substance at the molecular level which tries to nullify the stimulus (action). He added further that this process occurs in a similar manner in both living and nonliving objects.

When the muscular tissue became fatigued at excessive cold or hot, it could not respond to any stimulus under such condition; it also took much longer time to recover to the normal state if it could respond at all, though at a very low level. Again at a particular temperature (optimum temperature), the muscular tissue could show maximum response. This optimum temperature for such response varied with the type of tissues used. By determining this type of response using self-made apparatus, he showed that the living and nonliving objects behaved similarly in respect of the response to external stimuli.

6.4 Plants have sensibility like animals

That the plants have life was known to all for a long time. But the people did not know that plants have sensibility. Jagadish Chandra established and presented this truth to the people of the world. When he was a student in the village school, he was very much excited by seeing the movements of leaves of Lajjabati and Ban Chnaral demonstrated by his friends; this observation led him to ask many curious questions about the plants. It is reported that when Jagadish Chandra joined the Presidency College, he was very much interested to join as a Professor of Botany. As there was no vacant post of Professor in Botany, he had to join as a Professor of Physics. Anyway, Jagadish Chandra became very curious to know the various processes and events that are continuously going on at the molecular level all the times in plants.

Most of the research works involve measurement of various parameters. Whether the inference(s) to be drawn from the results of any experiment will be correct and flawless will depend on the accuracy and correctness of the measurements of relevant parameters. So, to know about the different physiological processes occurring in plants, Jagadish Chandra designed and constructed various instruments mainly with the help of local unskilled blacksmiths and carpenters. The special feature of all those instruments was the increased sensitivity of measurements which was

effected by magnifying several-fold any small changes (increase or decrease) that might be obtained in any experiment. All those instruments were accepted very well by the Western scientists. Some of those instruments are described below.

Magnetic Crescograph : By this instrument, Jagadish Chandra measured very efficiently the different types of movements of plants. The mechanical recording by this instrument was about 5 crore times more sensitive than that by the then highest magnifying microscope.

High Magnification Crescograph : With this instrument, he measured very small growth of plants with high sensitivity and accuracy. By a double lever mechanism, he achieved the magnification to the extent of 10 thousand-fold. A clock work mechanism drives a smoked glass screen on which the tip of a second lever mechanism records the movement. He also measured the changes in growth rate when plant was given chemical or electrical stimulus. The average growth rate of a plant was recorded as 42/1,00,000 part of an inch per minute. When the plant was hit with a cane, this growth rate reduced. To recover from this injury, the plant required around 30 min.

Resonant Recorder : This instrument was designed by Jagadish Chandra for automatic recording of the velocity of transmission of impulse in sensitive plants. He determined the time required to respond against a stimulus.

Conducting Balance : With this instrument, he studied the effect of various poisons on the neural impulse in plants.

Electric Probe : He used this instrument for locating the tissues which are responsible for transmission of stimuli in the petioles and stems of sensible plants. This was also used for detecting and measuring the pulsation in young stem of Brassica (Mustard) in connection with the study of ascent of sap.

Electric Phytograph : By this instrument, he measured the rate of upward movement of liquid and its changes under different conditions in plants.

Transpyrograph : With the help of this instrument, he measured the rate of release of water vapour into air through the stroma of the leaf of plants.

Optical Sphygmograph : With the help of this instrument, he measured the pulse rate of plants and its change under the influence of drugs.

Photosynthetic Recorder : By this instrument, he measured the rate of carbon dioxide assimilation during photosynthesis. He also measured very accurately the production of as low as 1/10,00,000 gram of sugar during photosynthesis.

Photosynthetic Bubbler : This is very sensitive instrument. He used this for automatically recording photosynthetic activity in aquatic plants.

Oscillating Plant Phytograph : By this instrument, the oscillations of leaves of plants like Ban Chnaral could be amplified. Jagadish Chandra used this instrument to study the plant movement and the effects of different factors on this phenomenon. He showed a good correlation between mechanical and electrical pulsation in plants.

Magnetic Wave Measuring Instrument : He measured very accurately the energy of individual ray of sunlight. With the help of this instrument together with the heat energy measuring instrument, he measured very accurately the efficiency of chlorophyll in trapping solar energy.

(Some of these instruments are depicted in Figs. 14, 15, 19 and 20).

6.5. Response of plants to external stimuli: Lajjabati (Fig. 15) and Ban Chnaral (Fig. 16)

Most of the peoples are aware of the fact that when Lajjabati is touched even gently at any part of its body, its leaves drop. To know the physiological processes, which are involved in this event, Jagadish Chandra did an extensive investigation. For this purpose he used the instrument Resonant Recorder. Performing similar experiments with the leaves detached from a plant and the total plant carrying leaves, he showed that the detached leaves also closed

their folios, which reopened on keeping dipped in nutrient solution; but they died after about 50 hours. The leaves still remaining attached to the plant (from which the above-mentioned leaves were detached) also dropped on touching the plant and their folios closed; but they came back permanently to their normal open state after sometime. To bring out the secret of this response of Lajjabati leaves to the stimuli, he applied his knowledge of Physics. From various experiments he showed that when stimulus was applied to the leaves (attached to the plant) of Lajjabati and Ban Chnaral, it was transmitted through electric impulse and reached the motor organ, the pulvinus (pulvinus is the bulged portion at the base of leaf through which the leaf is attached to the stem). This electric impulse was carried by the phloem tissue of the leaves. The mechanical and electrical stimuli worked in a similar manner. If the electrical stimulus was very strong, then the leaves of Lajjabati closed even without any mechanical stimulus. In an analogous experiment when the leaves of Ban Chnaral plant were detached (with pulvinus) from the stem, they lost the rhythm of down-up movements. But, if an electric current was allowed to pass through the pulvinus of the detached leaves, they regained their down-up rhythmic movements. Because, the response to stimuli was generated through the electric excitation of the protoplasm, therefore, this was dependent on the livingness of the relevant cell. If the path of current flow was blocked, the transmission of excitation stopped. The velocity of transmission of excitation had been shown to be different in different seasons and was dependent on temperature, presence of light and the physical state (sick and healthy plants showed reduced and increased the velocity of transmission, respectively) as well as the age of the plant. Thus, he showed that during summer days, the velocity of closing of Lajjabati leaves in response to stimulus was 30 mm/sec, while it reduced to about 5 mm/sec in winter. Similarly, the time of one cycle of up-down movement of Ban Chnaral leaves was one minute in summer and 4 minutes in winter.

When the leaves of Lajjabati closed and those of Ban Chnaral dropped in response to stimuli, the contraction of cells occurred and the current flow was reduced, and their come-back to the normal open state was accompanied by an increase of current flow. Jagadish Chandra showed further that there was not much difference in the time interval in between the events of increase and decrease of electric current during the time of electric pulsation and that of the application of stimulus. In an attempt to explain this, he said that all strong stimuli reduce the turgor pressure, induce the cells to contract, and stops growth of the plant (at least for a short time); the leaves close (Lajjabati) or drop (Ban Chnaral) with simultaneous reduction of the current flow. The weak stimuli, on the other hand, show the opposite effects. He was the first to discover the pulsatory state of electric potential, and he proved that this state of electric potential is intimately connected with the up-down movements of Ban Chnaral leaves. He also performed experiments to show the response to stimuli in other plants besides Lajjabati and Ban Chnaral.

On May 10, 1901, he delivered a lecture on the response of living and nonliving objects and plants against stimuli in the Hall of Royal Society (London) in the presence of many famous Western scientists. These works created a sensation among the audience.

When he was delivering a lecture in Paris during a subsequent scientific mission, a funny incident occurred. The title of his talk was "The death of plants by the application of poison." Basiswar Sen was his assistant during the whole tour. After the lecture, Jagadish Chandra was demonstrating the poisonous effect of potassium cyanide and chloroform on Ban Chnaral plant. On being directed by Jagadish Chandra, Basiswar applied potassium cyanide to the plant in the first experiment. By such application, the up-down movement of the leaves of Ban Chnaral and the mechanical recording of this physiological event were supposed to be stopped. The spectators from the floor were waiting with intense curiosity to see the effect of the

poison. But the mechanical recording did not stop. Jagadish Chandra was astonished at the failure of potassium cyanide to show its poisonous effect. Then he asked Basiswar to add more potassium cyanide. Basiswar obeyed his master. But this time, the result was opposite. The speed of mechanical recording increased. Jagadish Chandra became dumbfounded. Immediately, he asked Basiswar to apply chloroform to the plant in the second experiment. It worked nicely this time. The up-down movement of leaves and the speed of mechanical recording gradually decreased and finally stopped. Jagadish Chandra was now satisfied. But he was very much disturbed mentally at the failure of potassium cyanide in the first experiment. He then guessed that possibly the material was not potassium cyanide. He asked Basiswar to investigate the matter. After a thorough investigation, Basiswar found his master's guess to be true. What actually happened was as follows: A few minutes before the start of the experiment, Basiswar found that the potassium cyanide stock was completely exhausted. Immediately, he sent a local (French) lady to procure potassium cyanide from a local drug store. But Basiswar did not give her any written document as a proof of its use for J. C. Bose's experiment. The shop-keeper thought that possibly the lady wanted the poison for committing suicide (which was very prevalent among French women those days). Therefore, he gave her little sugar (powder) instead of giving potassium cyanide. So, the guess of Jagadish Chandra was proved to be true, and he got a relief.

In later years, Prof. Debendra Mohan Basu (the nephew and the successor of Sir J. C. Bose as the Director of Bose Institute) thought that during the movement of Lajjabati leaves, the contraction of pulvinus possibly occurs as a result of changes in the higher order structures of certain specific protein(s) within the pulvinus. Being guided by this idea, around the end of 1960s, Prof. D. M. Basu and Prof. Susweta Biswas isolated certain proteins in pure form from the pulvinus of Lajjabati leaves and studied their properties. They showed that the properties of these purified proteins

were similar to those of the proteins actin and myosin, which control the process of contraction of muscles in animals. From these observations, they concluded that the movement of Lajjabati leaves is controlled by a physico-chemical process.

Assisted by Benoy Krishna Dutta and Ashutosh Guhathakurta, Prof. D. M. Basu studied also the up-down movements of Ban Chnaral leaves. They did an experiment using Phytograph instrument along with an electronic instrument and showed that the mechanical recording during up-down movement of leaves appeared to be exactly identical with the electro cardiographic recording of a functioning heart of an animal. They showed further that the new leaves (around the bud) did not show movement at night, but did so during the day time, while the matured leaves could execute the movement at both day and night. They also showed that if the new leaves were fed glucose, then their movements occurred both at night and day. From these observations, they inferred that due to low chlorophyll content of new leaves, they cannot make sufficient sugar (glucose) by photosynthesis. So, the new leaves cannot accumulate sugar which can be used for providing energy of leaf movement at night.

From the various information obtained from experiments done with plants, he concluded that the plants possess a special type of intelligence by which they can learn through the electro-mechanical impulses and neural transmission and store those information as memory. This theory of Jagadish Chandra was not accepted at his time; but now, after about a century, this theory has entered the main stream of science and has founded the Plant Neuroscience branch.

6.6 Photosynthesis or carbon assimilation

By the process of photosynthesis, plants fix carbon dioxide from air to synthesize glucose in their green leaves in presence of sun light; in this process they generate oxygen and release it into the air. In leaf, this reaction occurs within

the chloroplast containing the green pigment chlorophyll. By this process, the solar energy is fixed as chemical energy within the molecule of glucose, and the plants also accomplish growth and storage processes. From 1919 onwards, Jagadish Chandra became interested to know as to what actually happens during the photosynthesis-mediated growth and storage processes. To quantify the amount of oxygen evolved during photosynthesis following carbon dioxide intake, he designed and constructed an instrument called Photosynthetic Bubbler. He also made another instrument called Photosynthetic Recorder by which he measured the increase of even a very small weight of plant during the photosynthetic assimilation of carbon dioxide. It was known at that time that the success of photosynthetic carbon dioxide assimilation depends on environmental temperature, intensity of light, concentration of carbon dioxide in air etc. It was also known that this process is completed in two distinct steps: reactions in the first step are dependent on the intensity of light (light reactions), while the second step can occur in the absence of light (dark reactions). Jagadish Chandra showed that the rate of photosynthesis was maximum in the presence of 680 nm wavelength light. If the plant was kept in dark for more than half second, then the time required for the initiation of the process of photosynthesis increases with the time of keeping in dark. He measured the carbon dioxide and light compensation points, relative quantum yield, optimum temperature of photosynthesis, the minimum temperature below which photosynthesis does not occur, and the efficiency of carbon dioxide utilization. He noticed that these parameters in summer were different from those in winter. The plant juice was acidic in summer but not in winter, and the acidity was found to be due to the presence of oxalic acid and malic acid. It was not known at that time what actually happens at the molecular level during photosynthesis and how solar energy is converted into chemical energy. After 1950, it has been shown that the 4-carbon malic acid is directly associated with the photosynthetic process in certain plants like sugar cane plant. In other words, 4-carbon malic acid is

produced at the first step of photosynthetic carbon assimilation in these plants. These plants have been classified as C-4 plants. The other plants, which produced 3-carbon glyceraldehyde molecule is at the first step of the process, have been classified as C-3 plants. Those days, it was believed that the molecular oxygen evolved during photosynthesis comes from carbon dioxide, and the oxygen of water is fixed in sugar molecule. But it has been established in subsequent years that the molecular oxygen is generated from water and the oxygen of carbon dioxide is fixed in the sugar molecule. The photon energy of sun light is fixed as chemical energy in the high energy ATP molecule (ATP molecule is the main energy currency in living organisms) through certain biochemical reactions. These ATP molecules then supply energy in subsequent steps of photosynthesis for the ultimate synthesis of glucose molecule. The total process is accomplished through several cycles of biochemical reactions. All these details were not known at the time when Jagadish Chandra worked. Around the same time, he performed another piece of novel work. He conceived the green leaves as photoelectric cells and showed experimentally that when one-half of a green leaf was exposed to light, while the other half was kept in dark, the light-half leaf became electronegative and the dark-half, electropositive. From this observation, he theorized that light could induce the electron to flow. He did another experiment in which he made a photocell with two longitudinally separated halves of the same banana leaf and compared the efficiency of two half-leaves of different ages in photoelectric cell activity. He showed that the middle-aged leaves served better in photocell functioning. Later, he thought of a plan to use chlorophyll for converting solar energy into usable fuel, but he could not materialize such plan. Of course, it is now known that if the path of electron to oxygen is blocked, then that electron moves to hydrogen ion producing ultimately molecular hydrogen which can be used as a fuel.

6.7 Ascent of sap in plants

Every member of the animal world takes foods/nutrients by

mouth and those materials are converted by the process of digestion into different simpler products, which ultimately pass into the blood. The heart of animal pumps the blood to different parts of the body whereby its each and every cell gets nutrients. The plants get nutrients dissolved in water from below the surface of the earth and send to all the parts of the plant body. This process is called ascent of sap. Plant does not have any organ like the heart of an animal by which it can pump water containing dissolved nutrients from underneath the earth's surface to the leaves. Then, how plants accomplish this essential process? According to the theory proposed earlier (in mid 1890) by Dixon, Jolly and Ahalknasy, the upward movement of water in plants is a physical process, which is aided by physical pressure generated in root and the suctional force (thrust) of transpiration occurring in leaves. Jagadish Chandra emphasized that the effect of regular wave-related impulse on the electric potential of the cell and the turgor pressure is a kind of inner signal. Based on the electrochemical phenomena in the living cell, he proposed in 1923 that the sap is propelled in plant tissues from the root to the leaf mainly by pulsatory activity of a layer of cells in the inner cortex, and the process is more of physiological than of physical nature. He showed that this process does not depend on transpiration and root pressure. Using the self-made instrument Sphygmograph, he performed experiments and collected information in support of his theory. During later years, the Western scientists did experiments using radioisotopes and showed that the rate of upward movement of nutrient solution was higher in the wooden part than that in the cambium part. When the two parts were in direct contact, the rate of upward movement of water was enhanced several-fold. Though the Western scientists could not prove the above theory of Jagadish Chandra, yet he remained firm in his own theory till the end of his life.

6.8 Plant-related other works

When a plant is kept in a dark-room at the open window,

then it bends towards light. To know about this type of phototropism, Jagadish Chandra examined the effects of the rays of each color of the visible light spectrum on the above process in plant. He observed that the blue region of spectrum was more effective, while the red region was not effective at all for the phototropic movement of plant. Later, other scientists have shown that the blue light is absorbed by a plant pigment called cryptochrome.

Movement of plant is also controlled by gravitational force. Jagadish Chandra showed that if the stem of a plant was placed horizontally, the gravitational force acted on the upper side (away from earth) of the stem and electric current flew from top to the bottom side. In Lajjabati leaves, the lower side of pulvinus was excited more than the upper side. Using Electric Probe instrument, he determined the location of the receptor cells of the gravitational force in plant. In subsequent years, the role of electricity on gravitation-induced movement has been established.

In an investigation on the effect of light on plant growth, Jagadish Chandra showed in 1918 that the ultraviolet light and the blue component of the visible light spectrum could retard plant growth. He used separately the seven colour-specific rays of the visible spectrum in such experiment and showed that the rate of growth of plant gradually increased when the applied component light rays were gradually changed from blue to red. Around the middle of twentieth century, it has been established that the effect of light on plant growth is controlled by a pigment called phytochrome. Jagadish Chandra emphasized that each and every cell of a plant is a photoelectric cell which, after receiving light waves, can generate force on electron that in turn induces plant growth at subsequent steps. When he used Radio Waves in such experiment, he observed an effect similar to that of visible light.

Jagadish Chandra also performed various types of experiments to understand the mechanism as to how the tendrils of a creeping plant move upwards by spiralling any kind of support materials. Earlier W. Pfeffer showed that

when a rubbing type of stimulus was applied to the plant belonging to *Cucurbitacea* species, a change in shape of protoplasm within the tactile pit of the tendril occurred. Jagadish Chandra did various types of experiments to understand the molecular mechanism of tendril movement in pumpkin (lau), gourd (kumro) and bellflower (jhumko lata) plants. He showed that when exposed to electric or mechanical stimulus, a kind of contraction at the front side (growing end) of the tendril was generated and that was followed by an enhancement of its growth. As an indirect effect of the stimulus, dilation occurred at the backside (away from the growing end) of the tendril. When a stimulus was applied directly, a curvature (convex) was produced at the front end (growing end) which helped in growth. As the point (region) of application of the stimulus was gradually shifted away from the growing end towards the back side, the convexness of the curvature gradually reduced, and ultimately it changed in opposite direction (concave). In case of plants belonging to *Pasciflora* species, the amount of response generated by the application of a stimulus to a tendril was around seven times more at the bottom side than at the top (front side). During subsequent years, the Western scientists have shown that on application of a mechanical stimulus, a plant hormone (auxin) exerts its effect at the back side of tendril whereby ethylene is produced; this in turn induces contraction. For the growth of air-contacted region of tendril in plants belonging to *Cascuta* species, the hormone Gibberalin is needed, while cytokinin is required for enhancing the rate of spiraling of the tendril. Jagadish Chandra made investigation on several other aspects of plant, which are not discussed here due to the limitation of space.

6.9 Unity of life

Jagadish Chandra asked, "Whether this world is in a disorganized state where the events are happening by the grace of God or it is such a place where the natural code of laws controlling those events will be discovered by the

inquisitive mind of man. Shall we be able to discover a unity inherent to the endless diversity? How life originated in this planet? Whether there is any uncrossable barrier between nonliving and living? Answers to these questions will not be available unless we know in details about what are happening beyond our visible limit. The plant has life. Then, how it differs from animal?" To get answers to these questions, he carried out various investigations on both nonliving and living objects, and discovered many new truths. Based on those truths, he conceived of a perception that led him to propose a theory, which followed the traditional Indian concept of ONENESS in all. He iterated, "The life of man has come to a state through evolution by which he does not hesitate to move in the forward direction to know the unknown. The man can sense the changes in or respond to the stimulus from his environment with the help of different specialized sense organs. If those organs lose their functional ability, then the co-ordination of body and mind will be lost leaving the body in a state of unconsciousness. Similar events excepting the superior activity of mind do occur in the other animals below the level of man in the evolution tree."

"The plants appear not to possess organs similar to those present in animals and human; but, if one looks into the wide and diverse plant kingdom, one can see that certain specific plants have specific organ (though those are not well organized), which continuously works without any outward show." Jagadish Chandra succeeded in identifying those sense centres by performing specifically designed experiments. He showed that the responses, which plants generate against any stimulus, can neither be seen by our eyes nor be heard by our ears, but those specific signals can be recorded by special instruments. In this way, he was able to show that the responses generated by both living and nonliving objects against the same stimulus are exactly similar. From the information he gathered from those experi-ments, he concluded that in order to induce any idle object to work, one has to apply stimulus from outside; while the objects, which are tired of continuous work, can

be brought back to full working condition by allowing them to take rest for some time. But, if the period of such rest is very long, then the object passes into idle state. In other words, the object loses its work habit. From the results of various experiments, he concluded that the borderline between nonliving and living does not exist, and there is a connecting link between them.

On the basis of similarity in the responses of nonliving and living objects against external stimuli, he emphasized that the plant is situated in between nonliving and the highly organized animals. He established that the plants also have organs similar to the nervous system of animals, although those organs are not present in all plants. There are many examples which support his above conclusion. Thus, the leaves of Lajjabati drop and those of Ban Chnaral show up-down movements in response to any kind of stimulus. Working of the insect trapping organ of pitcher-plant is in the same line of the nervous system, and the insect digestion process of plants is similar to those of the digestive organs of animals. These organs of plants secrete a kind of juice, which can digest the body of the insect, and the plants get nutrients from those digested products. In animals, the nutrients are carried to different parts of the body through blood circulation. The process of lifting nutrient solution from below the earth's surface by plant is similar to that performed by the capillary tentacles in lower category animals. He showed that the process of ascent of sap in plant is mediated by nerve-like impulse and reflex arch. If the amount of applied stimulus is excessively high or if a poisonous chemical is applied, the plant either becomes nonresponsive to subsequent application of stimulus, or it may even die. He further concluded that the thrill of life, thrill of objects, impulse of life and the passion of life, all transmit via nerve. Though these events happen separately, yet there is a unity among them. While passing through the long path of evolution, the plant species have acquired one or more such properties. So, most of the plants possess all the important physiological processes which are present

also in animals. The examples are: (1) Due to any external stimulus, a contraction occurs in relevant organ, which then induces movement. (2) The impulse generated in response to stimulus is transmitted to a distance. (3) There is a kind of rhythm in the process of movements. (4) Any poisonous chemical produces similar type of harm in both animals and plants.

He said, "Science is universal; is there any area in the greater field of science, which will remain undiscovered without the austere endeavour of Indian Scientific Devotee? Surely, there is (are) such area(s). Science has diversified. In Western countries, science has been expanded with division in various areas for so called better working, and uncrossable barriers have been erected between those branches. The visible world is very mysterious and polymorphic. It is not perceivable that there is similarity among such diversity. The animals are very mobile, while the plants are inherently speechless and immobile; there is apparently no similarity among them; and different plants respond in different ways against the same stimulus. But, in spite of such dissimilarities, the Indian cogitation has been able to create a bridge among nonliving, plants, and animals. By the command, the Indian Devotee Scientists have infused life in the insensate-like fingers, and where the human sense organs have been defeated, they have created supersensible organs." He has shown by extensive experimental investigation that Physics, Botany and Zoology, and even Psychology have merged at one centre. So he commented, "If the creator has allotted any specific Holy Place for the Indian Scientific Devotees, then the crossing point of the above four Vedas is that great Holy Place."

He said, "We observe among all the livings from plants to animals that as the living organisms have climbed up gradually the ever nonending steps along the stairs of evolution, the various physiological processes have been evolved with gradual improvements and have advanced by overcoming all the adverse and accepting the friendly conditions of the environments, and acquired the power to

keep under their own control. All the objects are sensorial and are capable of generating response to counteract any sort of mechanical or electrical stimulus. It seems now that this power of counteraction is an inherent property common to all objects, and the complex and well-organized animal world has been developed from non-complex nonliving objects through continuous evolutionary processes."

It is now clear that Jagadish Chandra not only perceived unity among all kinds of living, but he also conceived such unity as a kind of unique force among the total diversity of nonliving and living, which has been working at every step of evolution. Proceeding in this way, such unity has brought all the physiological activity-related processes to more improved and organized state as we see in the evolutionarily most advanced animal like man. Through these conceptual ideas, he has actually hinted indirectly at what we know now as molecular evolution.

If we accept the modern theory of evolution in the context of the formation of this COSMOS, then, according to the BIG-BANG theory, the first material objects started appearing from the time of explosion of a store of infinite energy under an extremely hot and dense conditions, and the process has gradually advanced from primarily simplest objects toward the most complex ones. Within the first few minutes in that extremely hot environment immediately following such explosion, hydrogen (deuterium) and helium were created. The principal components of these elements are electron, proton and neutron, which have been considered as fundamental particles. Naturally, it may be taken as granted that these particles (electron, proton and neutron) were created at least at the very moment of making hydrogen and helium, if not before that. From that time onwards, the temperature of that environment started decreasing with time. During that period, electron, proton, neutron and few other fundamental particles became associated in different numbers to create various chemical elements (metals, nonmetals and metalloids). When these elements are arranged in order of increasing atomic weights, it would be

observed that the number of both electron and proton increased by one each at a time, and to these different electron-proton combinations different numbers of neutrons were added. These chemical elements have acquired certain properties, which differ from one element to the other. The fact that is known till now is that all of the living objects present in this COSMOS (at least in this inhabitable earth) have been made by different combinations of various elements in definite ratios. If all the nonliving objects are analyzed by suitable means, only electron, proton, neutron and certain other fundamental particles would be obtained as end products. If the living objects are also similarly analyzed, at first the atoms of certain elements (like carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur etc.) would be obtained. All these atoms contain electron and proton (in 1:1 ratio), neutron and other particles in different numbers. The nuclear theory of atom as proposed by Lord E. Rutherford was known at the beginning of the twentieth century. Since then, it took a long time to understand the details of the structure of atom. In his orbital theory of atom, Niels Bohr elaborated that electrons present outside the nucleus of any atom rotate independently in separate orbits surrounding its nucleus. Moreover, an electron also spins centering its own axis like a top. The energy content of an electron rotating in an orbit depends on the distance of its orbit from the nucleus. The energy of electron in any outer orbit would be higher than that possessed by the electron in any inner orbit. According to the axioms of the orbital theory, an electron can change its orbit under certain conditions, and during such change of orbit, the energy content of an electron will increase when it passes from inner to the outer orbit, while it releases certain amount of energy when it moves from the outer orbit to the inner one. The amount of energy thus released or taken up would be equal to the difference in the amount held by the electron at the two orbits. Powered by this property of electron, all the various changes are occurring in this Universe, and various chemical reactions, both inside and outside the living world, are

occurring through give-and-take of electrons. The movement of electrons within nonliving objects is an electrical process. On the other hand, the electrons have also the controlling role in various events occurring within the living organisms. The energy transaction during the trapping of solar energy as chemical energy during photosynthesis and spending of the energy obtained through respiratory activity in various physiological processes, and the transmission of nerve impulse, all are dependent on the movement of electrons through chemical molecules. So, with the passage of time following the BIG-BANG explosion, electrons, protons, neutrons and other fundamental particles were conglomerated at different times forming different elements. In turn, these elements formed different compounds and material objects (first the nonliving objects). From the environments of the nonliving objects appeared first the unicellular organism(s) through series of steps and stages during the billion of years that followed. Starting from the time of formation of unicellular living objects, gradually simplest multicellular and then complex multicellular living objects appeared during the progreess of evolution. Of course, before the appearance of unicellular organism(s), the genetic materials had to be made. Now, we know that the 4 specific basic chemical compounds (adenine, guanine, cytosine and thymine), a pentose sugar (deoxyribose or ribose) and phosphoric acid combined in definite manner in various sequential arrangements of the above bases to form the genetic material DNA (how it appeared first is not yet established). The genetic material changed gradually its size and structural organization with the progress of time to generate ultimately the diversity among unicellular and multicellular living organisms. The genes, the specific regions within the genetic material, control common physiological and biochemical processes occurring in all the living beings almost in similar manners. Again, the processes by which the living organisms gradually proceeded from simplicity to complexity in organization and function, have been developed by gradual evolution of new genetic systems, both simple and complex,

that ultimately led to the creation of complex genetic regulatory networks as are seen in man. In which direction the change of this complex genetic network will proceed in future, that will be dictated by the continuously changing environments. So, the chemical substance under the same generic name of DNA has been controlling the expression and manifestation of various properties of different living organisms belonging to different species and Genera according to the genetic assemblages in their DNAs, which have evolved during the long course of evolution. Jagadish Chandra said, "That man is superior among all living organisms, is not correct all the times. The power which has transformed the primarily made living unicellular organisms into man, by whose passionate outburst this polymorphic world and in like manner the wonderful life have originated from vast endless sky, that supreme power is continuing to flow still today. The direction of creation is towards higher (better) objectivity. And endless time and endless progress are stretched out ahead." During the period when Jagadish Chandra carried out his researches, the details of the structure of atoms, and the structure and organization of gene or genetic material were not known. In spite of those lacunae, the perception of Jagadish Chandra about the unity among the diversity of living organisms as well as that between nonliving and living has a similarity with the theory of molecular evolution to a certain extent. If one considers from this angle, one can conclude that Jagadish Chandra was also much in advance to his time in his perception about molecular evolution leading to the formation of plants and animals.

"The specific requirements for making great discoveries are vivid imagination, clear inner vision, great faculties of invention and experimental skill of the highest order."

ACHARYA JAGADISH CHANDRA BASU

7. Persons who inspired Jagadish Chandra

Success did not come in Jagadish Chandra's research life so smoothly. He had to work very hard to achieve his goal. In this regard, one important aspect of Jagadish Chandra's life will remain untold if at least a brief account of how some peoples had inspired him in his way to such a great success is not discussed. Among them, the first man to mention is his father Bhagaban Chandra. From the reality-based philosophy of his father, Jagadish Chandra learnt to go in the forward direction defeating various obstacles and impediments, and developed his mentality to face, accept and answer the challenges, which might come on his way to destination. The deep affection of his mother Bamasundari Debi helped him make his mental set up to proceed to fulfillment with perfection. Initially, Bamasundari Debi did not give her consent for his son going abroad for higher study; however, considering his future, she not only gave her consent later, but also considered seriously about the bad health and financial condition of her husband, and she wanted to give away her all savings and ornaments to render financial help in connection with her son's higher education abroad. Even the sisters of Jagadish Chandra used to inspire him for higher education and research work.

Next person to be named is his wife Lady Abala Basu. She actually inspired Jagadish Chandra throughout his life in professional and other activities. Lady Abala Basu (then Das) went to Madras for studying medicine. Those days, there was no provision for female candidates for studying medicine at the Calcutta Medical College. So, she went to Madras. During her 4th year of medical course at the Madras Medical College, she was married to Jagadish Chandra in 1887. Abala Debi was the second daughter of Durga Mohan Das and a cousin of Desh Bandhu Chitta

Ranjan Das. After her marriage, she gave up her study and became an integrated part of her husband's life both domestic and scientific, especially after she gave birth to a still-born baby. She took all the responsibilities of family management and helped in every possible way to assist Jagadish Chandra to achieve his goal and fulfill objectives very smoothly. Lady Abala Basu imbibed him with mental spirit and enthusiasm whenever he went abroad to deliver lectures on his scientific research. She entertained her husband's students and guests (both Indian and foreign), well wishers etc. with due respects and hospitality. After joining the Presidency College when Jagadish Chandra refused his salary in protest against the discrimination between Indians and British prevailing in respect of service rank and salary, at that time Abala Debi led the wheel of the family with strong hand and managed with economy to cope with financial stringency. Influenced by sister Nivedita, she became very much interested and inspired in spreading female education. She served as a Secretary of the Brahmo Balika Vidyalaya opposite to their house. She set up woman educational organization to spread education among the rural women, established Vidyasagar Banibhaban at Jhargram to make the widows self-sufficient, and founded woman's co-operative society for the poor and refugee women. She was the president of 'Sadharan Bramho Samaj' for some time. She voluntarily donated all her ornaments and savings to her husband at the time of establishment of 'The Bose institute' ('Basu Bijnan Mandir'). That is why Swami Vivekananda called her an accomplished chaste housewife.

From among the persons outside the family circle of Jagadish Chandra who inspired him most in his research, Rabindra Nath was one of them. In their early lives, they were not known to each other. When Jagadish Chandra was a student of class X in St Xavier's School, Rabindra Nath took admission in class IX in the same school; yet they did not know each other during their days in this school. Later, their friendship reached a high level owing to their individual achievements and nationalistic attitude. On

his return to India after successful completion of the first scientific mission in Europe in 1896-97, Rabindra Nath went to the house of Jagadish Chandra with a flower bouquet to welcome and congratulate him on his success abroad. Whenever Jagadish Chandra went to London and other Western countries, and narrated in details about his success there through letters, then Rabindra Nath not only felt proud of him, but also he conveyed immediately the fellow-countrymen about his research works in simple Bengali language to let them know about the achievements of Jagadish Chandra. While praising the different instruments Jagadish Chandra invented for his research work in Plant Physiology, Rabindra Nath said that those instruments had shown their excellence in spying into the inner environment of the plants. Rabindra Nath gave vent to his emotion and feelings about Jagadish Chandra's achievements and success through numerous poems and essays as well as through his inaugural and memorial lectures on the auspicious occasion of the foundation day of Basu Bijnan Mandir. Rabindra Nath helped in every possible way to collect funds for the establishment of Bose Institute. Once Rabindra Nath invited Jagadish Chandra to visit Shilaidaha and spend few days with him. At this, Jagadish Chandra imposed a condition that Rabindra Nath would have to tell a new story every day during his stay at Shilaidhaha. Rabindra Nath accepted such condition and wrote many short stories, and narrated those to Jagadish Chandra one every day. It is known that by being requested by Jagadish Chandra, Rabindra Nath composed the famous poem 'Karna Kunti Sambad' in which the character of Karna was designed by the poet as per the desire and direction of his scientist friend.

When the Royal Society of London did not publish the work of Jagadish Chandra on the plea that those were nonscientific, then Rabindra Nath said, "Jagadish Chandra has discovered such a great scientific truth that its impact will be far-reaching and eternal. Now, he will have to fight courageously to establish his theory among the common peoples, and then he can take rest. The person who has

started such work, he will have to complete that himself, because it is well within his capability and competence. So, unless he completes the initiated work, it will lose its charm." Whenever Jagadish Chandra felt disappointed, Rabindra Nath used to encourage him with mental boost to continue his work. Once he told him, "Every great invention compels the science to build its foundation in a new or novel way that is not accepted or granted in a day. One has to fight for long to desist the oppositions and contrarieties that may crop up at the initial stage; the scientific truth has to prove its honesty through long and continuous struggle." This way Rabindra Nath used to cheer him up all the times.

A bamboo plant named 'Muli' bamboo grows in Tripura. The growth rate of this bamboo is very fast at the baby stage. When Jagadish Chandra was doing experiment for measuring the growth rate of plant with the help of self-made instrument, that time Rabindra Nath wrote a letter to the Maharaja of Tripura, Radha Kishore Manikya Rai Bahadur requesting him to send saplings (with roots) of Muli bamboos which would be very good research material suitable for measuring plant growth in experiment to be done by his scientist friend Jagadish Chandra.

Jagadish Chandra had a good progress in his research while staying in England in 1901; but his tenure of staying there was over. He appealed to the Secretary of States for an extension of his tenure for two more years; but it was not approved. That time Rabindra Nath wrote to him that this type of permission was not necessary if he would like to stay without any scholarship money; so, he might stay there for the period needed to complete his work and then come back to India. Rabindra Nath wrote further that he would arrange for sending the extra money required for his extended stay in London. In order to materialize this plan, Rabindra Nath requested many respectable persons for extending help by way of donating money. Most of the peoples complied with this request of Rabindra Nath. The Maharaja of Tripura, Radha Kishore Manikya Rai Bahadur also responded and donated money.

Swami Vivekananda

Sister Nivedita

Lady Abala Basu

Mrs. Ole Bull
(Sara Chapmann Bull)

Figure 21

Group at Shilaidaha: (From left)
Sitting: Jagadish Chandra, Lokendra Nath, Rabindra Nath
Standing: Rathindra Nath, Mahim Chandra and Surendra Nath Tagore

J. C. Bose with the students:
From left: Sitting Meghnad Saha, Jagadish Chandra, Jnan Chandra Ghosh;
Standing: Snehamoy Dutta, Satyendra Nath Basu, Debendra Mohan Basu,
Nikhil Ranjan Sen, Jnanendra Nath Mukhopadhyay and
Nagendra Chandra Nag.

Figure 22

When Jagadish Chandra went to Europe and U.S.A. (1908-09), he attempted to publish some of the writings of Rabindra Nath after translating them into English. In the first attempt, he tried the English version of Tagore's short story 'Kabuliwala' to publish in the magazine of M/s Harper. Though Prince Kropotkin highly acclaimed the story, but the Editor of the magazine did not agree to publish it showing the reason that the publisher was not at all interested to publish a story about the life of any Indian native. However, during his next visit to U.S.A. (1914-15), Jagadish Chandra succeeded in this endeavour.

The degree of attachment of Rabindra Nath with Jagadish Chandra can be revealed through his various letters written to his scientist friend as well as to various renowned persons (Vol. 6, Chithipatra (Letters), Rabindra Nath Tagore, Viswa-Bharati publication). Rabindra Nath also expressed his deep association and feeling through several poems written about Jagadish Chandra. The English versions of these poems have been annexed at the end of this book.

From outside of the family circle, Jagadish Chandra also got inspiration from Swami Vivekananda, Mrs. Ole Bull and Sister Nivedita. Mrs. Ole Bull was an American. Her husband was an excellent Violin player. Mrs. Bull used to patronize art and culture. Her husband died in 1880. In 1893, Swamiji created a sensation in America by his Chicago speech on Indian Religion. That times Swamiji stayed in America for one and a half year to preach the massage of Indian Religion. In 1894, he came to England with the same mission for a few months and again went back to America. At that time in mid 1894, Mrs. Bull came in contact with Swaminji; thereafter, an intimacy grew between them. Swamiji called her 'Dhiramata'. It was not exactly a 'mother-son' relation, but, as Mrs. Bull was very religion-minded, their relationship was never estranged. Later, Mrs. Bull accompanied Swamiji to England and subsequently to India. She extended all possible help and cooperation to Swamiji in his various developmental works. By her financial assistance, the old 'Thakur-Ghar' at Belur Math was repaired,

and the residential complex for the monks of Belur Math was built.

Margaret Noble was an Irish lady. She was a great lover of education at heart and was involved deeply in the spread of woman-education. She came in contact with Swami Vivekananda in London in November 1895, when he was busy in preaching the message of Indian Philosophy and Religion there. That time, Margaret Noble's belief in religion was going to be influenced by liberal thoughts and opinions. As a result, she was going far away from the main stream of Western Religion. At that time after coming in contact with Swami Vivekananda, she realized the difference of Hindu Religion from other Religions. Being influenced by Vivekananda as well as by the magnanimity of Hindu Religion, she came to India in January, 1898. In next March, she was initiated to the Order of Sri Ramkrishna and was named Nivedita. Since then, she was popularly known as 'Sister Nivedita'. Around this time, Nivedita had also developed friendly relationship with Mrs. Bull, while both of them were in Kolkata. Nivedita was the mother of woman education in India. She set up a Girl's School at Bagbazar in North Kolkata, and Mrs. Bull helped her financially in this benevolent work.

After the initiation of Nivedita in the Hindu Religion, Swami Vivekananda tried to make direct contact with the then celebrated persons of Bramho Society through her. Within a few days, as a result of such effort, Nivedita became acquainted with Jagadish Chandra. Based on the success in research of this newly established Indian scientist in the world Court of science, their intimacy gradually grew deeper. Taking advantage of her close relationship with Jagadish Chandra at one side and Mrs. Bull on the other, Nivedita repeatedly wrote letters to Mrs. Bull intimating her about the genius of Jagadish Chandra and persuaded her to come closer to tie him with motherly affection and to give encouragement in his research. Being a progenitress of genius, Bull complied with this request of Nivedita. In 1899, Nivedita took Mrs. Bull to the laboratory of Jagadish Chandra

at the Presidency College and introduced her to this scientist. After knowing in details about the progress of his research, Bull was very much impressed and fascinated. Since then, a good relationship developed gradually between Bull and Jagadish Chandra. In 1900, Jagadish Chandra participated in the International Congress of Physicists held in Paris. That time, he became seriously ill. Getting the news of his illness, Bull rushed to Paris and took over the responsibility of his treatment. Since then, the intimacy between them grew deeper, and Jagadish Chandra started looking at her as a substitute for his own mother. Also, Bull reciprocated by showing motherly feeling to him and rendered financial help in his research. When Jagadish Chandra went to America later (1908-09), he opted to stay with Bull's family and visited several Universities in America to deliver lectures on his work. Gradually, his relationship with Bull became very close also at the family level. Due to such relationship, even after Mrs. Bull's death when Jagadish Chandra went to America in 1914, he stayed at the residence of Mrs. Bull's brother (Mr. Thorpe) as his guest. From there he contacted various scientists at Harvard and Boston. A very delightful outcome of their intimate relationship was that before her death, Ole Bull executed a WILL covering all her wealth and savings. In that WILL, a large amount of money was earmarked for Jagadish Chandra for his own research as well as for the progress and development of science in India. Jagadish Chandra was never interested in taking patent for his invented instruments. However, by the eagerness of Ole Bull and Sister Nivedita, a patent was taken for the 'Galena Coherer' where Mrs. Bull bore the whole expenditure of the patent, and she was also the legal representative for 50% share of the ownership for the royalty income. Another example of Mrs. Bull's genuine love and affection for Jagadish Chandra was that she persuaded him to preserve all the outcomes of his research in writing so that those could be available to other scientists even after his death. In this context, she also assured him that Nivedita would assist him with every responsibility in

such compilation work. Nivedita became associated with Jagadish Chandra just like a member of his family and extended help to the best of her capability to publish the research works of Jagadish Chandra in the form of books. Of course, Ole Bull bore the entire cost of those publications. Unfortunately, Nivedita could not continue this work for long; because she passed away in 1911 after the publication of the first three volumes. It is known that the contribution of Nivedita in compiling those volumes was so extensive and significant that peoples expected Nivedita to be a co-author of those volumes. Nivedita used to call Jagadish Chandra 'Khoka' and Abala Debi as 'Bow'. Nivedita's enthusiasm for the establishment of a research laboratory in Kolkata was simply tremendous. Once Nivedita went to Buddha Gaya accompanying Jagadish Chandra's family; there she discovered the 'thunder-emblem' under the base of alter of Buddha sculpture. Then and there she thought that this 'Thunderbolt' should be the symbol of India.

Nivedita realized from the core of her heart about the importance of Jagadish Chandra's research work. She also felt that the scientific activities of high standard had been initiated in India. Jagadish Chandra developed a good relationship at the family level with Nivedita's mother also. Nivedita was a great well wisher of Jagadish Chandra in his victorious journey in the path to scientific achievement. She praised immensely the success achieved by Jagadish Chandra despite various difficulties he faced in absence of any infrastructure suitable for carrying out basic research in comparison with those available in the Western countries. Not only that, with a view to evaluate his work in a letter written to Rabindra Nath, she made a detailed analysis and reviewed about Jagadish Chandra's researches in both Physics and Plant Physiology. And at the same time, she harshly criticized the insulting and jealous mentality of the Western scientists. She also criticized about the obstructions the British government created from time to time in his research. She emphasized on the importance of personal freedom of a researcher and felt from the core of her heart

that the way Jagadish Chandra was carrying out high quality basic research under various adverse conditions, carries symbol of his mental perseverance. At the end, Nivedita requested the motherland saying, "Ah India! India! Can you not give enough freedom to one of the greatest of your sons to enable him, - not to sit at ease, but - to go out and fight your battles where the fire is hottest and the labour is most intense, and the contest raging thickest ? And if you could not do this - if you cannot even bless your own child and send him out equipped, then, - is it worthwhile that the doom should be averted, and the hand of ruin stayed, from this unhappy and so beloved land?" Nivedita esteemed researcher Jagadish Chandra high above other scientists like Marconi, Tesla or Mascot. She mentioned again and again about Jagadish Chandra's feeling that if he failed in his own target then all the countrymen would be deprived of their right of education.

In 1896, when Vivekananda was engaged in preaching Hindu Religion in London, that time he heard the sensational news of Jagadish Chandra's research and felt very proud. Though Vivekananda was a preacher of spiritualism (science), yet he was very much interested in advancement and progress of India in all respects. Later in 1900, when Jagadish Chandra participated in the International Congress of Physicists held at Paris, that time Vivekananda also came to Paris to participate in the Conference on the History of Religion. During this period of stay in Paris, these two great sons of India met each other for the first time. Vivekanada realized that with his deteriorated health, he himself would not be able to do much for the country. But during this tour of Paris after seeing Jagadish Chandra lecturing in the Scientists' Conference, he felt that down-headed India is going to be reanimated with renewed vigour and enthusiasm. In the letter he wrote from Paris at that time, he expressed his unusual feeling. He wrote, "Today, in Paris, the men of genius from different countries have extended the glory of their own countries by expressing their brilliance. Today, the drum-voice of this great centre will

announce the name of a person, that sound wave will immediately glorify his country before all the people. And my motherland - where are you Bengal in this Capital embellished with German, French, English, Italian friends? Who will pronounce your name? Who will announce your existence? One young celebrated hero from among many white geniuses announced the name of our motherland – that hero is world famous scientist Dr. J. C. Bose! Today, the Bengalee youth Electric Man alone charmed the Westerners with the speed of electricity by his own brilliance-like glory, - that electric pulse imparted new life wave in the dyeing body of the motherland! Today, Jagadish Basu is the topmost man among all the Electric Men – Indians - Bengalees – thanks to the hero! Whichever country the Basu and his perfectly chaste wife with all good qualities go, there they glorify India – uplift the honour of Bengalees. Thanks to the Basu couple?" Dr. Sankari Prasad Basu has said, "The friendship of Jagadish Chandra and Vivekananda was neither childhood-friendship, religious-friendship nor professional-friendship; that was a relationship of mutual appreciation of good qualities in them. They caught hold of each other's hand to bring out the truth of life of the motherland and India, the progenitrix land of multi-civilization. Nevertheless, they have significant differences at other side of their lives. In spite of such differences, they accepted each other with profound regards and love, which indicate that the great men have a meeting hall where they can meet with cordiality and pleasure leaving their companions of the environment outside."

Vivekananda believed that the main truth of religion would be accepted after being examined scientifically. He found 'That Oneness with full of Love' (Sei Premamoy) within all living beings (which is the key idea of Indian Philosophy), while Jagadish Chandra found 'One Oneness with full of Sensibility' (Ek Premamoy) within all living organisms. The perception of this Oneness by them was, though in two different ways from two different angles, primarily based on the 'Eternal Non-Dual Theory'. That is

why, when Jagadish Chandra proved the existence of that Undivided Truth within nonliving and living (plants and animals) with the help of self-made instruments, Vivekananda was overwhelmed with joy.

The most important contribution of Vivekananda on the way to attaining excellence in research by Jagadish Chandra was that, he induced Mrs. Ole Bull and Ms. Margaret Noble to come to India by influencing them by the liberality of Hindu Religion. And these two ladies influenced each other to extend various kinds of help and co-operation to Jagadish Chandra for the accomplishment of his research. They also reanimated Jagadish Chandra in his austere practice of science like a Mantra of Spiritualism.

Besides the persons mentioned above, the others who inspired Jagadish Chandra and extended help in various ways in his research were, Acharya Prafulla Chandra Ray, Sri M. K. Gandhi, Dr. Nil Ratan Sircar and Sri G. K. Gokhale. As a great dedicated and responsible teacher, Jagadish Chandra built a school of successful students, each of whom has helped glorify India. They are: Dr. Satyendra Nath Bose, Dr. Meghnad Saha, Dr. Debendra Mohan Basu, Dr. Jnan Chandra Ghosh, Dr. Snehamoy Dutta and Dr. Jnanendra Nath Mukherjee.

At last, I must mention the names of two persons whose close association made Jagadish Chandra inclined towards the study of Physics. One of them was Father Eugene Lafont, Professor of Physics in St. Xavier's College, Kolkata, and the other, Lord Rayleigh, who was also a Professor of Physics in Christ's College, Cambridge. The excellent teaching of these two great teachers helped create in Jagadish Chandra the mentality of a successful teacher, and a constant source of motivation and infinite energy for scientific research. Both of them belonged to the Europian white community. The first Professor contributed significantly in the advancement of science education in India staying in this country of natives. He actually gave the direction and imparted speed to the future life of Jagadish Chandra. He sowed the seed of science within Jagadish Chandra and

germinated it, while Lord Rayleigh, an established Professor and a top ranking scientist staying far away from India, started from the point where Lafont left it at the germinated stage and ultimately converted it into a big plant. Though Jagadish Chandra had personally a strong inclination for the study of Botany (Plant Science) in the core of his heart, these two Professors pulled him towards Physics. Of course, he did not keep himself confined within the boundary of Physics, but he utilized the knowledge acquired from his research in Physics to remove the boundary line between nonliving and living (plant and animal) objects, and created a new branch of science, Biophysics or Electrophysiology in India. Thus, we have witnessed Jagadish Chandra in his ultimate bright form because, he started his research in Physics at the initial phase and later moved into Plant Science research where he utilized his knowledge of research in Physics acquired at the initial phase.

"To know the complex processes of plants, one has to understand the molecules of life. To visualize those invisible happenings, one has to go beyond the microscope aided limited visions".

ACHARYA JAGADISH CHANDRA BASU

8. Basu Bijnan Mandir

The establishment of 'Basu Bijnan Mandir' is an eternal and glorious contribution of Acharya Jagadish Chandra Bosu. Though it was founded in 1917, but the idea of establishing such a laboratory was conceived by him in 1898 through an unpleasant incident. After delivering lectures in many renowned Research Centres and Royal Society (London) during his first scientific mission to Europe in 1896-97, Jagadish Chandra came back to India and started his research on 'Coherer' in Presidency College. At that time (1898), Lord Rayleigh visited Ceylon (now Sri Lanka) to witness full solar eclipse. On his way back to England, by the invitation of Lord Ripon, the then Viceroy of India, he came to Kolkata. During that short period of stay in Kolkata, one day Rayleigh came to see his laboratory in Presidency College without invitation. He was very much impressed with the progress of Basu's research and praised him heartily. After Rayleigh's departure in that afternoon, the Principal summoned him almost in the language of 'show-cause' as to why Jagadish Chandra brought a famous scientist like Rayleigh in his laboratory without permission of the Principal. At this uncourteous behaviour of the Principal, Jagadish Chandra felt insulted and protested in strong language. As a result, the authority became very much angry with him and began to create troubles which disturbed his research work. After this incident, Jagadish Chandra decided to establish a Research Institute under his supervision, where Indian scientists could pursue their research independently. However, prior to the above incident, during his first scientific mission to Europe in 1896, he was so much impressed by the congenial atmosphere of research existing in various laboratories in London that he nurtured a faint hope to build a good research laboratory in

Kolkata in near future. So, that faint hope turned into a firm decision later in 1898 after the above unpleasant event. He discussed about this decision with Rabindra Nath, who assured him to assist financially to activate such plan. But due to several reasons, the plan could not be materialized that time. After his retirement from the Presidency College, he was appointed as an Emeritus Professor for five years. During this period of his Emeritus Professorship, he collected about four lakh rupees by summing up his own savings and his wife's assets. With this money, building was constructed at 93/1, Upper Circular Road (now, Acharya Prafulla Chandra Road) and was inaugurated on 30th November, 1917 on his 59th birthday with great pomp and grandeur. He named it 'Basu Bijnan Mandir' in Bengali and 'The Bose Institute' in English. To explain the objectives of establishing this Institute, he said in his inaugural speech, "It is not only a Research Laboratory, but also a Temple. Broadly, we know that science tries to reveal the truth through cognition, and the instruments widen that cognition. There are certain truths, which exist outside the domain of scientific methods, and which are to be acquired solely by faith and belief. That is the main reason for establishing such a Temple because, it is the most befitting place for perceiving that faith-influenced truth. This Institute will sow the seed of such specific belief and conviction, which will open the door for fulfilling the greater demand and to convert the impossible into possible in future." Being influenced by such arguments, he named it 'Basu Bijnan Mandir' in Bengali. At the same time, he dedicated the institute to the nation by a message in his own handwriting in Bengali (this message in Bengali is shown in Fig. 18 and its English translation in the Legend to the same figure).

After four years, in the preface (Katharambha) of the book ABYAKTA composed and published on 1st Baisakh, 1328, he said, "My several articles on science and other few essays were written in Bengali 30 years ago. Then I started research on 'Electric Waves and Life', and in that pretext I was entangled with various litigations. The Court

pertaining to these areas is situated in the foreign country where arguments-disputes are allowed in European languages only. In our country also no litigation in a Court is resolved until there is an order from the 'Privy-Council'. What could be more insulting than this in a national life? As a remedial measure for this, I tried to set up a Court of science in this country. I may not be able to see its achievements and progress in my life-time; future of this newly established Bijnan Mandir' is left on God". Jagadish Chandra constituted the Management Committee of this Institute consisting of the following members: Rabindra Nath Tagore, Bhupendra Nath Basu, Sudhansu Mohan Basu, Satish Ranjan Das and Jagadish Chandra himself. He also formed a Regulatory Committee to let this Bijnan Mandir run under strict discipline and regulation. The members of this later committee were: Jagadish Chandra Bose himself, Rabindra Nath Tagore, Lady Abala Basu, Nil Ratan Sircar, Sudhansu Mohan Basu, Satish Ranjan Das, Pran Krishna Acharya, and Banwarilal Chowdhury. There was no European or British in any of the above two committees. Furthermore, Jagadish Chandra gave a declaration that the British Government would have no right to interfere in any affair of the 'Basu Bijnan Mandir'. He became the executive head of the Institute as Founder Director. Sister Nivedita was very much interested in the establishment of a good laboratory like 'Basu Bijnan Mandir'. Unfortunately, she could not see it in her lifetime. So, to commemorate Nivedita's desire, the 'Thunderbolt' symbol was set up on the peak (above the roof) of the Institute. The ashes of the funeral pile of Nivedita were kept in a bowl and placed by the side of a lotus-shaped water-tank near the entrance of the Bose Institute. A torch-bearer 'Relief Idol' (Lady with the Lamp) was placed there. Also a 'Sephali' flower plant was planted there. There is a big lecture hall with a capacity for accommodating 1,500 peoples on the right side of the entrance passage of the Institute. The famous artist Nanda Lal Basu designed the painting of the interior of this lecture hall. Rabindra Nath composed the song "Matrimandira punya angana.....", which was sung in

the Inaugural Ceremony of the Institute held on November 30, 1917. Since then, this song is being sung as the opening song on every Foundation Day and during any other functions which are held at the Bose Institute.

Jagadish Chandra planned the Institute in the protocol of Royal Society (London). From the starting year, he planned to publish an Annual Science Journal named 'Transaction of the Bose Research Institute' to relate and convey the progress of the research done in this institute to the scientists of the Western world. In those days, there was no centre for carrying out basic research in India when publication of a Science Journal was a far cry. After knowing about the research and related experiments conducted at the Bose Institute through the first and second yearly issues of this journal, the scientists of the Western world were very much delighted. Letters of appreciation and certificates from foreign scientists were published in the 'Nature' journal.

Thus, the 'Basu Bijnan Mandir' was founded, but a huge amount of fund was necessary to run its well-planned research activities. To raise fund, Jagadish Chandra appealed to the fellow countrymen, and most of them responded to his call incredibly. Maharaja Manindra Chandra Nandy and Maharaja Gaekwad donated a huge amount each; even the common people did not recoil to donate their utmost. Since 1919, Jagadish Chandra followed a novel policy to collect money for this purpose. He began to deliver lecture at different places to percolate among the common peoples about the outcomes of his research. He charged an 'entry-fee' to the peoples who attended his lecture. In spite of such fee, the hall was overcrowded during every such lecture. He also went to Bombay with the same mission of collecting funds by delivering lectures. For one such lecture, Gandhiji made an appeal to the common peoples for donating money for the development of the Bose Institute. Gandhiji's call was highly responded by the public. From his lecture delivered in Opera House (Bombay), about fifty thousand rupees were collected. At this success, the 'Hindi Punch'

news paper wrote, "Such a vibrant response from public has never been seen - congratulation to Acharya Jagadish Chandra, gratified are the knowledge-thirsty peoples of Bombay, fortunate is the Bose Research Institute". In this way, Jagadish Chandra was able to collect eleven lakh rupees for the Institute. In 1924, the Editor of the Journal 'Nature' wrote, "The establishment of 'Bose Institute' and gradual progress of research in this institute have proved that India has owned a real great man." When the Institute's research work was going on smoothly by the donation of public, then the British Government, out of mere feeling of delicacy, sanctioned one lakh rupees as Annual Grant. In his life-time, Jagadish Chandra made a Trust Fund of twelve lakh rupees. After his death, Lady Abala Basu also built a trust fund of more than three lakh rupees. After Jagadish Chandra's death, Rabindra Nath remarked in his memorial lecture that Jagadish succeeded in bringing Lakshmi (the goddess of wealth) in his own favour so easily only due to his personal magnetism.

Initially, this Bijnan Mandir started with three Departments, Physics, Botany and Chemistry, and one Section of Animal Physiology. Subsequently, three other Departments, Microbiology (1942), Biochemistry (1974) and Biophysics (1983), and three other Sections, Plant Molecular and Cellular Genetics (1989), Environmental Science and Immunotechnology (1992) were created. Besides these, two Experimental Stations were established, one at Madhyamgram and the other at Shyamnagar at far North of Kolkata where the results of laboratory-scale experiments on plants done in the Institute laboratory are confirmed by pilot plant experiments. Another such branch laboratory was built at Mayapuri in Darjeeling in 1922 by the financial help of the industrialist Jamunalal Bajaj. Moreover, there is another building with a big experimental garden at Falta on the bank of Ganges. Jagadish Chandra used to feel the depth of his mind sitting by the Ganges and listening to its babbling sound. In 1978, by the financial assistance of the Department of Science and Technology, Government of India, 'The

Regional Sophisticated Instrumentation Centre' was set up. Recently, it has been renamed as 'Sophisticated Analytical Instruments Facility'. Various costly modern instruments have been housed in this Centre, which are used not only by the scientists of this Bijnan Mandir, but also by the scientists from the Eastern part of India for their specialized research works. By the financial help of the Biotechnology Department, Government of India, a Bio-Informatics Centre has been created in 1988; this Centre has been catering services to the researchers to a great extent. Moreover, another Instrument Centre has been developed under one cover in the name of 'Central Facility' with various modern, sophisticated instruments and ancillaries suitable for carrying out modern research in Life Science. Besides these, 'Genomics and Proteomics Centre' has been developed in the Centenary Building Campus and 'Astroparticle Physics and Space Science Research Centre' has recently been set up at Bidhannagar.

From the beginning, Jagadish Chandra was directly involved in research in both Physics and Botany. Dr. J. C. Nag, Dr. J. P. Sarkar, Basiswar Sen, G. Das, Gopal Chandra Bhattacharya, N. N. Das, N. N. Neogi, N. N. Sengupta, S. C. Das, L. M. Mukherjee, A. C. Nag, Ashutosh Guha Thakurata, B. K. Dutta, B. K. Palit and many other scientists used to assist in his research. During subsequent years, many of the scientists working in each Departments and Sections not only have established themselves at both national and international levels, but also have brought the Institute step by step towards fulfilling the objectives Jagadish Chandra spelled out. The Basu Bijnan Mandir is a special resort of scientific research in whole of India and has acquired a permanent place in the scientific map of the world with its own glory. Every year, the Foundation Day of the Institute is celebrated figuratively through lectures, seminars etc. Many renowned scientists and Nobel Laureates also visited this institute and delivered lectures.

After independence, the Government of India took over the financial liability of this Institute in 1950s. Subsequently,

when the Department of Science and Technology (Government of India) formed, it took over the charge of Bose Institute with total financial liability, but the Institute has been running autonomously as was practised during the time of Jagadish Chandra.

In 1983, 'The Acharya J. C. Bose Centenary Building was founded at Ultadanga (the land on which this building was erected was donated by the Government of West Bengal to commemorate the Birth Centenary of J. C. Bose in 1958) adjacent to ESI Hospital, and the then Prime Minister of India, Sri Morarji Desai inaugurated the building. Soon after that, the Administrative office, Biochemistry and Microbiology Departments, Animal Physiology Section and a larger part of the library moved from the main campus to this Centenary Building Campus. Around late 1980s, a hostel was made for the Research Scholars in Sector 5, Bidhannagar by the financial assistance of the Government of India. Another new building has also been built annexed to the Centenary Building in 2006 financed by the Government of India. A new Section under the name 'Molecular Medicine' has been created in 2008 with all the faculty members of 'Animal Physiology' and 'Immunotechnology' Sections and few faculty members of the Chemistry and Microbiology Departments. An integrated M.Sc.-Ph.D. Course (affiliated to the Calcutta University) has been introduced in Plant Molecular Biology and Biotechnology in 2007 under the management of Plant Molecular and Cellular Genetics Section. The library of this Research Institute is well-equipped with various kinds of books, magazines, journals etc., which acclaim excellence not only in Kolkata, but also in the whole of Eastern India. It has been serving the researchers, teachers and students to a great extent. From the recent past, the library is also giving service with various kinds of modern equipments.

From the very beginning, Jagadish Chandra worked as the founder Director of the Institute. After his death, his nephew Prof. Debendra Mohan Basu was the Director for the period from 1937 to 1967. In subsequent years, the post of Director was held by Prof. Sourindra Mohan Sarkar

(1967-75), Prof. Sushil Kumar Mukherjee (1976-77), Prof. Sasanka Chandra Bhattacharya (1977-84), Prof. Birendra Bejoy Biswas (1985-90), Dr. Prasanta Kumar Roy (1992-2000), Dr. M. Siddiqui (2001-05) and at present, Prof. Sibaji Raha (2006–). From 1950s, the trend of life science research rapidly changed at the international level, mainly in the direction of Molecular Biology and Genetics. In this institute also, the trend in both basic and applied researches in different areas of Life Science have adapted to such changes (at the international level) with the promise of high quality research. Gradually, with the development of better facilities and infrastructures befitting the need of time, the standard and qualities of research in this institute are attaining a high level day by day. Working in this institute, many scientists have been recognized with honour for their contributions in Indian as well as in world science. From 1970 to 2008, three scientists have received 'Santiswarup Bhatnagar Award', nine scientists have been elected Fellows of the Indian National Science Academy (New Delhi), twelve as the Fellows of the Indian Academy of Sciences (Bangalore) and eleven as the Fellows of the National Academy of Sciences, India (Allahabad). Many of these scientists are also the Fellows of above three National Science Academies. There is one scientist who is a Fellow of 'the Academy of Science for the Developing Country'.

"We are all 'Jatakas' in the path of knowledge and must offer our life's devotion to our country."

ACHARYA JAGADISH CHANDRA BASU

9. Researches of Jagadish Chandra : Responses Outside and Inside the Country

The researches of Jagadish Chandra were accomplished in three different phases. In the first phase (1894-99), he made small wave length EMWs and studied their properties that were known for the visible light. He also prepared various coherers made from different materials (metals, nonmetals and metalloids) and studied their properties. He also designed and made new coherers based on which he developed various sensitive methods. Using those methods, it was possible for him to generate and detect the microwaves. In the second phase (1899-1902), he proceeded with an aim at understanding with perception the unity between nonliving and living objects. In this phase, he showed that both nonliving and living objects could generate similar response against any kind of stimulus. In the third and last phase (1902-33), he showed that the plants have sensibility similar to that of animals. He accomplished all these works at a level comparable to that in which the Western science was progressing, and even in many of the cases, he was much ahead of the Western scientists.

The Royal Institution was established in London in 1799 with an objective to present new scientific discoveries before the common people as well as various scientists as a promise for social upliftment and also to effect gradual improvement of scientific researches. In the same Institution, Friday Evening Discourse was initiated in 1822. Any discovery could come to the public through the lectures in this Evening Discourse every Friday. The lectures were always followed by detailed discussions and criticisms. As a result, the standard of research activities did improve and further new discoveries found their ways. The fact was that the importance of such discussions for any kind of high-value research was felt well by the Western scientists. But in

India in those days, infrastructure facilities for carrying out basic research in Physics (as well as in other branches of science) were nonexistent, and also, the open platform similar to that present in Royal Institution for discussion of raw data coming out from scientific experiments did not exit. For this reason, Jagadish Chandra had to go to the scientists of the Western countries for evaluation and publicity of his research works. After those works got recognition from the Western scientists, the peoples of India could feel their importance. On this issue, Jagadish Chandra pointed out, "All my discoveries, which have earned reputation abroad in recent times, were earlier published here in mother language. But, as the ill luck would have it, those works were not able to arouse any interest even among the most learned men of this country for a long time. The Universities also were suspicious about the value of the works, if those were not stamped with foreign recognition." He was a pioneer of basic research in Physics in India. Keeping his head in upright position, Jagadish Chandra gave proper reply to the despised attitude of the British Government and the peoples of Western countries about the capability of doing basic research by Indians. And how he did it? He did it by making all the instruments needed for his researches with the help of inexperienced native carpenters and blacksmiths and using those instruments in all his experiments. He also established that those instruments could generate very reliable and error-free data. Here lies his credit.

He undertook a total of ten scientific missions to foreign countries. The list of these missions is presented in Table 1 (see Annexure). In each of these tours, he carried with him all the relevant instruments and showed demonstration experiments before the scientists there. And also, after his return to India following each such mission, he was given felicitations in a befitting manner. During his first such tour, after he delivered lecture on Electric Waves in the Royal Society, Lord Rayleigh made a comment, "Such kind of flawless experiment can never happen; it would have been a genuine case if certain mistakes were there; as if it is a

network of illusion." While praising the simple and powerful 'Artificial Eye', Prince P. A. Kropotkin said, "The instrument, Professor Thomson showed about a week ago for demonstrating the polarisation of microwave at the Royal Institution, was several yards long, but Prof. Bose showed the same experiment with success with the help of a railway Bradshaw (a book)". He commented further, "This sort of simplification of such a complex instrument is possible only by a scientist endowed with exceptional creative faculty." Jagadish Chandra had a great innovative power of creating instruments. He used to say that for making a great discovery, one needs to have clear inner vision, great faculties of invention and experimental skill. Wilhelm Roentgen discovered the X-ray machine in 1895. That time, Jagadish Chandra fabricated an exact copy of such machine just from reading its description from a journal. With the help of that self-made X-ray machine and the barium platinocyanide film made by his colleague Nagendra Nath Das, Jagadish Chandra took photographs of broken bones etc. of many affected peoples. Actually, the conceptual depth in the subject was in good agreement with his fine scientific thinking, and both were merged with an unprecedented resonance. As an outcome of that, he could think ahead about the finer link between the working principle and the probable design of the instrument he needed for carrying out the researches he planned for, and he made the instruments accordingly. The design of the instruments and thinking of their operator (Jagadish Chandra) were always flawless, which actually helped him get success in his researches. Lord Rayleigh and Sir William Crooks said, "The methodologies, which Jagadish Chandra developed and used in 1895-96, were unquestionably very accurate; even in 1901, other scientists could not apply those methods with such perfection." In 1899, Lord Kelvin wrote to Jagadish Chandra, "I am overwhelmed with astonishment at your entry into the impenetrable area of science by doing novel experiments and my congratulations to you." The past President of French Academy of Science and a renowned Physicist then working in an area similar to that of Jagadish Chandra,

Prof. M. Cornu wrote to Jagadish Chandra, "The results of your researches in the first phase document your profound capability and credibility in leading your science in vertical direction. From the point of view of my own research, I have taken part in flawless experiments with the instruments you made. I shall be able to complete my work taking full advantage of those instruments." The Physicist Sir Neville Mott, a Professor of Cambridge University, who got Nobel Prize in 1977 for his contribution on solid state electronics, commented, "Jagadish Chandra was at least 60 years ahead of his time in his research, and he had anticipated the P-type and N-type semiconductors." While praising about Jagadish Chandra's work, the Vice-Chancellor of London University, Sir Henry Roscoe said, "The East has showed reputation in scientific research, and the discovery made therefrom are comparable to those occurring in the West." The Secretary of the London Spectator magazine initially passed adverse comments on Jagadish Chandra's work. Later, he was invited to attend the lecture delivered by Jagadish Chandra in Royal Institution. On listening to the lecture, the Secretary was completely changed, and he praised profusely. In the December 1895 issue of 'The Electrician' journal, the coherers discovered by Jagadish Chandra were reviewed in details and were highly praised. The photographs of all those instruments discovered by Jagadish Chandra were printed in various text books, specific essays, in the book 'Electricity and Magnetism' authored by Prof. J. J. Thomson, and in the 9th edition of 'Encyclopedia Britannica'. In his seventh scientific tour to Europe in 1926, Jagadish Chandra delivered a lecture at the Geneva University. After that lecture, the Nobel Laureate Albert Einstein said, "A Victory Tower may be erected for any one of the invaluable truths from among many which Jagadish Chandra has presented to the world." After their return from a scientific tour in U.S.A. in 1945, Profs. M. N. Saha and S. K. Mitra reported that, in many Universities in U.S.A. even in 1945, the RADAR-linked workers were given training with the help of instruments, which were exactly identical with the ones discovered by Jagadish Chandra. So, one can infer that

even after 50 years from the time of discovery of those instruments by Jagadish Chandra, no better instrument having improved function could be made in the birth place of modern science.

Certain Biologist of West remarked in a taunting tone, "You have worked with metallic particles. But, if you could make a whole piece of solid metal to develop such symptoms of sensitive response by pinching it, and if those symptoms show similarity with those developed by animal body after giving an identical pinch, then that will be understandable to all the people." Also, the 'Globe' magazine treated with contempt and said, "At the time of tyrannizing the metals, both the eyes of Professor were filled with tears. For this, we gratify him. But, when a fire-agitating iron rod will drop on a fire-place, then considering that this rod has received injury, one will lift it quickly and start caressing it – that situation will not come up at least in the near future." He absorbed all those sarcastic comments. However, during the later period, he gave proper reply to various bantering criticisms by performing more newly designed experiments with the help of proper instruments made by him for the purpose.

In the first phase, he got success in his researches on microwaves and created sensation among the scientific community of the West. In spite of that, why he had left those researches and became inclined towards Life Science research – many peoples may rightly ask this question. Actually, considering the environments and infrastructure facilities around that time, it could be apprehended that while he brought the research on microwaves almost single-handedly to a high level of standard, but more sophisticated and sensitive instruments were probably necessary to make further progress beyond that level. It would not have been an easy task to make such instruments by the local mechanics. The fact that in the Western countries also the environment suitable for supporting the finer research like that of Jagadish Chandra was not yet developed to that level was clear from the comments made by Lord Rayleigh and Sir William Crooks, which have been mentioned earlier.

In the perspective of time, Jagadish Chandra was ahead vertically through many steps. In spite of that, the then environment did not lend any support, and probably the fellow Indian scientists could not provide him any help in respect of thought and idea, which could complement his basic thinking. Whenever he had made a new discovery, he had to prove his dexterity, honesty and depth of work related to that discovery by delivering lecture on the work as well as by demonstrating the supporting experiments in the better scientific environment of the West. However, he himself said, "While working, as if I reached the boundary of Physics and Physiology, and I was astonished to see certain events happening there. What I observed was that there was no boundary line between Physics and Physiology. I got the perception that there is some form of connection between the two." After the discovery of short wave length Electric Waves (microwaves) during the first phase of his research, when he was studying their various properties, possibly at that point he became interested to know the effect of those waves on metals and nonmetals (inert objects) out of curiosity. In this way, it may be possible to widen the thinking related to research by a kind of normal and rational analytical power of a well organized scientific mind. It was known earlier that those waves could travel through air. But, when he observed that those waves could penetrate and pass through solid objects, might that be brick wall or a metal plate, then he became very excited.

Finding similarity of any past event amassed in mind for a long time with a current event is guided by a deepest basic thought. Especially, when any person remains absorbed in thought about an event that happened later, then, if he tries to find its similarity with other events remaining amassed in mind for a long time, a possible correlation may come out. Examples of this kind of events exist in scientific history. We know that the Scientist Kekule was thinking days and night about the probable molecular structure of benzene. A benzene molecule is made up of six carbon and six hydrogen atoms. If the valency of carbon is taken as four and that of hydrogen one, then how these atoms

can combine to form a stable molecule benzene after fulfilling the general condition of chemical combination? Kekule had this thought rolling in his mind irrespective of whether he was in a state of sleeping, dreaming, or awakening. With such a state of thought-loaded mind during sleep one night he dreamt about the formation of a chain by some snakes, which finally formed into a closed (circular) ring. Immediately, he waked up and arranged six carbons, each holding one hydrogen atom, in the form of a cyclic (ring) chain and found that this arrangement could satisfy the valences of both carbon and hydrogen (the terms and condition of sharing electrons were fulfilled). Actually, an absorbedly attentive mind can silently work at the interior of brain (neuronal network of brain) at all the situations, be it in a state of sleeping or waking. Arjuna (in Mahabharata) took his attention to a level of concentration (rapt attention) of such a higher degree at the time of hitting the eye of the fish hanging very high with his arrow that he was not seeing anything but the eyes of the hanging fish. If the concentration of mind could be taken to such a degree within the framework of one's thinking about a problem or of a desired material, the path of solution of the problem may be found out. We know the story of Archimedes. The Emperor Heinron showed Archimedes a newly made golden Crown (in certain writings, mention has been made as Wreath in place of Crown) and asked him as to whether he would be able to test to find out if the Crown was made of pure gold. In the perspective of time, his mind was fully occupied by the thought about how this problem could be solved. With such a state of mind, one day he entered bathroom for taking a bath (as he used to do every day) and threw himself into the bathtub with water filled to the brim. No sooner than he did it, he observed that certain amount of water overflowed out of the bathtub, and at the same time he felt himself lighter than his weight, while his body was floating on the tub water. In other words, he felt that he had apparently lost certain amount of his body weight. The problem given by the Emperor was keeping his mind in an absorbed state. Immediately, it clicked to his

mind that the amount of water overflowed out of bathtub had surely certain relation with the amount of loss of his body weight. Immediately, he started shouting "Eureka, Eureka" and ran out of the bathroom. He then went to the Emperor, and took that Crown and an equal amount of solid pure gold. He did an experiment and concluded that the Crown was made of alloy of gold with other metal. The most important and historical outcome of this experiment was that he discovered the famous 'Archimedes' Principle', which is related to the floating and immersion of any material in any liquid material. This type of event (overflow of water from bathtub) had surely happened to Archimedes previously at the time of taking bath, but that time he did not think of any possible scientific relevance of such event. Now, as the problem given by the Emperor occupied his mind, he did find out a scientific truth correlating the event with the problem through his analytical mind. There may be many such events behind the discoveries of various kinds. But let us now come back to the case of Jagadish Chandra. He said, "Apple falls. Newton asks 'why?' But the average man pockets the apple and says no more about it." From the intimate association with his friends in the rural environment in his childhood days, a lot of curious questions about plants (specially the movements of leaves of Lajjabati and Ban Chnaral) did arouse in his mind. Those questions did never move out from his mind, and hence, he dared to ask as to whether the microwaves and electricity have any role in those types of leaf movement events he witnessed 35 years ago. In that process of thinking, as if a dormant volcano of basic thinking was awaken. As a result, the lava which came out in the form of scientific truth did only emit the light of knowledge, which did spread worldwide, while that had no destructive heat.

When Jagadish Chandra was demonstrating an experiment on the responses of plants against stimuli in the premises of Royal Society, that time the reputed biologist John Burdon Sanderson commented, "We did not succeed in doing the experiment that you have performed on the life process; so, your findings are absurd and unacceptable.

You are a trespasser in this area of science. You have earned enough reputation in Physics; many successes are waiting in that vast area which is lying before you. You please retract from this area, which is unknown to you." Sanderson said further, "I have observed that no other plants excepting Lajjabati and Ban Chnaral could respond to stimuli." But Jagadish Chandra showed such responses in many other plants besides Lajjabati and Ban Chnaral. Under such circumstance, after listening to what Sanderson said, Jagadish Chandra took a solemn oath saying, "I will not retract, and this uneven path is my path. I quit the smooth path from today. What is rejected today, that is the truth. Every body will have to accept that truth willingly or unwillingly." He said that he was influenced by the instigation of the evil sense (Kumati), one of the two hostile drivers, good (Sumati) and evil (Kumati) senses, which were conspicuously existing in his mind. He said further, "I was thinking of going back to Physics research after leaving these novel truths to the biologists; but good resulted in a great harm" (in the essay 'Hajir' in Abyakta). During the next twenty years, he established those truths with strong foundation by performing more experiments of different kinds applying his tireless efforts. At that point of time, he got directive from the interior of his mind that he should then go abroad. He hesitatingly asked, "Travel abroad! Who will listen to me there?" This time somebody said in more firm voice, "My name is HUKUM (order); your name is TAMIL (compliance)! Who are you to speak about gain and loss? I accepted the command for going abroad." During this scientific tour to the Western countries, he realized that the situation had changed completely. While expressing his delightful feeling which he perceived, he said, "Those who were hostile before, talked now very friendly. The works, which were rejected during earlier visit, were accepted at all those places. What I thought to be a bad sense (KUMATI) twenty years back, now I found that to be a good sense (SUMATI) again." Therefore, it now appears that the hostile comments of Sanderson compelled Jagadish Chandra to take a new challenge; he could not go back to research in

Physics. Now, the readers can surely understand as to why Jagadish Chandra left the researches in Physics which he brought to a high level and became inclined towards Life Science (Plant Science).

In this context, another painful event, that shocked Jagadish Chandra, may be briefed. He submitted a paper based on his work on the 'Response of plants against stimuli' to the Royal Society Journal to be considered for publication. But the paper was not accepted but archived by the Royal Society. After a few days, he delivered a lecture on the same work in the Linnaean Society, and this work was highly appreciated there. It was discovered later that a paper having scientific content similar to that of the paper of Jagadish Chandra, earlier rejected and archived by the Royal Society, was published under the authorship of the famous biologist Augustus Desire Waller. On this issue, a lot of arguments and counter-arguments regarding the priority of the discovery between the two scientists were published in journals. However, it is known from his letter written to Rabindra Nath that the priority, if not the total scientific content of that paper, belonged to Jagadish Chandra. He was very shocked at the mean mentality of this reputed Western scientist. This led him to take a firm decision to publish the results of his research from that time onwards first in the form of book and subsequently in journals. It may be mentioned that, though Waller was very hostile to Jagadish Chandra at their first encounter, but later, when he learnt more about the work of this Indian scientist, he was changed and became friendly to him. Even he invited Jagadish Chandra to his laboratory.

The German Professor W. Pfeffer of the Leipzig University had an unprecedented contribution towards the advancement of plant science. Certain discoveries of Jgadish Chandra contradicted some of the theories of Pfeffer. Under that situation, when Jagadish Chandra went to Europe, he thought that possibly he had displeased Pfeffer. So thinking, he went to the Vienna University instead of going to Leipzig, and there he saw that Pfeffer had sent his Assistant Professor to invite him and also sent a message that the

novel truths discovered by Jagadish Chandra had reached him at the fag end of his life. He (Pfeffer) also regretted that he would not be able to see the ultimate consequence of all those truths discovered by Jagadish Chandra. At this type of lamentation of Pfeffer, Jagadish Chandra felt mental pleasure by thinking, "Whom I took as my enemy, he accepted me as a friend. This is the heroic principle."

Once having been invited by Sir Oliver Lodge, Jagadish Chandra was demonstrating photosynthesis experiment at India House using the self-made instruments. In the audience were the Prime Minister of England McDonald, Oliver Lodge, George Barnard Shaw and few other dignitaries. After completion of the experiment, Barnard Shaw made a joking comment, "I am sure that this speaker will be successful in doing flawless experiment to show the competency of politicians and others for doing work as well as their skill."

The Basu Bijnan Mandir was set up on 30th November, 1917. Before that he was awarded with Knighthood by the British Government for his contributions in basic research in science. That year (1917) on November 25, an appeal was made in a Bengali Daily News Paper to the general public for extending their cooperation and help for the prosperity of this Bijnan Mandir along with a note of profound praise about the scientific researches of Jagadish Chandra. Seeing that appeal, a so called Physicist published a letter as a complaint against that appeal in 'The Statesman' dated 27th November wherein he under-evaluated Jagadish Chandra's research activities. He wrote that there was no personal thought in his research etc., etc. Jagadish Chandra did not care to reply in protest of that letter. However, a person named Harit Krishna Deb gave a proper reply to this letter arguing in favour of Jagadish Chandra. Even after that, the former person (the Physicist) wrote another letter again with attacking language. Later in May, 1920, Jagadish Chandra was elected a Fellow of the Royal Society. Of course, much earlier in 1903, he was elected a companion of Indian Emperor. In the meantime, he got full recognition for his research works from the Western scientists. This was indeed the reward of his hard struggle. The above referred

jealous Physicist got proper reply from these attainments of Jagadish Chandra. In 1940s, in the context of adverse criticisms in India on Jagadish Chandra's researches, Mr. Sajani Kanta Das, the then Editor of the magazine 'Sanibarer Chithi' (Letter of Saturday) wrote, "Common people of India has no idea – clear or unclear – about Jagadish Chandra's scientific achievements". Professor Patrick Geddes, the biographer of Acharya Bose, said, "The scientists, who walk down the street accepted by science, get Honour quickly; that Honour comes very late to the scientists like Dr. Basu who opt to travel down a difficult and nontraditional path." When there were anti-propaganda about Jagadish Chandra's researches within and outside India, then in an attempt to clarify those, Prof. Harris Molisch, the then Rector of the Vienna University, wrote an article in Nature in 1928. In that article, he explained that he was aware of the details of Jagadish Chandra's researches for a long time. All his researches in Plant Science formed the new leadership in modern science.

His 70th birthday was celebrated on December 1, 1928 with much grandeur. Prof. Molisch participated in that celebration as a guest scientist. Many dignitaries expressed their good wishes in various ways. Various other men of positions like Abanindra Nath Tagore, Gaganedra Nath Tagore, the poet Kamini Roy, Dr. Nil Ratan Sircar, Dr. Debaprasad Adhikary, Dr. Kali Das Nag, Dr. Chunilal Basu, Prof. Jadu Nath Sarkar and Prof. Prasanta Chandra Mahalanabish attended the above celebration. Besides these people, Netaji Subhash Chandra Bose, Sarbapally Radhakrishnan and many others expressed their good wishes through letters. Recently, Jagadish Chandra has been given recognition as the father of microwaves and semiconductors. On the occasion of hundred years of microwave discovery, an International Seminar was held in 1995 at Denver, U.S.A. In honour of his recognition for the discovery of microwaves, arrangement was made to review thoroughly all his research works. Also, Mr. Dibakar Sen, the then in-charge of the museum of Basu Bijnan Mandir and Dr. Arun Kumar Sen of the Department of Radiophysics of the Calcutta University participated in

that seminar on behalf of the Basu Bijnan Mandir. They performed several demonstration experiments using instruments invented by Jagadish Chandra. In 1997, a similar seminar was held at the Basu Bijnan Mandir to commemorate the centenary of the discovery of microwaves by Jagadish Chandra by reviewing all his works. Many scientists of international repute from both India and abroad participated in that seminar. In 1997, the Institute of Electric and Electronic Engineer, a famous organization in U.S.A., made a thorough investigation, which involved an extensive search of various old documents and records related to the microwave works done in the last decade of nineteenth century and thereafter. Based on various such records, the above organization claimed that it was Jagadish Chandra who actually discovered microwaves and the related receiver apparatuses. He should have been awarded with Nobel Prize. The instrument, which Guglielmo Marconi used at the time of demonstration of trans-Atlantic communication of wireless message, was the exact copy of the mercury-coherer Jagadish Chandra invented. In 2004, another seminar was held at the Basu Bijnan Mandir to commemorate hundred years of the patent on lead sulphide receiver for microwaves invented by Jagadish Chandra. The Italian Space Physicist and the grandson of Guglielmo Marconi (the recipient of Nobel Prize as the then recognized discoverer of wireless communication), Dr. Francesco Paresce Marconi visited Basu Bijnan Mandir in 2006. After looking at all the instruments made by Jagadish Chandra, he commented, "It is a matter of astonishing experience to me to know that J. C. Bose did demonstration of wireless communication before my grandfather did so."

"Every one must work for the honour of the country in his own way and according to his own light."

ACHARYA JAGADISH CHANDRA BASU

10. Jagadish Chandra's Science in Bengali and its Literary Impact

It is easy to understand and assimilate any communication related to thought, argument, doctrine and facts through mother language. The common men usually feel that science is unintelligible and is very difficult to assimilate by them. Presentation of the same scientific matter can be made in different ways depending on the place, time and persons concerned. In this context, we can classify the receiving peoples in three categories: the real scientific community, the peoples who understand science at the surface only, and those who are completely ignorant of science. The peoples belonging to all these categories cannot get into the science with the same level of understanding. So, there is a need for presenting the same scientific matter in different ways to the peoples of different acceptability. This may be considered as a prime criterion of presentation of science by a presenter. The common man can understand at least to a certain extent if the science is presented in simple mother language. So, it is the duty and responsibility of a scientist to present various scientific matters in an easily understandable form if he is willing to make the common people aware about the contribution of science. To be successful in this venture, one needs to use mother language as the medium of presentation and of course the person presenting must have to assimilate the subject matter of the same. Vivekananda said, "An idea is the first to consider and language is the next. The language is the medium by which the idea is expressed. It does not look decorous if an odd-looking monkey (as mount) is made to sit on the back of an elephant gorgeously decorated with precious jewelries." By the use of ornamental language, if the idea is not easily intelligible, or it becomes non-intelligible, then the purpose of

writing is sure to fail. But the writer is very much creditable when the readers do not feel any sort of deficiency in spite of the lustrous language, or the expression of the idea becomes clear to the reader by clever use of language. The literature is the medium of mental communication between the reader and the writer. From this point of view, if a writer can carry the idea generated within his mind to the reader at least to the level of his own thinking then that will be enjoyed by both of them. It does not matter if the language is glamorous or not.

The writings of Jagadish Chandra are very limited in number. Based on the information available from the writings of various writers, the estimated number of his writings comes to around forty. All those articles were published in various Bengali magazines around that time. Subsequently, having been requested by his friends, Jagadish Chandra compiled twenty articles from among those forty in the form of a book, which he christened as 'ABYAKTA' and published it on Baishakh 1, 1328 (Bengali Calendar system). The general readers have remote possibility of getting into the other twenty articles besides those published in 'ABYAKTA'. Through the christening of the book as 'ABYAKTA', he has brought about a harmony between his literary taste of mind and organized scientific thoughts. There is a Bengali proverb saying, 'ABALA BALE BISTAR' (the speechless also speaks too much). He has made the mind of speechless express so many thoughts in various ways through the articles compiled in ABYAKTA. Among these twenty articles, seven are directly related to science and two are science-based delightful stories. Again, several articles (like Gacher Katha, Udvider Janma-Mrityu, Nirbak Jiban, Ahata Udvid, Snayu-Sutre Uttejana) among the seven science-based ones and a few lecture-based essays have been written on different aspects of plants. Some of the latter essays are written for children. Besides these, the writer has pointed out various problems of the then society to the readers and has also suggested the ways for their possible solution through other stories and lecture-based essays. In several of the science-based essays, he has presented the scientific information

and truths discovered by him. He has also written in other areas of science outside the domain of his own research. All these articles were written in simple Bengali language.

The first and foremost task of a man of literature is to engage his thinking most of the time in the creative work related to literature and society. But a research scientist has to direct the concentration of his mind most of the time in the path of novel creativity in science. So, the literary creativity of a scientist like Jagadish Chandra cannot be compared with that of a person practising literature by the volume of writings. Till the fag end of his life, Jagadish Chandra had been involved directly in high quality research. In spite of that, he was able to contribute to Bengali literature to a certain extent. From the view point of quality, he maintained such an excellence that those writings are sufficient for the appeasement of literary hunger of the readers. After he published ABYAKTA, Jagadish Chandra sent a copy of this book to his friend Rabindra Nath; with the book he also sent a letter in which he wrote, "Today I am sending the dim light of fire-fly to the dazzling light of Rabi (Sun)." In reply, Rabindra Nath wrote, "Many of the articles of ABYAKTA are well acquainted to me from before; after reading them, I have thought many times that, in spite of the fact that you have made science your No. 1 queen (first wife), even then Sahitya Saraswati (literature) could have made that claim; she has been staying neglected by your carelessness only." About the Bengali writings of Jagadish Chandra, the Bengali Sahityik Pramatha Nath Bishi said, "There is no conflict between the pen of a poet and that of a scientist, there is invisible cooperation between them; however, that cooperation is not detectable most of the time as because the two (poet and scientist) are in different fields." He also said, "Jagadish Chandra has lighted the lamps of many probabilities within the temple premises of mother language. If the destiny-prescribed inspiration did not lead him in a different path, those lamps of probabilities would have been illuminated with dazzling light and been able to make an undecaying 'Great Bear' (Saptarshimandal) in the sky of Bengali literature – he had enough of that

power, that poetic mind, that savoury and perspicuity." However, the readers may also think that, if he did not proceed in the path of science, then the name of India would have remained non-articulated in the Science Court of the world for a long time, and the initiation of research in modern science in India would have delayed much.

Those who have gone through all these writings of Jagadish Chandra will agree with undisputed voice that the most delightful essay 'In quest of the origin of Bhagirathi' (Bhagirathir Utsa Sandhane) is a repertory of an extraordinary literary value. Many high profile writers and literary magazines have given such recognition. In this article, he has presented the scientific and geographical truths as a complementary to the ancient ones. By virtue of a deepest friendly relationship between any two persons, it is possible to exchange frankly and exhaustibly everything related to both joy and sorrow from the core of their minds. That is why he said, "I developed intimacy with the river (Ganga) from my childhood." Thereafter, through conversations with the river, he gave a description of all the events that occur in the natural and geographical environments during the course of the river starting from the origin down to the sea. In this description, he has blended ancient events with scientific truths and brought the literary taste to a degree of universal acceptance. By virtue of his friendly relation, he could hear a lot of statements from the babbling sound of the river. Sometime he thought, "This profuse stream of water is flowing every day, which never comes back. Then, wherefrom this never-ending stream is coming?" He then asked the river, "Where are you coming from?" He also drew out the answer of this question from the river. The river answered, "From the matted hair of Mahadeva (Shiva)." Through this statement (answer) he reminded a series of events that have been described in 'Purana'. The king Sagar arranged for a horse-sacrifice ritual. The horse selected for sacrifice was stolen away to the netherworld (underground place) and was kept in the Ashrama of Kapila Sage. Then sixty thousand sons of Sagar went to Agastya Sage for help. Agastya helped them by drinking whole of the sea water in a single handful

step and made the way to the netherworld. In an attempt to bring out the stolen horse, those sixty thousand sons of Sagar traveled down to Kapila Sage's Ashrama, when they were all burnt to ashes by the fire of anger of Kapila. In order to bring back the lives of his sixty thousand dead ancestors a few generations later, Bhagirath (the name Bhagirathi for Ganga has been coined after the name of Bhagirath) wanted to bring Ganga from the heaven to the earth by gratifying her by asceticism. Ultimately, Ganga agreed to come down to earth. But the problem was - who would slow down the very high speed during her come down. Therefore, Bhagirath again requested Mahadeva (Shiva) for extending help. So, the Ganga first came down to the head of Mahadeva, but she lost the way out being confined in his matted hair. Bhagirath again gratified Mahadeva by his asceticism and made Ganga free from the matted hair to come down to earth. Jagadish Chandra reminded the readers about all these chronological events through the answer pulled out from the river by the above single short statement. Again, he imagined the river as a course-changing living object, and through conversation with it, he gave a concrete literary shape about what he wanted to say. By this, he has brought out the feelings of the speechless (Abyakta). Again, based on the extramundane relation of Ganga with man after his death, Jagadish Chandra thought, "Those who go away do not come back. Do they then become extinct for ever?" He then posed another question, "Is death the end of life? Whoever goes, where he goes?" Then he got the answer from the babbling sound of the river, "He goes to the feet of Mahadeva." As an alternative answer, he also heard, "We go back to the place wherefrom we come. After a long banishment, we are going to meet at the origin." The way he described the natural scene on the way to the origin of the river, indicates that he became an intimate part of nature. After reaching the origin, when he saw the two mountains, 'Nanda Debi' and 'Trishul' situated side by side, he imagined them as Shiva and Rudra, the symbols of protector and destroyer respectively. He then

said, "I clearly saw with my mind's eye the voyage of water to the sea and returning back to the origin. In this great cyclically flowing stream, I did see the creation and destruction situated side by side."

He described the formation of water drops from cloud and their fall on earth as rain, the subsequent journey of the water from mountain till it meets the sea, and the creative and destructive acts it performs on the way. These descriptions were very concise yet explanatory. He also did not forget to provide scientific insight of the water cycle. After reading this article, Acharya P. C. Ray jokingly said, "Surely, this has been written by your sister, and you have managed to publish as your own." About this article, a critical comment was made in the Sahitya Patrika (a Bengali magazine of the time), which is as follows, "The writer has described the inner truths of science in the language of poem and jingling sound of song."

His essay entitled 'PALATAK TOOFAN' (The Fleeing Hurricane) was awarded the first prize in Kuntalin Galpa Puraskar' (Kuntalin Story Prize) competition founded by Hemendra Mohan Bose. At first, the story has been initiated with a prediction of weather condition from two different forecast offices; the first one came from the Simla Office (under Central Govt. Administration) and the second, from the Alipore Office at Kolkata. Both the forecasts announced the possibility of a dreadful hurricane within and around Kolkata that night. Peoples of the to-be affected locality spent sleepless night, but no storm came excepting slight cloudy atmosphere and a drizzling for a while. So, the peoples considered the forecast to be wrong and hence, the science working behind such forecast prediction was also wrong. In view of this, they expressed their grievance that their tax money was being misused. With these comments, they became silent. At this point, while explaining the cause and effect relationship of the atmospheric condition and the possibility of hurricane through a British Scientist, the author created a novel literary environment enriched with scientific truth. He explained as to why the different components of atmosphere high above the earth could not

leave due to the gravitational pull. Also, he discussed the role played by specific-gravity in the process. Lastly, he brought in also another example that disobeys specific-gravity theory. This is as follows: In the Indian Society, women are less important and men are more important in respect of their gravity (personality); yet women with less gravity are restricted in their free movement, while the men with more gravity are free to do so; these are not obeying specific-gravity rule. But, why the hurricane retreated was not explained. The actual cause of this has been explained in the second part of the essay. In spite of the prediction of hurricane, the author set out for a journey into the sea by a ship in that very evening. He was bald-headed, and the baldness was surrounded by few tufts of hairs. For the protection of those hairs, his daughter gave a bottle of 'Kuntal Keshari Oil' in his bag. At night in the middle of the sea, a violent hurricane started. So, all the passengers in the ship were spending time facing life and death struggle type of situation. At that moment, the author could suddenly remember that he had with him a bottle of Kuntal Keshari Oil. Wasting no time, he at once threw the oil from the bottle on the water of the sea around the ship. That made the high waves disappear, and as a result, the hurricane retreated. So, he took an attempt to defunct the high waves by adding oil to the water surface. Here, he tried to utilize the scientific principle that oil acts on surface tension of water to defunct the high waves. In the statement of the author, the waves subsided thereby causing the hurricane's defeat/retreat. This is a kind of strange imaginary science. While a movie film is being shown in a cinema hall, if the rotation of the reel of the film at some point is reversed, then the sequences of events which were happening immediately before will now happen in the reverse direction. Let us take an example where the event being projected on the screen in a film show was that a corked bottle was caught in a fisherman's net. When the fisherman uncorked the bottle, a hostile monster came out of the bottle being wrapped with dense smoke and was about to catch hold of the fisherman. Just at this moment, if the rotation of the

reel of the film was reversed, then the monster would walk backward and enter the bottle along with the smoke. Finally, the bottle would be corked by the fisherman thereby trapping the monster within the bottle, and the fisherman would be saved from danger. In this article (Palatak Toofan), though the scientific truth is correct, yet there is a serious flaw in respect of its use. The high wave is not the cause of hurricane, while a depression in the atmosphere is its cause, which in turn is the cause of high waves. If the depression is made to subside by any means, then the hurricane will stop, and as a result the high waves will also stop. If the waves are made to stop as an isolated event by any means (here by the addition of oil), the hurricane is not supposed to be stopped. Over and above, a small bottle-full quantity of oil can defunct the high waves of water surface over a wider area of sea – this is only possible in the imagination of a poet. If it is judged from this point of view, then it may be viewed as a bit of weakness in the plot of the article in terms of scientific truth or view. However, due to the presence of such weakness, a humorous literature in the form of imaginary science of a different taste has been created. What is more is that the reduction of atmospheric pressure would cause the inflation of the artery resulting in more circulation of blood (in man); but in the other fronts of the society, the increase of pressure at different levels due to various causes like malaria, income tax, municipal tax etc. could nullify the low pressure caused by depression in atmosphere. This is also a kind of humorous at the same time a mockeric presentation.

Also, in the other science-based stories/essays/ lectures, he has established harmony between real science and literature. In all those cases, it is hard to understand as to whether the literature has been created for making science understandable or science has been used to create literature!

In the essay entitled 'Adrishya Aloke' (Invisible Light), with a view to make others understand about the invisible light (microwaves or Electric Waves) he said, "The way sound is produced by the vibration of air, is indeed a similar way the light is produced by the pulsation of sky. For the

imperfection of our hearing organ, we can hear only eleven heptad notes of sound. But the imperfection of our viewing organ is far more; so, we can see only one heptad beam from among uncountable ones of the sky. If the pulsation of sky occurs at the rate of 4×10^{14} times per second, we sense that as red; if such pulsation increases two-fold more, then we sense it as violet light. The yellow, green and blue light are in between the above two extreme components of the heptad. If the pulsation rate exceeds beyond the above limits, our eyes fail to sense, and the visible vanishes into invisible." Subsequently, he also said, "If the power of our vision could have been widened, we would have sensed the existence of various unimaginable novel worlds other than those colours constituting rainbow; would we have our thirst for colours quenched by that?" By the last statement, what the author (Jagadish Chandra) has indirectly hinted at, let the readers try to think about it!

In order to explain the phenomena of reflection and refraction of invisible light on and through different objects, he said, "The power of restricting the invisible light by Chinawares (China Utensils) is several-fold higher than that of diamond. So, if our power of vision crosses the limit of red colour anytime in future, then diamond will become unsubstantial, and the price of Chinawares will enhance indefinitely. At the time of going to England for the first time, due to the habituated superstition, I hated to touch Chinawares. But later, having been invited by a respectable English family, I saw that the inside walls of their house were decorated with various Chinawares. How precious these materials were so that these were cared so much? At the first look, I could not realize. But now I have understood that the English are expert in business. If the invisible light is changed into visible light, the Chinawares will become precious. Then diamond will become insignificant when compared with the Chinawares. Those days, fancy ladies will reject diamond necklace and proudly accept the necklace made of cups and saucers, and they will look at the ladies not wearing such necklace with the feeling of contempt."

With a view to explain the phenomenon of polarisation of light, he cited the example where a stork and a jackal invited and cheated each other by offering drinks in bottle and plate respectively. To explain the polarisation of light, he compared this process with the crossing of a vertical iron grill by a stork (who could pass) and a tortoise (who could not pass, here the passing of stork is considered as analogous to polarised light). Again, to explain how the polarisation of invisible light could be done with the help of different objects, he personally did a unique experiment about which he said, "I discovered a method of polarising light. In spite of the fact that the pulsation of sky incoherently enters the tufts of hairs of women, yet they are polarised at their exit from the hair. I collected various types of hairs from the barbers' shop in Europe. From among all those varieties, the dense black hairs of French women were found to be very much effective for polarising light, while the golden hairs of German ladies were much inferior in this respect. When I demonstrated this experiment in Paris, the participating learned French peoples were excited after knowing this novel theory. There was no doubt about the fact that their dominance over the inimical nation (Germany) had been proven by this experiment. It is needless to say that I abstained from showing this experiment in Berlin." In the above instances, both science and literature are presented being moistened with an unusual joke.

In the concluding part of the essay 'Adrishya Aloke' (Invisible light), he made a very great and noble statement, which has a far-reaching impact. He said, "As if we are aimless in the midst of infinite. How much we can see? That is very insignificant. We are roaming like a blind in the midst of profound heavenly light and have made a sincere and earnest effort to cross an ocean with a broken mariner compass. Oh traveler! What provisions you have for the journey on an infinite path? You have nothing but blind faith based on which coral has been creating a great island in the depth of an ocean. In a similar way, the knowledge-empire is being built up slowly by the hard and continuous efforts of learned peoples. It starts with darkness and ends

in darkness – in between few dim light rays are being seen. By the sustained effort of man, the dense fog will go away, and the world will become luminous some day."

In the essay entitled 'Ahata Udvid' (Injured Plant), in order to explain the phenomenon of growth and its response to injury in plants, Jagadish Chandra has created a humorous literary environment. He said, "This instrument can record as to how much a growing plant grows in one second. From an experiment using this instrument, it was recorded that this plant was growing at the rate of 42×10^{-3} inch per minute. At that growth condition, I hit this plant very gently with a cane. At once the growth rate was reduced significantly. The plant took about 30 minutes to recover from that hit-injury, and thereafter, it started growing again very slowly. Oh the school master with cane in hand, there is no doubt about the fact that some of your students after being humiliated by ear-pulling by you have become High Court Judges. But the students after being caned by you will suddenly start growing in height, there is a serious doubt about it."

Jagadish Chandra used to think that there is no conflict between the practice of science and that of the literature. In this context, in his essay entitled 'Bijnane Sahitya' (literature in science) (this essay was the written form of his presidential address in the Mymensingh Session of Bangiya Sahitya Sammilani) he said, "The sense perception of both scientist and poet has been set out in search of ineffaceable oneness. The difference is that the poet does not care for the path, while the scientist does not avoid it. The poet has always to be self-absorbed, it is impossible for him to restrict himself. But the poetic imagination (talent) of a poet cannot pull out the proof from the interior of his passion. For this reason, he has to use the language of comparison. In every statement he has to add 'as if' or 'so that'. Jagadish Chandra was very much conscious about the amelioration of literature. He said, "This Literature Conference (held at Mymensingh) has been carrying the concentrated consciousness of the Bengalees' minds from one border-line to another of Bengal and rousing earnestly the trial of

success everywhere. Here, the literature has not been restricted within a small regional area; rather, it seems that we have resolved to perceive it in a wider way. Today, the literature is not only a delightful ornament to us – we have been inclined to see all the attainments of our mind as one in the name of literature."

He said further, "The path of a scientist may be self-guided, but his scientific accomplishments do agree well with that of a poet. Where the light of vision ends, even there he pursues for light. When the power of hearing reaches the end boundary of the note, he also collects vibrant voice from that point. The inexpressible mystery which has been working day and night from behind the screen, the scientist has been questioning that secret and pulling out an unintelligible answer, and has been has been expressing that answer in human language."

He wrote to Rabindra Nath, "You might have heard from me many times that, the greatest poet and greatest scientist have never been born on this earth. Because, both will remain incomplete for the period during which there is no engrossment of the above two in the same person. However, the poetic imagination will survive indefinite period when the knowledge of a poet becomes more boundless and extended. The deep friendship between Jagadish Chandra and Rabindra Nath influenced each other to express out their (each other's) mental glow. Rabindra Nath helped rouse the literary instinct of Jagadish Chandra. The scientist friend remained always eager to read new writings of his poet friend. In a reciprocal manner, the poet friend also remained very eager to know the story of his various novel discoveries. All these facts, especially the stories about the discoveries of Jagadish Chandra have been narrated in the letters written to Rabindra Nath by him. Such communications between them through letters were made whenever Jagadish Chandra stayed in England (or toured foreign countries), or whenever Rabindra Nath stayed away from Kolkata. The scientist friend used to write the stories in details about his discoveries with scientific information and theories, or even sometimes with graphical presentation

to explain his views. Through these letters, most of the scientific discoveries of Jagadish Chandra as well as the inner stories behind them have been elaborated in the form of self-eulogium and self-scrutiny, the literary values of which have become so indescribable. Though Rabindra Nath was not a scientist, yet he could perceive science from the core of his heart. Like the process of electromagnetic induction discovered by Michael Faraday, they could induce each other to inspire and bring out the best of their literary excellence and the scientific truth-rich literary amelioration. In this context, it may be mentioned that Jagadish Chandra wrote to Rabindra Nath, "I shall not allow you to stay hiding in the rural environment. Why you compose your poems in such language, which hinders their publication in any other languages? But I shall publish your short stories in the Western country where the peoples will understand your writings to a certain extent. The way your writings ignite me, they must do the others in a similar way. I have made several plans for your writings. I want to see you crowned with fame. You must not stay confined in the rural environment. When I often narrate the English version of your writings to the friends in this country, they cannot but shedding tears."

After going through the mythological poems written by Rabindra Nath, Jagadish Chandra wrote to him, "You should compose many poems based on the events or stories of Mahabharata. Once I requested you to write about 'KARNA'. We are overwhelmed at the god-like character of 'Bhishma', but we feel sympathetic to 'KARNA' for his unfulfilled life, which symbolizes a blending of vices and virtues. 'KARNA' could easily attract our mind, because his life could not be fulfilled accidentally, the meanness and struggle for noble cause were staying ignited in his life all the times; being a human who might be a god, whose defeat is greater than victory." After getting such a letter, Rabindra Nath composed 'KARNA-KUNTI SAMBAD'.

Once Rabindra Nath said, "From my childhood, I was lonely. Those days, we spent within the cornered barricade created within family. In my life first friendship developed

with Jagadish. He pulled me out from my habituated corner in a way by which the glory of the dew-like pleasant sunrise of autumn has dragged me out of my bedroom all the times. I found easily a wealth in him. He did not express himself more than what is seen with most of the peoples. In other words, the earthen lamp is visible but not it's light. I saw the light within my friend."

However, through his limited writings, as if Jagadish Chandra prepared special fragrant materials by dissolving science in a literary juice (as solvent). Such products appear MUSK-like literary objects. These products (articles) have become the permanent source of long-lasting literary fragrance. Over and above the essays discussed above, there are others like 'AKASH-SPANDAN O AKASH SAMBHAB JAGAT', 'SNAYU-SUTRE UTTEJANA PRABAHA', and 'NIRBAK JIBON', which can also be included in the above group. Being attracted by the long-lasting fragrance, various classes of peoples irrespective of scientists, scientific and non-scientific men of literature attempted to bring out the literary taste in various ways, and still they are continuing to do so. Based on these limited writings as well as on the various aspects of his multidirectional life, many peoples have created novel types of literature. It seems that so much discussion based on the writings in Bengali on science and literature created by a scientist (other than Jagadish Chandra) has not been done in the past as well as at present. All these discussions have been possible only in view of the fact that he was very successful in his scientific researches by virtue of which he placed the motherland in the World Court of science with justified Honour. As a result, many peoples engage themselves in discussion on the literature in science created by him as well as on his scientific researches. Such discussion knows neither a pause nor an end.

"It is tragic that our country, with its great potential wealth and possibilities of industrial development, should be in such a hopeless plight."

ACHARYA JAGADISH CHANDRA BASU

11. Nationalistic Feelings of Jagadish Chandra

While discussing about the nationalistic feelings of Jagadish Chandra, one has to remember about the nationalistic activities of his father Bhagaban Chandra first. This matter has been dealt briefly in Section 2 earlier. Bhagaban Chandra did not allow his son to join Indian Civil Service. Although Bhagaban Chandra was in Government service, yet he never liked to be a yes-man type of employee of the British Government. Besides, he always liked to maintain a direct link and association with the common peoples of the country. Considering the financial hardship of those people, he used to spend his own money for launching various projects to help them earn their livelihood. Learning from his father, Jagadish Chandra developed the mentality of performing everything keeping his motherland and her underdeveloped conditions in the forefront. The nationalistic feelings of Jagadish Chandra originated from his father's lifestyle, widespread social services, thinking and nationalistic ideology. Later through various ups and downs with time, such feelings became deeper. In his later life, Jagadish Chandra was directly associated with various personalities, who were patriotic and/or social reformers. Thus, his brother-in-law Mr. Ananda Mohan Basu was a social reformer and nationalist. He was the President of National Congress at Madras in 1902. He founded the City College in Kolkata. He was one of the founders of both the Indian Association and Institution of Higher Education of Indian women as well as a member of the Educational Commission. His father-in-law Mr. Durga Mohan Das was a leading advocate of the Calcutta High Court and a political leader. His brother-in-law Deshbandhu Chitta Ranjan Das (cousin of Lady Basu) was a renowned Barrister, and had a leading role in India's freedom movement as a member of the National Congress. Jagadish Chandra had also close connection with Mr. M. K.

Gandhi and Mr. G. K. Gokhale. His association with all these peoples kept him mentally alert about various kinds of National problems and helped boost the national feeling in him.

In his life-time, the way he dealt with various anti-nationalistic problems with firmness that it would not have been possible unless he had a profound love for the country. He witnessed the British Government's despised attitude towards Indians when he joined the Presidency College. He protested with his head upright against the discrimination created in respect of recruitment of Indians and English in Imperial Service. After selection for the post of Professor, he was appointed on a temporary basis with only one-third of the regular salary that was being given to the white peoples. He refused the salary for three years without neglecting his teaching job. However, after three years seeing his stern attitude at the same time his sense of responsibility and sincerity in his duty, the Government ultimately lifted the condition imposed at the time of appointing him and granted the full salary with retrospective effect. In this way at the first encounter, he compelled the British Government to bow down and made them understand that he was not the man to submit to injustice and discrimination. In the later period, the Government created conditions to deprive him of his freedom in pursuing research. All these incidences and several others (discussed earlier in other contexts) made his attachment to the motherland stronger. In fact, his devotion for the motherland was the main reason for the development of his intimate friendship with Rabindra Nath.

He was so duty-bound to his motherland that he did not accept the offer of pursuing high quality research activities in the better environment staying permanently abroad. It is worth mentioning two such instances. (1) During his first scientific visit to Europe in 1896-97, he delivered lecture on his research on microwaves. After his lecture, Prof. Lodge and Prof. Kelvin asked him to stay and join the post of Professor there. Jagadish Chandra replied that he was

unable to work without the Indian environment. (2) During his second visit to Europe in 1900, he delivered an invited lecture on his work at the Bradford Meeting of British Association. After listening to his lecture Prof. Lodge told him, "You are now doing high quality research; Carry on." Then he asked, "Do you have plenty of money? These equipments are very costly, and you have enough time ahead. Your research can make important contributions." Next day after discussing with Prof. Lodge, Prof. Barrette told Jagadish Chandra, "You are wasting your time in India, and you have been facing various difficulties in your work there. Can you not come to England? Will you be interested in accepting a post of Professor in a renowned University here?" This time he was very much on the horns of a dilemma. He knew that more success would come quickly by working in a better research environment. As a result, he would be able to contribute more, there was no doubt about it. On the other hand, he was thinking that the name of his motherland would not be associated with the work to be done in a foreign laboratory. Later in 1901, he wrote three papers based on work done by him in London totally on new subject. The Royal Society agreed to publish those papers. While conveying this news to his friend Rabindra Nath he said, "But I would have considered my life meaningful if I could have done this original work on a totally new subject from our country." In this way suffering mentally from internal conflict, he wrote to Rabindra Nath for his advice, "The work that I have started now requires tremendous diligence and favourable environment. On the other hand, my heart and mind cannot sever the attraction of my poor country. I cannot decide as to what I should do. All my inspiration comes from the love of my countrymen." In reply to this letter, Rabindra Nath advised him to continue research abroad. In reply, he again wrote to Rabindra Nath, "Are you also trying to tempt me? Think about it. If we all shake off our responsibilities, then who will bear it? I hear the voice of my motherland from your inspiring words. I have already fulfilled enough of my expectations and despair.

But I am unable to repay for your affection. Very often I feel tired and dejected, but I cannot take rest because of you all. You have tied me up very much. I always visualize behind you the image of a distressed lady (mother) in tattered dress. I take shelter in her lap along with you. I cannot make myself detached from that bondage." Also, he wrote to his poet-friend, "My heart is rooted in India. I will be more than satisfied if I can perform well staying in India. I can foresee the obstacles that I may have to face after returning to India. Even if my desires remain unfulfilled, I will bear with it." It is quite clear from these statements that he loved to be intimately involved in scientific research, and was very eager to move forward with new thinking every now and then. Yet he declined to accept the opportunities suitable for pursuing research in a much conducive environment only because of his love for the country. Later, he also wrote to Rabindra Nath, "I feel dejected with words of despair. But your inspiring words have aroused much hope in me. Welfare of India depends on us, and we will sacrifice our lives to fulfill our hope, bear with our sorrows and share the joys. We should not be misled by pseudo glamour. We will not be able to achieve the targeted goal by deceiving ourselves from within or from outside." In this context, it is worth mentioning another incident that happened abroad, which substantiates his strong nationalistic feelings. In a felicitation ceremony after his lecture on research done in the first phase, the famous scientist William Ramsay congratulated Jagadish Chandra and then sarcastically said, "Some people may think that from now on a new era of knowledge has begun in India. But it is not reasonable to think that cooing of one cuckoo indicates the advent of spring." At once Jagadish Chandra audaciously said with a firm voice and clear language, "You need not have to worry. I assure you that soon hundreds of cuckoos will usher the advent of spring in Indian Science." He never failed to resist firmly any attempt to disregard his motherland.

We find evidences of his deep-rooted nationalistic feelings in his several lectures delivered on various occasions.

His lecture at Sahitya Parishad, where he wanted to express his devotion for the motherland, has been recorded in the article 'Injured Plants' (Ahata Udvid). In this article he wrote, "For what reasons an injured tree with detached branches regains its life from the point of death, while the detached leaves succumb to death even if those are given good nutrition? The reason for this is that the root of the tree is fixed in a soil at a definite place, and it continues to grow with the juice (sap) supplying nutrition from that place. That land is its own country and is a caretaker."

"Plants have also another intrinsic strength that protects them for ages from being extinct. In the face of lot of changes in the external environment, they are not defeated by the irony of fate. They struggle against external adversity with full strength. They have accepted the changes, which are essential for survival and left out those, which are not essential like senescent leaves. In this way, they have succeeded in overcoming the external threats."

"They capitalize on another everlasting strength. For a banyan tree, all its body parts carry the signs of the memory of the fact that it has born of a banyan seed. For this, its root is fixed in the soil at a specific place on earth from where it gets the sap and grows. That place is its own country and its caretaker. The head of the tree is held high in search of sunlight, and the branches and twigs spread on all sides offering shades. Then by what strength it continues to live in spite of being wounded? That strength is its patience and firmness, which help it remain firmly attached to its own place; that strength is its feeling that harmonizes outside and inside; and that strength is acquired through many generations and is fixed as its own in its memory. If a person detaches himself from his own place and country, lives on others' favour, and forgets about his national heritages, then with what strength he will survive? Destruction is very close to him and ruin is his ultimate end." Discussing from scientific point of view through all these statements, he reminded our duty-boundness to the motherland by citing the examples of plants having life-long

attachment to their birth-place (motherland). He also reminded that if we would forget about all these parameters, we could neither repay our debts to our society nor take responsibility for welfare of the country.

A permanent proof of Jagadish Chandra's nationalistic feelings is the establishment of 'Basu Bijnan Mandir'. Through the establishment of this research centre, many facets of his patriotism became clearly manifested. In 1897, he decided to set up a national laboratory to carry on research independently. In this context, it may be mentioned that such idea took its root after he received an insulting letter from the Principal of the Presidency College. He established the 'Basu Bijnan Mandir' and dedicated it to the nation. He included only the Indian well-wishers in its Management Committees, but no white people. Not only that, he himself declared that the British Government would have no influence and interference in any matter of 'Basu Bijnan Mandir'. He made it clear at the beginning that the 'Basu Bijnan Mandir' would be a national asset, and would be used for the welfare of our nation.

On 30th November, 1925, in his lecture on the occasion of celebrating eighth foundation day of the Base Institute he said, "I accepted only those as my disciples who would spend their lives in conducting research, who would take up research work with a bold character, firm resolution and determination, and who would be able to uncover the real truth. The stigma that Indians are incapable of moving forward in any work has dumbfounded them. I was determined to remove that stigma for ever". As other reasons for establishing this research centre he also stated, "In this country there is no research centre like those in England. Many times I heard that sophisticated equipments could not be made in this country. Then I thought that only those, who have lost their vigour, lament in vain. We have to get rid of our weariness and weakness. India is our place of work, and the easily accessible methods are not for us."

In spite of having strong nationalistic feelings, Jagadish Chandra never took part in active politics. Realizing the

nationalistic aptitude in him, Swami Vivekananda made an earnest request to him to restrict nationalism in science only to uphold the scientific values of Indian minds. Because, Vivekananda felt that Jagadish Chandra had the never-ending strength and quality to take Indian Science to excellence and to establish India at an honorable position in the World Court of science, and that this important task would be neglected if Jagadish Chandra would join active politics. To save the country from the clutch of inauspicious phase the national life was passing through, he tried to inspire the countrymen, especially the youths in different ways. To the students of Bose Institute' he said, "Morning begins from the time when darkness reaches its maximum. Light emerges when the cover of darkness is removed. What covers have filled our lives with darkness and failures? Those are laziness, selfishness, and envy. Remove all the covers of darkness. Let your inner light flow outside and illuminate all the places extending to the horizon."

He also said, "If you want to maintain a vibrant India, you need to keep the mental strength of its people unhindered. Many old nations contemporary to and competitive with India have disappeared from this world. Physical death is not so dangerous for us. National hopes and thoughts are not lost even though mortal body becomes a part of the soil. Running out of mental strength is the real death."

He not only explained the depth of love for the country, but also indicated about our duty-boundness to it. He said, "Everyone wishes to see mother Bengal established at an honorable position. However, it is needless to say that blaming each other is of no help without taking the trouble of finding ways for that. It is essential for the Bengalees to wake up to achieve excellence in many fields and gain sense of self-esteem. But we forget this very often."

To express his liking for the mother tongue, he attempted to christen the instruments (invented by him) in Bengali or Sanskrit. He thought of calling the 'Crescograph' as 'Briddhiman'. He named another instrument as 'Kunchanman'. But to the Englishmen, it turned into

'Kanchanman'. Then he realized that it might be possible to make Hiranyakasipu pronounce 'Harinam' (the name of Hari, the God), but it is impossible to make an Englishman pronounce Bengali or Sanskrit words. So, he abstained from trying to follow this practice anymore.

In the article 'Diksha' he said, "One important truth of life is that death casts its shadow on life from the day one loses the desire to prosper. It is also true for the nation's life. We have started declining from the day we have lost our ambition to grow. We have to survive, save and grow." Again in the later part of the same article he said, "Mental strength is the source of utmost passion. Feel that this holy nation remains vibrant by this strength. We can reach the same destination through services, devotions, or knowledge. You also follow one of these means. Life is also its consequence. Let this world and the other one be the aim of your austere endeavour. Sacrifice your life for the struggle like an undaunted hero."

Rabindra Nath asked Jagadish Chandra to write a proposal so that he could work independently. Out of many proposals he prepared, one showed his sense of duty-boundness towards the motherland. He wrote, "I need to come to this country (Europe) every three years for publicity of our work. At the same time, I don't want to severe my association with the Presidency College permanently so hastily, because no Bengalee (Indian) will be appointed in my post. Secondly, the researches of other students will suffer." Both these reasons clearly indicate his nationalism. He used to think deeply about the most important issues related to his own countrymen with preference before taking any decision.

When Rabindra Nath relinquished the 'Knighthood' after the Jalianwalabag massacre, Jagadish Chandra felt proud and wrote, "You are great, my friend!" Rabindra Nath proudly expressed his joys through his writings when Jagadish Chandra placed India permanently in the world-map of science through his high quality research. Similarly, when Rabindra Nath placed the motherland in a world-victorious

position by receiving the rare Honour of Nobel Prize, his scientist friend also expressed his boundless joys through a letter. He wrote, "I had a painful feeling to find you without being honoured with any laurel for so long at the global level. Today, I am relieved of that pain. How do I express my gratitude for this God's grace? Be powerful for ever, be victorious always. Let virtues be in your favour."

Jagadish Chandra had to work hard when he was carrying on research work in London in 1901. At that time in the month of July, Rabindra Nath sent few poems to him. Those poems gave him some peace in the midst of mental and physical tiredness. To express that feeling to Rabindra Nath he wrote, "Staying abroad and working day and night, I have become somewhat mentally exhausted and dull. I could see an unknown world in front of me; I am tired of looking for the ways to that world alone; and I am moving in search of certain novel light if I find it. I hear in your voice the feeble voice of motherland. Who is there to be worshipped excepting mother? I gain strength from her strength." Jagadish Chandra often used to think about various national problems. To express his thoughts about such problems, he stated in one of his lectures, "The aim of science is to reduce the burden of mankind. Poverty and scarcity are pushing the national life to destruction. To improve the economic condition of the country, both agriculture and industries have to be improved. I have proved that Indians can excel in science through investigations and inventions. The wretched economic condition has led to unrest in Europe; similarly, the economic problems are the root of all unrest in India. The only way to unearth the natural wealth and resources of the country is to train large number of youths in high standard scientific processes and then engage them in developmental works for the welfare of the country." In 1911, he was selected as the President of the Mymensingh Session of Bangiya Sahitya Sammilani. Peoples of the locality were very much eager to attend and listen to his lecture in that conference. But the space earmarked for conference was inadequate to accommodate

a large audience. So, the organizers of the conference planned to charge an entry fee for the audience to restrict their attendance. Therefore, they wrote to Jagadish Chandra seeking his compliance to such arrangement. Jagadish Chandra did not agree to this proposal. In reply he said that his lecture would be for all to listen and not for the rich only. If required, he would deliver the same lecture on two consecutive days. In fact, he delivered the lecture on two days, on the first day in Bengali and on the second day in English.

In 1905, Lord Curzon (then Viceroy of India for the second time) announced the partition of Bengal on July 19, which was to be effective on and from October 16 (same year). The partition was planned as follows: (1) Chitagong, Dhaka, Parbatya Tripura, Maldah, Assam together constituted the new province of 'East Bengal and Assam', and Dhaka would be the Capital of this new Province; (2) certain regions of Orissa including Sambalpur were attached to the remaining regions of Bengal. In protest of this partition, anti-partition movement was initiated. It was resolved in a meeting that a RAKHI BONDHON ceremony would be celebrated on 16th October, 1905 as an occasion of unity between the peoples of Eastern and Western Bengal. Rabindra Nath composed the song 'Banglar Mati, Banglar Jal ...' on this occasion. During the period of celebration, every Bengalee irrespective of Hindu, Muslim, or Christian practised self-restraint, wore a yellow three-threaded RAKHI in the right hand and pronounced the mantra, "Brothers are united, no difference in them." The day was celebrated as a no cooking and no work (Hartal) day. Rabindra Nath was in the forefront. Though there is no record of direct participation of Jagadish Chandra in that movement (that time he was in Darjeeling; possibly there was certain restriction on any Government employee for participating in such movement against the Government), but he supported the above movement from the core of his heart. He responded by sending a Rakhi to Mrs. Ole Bull by post with a note, "They have divided us by making law; but through this symbolic

Rakhi Bondhon, we want to perpetuate our unity all over the country."

In 1916 being insulted by Prof. Eton at the Presidency College, Subhas Chandra Bose started student movement under his own leadership. As a Professor Jagadish Chandra supported this movement. When Jagadish Chandra went to visit Gaya accompanied by Lady Basu, Rabindra Nath and Nivedita, they met the patriot-poet Dwijendra Lal Roy who was then a Deputy Magistrate there. He entertained Acharya Bose and his companions by reading patriotic articles and singing patriotic songs written by him. Jagadish Chandra was deeply moved by listening to those articles and songs, and he requested Mr. Roy to write patriotic songs on Bengal and the Bengalees. Later, Jagadish Chandra was very much delighted to know that D. L. Roy honoured his request.

Jagadish Chandra has pioneered the path to progress for the present and future by re-establishing the lost glory of Indian Science of the past by attaining world-wide fame through his solitary effort in pursuing research in modern science keeping his Indian identity unblemished.

12. The Last Journey

During last several years of his life, Jagadish Chandra had been suffering from hypertension and diabetes. So, to reduce mental pressure and tension, he had to withdraw himself gradually from the direct involvement in his research. He needed rest. So, he went to Giridih (health resort area) on November 2, 1937 being accompanied by his wife. He was staying there in the house of one of his cousins. During his stay there, he corrected the final proof of 1937 issue of the 'Transaction of the Bose Research Institute', the annual science journal of 'Basu Bijnan Mandir' and sent it to Kolkata by post. Their return to Kolkata was scheduled on November 29. But, in the morning (around 8 a.m.) of November 23 after waking up from bed, he went to bathroom for having a bath etc. Lady Basu had an idea about the time he used to take to complete his bath etc. When he did not come out of the bath room even after the stipulated time, Lady Basu broke open the bath room door with the help of other persons and found her husband lying on the floor. She immediately called in a doctor who examined and proclaimed that he was no more in this world. Jagadish Chandra could not conduct the 20th foundation-day celebration of 'Basu Bijnan Mandir' scheduled to be held on November 30 next. His body was brought to Kolkata by car and cremated in the same evening. Many peoples from different parts of India and abroad paid homage to him. The proof of the magazine that he posted from Giridih reached 'Basu Bijnan Mandir' after his body was brought to Kolkata.

13. The Honours Bestowed on Jagadish Chandra

1903: Elected Companion of the Order of the Indian Empire.
1912: Elected Companion of the Order of the Star of India; Awarded with the honorary D. Sc. degree by the Calcutta University.
1917: Received Knighthood from the British Government.
1920: Elected Fellow of the Royal Society on 13th May and awarded Honorary L.L.D. Degree by the Aberdeen University of London.
1926: Bestowed with the title 'Decoration of Commander Order the Leopold' by the king of Belgium.
1928: Elected Fellow of the Vienna Science Academy as well as the Member of the League of Nation Committee for Intellectual Cooperation. Awarded honorary D Sc. degree by the Allahabad University.
1931: Received the Sri Sayaji Rao Gaekowad Prize and Annuity Award; Felicitated by the Calcutta Corporation under the Chairmanship of Netaji Subhas Chandra Bose.
1933: Was awarded honorary D Sc. degree by the Benaras Hindu University.
1935: Was awarded honorary D Sc. degree by the Dhaka University.

On the occasion of 150th birth anniversary of Jagadish Chandra, a brief description of his life and research has found a place at the Electronic Museum of Baltimore, U.S.A. in 2008. In addition, as a distinguished and successful alumnus, a bust of J. C. Bose, made by Mr. Biman Bihari Das (a Kolkata sculptor and former Principal, Governt Art College, West Bengal, Kolkata) and installed within the premises of Christ's College, Cambridge, was unveiled on December 6, 2008 by Shiv Sankar Mukherjee, India's present High Commissioner in London. Also, to show respect to

The Cenotaph of J. C. Bose
(inside the old campus premises)

The Sculpture of J. C. Bose
(Sculptor : D. P. Raychaudhury)

Figure 23

Cartoon drawn by Gaganendra Nath Tagore in 1921 at the time of Non-Cooperation Movement. This was published in the 'Shraban' issue of 'Prabasi' (a Bengali magazine).

[Theme: Jagadish Chandra aroused responses in nonliving and living (both animals and plants)]. Explanation: Lajjabati is shouting 'Shame ! Shame !' ; Bamboo shouting 'Strike, Strike'; Ban chnaral shouting 'Agitate, Agitate' (movement) ; Moon asking for subscription ('Chand' asking 'Chanda'); Frog shouting 'Bande Mataram'. The date tree of Faridpur is bowing down and looking at the events with eyes open wide; the Himalaya is viewing all with wonder. On the other side of it, Jagadish Chandra got back to sense after seeing thunder-bolt in clear sky (thunderbolt is the symbol of precautionary measure of Jagadish Chandra).

(As if all the components of the natural environment have been engaged in Non-Cooperation Movement against Jagadish Chandra).

Figure 24

Jagadish Chandra's research work on Plant Science, a seminar was held where lectures by highly acclaimed scientists were organized to make people aware of the current progress made in Plant Science researches on the above occasion. Among the few others with whom Acharya Basu got a place in the history of Christ's College are: (1) Poet John Milton, (2) The father of evolution theory Robert Charles Darwin, (3) Jan Smut and (4) Earl Mountbatten (Burma). Prof. Shibaji Raha (Director, Basu Bijnan Mandir) and Prof. Bikash Chandra Sinha (Director, Saha Institute of Nuclear Physics, Kolkata) attended and gave deliberations in this ceremony. Dr. Partha Dasgupta, Professor of Economics at Cambridge, Dr. Ashok Parthasarathi and Dr. Ranjit Nair were also present. Also to show respect to Acharya Bose, the Indian Botanic Garden at Shibpur, Howrah has been renamed as Acharya Jagadish Chandra Bose Indian Botanic Garden in June 2009. It's all glory for Acharya Jagadish Chandra Basu as well as for the Basu Bijnan Mandir. We, as Bengalees as well as Indians, feel proud to share this glory.

14. Concluding Remarks

To write about Jagadish Chandra on the occasion of his 150th birth anniversary, an attempt has been made to give an overall account of various aspects of his life. In the past, science was practised in India for a long period. But due to the reason unknown, such trend could not be maintained. From the end of nineteenth century, the Indian Science was revitalized again following the path of the then developing modern science by the effort of Sir J. C. Bose. He said very often about the progress of science in India in his time that, his aim was not to initiate scientific research culture in India but to reestablish Indian science which was discontinued for a long time. Though he believed in Veda and Spiritualism, yet he felt that if Veda could not complement Truth, the Veda might not be acceptable. So, there was a homogeneous mixing of his personal view of spirituality with scientific rationalism. He realized that the bindings of scriptural rules are the real obstacles in the path of searching truth.

In the odd phase the nation was then passing through, he invited the youth community and tried to sow the seed of national feelings in them by narrating the experiences of his own life, and discussing how he established and manifested his life's philosophy through life-long activities. He told that his work was his teacher, his failures had given him necessary incitement, and his past experiences were the sources of continued encouragement to him. Again, in order to explain as to how he overcame the various obstacles in the way to success in his researches, he said, "If any success ever comes in my life, that results from keeping myself conscious by constant self-stimulation all the times. The days of dreaming are past. If you intend to survive, then you must keep yourself alert by whipping your own conscience."

To celebrate 150th Birth Anniversary of Jagadish Chandra this year, we have initiated discussion at various levels at different degrees. His birth centenary was celebrated in 1958

also with pomp and grandeur; different aspects of his scientific performances were discussed, and many writings on him also appeared. The aim of those activities was to inspire and encourage the youth communities to mould themselves following the examples of how Jagadish Chandra applied his own thinking for attaining successes at various levels of his activities. If this could be successfully done, then such celebrational activities would become meaningful. During the next fifty years since the celebration of his birth centenary, lot of changes have occurred in the Indian Society. Those changes have both good and bad sides. All will agree that among the multiple good effects in a society, even a little bit of bad or odd may nullify the good effects, like a bit of dung in a pot of milk. In the language of a poet, there is a statement, "Every small mistake and every little crime gradually drag the society to the path of sin and brings about inadvertence."

Around the end of immediate past half century, another new parameter in the context of Acharya J. C. Bose has been cropped up in connection with the discovery of wireless, and J. C. Bose-Marconi debate has been crystallized in a new form. After an extensive investigation at the International level looking into various authentic documents, it has been established that the real discoverer of Radio Waves was Jagadish Chandra, not Marconi. As a result, a whispering in a new form has started at different corners of the Indian Society as to why Jagadish Chandra was not awarded with the Nobel Prize. After about 100 years, if the wheels of history is not made to roll backward, but is rolled forward in the required path considering the need of time for rationalistic education of high value (including science education and research) suitable for mental amelioration, then and then only a proper tribute will be shown to Acharya J. C. Bose. Long time after his death, Jagadish Chandra has got recognition at the international level for the discovery of Radio Waves. This recognition is surely of a great value to us. If this recognition can inspire and reanimate us mentally, then we will see the march of progress in our society.

Jagadish Chandra used to think that the backbone of a nation can be strengthened through acquirement and preaching

of knowledge. India has now been able to fulfill mission to moon. But, in spite of such scientific advancement and achievement, our society could not come out of the network of blind faith, superstition and quackery due to the lack of proper and far-reaching rational education. To make the society come out of such back-dragging network, attempt was initiated from the time of Ram Mohan Roy. Since then, scientists like J. C. Bose, P. C. Ray and many other personalities in the category of social reformer have tried a lot. Jagadish Chandra desired that getting lesson from the philosophy of his life, the youth communities of India could pursue research of higher standard in developing modern science fearlessly and with great devotion. By this, they will be influenced and inspired for the progress of motherland thereby helping recover the lost pride. By educating themselves in the different areas of modern science and utilizing that education, they will be able to make the country prosperous.

He wrote to Rabindra Nath from London, "Once I thought that a time would come when the knowledge-seeking persons from different countries would come to Indian Holy Place for acquiring knowledge. This expectation has not been fulfilled even though it was about to be. I shall have to come back with empty hand leaving all my wealth behind in this country, because my fellow countrymen are always blind of only the past pride. Even though our present is directed downwards, we will remain highly contemplated remembering the pride of the past."

When he initiated research, there were no facilities and infrastructures for carrying out scientific research. In spite of that, he took up a research project on a modern topic of Physics, the continuation of which was fully dependent on various instruments. He took that challenge and built various instruments from the rejected scrap materials. What a bold step he took? These days, research in any branch of science cannot progress even through a single step ahead without the use of extraordinary modern instruments. It is also a fact that the method and manner of scientific research have changed these days, and an environment of unthinkable competition prevails. Starting his research around the end of

1894, he created a sensation worldwide by successfully carrying out his research with the help of various self-made instruments. The specialty of his character was that, he was determined to complete successfully the work he planned to do. During the long period from 1894 to 1933, he made all the instruments (more than 100) that were required for his researches – what an unthinkable sincerity and contact-boundedness in work! While delivering lectures at different places abroad, though he received heartfelt praise for his works, he also faced adverse criticisms in several occasions. He was never demoralized by such criticisms. He gave proper reply to those criticisms later by performing newly designed experiments with newly built instruments. If one's thinking behind planning any work is error-free, and if one has absolute confidence in the flawless performance of the experiment, then one can establish one's proposed theory overcoming any kind of criticism that one may face. Jagadish Chandra was a scientist belonging to this category. The statements like "I am defeated" and "I am unable to do" were nonexistent in his thinking and character. He used to explain the prime principles and information related to his life's philosophy to the youth/student communities. The key 'Mantra' for leading a society in the path of progress by choosing proper direction and activity plan for future life of the youth communities is hidden in every step from the origin to the end of the path covering the life and activities of Jagadish Chandra.

At the time of Jagadish Chandra, the problems of Indian Society were mainly due to the British Rule for a long time. The then educational system was not conducive for solving the social and other problems. With a view to solve the problems of the time, Jagadish Chandra invited the youth communities to become trained in science and to use that training for solving the problems by utilizing various wealth of the country. In the present context, the problems have taken different forms world-wide. The main reason for this is the limitless craving for earthly pleasures. As a result, the lack of moral responsibility has been taking dominance at every level of the society. Briefly, due to the lack of proper control, law and order, moral-conscious feeling etc., the entropy (a

measure of disorder) has been increasing by leaps and bounds at every level of the society, and the truth-seeking mentality and sense of value have been disappearing slowly. These days, in most of the instances, the analytical and rational sides of education are being neglected due to giving more importance to its financial side. Due to excessive craving for earthly pleasures, equal distribution of merit at all the levels of the society does not take place. If the overall entropy of the society continues to increase at its present rate, then a time will come in near future when the existence of society will face crisis, and this sort of disorderliness will reach its maximum from all directions. Since, the manifestation of personality is dependent on place, time and the person himself, therefore, all the members of youth community will not become scientist(s) of J. C. Bose standard, but all of them need to become the possessor of scientific and rational mind. Through proper education, mental orientation suitable for cultivation of analytical and rational thinking can be developed by which it is possible to develop research-oriented mind. By such education, it is possible to direct the stretchable young mind towards research while advancing through the period of youth starting from childhood days. In this way, if the youth community becomes the possessor of creative intellectuality, they will be able to take a leading role in solving various problems of the greater society by giving priority to justice and morality by choosing a profession according to personal taste and inclination at any level of the society like judicial system, education, politics, health, social service, and researches in basic and applied sciences etc. When this situation will prevail within a society, then the rate of increase of entropy at every level of society will be under perfect control. Besides, in this age of science-based civilization, it is possible to accelerate the trend of progress by high quality researches in basic sciences. So, to ameliorate further the standard of research in basic sciences, it is important that the meritorious students should come forward. In conclusion, it may be said that by learning appropriate lesson from the life of Jagadish Chandra, the youth community should wake up and activate themselves for the betterment of motherland.

ANNEXURES

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A. Scientific Missions and Lectures.

Table 1. The List of Scientific Missions of Acharyar J. C. Bose to Foreign Countries.

Sl. No.	Year	Place of Deliberations and Subjects
1. Europe	1896-97	British Association (Liverpool), Royal Institution (London), Paris (France) and Keil (Germany). Subject : Properties of Electric Waves.
2. Europe	1900-01	International Congress of Physicists at Paris, Different Research Institutions in London. Subject: Effect of Electricity on Nonliving and Living; Response of Nonliving to Mechanical and Electrical Stimuli.
3. Europe U.S.A.	1908-09	British Association (Dublin), Eight Institutions in U.S.A. Subject: Response to Mechanical and Electric stimuli.
4. Europe U.S.A.	1914-15	Different Institutions in UK, Vienna (Austria), Germany, 12 Institutions in U.S.A., and Japan. Subjects: Researches related to Plants.
5. Europe	1919-20	Deliberations in different Institutions in England and in India House.
6. Europe	1923-24	Denmark, London, Copenhagen. Subject : Researches related to Plants.
7. Europe	1925-26	Different places in England, Paris, Belgium, & Geneva. Subject : Researches related to Plants.
8. Europe	1927	Some Universities in France
9. Europe	1928	Vienna, Munich, Geneva, Egypt. Subject Researches related to Plants.
10. London	1929	India Office in London. Subject: The mystery of life of plants. Participation in the meeting of League of Nation Committee on Intellectual Co-Operation.

Table 2. The Places in India where Acharya J. C. Bose delivered Lectures;

Year	Place and Subject of Lectures
1895	Calcutta Town Hall. Subject: Production of short wave length electric waves and demonstration of its property of passing through solid objects which actually formed the basis of wireless communication.
1911	Presidential address in Mymensingh session of Bangiya Sahitya Parisad.
1916	Inaugural Speech on the occasion of establishment of Banaras Hindu University. Subject : From Voice to Unvoiced.
1917	Lecture on the life and activities of his father Bhagaban Chandra Basu in Industrial fare at Faridpur.
	Inaugural address on the occasion of Inauguration Ceremony of Basu Bijnan Mandir on 30th November. Subject : Voice of Life.
1924	Convocation address at Punjab University.
1925	Convocation address at Banaras Hindu University. Deliberation on Invisible Light at Basu Bijnan Mandir.
1927	Presidential address in Lahore Session of Indian Science Congress.
1928	Convocation address at Mysore University Convocation address at Allahabad University Convocation address at Patna University
1934	Convocation address at Nagpur University Besides these lectures, he also delivered lectures at different times in reply to the felicitation shown to him by different organizations.

B. Publications of Acharya J. C. Bose

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10. The Physiology of Photosynthesis. Longmans, Green & Co. (1924).
11. The Nervous Mechanism of Plants. Longmans, Green & Co.(1926).
12. Life Movements in Plants. Vol II 1926.
13. Collected Physical Papers. Longmans, Green & Co. (1927).
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    iii) Instruments of Acharya Jagadish Chandra Bose,
    iv) Letters and Writings,
    v) Art Works at Bose Institute.
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One can contact Publication, Bose Institute, 93/1, A.P.C. Road, Kolkata-700 009 For detailed information about these books.

C. Jagadish Chandra's eleven commandments for younger generation :

1. Have some life purpose.
2. Do not be dismayed by difficulties. Difficulties were created that man should not rise above them.
3. There is no credit in succeeding when everything is favourable. It is nobler to say: "I owe nothing to circumstances."
4. Create something which does not exist.
5. Prove to the world that its advance will be incomplete without your contribution.
6. This world is a pageant of suffering. Wrong exists everywhere in the world.

7. Choose the ban of the disinherited – like Mahatma Gandhi in South Africa. Determination, and not talk, shall remove injustice.
8. The energy of the world is constant; don't waste it by talk.
9. Have thoughts; translate thoughts into action.
10. Whatever you do, do it greatly. If a lawyer, be a great lawyer; if a scientist, be a great scientist.
11. Bring the most intensive concentration to bear on your life-purpose."

D. Jagadish Chandra Bose National Science Talent Search

In 1958, a Committee was constituted with the leadership of the then Chief Minister of West Bengal, Dr. Bidhan Chandra Ray to make a meaningful plan for the Celebration of Birth Centenary of Acharya Jagadish Chandra Bose. That time, the then Chairman of Tata Steel, Sir Jahagir Gandhi came back from U.S.A. As a best way to show respect to Acharya J. C. Bose, he advised the above Committee to initiate Sir J. C. Bose National Science Talent Search Programme in the protocol of Westinghouse Talent Search Programme run by the Science Service of Washington. Accordingly, an organization in the above suggested name (more popularly known as JBNSTS) was formed with the objectives to identify and select talented students and to influence them to choose science education and research. The selection of talented students started through competitive examination. The financial liability was met by the assistance from West Bengal Government as well as from magnanimous peoples. The award of scholarship started in 1960. Among the recipients of scholarship in the first batch there was a female student named Papiya Sengupta (now Nandi), who is now the Honorary Director of this organization (JBNSTS) and is a Professor of Physics in the Jadavpur University. The scholarship is awarded at two levels: after passing class X (junior) and class XII (senior) final examinations.

Earlier, the values of these scholarships were Rs 300.00 and Rs 500.00 respectively per month, which have now been enhanced to Rs 500.00 and 1,000.00 per month respectively. In addition, annual book grants of Rs 750.00 (for junior) and Rs 1,000.00 (for senior) are also given per awardee. The recipients must continue studying Science, Technology or Medicine. At present, the financial liability for running this project is met by the assistance from the Departments of Higher Education and Science & Technology, Government of West Bengal, Central Government Organizations like CSIR and DST, various Institutions, Industrial Organizations as well as from personal donations. From the start, the office of JBNSTS was housed in a small room within Bose Institute Old Campus. At present, this has been shifted to its own two-storied building situated opposite to Ruby Hospital on E.M. Bypass. It is an autonomous organization and has no relation with Bose Institute. This Organization has been working following the ideal of Acharya Jagadish Chandra Bose.

E. Poems written on Jagadish Chandra Basu by some poets

(All but the last poem have been translated from Bengali into English by Prof. Nitai Chandra Mandal)

A. Rabindra Nath Tagore

The inextinguishable lamp which you lighted in the Temple of Truth
That lamp made you luminous along with your object of worship.

Dedication of KATHA (a book of verse)
To: My Friend Srijukta Jagadish Chandra Basu, Bijnanacharya

You offered the gems of truth, in lieu of that
I dedicate you the 'KATHA and KALPANA' only.

Shilaidaha
Agrahayana 1306.

(1) Enterer (Prabeshak)

In the favourite Western Temple of the Goddess of Science
On the bank of the ocean far,
Oh my friend! You've gone; the victory necklace
You've brought from there
And silently put on the shame-down head of the poor,
Distressed, deprived Mother.

In the gathering of luminous, glorious learned men
In the foreign land
You've heard the applauses with proud
In many and diverse voices!
Those voices transmit in all directions with deep barytone
Crossing the ocean.

Today, the Mother is sending her blessings
In the message drenched with tears
To the world community through the voice of rustic,
Unknown poet, brother!
That message will reach only your heart through
The feeble voice of Mother.

4th Shravana, 1304 (19th July, 1897)

(2)

Who are you the youth symbolizing which old sage of India
Oh Arya, Acharya Jagadish? What an invisible land of austerity
You built underneath the dry dusts of this stony city?
Where you got that peace in the bustle of this madding crowd?
Within which you stood in a moment with rapt mind
Alone amidst the whole world - where exists only oneness
In sun, moon, flowers, leaves, animals, birds, dust and stone,
Where one sleepless Life is making the whole creation oscillate
In soundless song on its own lap! When we were
frenzied in the fruitless glory of the long past
With alien's clothes, language and manners as mockery
We were shouting with loud voice in the small dark well.
How far were you? Where did you lay
Your seat of meditation? With restrained, solemn mind

You were absorbed in ascetism searching for the wonderful rays
Beyond the visible world, where the ancient sages used to stand
Voiceless, astounded, astonished with folded hands
For the perception of unity among the diversity!
Oh Hermit ! You give a call by a hymn of Sama in thundering cloud,
"Rise! Enlighten!" Invite the proud scripture-loving peoples
From the baseless debate of wisdom! To the world platform
Invite the ignorant vainglorious men! Invite your disciples.
Let them stand together surrounding your sacrificial fire!
Let our India come back again to herself in firm faith,
Respect and meditation; let her sit with unruffled mind
At the greedless, vanityless, pure and calm alter of GURU!

(1308)

(3) Felicitation Song

Let victory come to you!
You bestowed plenty of undecaying honour
On your native land!
For a long time, the voice of India
Was staying silent annihilating the insults;
These days, you made her wake and gave publicity
To the whole world.

The novel flame of light you've lighted
In the temple of knowledge,
That flame has put a glowing holy mark
On the forehead of all your brethren.
Your victory-chariot, with unrestricted movement,
Travels around the whole world.
Our sorrow and poverty that we have
Do not hinder you.

(Read in the ceremony on Magh, 1308)

(4) Dedication of KHEYA

My friend This is my 'Lajjabati Lata'.
What she has got from the heaven,
What has come from the waves of air,
Hiding in the fold of her leaves
Are the secret thoughts of her mind.
You'll have to comprehened them
By careful search,
You'll have to remove
Her voiceless impatience.
My 'Lajjabati Lata.'

My friend Evening has come,
Kissing the dreamful air.
The branches with leaves
Are falling asleep.
Her blue-eyed flowers
Silently gazing at the stars
in the sky,
Are rapt in which meditation!
My 'Lajjabati Lata.'

My friend, Bring your electric touch,
Impart her with joy,
With your widened compassionate eyes
Look into her mind.
With her heart filled with fragrant hymn
And memory of light of the day,
She has bentdown to earth.
My 'Lajjabati Lata.'

My friend, What you know as tiny
Tiny that is not;
Where exists even a grain of truth
The whole world's support is there.
Look, she remains closed in shyness,
You'll read within this
The messages of life and death,
Of sun and shadow and storm!
My 'Lajjabati Lata.'

Kolkata
18th Asharh, 1313

(5) Invocation

Holy premises of the Mother-Temple
Make it great-glowing today!
Blow, blow the austere conch!
Fulfill the perpetual expectation of dense dark night,
And take initiation of Devine Light,
All the fellow-worshippers, get ready!
Blow, blow the austere conch!
Say "Victory for the best man, the most virtuous man,
Oh, the king of ascetic, triumph for you!
Be victorious, be victorious, be victorious !"

Come on thunderbolt-seat, in the blessings of mother,
All the Devotees come, gratify this country!
Come all the Yogis, all the self-deniers,
Come the unbearable sorrow-sharers
Come the wealth of invincible power.
Extricate the society from captivity!
Come wise, come hard-working,
Exterminate Indian's shame!

Come well-being, come dignified,
Come imperishable virtuous fragrant,
Come like bright glowing sun,
In the firmament of fame!
Come in heroic and virtuous acts
Oh, the Lord of the Universe!
Blow, blow the austere conch.
Victory for the best man, for the most virtuous man,
Oh, the king of ascetic, triumph for you!
Be victorious, be victorious, be victorious!

Sri Rabindra Nath Tagore
14th Agrahayana, 1324

(Invocation song composed on the occasion of the inaugural ceremony of the Basu Bijnan Mandir)

To,
Sri Jagadish Chandra Basu, the dearest

My friend,

When the earth was painless, voiceless wilderness
The plant appeared with pleasure in that loneliness,
With fear and sorrow of life! For long
She was paying heed to hear the footfall
In the dense forest. When the human guest appeared,
She gave them flowers, fruits and stretched the row of shadows.
The prime voice of life was dormant in her heart,
Not fully expressed in her movement, manners and rustle sound.
Her day-night journey of life was continuing in diverse paths
Throughout the earth with soundless ever uproar
In the boundless future; the silent jingling music
Blazed up every day in the restless molecules
By the touch of light with palpitating speed. Hymn song for the sun
Was sung in the morning air in silent Hymnody.
The maiden voice of life thus waked up on all the points of compass In
the grass, in the forest, yet that remained in secret,
Which we could not hear even from nearby; oh worshipper!
You single-mindedly imparted voice to the unvoiced;
You've listened to hearty feeling of the forest sitting in private;
The cry of voiceless life, which initiated nonstop beating of heart
In the mother earth, started in germination spreading hundred
Dangling branches, with motion in leaves, in the zigzag roots,
In the battle of life and death; its mystery was expressed
Suddenly in various scripts to you. You brought to the light of vision
The eager voice of life from the inside core of voiceless
Ferrying across the darkness. The kinship of human mind
With the plant feeling now speaks in your genius-illuminated heart;
Aprises the lineage of the most primordial relation.

Oh Devotee the best, your arduous performance gains victory;
Where the God has carefully kept the secret voice concealed,
You entered into that secret area alone with a lamp in hand,
And waked her up. When the God was pleased
By his own defeat, then the sounded Heaven
Built the alter with joy by the voice of liberal victory
For the triumphant hero, the flag of fame flied on the top
Of sky-touching earth.

Do you remember once when your seat
Was covered and merged in the darkness of irreverence,
You were moving on a jealous, thorny path with distressed steps,
You became tired and sick by needless fight against trifling enmity
Every moment. That sorrow was your provision,
That fire lighted the journey lamp, contempt gave the benefit,
You've got your reward in the core of your heart.
Conch of your celebrity blows these days on all sides to the horizon,
On both the lands separated by sea; you are illuminated today,
My friend, by your own brilliance; the Mantra of your vast glory
Is being announced with a burst through your own acts.
Where your place exists in the midst of luminaries,
There thousand lamps blaze in the lighting festival these days;
When I added one lamp of mine to those thousand,
You looked at that lamp to feel it was lighted by your friend;
When your place of worship was lonely and secluded,
Barricaded and confined by hindrances, in that doubtful evening
The poet himself had put the garland of highest honour on your head,
My friend! He did not even wait for the appreciation of crowd;
On evil days he lighted the lamp on your empty offering plate.
Today he announces with thousand others - gratified and fortunate
You are, gratified are your friends, gratified is your Holy Motherland.

Sri Rabindra Nath Tagore
Shantiniketan
14th Agrahayana, 1335 (30th November, 1928)

(Composed on the occasion of 70th Birth day Anniversary of Acharya Jagadish Chandra Bose)

B. Satyendra Nath Dutta
Manishi Mangal (Salutation to a Genius)
(Composed on the occasion of giving felicitation to Bijnanacharya
Dr. Sri Jagadish Chandra Basu)

Who you are wandering in impenetrable sphere with a lamp of wisdom
And beholding a life activity similar in animates and inanimates.
You discover ever novel paths in the darkness,
Oh, traveler in the path of truth, I salute you.

Born in the country where servility is fated,
Now you're adorable in the world for the bloom of glow of your genius;
You're mounted high up in the sky like Vinata-nest-born Garuda,
What a wondrous eye is glowing on your forehead like that of a God!

As a compassionate you've felt with sympathy the life of plant,
Mine's iron vibrates and animal's blood throbs by your touch;
Sorceress you're, enchanter you're, what a magic of you!
The forest plant Ban Chnaral performs dance by the command of you!

Sympathetic you've searched only the eternal truth,
What a shyness Lajjabati has, you've felt;
Like a stranger prince you've trespassed alone into the territory of inanimates
With what a golden stick you've touched the forehead of the princess.

Chilled she was now became warmed, opened her eyes and fainted,
By the novel sandal-like new acquaintance she was painted!
As if a fairy of forest yawned and her breath made air to blow
Inanimates opened their minds with a trust to you.

Suddenly, all the life-long disputes were resolved!
People of the world revealed that nonliving and living have no difference!
Eternal and undivided life exists throughout the Universe
Unthinkable life activities exist within both inanimates and animates!

You, the ocean of knowledge, made many rivers meet,
The thunder-lightning pierces your genius and penetrating intellect!
Oh, you're always the stair of knowledge in the heaven of pleasures.
Oh, you're the Holy Junction of the oceans of truth!

The Creator of Ocean is tinier than atom;
You've made Him cognizable to both Brahmins and Shudras;
You resolved the path of disputeless pleasure;
Oh traveler in the path of truth, I salute you.

C. Dr. Tushar Kanti Ray*

Sir Jagadish Chandra Bose

Vijnan-Acharya Sir Jagadish Chandra Bose
A towering son of Mother India,
First to transplant the contemporary science
In her rich soil of Vedic wisdom,
Thus creating a worldwide sensation
Unparallel in the recent past of our nation,
The impact of which still vibrates
Amid microwave, radio and worldwide web.

His genius was not limited to material plane
Became pioneer in the plant life as well
Revealing the plant-nature compared to animals
With homemade tools to meticulously unveil.
He showed the parallelism in the living kingdom
Being truly blessed in the Vedantic wisdom;
He could see the truth from the universal stand
Helping the enthusiasts to see the unseen.

He inspired our young to follow basic sciences
Setting novel example for others to follow
And new breed of scientists were created thus
Helping to spread India's modern image.
Immensely we owe to this scientist cum patriot,
Must offer our best to this great luminary
And adore him as a pioneer of our modern India
On this era of his 150th birth anniversary.

September 1, 2008

**Division of Life Sciences,*
Central Yoga School of Mind-Body Fitness
& Ramkrishna Ashram Vendanta Center-Phoenix, Arizona
(www.centralyoga.org)

Dr. Nitai Chandra Mandal

Born in 1938 in the remote village Madhubanpur under P. S. Debra in the District of Midnapore (now West Midnapore), he passed B. Sc. (Honours in Chemistry) from the Midnapore College (1959), M.Sc. (1962) and Ph.D. (1969) in Biochemistry from the Calcutta University. He did post-doctoral research in Molecular Biology in U.S.A. (1970-1973), and then served as a faculty in the Bose Institute (Kolkata) from 1974-2003 as Lecturer, Reader, Professor and Emeritus Scientist. He spent two years (1987-89) as a visiting Scientist at the National Institutes of Health, Washington D.C., U.S.A. He was also associated with the Calcutta University as an honorary teacher in the Post-Graduate Biochemistry Department from 1974 to 2003. At different times, he also taught Molecular Biology in Jadavpur, Vidyasagar (Midnapur) and Kalyani Universities. He was associated with the IISER, Kolkata as a Guest Scientist for two years (2006-2008). He is a Fellow of the Indian National Science Academy (New Delhi), the Indian Academy of Sciences (Bangalore) and The National Academy of Sciences, India (Allahabad). He received a few awards and represented various National Committees. Presently, he is a member of the Board of Undergraduate and Post-Graduate Studies of the Calcutta and Kalyani Universities respectively.

Biographical portraits of Jagadish Chandra.

Seven Horse-linked chariot-embedded copper plate designed by Nandalal Basu. This is placed at the front side of lecture-platform facing the audience in the Lecture Hall of Bose Institute (Old Campus).