N. R. Dhar

NIL RATAN DHAR

(1892—1986)

Foundation Fellow

Early Life

Nil Ratan Dhar was born on January 2, 1892 in Jessore, now in Bangladesh. His father Prasanna Kumar Dhar was a lawyer and his grandfather Prem Chand Dhar, a landlord of the place. His mother Nirode Mohini Dhar was the daughter of Kunja Bihari Ghosh, a zamindar of Fatehpur, Jessore. Prasanna Kumar Dhar had six sons and three daughters. Eldest son Amulya Ratan Dhar was a lawyer in Jessore. Second son Captain Jiban Ratan Dhar, IMS became Minister of Health in West Bengal in the Ministry of Dr BC Roy. Third son was Professor Nil Ratan Dhar. Fourth son, Dr Durga Ratan Dhar, FRCS, London became Professor of Medical College, Calcutta. Fifth son Prasanta Ratan Dhar is a manufacturer of drugs and chemicals at Allahabad and the sixth son Nirmal Ratan Dhar was a Government employee in steel industry. Eldest daughter Probha was married to Jamini Bose, a zamindar and Head Master of a High School in East Bengal, now Bangladesh. Second daughter Swarna was married to Indra Kanta Mittra, Government Military Accounts Officer in Meerut. The third daughter Sudhahasi was married to Dr Suresh Chandra Roy, Director-General, Meteorological Department, Government of India, Delhi.

Education

Education in Jessore

Nil Ratan, at the age of five in 1897, was admitted to Government Zila School, Jessore which was at a distance of about one mile from his home. He always stood first in his class and passed the entrance examination held by the Calcutta University in 1907, at the age of 15, in first division with distinction and obtained a Merit Divisional Scholarship of Rs 15/- per month tenable for two years. In those days there was no science teaching in the Indian schools. He studied english, sanskrit, very little bengali, mathematics, history and geography. He was deeply interested in acquiring knowledge and studied hard, specially english, history and geography. In the school senior classes he could compose small articles in sanskrit and memorised english and history books easily.

Education in Calcutta

In 1907 Nil Ratan left Jessore and joined the famous Rippon College established by Sir Surendra Nath Banerji, the uncrowned king of Bengal, and studied the newly introduced ISc course with physics, chemistry, mathematics and english. He became highly interested in both physics and chemistry. There were only seven students joining the course in the college and Nil Ratan became the leader of the group. He organised a small laboratory for practical work and prepared reagent solutions even with silver nitrate and gold chloride and had patches of black silver and brown gold on his fingers. He was lucky in having excellent teachers even for the intermediate course. The eminent Principal Professor Ramendra Sunder Trivedi, PRS taught physics, Professor Gangadhar Mukerji taught both physics and chemistry, and Professor Haran Chandra Banerji, son of Sir Guru Das Banerji, famous High Court Judge and Vice-Chancellor of Calcutta University taught mathematics. English was taught by Sir Surendra Nath Banerji.

While studying in Rippon College from 1907 to 1909, Nil Ratan regularly attended the excellent lectures in chemistry by Rai Bahadur Chuni Lal Bose, MB, Chemical Engineer of the Bengal Government and Physics lectures by Professor AN Palit, Professor of the Metropolitan College. These lectures were delivered at the Indian Association for the Cultivation of Science with experimental demonstration. At the end of the two years, when an examination was conducted, Nil Ratan was the recipient of many books as prizes in science.

In 1909, Nil Ratan passed ISc examination in first division obtaining high marks and was awarded a Government Scholarship of Rs. 20/- per month tenable for two years. He joined the Presidency College, Calcutta in July 1909 which was the best place for higher education with physics, chemistry and mathematics, having Honours in chemistry. He resided in the famous Hindu Hostel in the same Room No. 4 where our first President Dr Rajendra Prasad lived when he studied in Presidency College eight years earlier.*

In the Presidency College there were several European Professors including the Principal, Mr HR James, MA (Oxon) who was very kind and helpful to Nil Ratan. There was a galaxy of famous Indian Professors, the most noted ones were Sir JC Bose, Head of the Physics Department. Apart from him Professor CW Peake, MA (Cantab) and Dr EP Harrison with a German Degree were his colleagues in Physics Department. Dr Harrison organised the practical instruction in physics and set up many useful experiments. Sir PC Ray was the Head of the Chemistry Department.

*This was mentioned by Professor Dhar in his Roorkee Science Congress Presidential Address in 1961 which was inaugurated by Dr Rajendra Prasad and the President was overjoyed on hearing this reference.

Professor Jyoti Bhusan Bhaduri, PRS taught physical chemistry and his elder brother Chandra Bhusan Bhaduri lectured on inorganic chemistry with special reference to manufacturing processes.

Influence of Sir JC Bose and Sir PC Ray

Professor Dhar in his *Reflections on Chemical Education* states : *Both Sir JC Bose and Sir PC Ray were originators of research work in science in Calcutta. Sir JC Bose had remarkable ability in devising experiments and manufacture of instruments by Indian mechanics for physical measurements and demonstration. In 1900, even before Marconi, he carried on experiments on wireless. Later on, he was interested in the physical aspects of photosynthesis and growth of plants and prepared the crescograph and other instruments in his own workshop. I attended his lectures on optics in the BSc course. Sir JC Bose spoke only for 20 to 25 minutes and with the help of his assistants showed numerous experiments. He was very able Professor and was friendly with students. I was very lucky to enjoy his affection and confidence.*

The honours in chemistry was two years' course those days. While studying BSc Hons. in chemistry, Nil Ratan being submissive attracted junior students towards himself. Thus JC Ghosh, MN Saha, JN Mukerji, Pulin Bihari Sarkar who were two years junior to him (studying in ISc at that time) and living in the Hindu Hostel used to come to him regularly for learning elementary physical chemistry. They all affectionately called him Nil Ratanda. In 1911, Nil Ratan passed BSc (Hons) in chemistry standing first in Calcutta University and was awarded Gold Medal and also a scholarship of Rs. 32/- per month tenable for 2 years for studying MSc course.

In July 1911, Nil Ratan joined MSc course in chemistry in Presidency College, Calcutta with research work in physical chemistry. In January 1912 Acharya PC Ray prepared several nitrites in which he specialised and wanted to go to London to determine the physical properties of these compounds but Nil Ratan told him that he would determine these properties in the Presidency College itself. Thus he started research work on nitrite chemistry in association with his *Gurudeb* Acharya PC Ray. In 1911, he first purified ordinary distilled water for obtaining conductivity water in which the nitrites were dissolved. The electrical conductivity water was prepared by him in a small laboratory near the stairs of the chemistry lecture theatre of the Presidency College. Soluble nitrites of sodium, potassium, calcium, barium, etc. were dissolved in conductivity water and electric conductivity and degrees of ionisation of these substances were determined. These researches were incorporated in an article which was read by Acharya PC Ray in London Chemical Society. Soon afterwards he determined the vapour density of the unstable substance ammonium nitrite in Torricelian vacuum. These findings were also published in the *Journal of the Chemical Society*, London in 1913. He also determined the EMF of various systems.

Nil Ratan presented a thesis on complex and double salts for his MSc examination. He passed his MSc examination in 1913 in chemistry in first division obtaining first position and secured highest marks amongst all the MA and MSc candidates. He received 20 gold medals and numerous prizes from the Calcutta University and also from the Asiatic Society of Bengal. He also won the Griffith Memorial Prize of Rs 900/. He was awarded a Merit Scholarship of Rs 100/- per month for carrying on research in Calcutta University.

After July 1913, Nil Ratan started research work independently. DN Bhattacharya, who was junior to him by one year, determined the mobility of ions at zero degree under his guidance. They also determined the transport number of nitrite ion by electrolysis of a solution of silver nitrite which is sparingly soluble in water. Both these works were published in Germany. Another research scholar AK Datta, who worked with him, determined the second dissociation constant of dibasic acids by increased solubility of CO_2 in sodium or potassium salts of dibasic acids. This research work was published in the *Journal of the London Chemical Society* in 1913. From July 1913 till beginning of September 1915, when he left for Europe, Nil Ratan carried on independent research work on double and complex salts, combination of solute and solvent and published these papers in Germany in *Zeitschrift fur Anorganische chemie*, *Zeitschrift fur Electrochemie Zeitschrift fur Physicalis chemie* since 1913.

Moreover, chemical kinetics, photochemistry and colloid chemistry were developed by Dhar and his collaborators. Hence Acharya Ray, in his autobiography first published in english in 1925, very graciously recorded that NR Dhar was certainly the founder of physical chemistry and physico-chemical researches in India. At a later date, Sir Shanti Swarup Bhatnagar in his Presidential Address to the Chemistry Section of the Silver Jubilee Session of the Indian Science Congress Association held in Calcutta in 1938, also recorded that Professor NR Dhar was the founder of physical chemistry in India.

First study trip to England

During the first World War (1914 to 1918) Nil Ratan was awarded a Government of India Scholarship (State Scholarship) of a value of £ 200/- per annum tenable in the first instance for 3 years for study in Europe and America. As he had to proceed to London first in September 1915 during the Great War between Germany and its allies on the one hand and the United Kingdom, France, Italy and India on the other side, all his relations and friends were afraid of disasters during these years and were against his proceeding to Europe. Even his *Guru* Acharya PC Ray under whom he was carrying on research and also his *Guru* Acharya Ramendra Sunder Trivedi, Principal Rippon College, were deadly against his going to Europe during the war periods. But the quest of learning in Nil Ratan was so great that ultimately he

left Calcutta on September 3, 1915. His close friend and colleague Shyam Tripathi (SC Tripathi, IES) was with him till they reached London. On reaching London in September 1915 they were taken to 21, Cromwell Road, London, SW 7, where the Indian students were accommodated for a few days after their arrival in England.

Being a Government of India scholar, Nil Ratan had to report to Dr TW Arnold, the adviser to the Indian students in London and Mr NC Sen, son of the great Bramho reformer, Keshav Chandra Sen who was the assistant adviser.

Next morning, Nil Ratan went to the Chemistry Department of University College London WC 1 to work under Professor FG Donnan, FRS, Professor of Physical Chemistry. Dhar was in touch with Professor Donnan from his Calcutta days and had got an assurance for joining his Department for the DSc degree. He was disappointed to find that the laboratory was undergoing constructional changes and some more time was needed for its proper functioning. Hence, Dhar decided to join the Physical Chemistry Department of the Imperial College of Science and Technology, South Kensington, London, SW 7 under Professor JC Philip, who became a Fellow of the Royal Society later on. Under the rules of the London University, candidates seeking admission for the DSc degree had to work independently of the Professor. Therefore Nil Ratan started work in the Professor Philip's laboratory in the last week of September 1915. He resided in a house in Belsize Park near Hampsted Heath. After breakfast in the morning he would catch the underground electric train to reach the laboratory before 9 am. He used to work in the laboratory till 6 to 7 pm with a break for lunch in ABC or Lyons restaurant costing 1 shilling.

In London, Nil Ratan carried on researches on the mechanism of the reaction between mercuric chloride and oxalic acid induced by potassium permanganate. He studied the reaction at various temperatures in thermostat and showed that even at zero degree the induction phenomenon is observed but formic acid cannot reduce mercuric chloride appreciably at this temperature. This proves that formic acid is not the intermediate product obtained in the reaction between oxalic acid and potassium permanganate, although M Berthelot of France separated formic acid by the distillation of tartaric acid and potassium permanganate. Dhar could not obtain formic acid by distilling a mixture of potassium permanganate and oxalic acid.

One Mr AB Manning, a trained physical chemist and a Research Assistant of Professor HB Baker, FRS was studying the hydrolysis of esters by water at high temperatures and found that hydrolysis takes place in absence of acid. Frequently Manning and Dhar discussed among themselves the mechanism of the induced reaction which could be demonstrated by taking strong solutions of mercuric chloride and oxalic acid in a big beaker and adding one or two crystals of potassium permanganate. A vigorous reaction between potassium permanganate and oxalic acid followed by

copious precipitate of white calomel took place. He also studied the photochemical reaction between oxalic acid and mercuric chloride. Earlier, J Eder of Germany had studied the effect of light on oxalate and mercuric chloride. Dhar discovered that oxalate can readily react with iodine and this reaction is highly photochemical. The dark reaction is slow with a high value of 7.2 as its temperature coefficient for a 10°C rise of temperature. In the light, the velocity is greatly increased with a rapid fall in temperature coefficient. Manning advised him to study chemical kinetics of the oxidation of oxalic acid by oxidising agent. Harcourt, Reader in Chemistry in Oxford and Esson, Professor of Geometry in Oxford in 1860, studied the kinetic reaction between oxalic acid and potassium permanganate and discovered that the reaction is unimolecular in presence of large amount of oxalic acid. The photochemical aspect of this reaction was studied by E Goldberg in 1904 in Germany. Dhar also studied the reaction between silver nitrate and formate, mercuric chloride and formate as well as the influence of catalysts and neutral salts on these reactions. He extensively studied the important literature of chemical kinetics and temperature coefficients in the South Kensington Science Museum Library. He wrote up his thesis for the DSc degree of London University and got it typed spending about £ 5 and submitted to the Registrar of the London University. Under the rules of the University of London, two examiners are appointed by the University to assess the thesis for DSc degree. The examiners were Professor WC Mc Lewis, FRS, Professor of Chemistry at Liverpool University and author of an important book in physical chemistry and Professor Philip, his own guide as the external and internal examiner. The rules guiding the examiners state that in the case the thesis is of special merit, the *viva-voce* examination, which is normally compulsory, need not be held. Within a few days Dhar was informed that no *viva-voce* examination is necessary as the thesis was of a very high calibre. Hence by June 1917, Dhar was awarded the DSc degree of the London University. About that time he gave an account of his researches in the London Chemical Society Meeting of which he became a Fellow in 1916. Sir Alexander Scott, the President of the London Chemical Society and also Professor Philip were highly impressed by Dhar's address in the Chemical Society.

While studying in England, Dhar came in contact with and attended lectures of eminent scientists like Sir JJ Thomson, Sir E Rutherford, S Soddy, Professor WH Perkin, Sir James Walker, Lord Haldane, Professor Gilbert Morgan, Lord Rayleigh and his son (at that time Hon'ble Strutt), Professor AD Fowler, HB Baker and others. Many of these people came from Cambridge, Oxford, Edinburgh and other places to London and delivered lectures either in the Royal Institution or the Royal Society or Chemical Society.

After receiving the DSc degree of the London University, Dhar wrote to Savante Arrhenius in Stockholm, Sweden to seek admission in his laboratory. Professor Arrhenius immediately sent a reply in a post card that the travelling from London to Stockholm was dangerous as the German submarines were sinking all steamers in the

North sea. Moreover there was food shortage in Sweden and fish was practically the only food available. Considering everything Dhar decided not to proceed to Stockholm.

Study trip to France

Dhar being interested in chemistry of Catalysis wrote to Professor Paul Sabatier of Toulouse University to admit him in his Institute but he replied in early October that his laboratory was burnt and out of use. Then Dhar wrote to Professor Georges Urbain of Sorbonne, Paris, a great authority on rare earth chemistry and Head of the Inorganic Chemistry (Mineral Chemistry) Department of Sorbonne. He immediately replied that he would gladly admit him in his laboratory and he persuaded the French military authorities to influence the British Government to permit Dhar to travel from London to Paris, because by October 1917 the war was bitterly fought and the civilians were not allowed to travel to foreign countries. In 1917, a British Passport was issued to him and being a Doctor of the London University he approached the military authorities in London who were responsible for giving visa to a British Passport-holder to be used in France. Dhar left England by middle of October 1917 with his friend VS Ghate who was carrying on research work in Sanskrit for the Paris University degree under Professor Sylvain Levi, the eminent Sanskrit and Oriental Scholar of the College of France.

On the next day after reaching Paris, Dr Dhar went to the Mineral Chemistry Department of the Sorbonne and met Professor G Urbain who was very kind and was keen on his carrying on the research work with him on cobalt amines and other complex compounds. Dhar prepared several cobalt and platinum complexes and determined their electric conductivity and also carried on electromotive force measurements with the help of a Calomel electrode using metallic cobalt or platinum as electrode. Professor Urbain communicated two papers to the French Academy of Sciences based on these results. On the advice of Professor Urbain, Dhar extended his induced reaction experiments carried on in London on the action of potassium permanganate on a hot solution of mercuric chloride and oxalic acid forming calomel; also the oxidation of tartaric acid by hydrogen peroxide aided by ferrous sulphate. Professor Paul Pascal who became Professor not only of applied chemistry but also of general chemistry and inorganic chemistry in Sorbonne was much impressed by Dhar's researches on chemical kinetics, especially the relationship between the order and temperature coefficient of reactions proving that unimolecular reactions have higher temperature coefficients than those of bi-and polymolecular reactions. In his book on *General and Physical Chemistry* and in his lectures at Sorbonne, Professor Pascal always referred to this research work on temperature coefficients and order and designated it as Law of Dhar.

Dhar wrote up his thesis for the Degree of Docteur es' Sciences (etat) of the Sorbonne for the highest degree possible in France. In the thesis all his researches

on chemical kinetics, neutral salt effect and relationship between the order of a reaction and its temperature coefficient were included. Professor Urbain deputed his colleague, Dr F Burion to help Dhar in writing the thesis in correct French language. Dr K Lindberg, a medical student in the Sorbonne and Mademoiselle Jeanne Mestre were extremely helpful in writing the thesis in French. Professor Burion carefully read through every word of the thesis. Under the rules of the Sorbonne University the Doctorate degree thesis must be submitted in a printed form (200 copies). When the printed thesis is received by the Secretary of the Science Faculty of the Sorbonne University, one copy is sent to all the Universities and Technological Institutions in France for careful examination and criticism. Moreover in France the *viva-voce* examination of the State degree candidate is compulsory and very serious. Hence in the case of Dhar, the *viva-voce* Board consisted of Professors G Urbain as Chairman, Jean Perrin, the Noble Laureate and Professor of Physics in the Sorbonne and Marchel Guichard, Head of General Chemistry Department in the Sorbonne. Under the rules of the country the public is invited and can cross-examine the candidate. In the case of Dr Dhar, the *viva-voce* examination lasted for about two hours and in the end the Chairman declared in the gathering that the State Doctorate of Science was being awarded to him (*Tres Honorable*) i.e. degree of the best standard.

Dr Dhar while studying in Paris came in contact and attended the lectures of Professor H Le Chatelier who was the Professor of General Chemistry in the Sorbonne and leader of thermodynamics and discovered the famous Le Chatelier-Braun Principle.

In 1917, Madame Curie was the Director of Radium Institute. Dr Dhar also attended her lectures in this Institute. After obtaining the degree from Paris, Dr Dhar arranged to work for one more year with the famous physical chemist, Emil Baur of Zurich University. Professor Baur was an authority on electrochemistry and carbon electrolytic cells. His aim was to obtain training in the three types of scientific disciplines prevailing in England, France and Germany. Having been educated in London in the British way and in Paris in the French way he tried to study in the University of Zurich, Switzerland which is run by professors trained according to the German system. But Acharya PC Ray and his friend Satya Nand Bose and others wrote to him that since he has already obtained the DSc of London University and State Doctorate degree of France he should try for the Indian Educational Service and return to India. Dhar came back to London in the end of January 1919 and again joined the Physical Chemistry Department of the Imperial College of Science and Technology, South Kensington by paying a fee of £ 5. At that time he carried on experiments on the action of phosphorous, hypophosphorous acid on chromic acid.

Service and Research Career

Appointment in the Indian Educational Service

After obtaining the DSc degree of London University in June 1917, Dr Dhar had registered his name for the Indian Educational Services in the British Board of

Education Office at Whitehall. When he returned to London from Paris in January 1919, one afternoon he went to the same office, now shifted at South Kensington, in his buttoned-up coat and trouser suit which was rather shabby looking and asked for the gentleman who dealt with the appointments in the Indian Educational Service. A short statured gentleman, with the name Mr Twentyman, came out and said, *Yes, you registered yourself for the IES job after taking your DSc degree of the London University in 1917, what were you doing after that* ? Dr Dhar replied that he went to Paris to study in the Sorbonne. He smiled and said, *Oh, you were in Paris and moved about with pretty French girls.* Dr Dhar replied no, he studied in the Sorbonne Science Faculty and obtained the State Doctorate of Science. Twentyman said that foreigners are not given the State Doctorate degree. They obtain only the University DSc degree. But on seeing the State Doctorate degree certificate with the mention *Tres Honorable* he was surprised but did not say anything. Next morning Dr Dhar went to meet Mr Bhupendra Nath Basu, Adviser to the Secretary of State for India, Hon'ble Mr Montagu, who on seeing him happily remarked that *You have been recommended for an immediate appointment in the IES by the British Board of Education.* Within a few days Dr Dhar met Mr Montagu and some of his officers who informed him that he was appointed in the IES as Professor of Chemistry. He was asked to choose one of the following posts : (*a*) Professor of Physical & Inorganic Chemistry, Muir Central College, Allahabad, (*b*) Professor of Chemistry, Presidency College, Madras, (*c*) Professor of Chemistry, Khalsa College, Amritsar; (*d*) Professor of Chemistry, Government College, Rangoon: (*e*) Professor of Physics, Presidency College, Calcutta; (*f*) Professor of Chemistry, Government College, Lahore. As Allahabad was a central place, Dhar accepted the Professorship in Allahabad.

On being appointed in London in the IES, Professor Dhar was granted the same privilege as British Officers and during the whole period of his service in the IES i.e. twenty seven and half years, (retirement age being 55 years) he drew overseas allowance of Rs 300/- per month in addition to his salary in the grade of Rs 500-50-1000. Professor Dhar left Marseilles on a British India Steamer on June 27, 1919 along with Professor Birbal Sahni, who returned from Cambridge to join his post as Professor of Botany in the Banaras Hindu University. Professor MacMahon, Professor in Chemistry, Lucknow University was also coming to India along with Dr Dhar. Dhar reached Allahabad Railway station at 1 am July 19, 1919 and tried to take a nap at the platform. In the morning when he reached the Allahabad University Senate Hall, where end of the War of 1914-18 was being celebrated by the citizens, he was introduced to Professor WA Archbold, Principal of the Muir Central College, RH Moody, UC Ghosh, Professor of Mathematics, Dr AP Sarkar, SC Deb, PES and KP Chatterji, PES.

Teaching and Research in the Allahabad University

In the Chemistry Department, Muir Central College, there was no European IES Officer. Professor Dhar succeeded the late Dr EC Hill who was a DSc from

Dublin University. He used to come on foot daily from his residence at 6, George Town, Fort Road and would reach the Chemistry Department by 9.30 am and stayed on there till 5.30 pm. He used to lecture occasionally with experiments in the ISc classes also and delivered a regular course in physical chemistry for the BSc I Year as well as in BSc II year. In July 1919 there was no MSc (Final class). The previous MSc batch consisted of IK Taimini, Abani Sanyal, BC Banerji, RC Banerji, MD Chaturvedi, PB Ganguli and M. P. Srivastava. As Head of Chemistry Department in the Muir Central College as well as in the Allahabad University, he had complete control regarding admission in the MSc classes. As Universities are seats of learning for students from all parts of the world, he made it a point to admit brilliant students hailing from other parts of India. Students from Kerala to Kashmir worked under him and carried the torch of research work to their respective places.

Brilliant Research Scholars

In August 1919, Professor KP Chatterji, PES a colleague of Professor Dhar who was 2 years older in age joined research work under him on the problem *Preparation and formation of sparingly soluble oxalates, tartrates, citrates and fluorides* and carried on experiments in his spare time. It was observed that when oxalic acid or a soluble oxalate solution is mixed with solutions containing bivalent copper, bivalent zinc, bivalent manganese, bivalent iron, bivalent nickel, bivalent cobalt at the laboratory temperature in equivalent amounts, there was no immediate precipitate of the oxalate. On the other hand, on warming these mixtures, there was an excellent precipitation of the oxalates. A similar observation had also been obtained with fluorides when mixed with solutions containing silver or lead ion, that is instantaneous precipitation takes place with silver and lead ions. Professor Chatterji carried on a very large number of experiments and obtained numerous oxalates, tartrates, citrates and fluorides under different concentrations and precipitation temperature and completely analysed the compounds formed with their water of crystallization. The publication of these results attracted the attention of Acharya PC Ray and many senior chemists. Dr Nitya Gopal Chatterji was the first to receive the DSc degree under Professor Dhar of Allahabad University. He studied on colloids sol formation and peptization and adsorption of electrolytes by freshly precipitated manganese dioxide. Dr Khitish Chandra Sen was the second doctorate under Professor Dhar and worked on the properties of colloids, adsorption etc. and obtained his DSc degree in 1923. BK Mukerji, CC Palit and Aboni K Bhattacharya also started research work for their Doctorate shortly afterwards. Later on Dr Satya Prakash, Dr Akshoy K Bhattacharya, Dr DN Chakravarty, Dr Gopala Rao, Dr Atma Ram, Dr WV Bhagwat, Dr RN Mitra and others obtained their DSc degree. Subsequently Ram Charan Mehrotra, Ramesh Chandra Kapoor, BNP Ghildyal, Krishna Bahadur, Sirtaj Bahadur Sinha, BK Dhar, and SG Misra worked under Professor Dhar and obtained DPhil

degree of the Allahabad University. These students later on created their own schools at different places of the country.

Study Leave to go to Germany in 1926

After seven years of service in the Muir College, Professor Dhar was granted study leave for about 6 months from May 1926. He delivered lectures in the newly constructed Chemical laboratories known as King's Building in Edinburgh University early in June 1926.

The first lecture presided over by Sir James Walker, was on slow and induced oxidation, in which he demonstrated that a mixture of sodium sulphite and arsenite solution kept at a temperature of 15° to 20°C for 3 weeks shows the test of arsenate by the formation of brown precipitate with silver nitrate due to the induced oxidation of arsenite to arsenate by sulphite oxidation. He also showed that the mercuric chloride-oxalic acid reaction can be induced by potassium permanganate and acceleration of H_2O_2-tartaric acid reaction by ferrous salt. Sir James Walker was favourably impressed by his lectures. His second lecture was on periodic precipitation in the Edinburgh University in which Mr and Mrs Bolam, who were carrying on research work on the same topic, participated actively.

From UK, Professor Dhar proceeded to Berlin and joined the Physico-chemical and Electrochemical Institute at Berlin-Dahlem. This Institute had flourished under the leadership of Professor Fritz Haber, a Nobel Laureate, as Director and Professor H Freundlich, an eminent colloid chemist, as the Deputy-Director. Freundlich was familiar with the researches of Dhar. He carried on his research activities and contributed valuable articles, attended colloquia, discussed his researches and visited laboratories not only in Berlin but also at Leipzig, Gottingen and Frankfurt-am-Main. Professor Dhar visited the Kaiser-Wilhelm Institutes. The Directors and the Deputy-Directors are recognised as University Professors and they work in collaboration with candidates carrying on research work for their Doctorate. A very important feature of the German system is the holding of colloqium. A research scholar who has almost completed his investigations is asked by the guide to deliver a lecture on his investigations and his achievement i.e. new points brought out by his work and not only all the workers of the same laboratory are invited to attend but research scholars from other institutions also take part in the discussion. Professor Dhar attended the colloquia of Dr Fritz Haber and Professor Walther Nerist and observed that they are well attended. Similarly he attended the colloquia of Professors Bodenstein, Freundlich, K Bonhoeffer, Otto Hahn who were eminent scientists in Germany.

Dhar met Professor G Tammann in Gottingen who used to deliver his University lectures at 7 am in summer and at 8 am in winter. He was a great leader in the

industries of alloy, steel and other useful materials. In the same university he visited Professor Coehn who was highly interested in Professor Dhar's experiments on induced reactions and effect of light in accelerating the reaction between oxalic acid and mercuric chloride. He also visited the Physical Institute of H Franck who became a Nobel Laureate and discovered that in the atomisation of iodine molecules, there is a large increase of light absorption.

In Leipzig which was Wilhelm Ostwald's main seat of activity, Professor Dhar visited the laboratories of his eldest son Wolfagang Ostwald, the famous colloid chemist and had long discussions with him. He also met the eminent photo-chemist F Weigert. He also had a meeting with Raphael Liesegang at his home at Leipzig who was the discoverer of Liesengang ring or periodic precipitation.

In Berlin, at Technische Hocchschule Institute at Charlottenburg, Dhar met Professor W Eilet, a great authority on silicates who showed great interest on the researches of Dhar and co-workers on periodic precipitation on silicic acid and gave an account of these work in his book *Silicates*. He also met here Professor Miethe who detected the presence of gold in all mercury vapour lamps and believed that gold was produced in small quantities from mercury. Dhar also met the eminent colloid-chemist Professor O Traube in Charlottenburg.

Dhar's theory of Photo-chemical Nitrogen Fixation

Professor Dhar in his Presidential Address to the National Academy of Sciences in 1935 and 1937 described his discovery of photochemical nitrogen fixation. Although animal dung and organic matter have been used as manure from time immemorial but their functions in the soil were not properly understood. He was first to explain the importance of organic matter in the fixation of atmospheric nitrogen in the soil itself. He demonstrated that organic matter such as straw, water hyacinth leaves, grasses, sawdust, seaweed, municipal wastes, animal dung etc. mixed with rock phosphate or basic slage or bone meal when ploughed in the soil supply all plant nutrients for good crop growth. Organic matter which creates the humus content of the soil undergoes slow oxidation in contact with air and liberates energy and this energy aided by sunlight fixes atmospheric nitrogen on the soil surface and the phosphate in addition to its being a plant food combines with proteins and aminoacids due to phosphorylation and forms stable compounds which are resistant to oxidation and thus the loss of nitrogen is checked.

The first step in the photochemical nitrogen fixation is the oxidation of gram mole of glucose accerding to the following equation :

$$C_6H_{12}O_2 + 6\ O_2 \rightleftharpoons 6\ CO_2 + 6\ H_2O + 676\ \text{k Cals}$$

The energy obtained from the oxidation of carbohydrates decomposes a gram mole of water according to the following equation :

$$H_2O + 112 \text{ k Cals} \rightarrow H + OH$$

The atomic hydrogen formed from the decomposition of water combines with nitrogen of the air and forms NH_3 which can be readily oxidised to nitrite and nitrate by air or H_2O_2 obtained from OH radicals. Nitrate easily reacts with organic matter and forms amino acids. When these systems are illumined by sunlight or artificial light, the light is absorbed and nitrogen fixed in presence of light is much greater than that obtained in the dark In all these experiments, the number of azotobacter, total bacteria and fungi are always smaller in presence of light which is harmful to micro-organisms, than in the dark although nitrogen fixed per gram of carbon of the energy material oxidized in light is much greater than in the dark. In the presence of calcium phosphates, the nitrogen fixation is greatly enhanced. This discovery of photochemical nitrogen fixation is important for land fertility and increased crop production all over the world. Professor Dhar stated : *Our researches have clearly shown that all organic substances aided by calcium phosphates can deliver the solar energy stored in the organic matter to the fixation of atmospheric nitrogen and enrichment of the soil. Man must understand that photosynthesis is not only the supporter of life on this planet but it is also the creator of land fertility required for crop production.*

In support of his theory, Professor Dhar cited the following facts : In the Rothamsted continuous wheat experiments, the original total nitrogen content was 0.122% in 1844 when the experiments were started. In 100 years it dropped to 0.09% in the unmanured and to 0.11% in the fertilized plots, whilst by adding 14 tons of farm yard manure per acre every year, the nitrogen status improved to 0.25%. Moreover, it has been estimated that world food and fodder production today is about 4000 million tons. Assuming that 1 ton of nitrogen can produce 10 tons food or fodder, the total nitrogen requirement to produce world food and fodder would be about 400 million tons, out of which factory nitrogen can supply only 30 to 40 million tons. Sir John Russell in his Presidential Address to the British Association in 1948 declared unequivocally that not more than 5% of the food and fodder production in the whole world can be attributed to artificial fertilizer nitrogen. Thus Professor Dhar's theory satisfactorily explains the 90% supply of nitrogen from the humus of the soil which has to be continuously enriched by the addition of organic matter and phosphate to the soil.

Nitrogen Loss from Soil

All over the world farmers have observed that the recovery of nitrogen by the application of nitrogenous fertilizers and manures by crop production is usually

low and is generally of the order of 25-30% of the applied nitrogen. From a survey of Rothamsted experiments with $(NH_4)_2SO_4$ at 1 cwt. per acre, Russell reported a nitrogen recovery of not more than 50% (wheat 39%, barley 47%, oats 46%, swedes 35%, potatoes 50%).

For a number of years Dhar and co-workers have studied the problem of nitrogen loss from soils and have explained the low recovery of nitrogen from nitrogenous fertilizers and manures. Under ordinary conditions of cultivation the proteins, amino-acids and ammonium salts present in the soil or added to it as fertilizers and manures undergo slow oxidation by air as in the following scheme :

$$\text{Proteins} \longrightarrow \text{Aminoacids} \xrightarrow{+O_2} NO_3^-$$

These are oxidation reactions which are accelerated by increased aeration, absorption of radiation and increase of temperature. In these processes of oxidation, an intermediate compound ammonium nitrite which is unstable and explosive is always formed and it readily breaks up into nitrogen and water with evolution of heat : $NH_4NO_2 \rightarrow N_2 + 2H_2O + 718$ k Cals. The formation and decomposition of this explosive substance cannot be avoided in land cultivation and crop production on application of nitrogenous fertilizers and manures. Dhar and co-workers have experimentally established that this loss can be markedly checked by mixing the nitrogenous fertilizers with straw, leaves, grasses etc. which contain carbohydrates capable of acting as negative catalysts in the nitrification of nitrogenous fertilizers and manures just as body proteins are preserved by the intake of carbohydrate food materials.

Professor Dhar advocated the application of Thomas slag (basic slag) mixed with straw or other organic matter to the soil. Thomas slag is alkaline due to its contents of CaO, K_2O, MgO etc., hence oxidation of cellulose and lignin materials in straw is greatly increased when basic slag is mixed with straw and ploughed in the soil. Moreover, catalysts like Cu, Fe, Mn, Ti, Mo, V, Zn, present in the slag also accelerate oxidation of cellulose and lignin. In this process energy is liberated and utilized in fixing atmospheric nitrogen on the soil surface and land fertility is markedly increased.

The manifold advantages of the application of organic matter mixed with basic slag or rock phosphate or bone meal to the soil at the rate of 10 tons of organic matter plus 1 ton phosphate per acre of land have been enumerated by Professor Dhar as follows : organic matter when added to the soil not only adds colloidal substances to the soil and improves its physical properties, tilth and crumb formation and water retention capacity of the soil but it also undergoes slow oxidation in soil and liberates energy which is utilized in fixing atmospheric nitrogen and enriches the

soil from nitrogen view point. Moreover, the carbonaceous non-nitrogenous compounds present in soil or added to it act as protectors of soil nitrogenous substances just as carbohydrates and fats act as protein sparers in the animal body. Similarly, when organic matter and phosphates are added to the soil, not only there is bumper yield of first crop but due to residual effect, second and third crops can also be grown without any further application of fertilizers or manures. Also, crops grown are more tasty being rich in proteins, vitamins and minerals. Along with the increase of crop yield, the fertility of the land is steadily increased. On the other hand, when fertilizers are added without organic matter, after the first crop no residual effect is observed and infact the crop yield decreases in successive years due to depletion of humus of the soil leading to deterioration of the soil.

International visits

Dhar went to Europe in 1931 and 1951 to deliver lectures on his researches. In 1953, 1954, he went with his wife and spent 10 months in the Uppsala Agricultural University, Sweden to demonstrate his method of photochemical nitrogen fixation. Professor C Bjalfve of Uppsala verified his observation that organic matter when mixed with soil or sand undergoes slow oxidation. It can fix atmospheric nitrogen in the soil itself increasing the fertility of the land and crop yield. Moreover, this fixation of atmospheric nitrogen is accentuated by addition of calcium phosphates and absorption of sunlight. Professor Bjalfve in his publications clearly declared that the photo and thermal fixation of nitrogen in the soil itself by application of organic matter and phosphate in presence of light as discovered by Professor Dhar is more important even in Sweden than the growing of legumes. Shortly afterwards Professor A Aslander of the Stockholm Technological University, Sweden proposed Professor Dhar's name for the Nobel Prize. Since then he had been invited to attend the International Soil Science Congress and visit Universities and Technical Institutes to deliver lectures on his researches. For this purpose Dhar crossed the Suez canal 20 times and the Cape of Good Hope twice for visiting European and American places of learning He lectured in London, Paris, Toulouse, Biaritz (France), twice he lectured in Madrid and in Rome. He also attended and delivered lectures in the International Congress of Soil Sciences in Paris, Wisconsin, Bucharest, Opatia in Yugoslavia.

Professor Victor Kovda, Director, Institute of Agrochemistry and Soil Science of the Academy of Sciences of the USSR, Moscow University and President of the International Soil Science Congress was much impressed by Dhar's discovery of thermal and photochemical fixation of atmospheric nitrogen in the soil itself by the slow oxidation of organic matter when added to the soil aided by calcium phosphates. So much so that he proposed the name of Professor Dhar for the award of a Nobel Prize for this discovery. In a letter to Dhar he stated as follows : *I am sure that maximal recycling of organic and mineral byproducts of argriculture, industry and cities be organised by every farm, region, country on the basis of scientifically sound*

composting and sanitation control. So you are thousand times right that a mixture of organic matter with sludges or phosphates will facilitate fixation of nitrogen and increase the fertility of arable soils. No doubt that the humanity will never forget your impact on this problem.

Dr Dhar's Contribution to Soil Science

Improvement of USAR Land

Professor Dhar and some of his associates had been working on the mechanism of nitrification and nitrogen fixation in soil and had advanced the view that former was mainly a photo-chemical process. The oxidation of organic matter added to the soil provided a good part of the energy for the fixation of nitrogen.

Almost at the same time Professor Dhar's attention was drawn to large tracts of usar lands (alkali soils in Allahabad district). He visited some of them. The alkaline lands used to be reclaimed by the application of gypsum which in course of time reduced alkalinity of the soil. Dhar suggested a simple method of improving alkali soils by the application of molasses, press-mud and other organic materials to such soil. The acid generated from the molasses neutralized the alkalinity of the soils and the energy generated during the oxidation of sugars present in molasses helped in fixing nitrogen. Many people came to seek his advice. Thus he became more and more interested in soil fertility and related subjects.

Thus the pioneering research of Professor Dhar and his devoted students at Sheila Dhar Institute spread over half a century were connected with soil fertility, mechanism of nitrogen fixation, role of organic matter, reclamation of alkali soils, formation of acid and alkali soils, value of phosphates etc. Their researches have established the key role of soil humus and of organic matter in increasing soil nitrogen through the fixation of atmospheric nitrogen by the slow oxidation of organic matter accelerated by sunlight specially in tropics where most of the developing countries are situated.

Dhar's Writings

Professor Dhar wrote more than a dozen of books and monographs mostly in english. Some popular books were written by him in bengali. His writings cover a period of 50 years. His mental alertness is evident from these writings. Reflections on Chemical Education is really his autobiography. The future generation will learn about him from his books.

Awards & Honours, Membership of the Societies etc

Professor Dhar was elected Fellow of the Chemical Society, London in (1916) and Royal Institute of Chemistry (1919); President, Chemistry Section, Indian

Science Congress (1922). In this session leading scientists of India brought a petition to Professor NR Dhar to start the Indian Chemical Society. The Society was formed and started working since 1924 with Acharya PC Ray as the first President. Dhar was elected President of Indian Chemical Society in 1933-34. He was the Founder Member (President, 1935, 1937), National Academy of Sciences, India (in Allahabad); Founder Member, National Institute of Science of India (now known as Indian National Science Academy; Member, International Agricultural Congress in Sveningen, Holland (1937); Foreign Member, French Academy of Agriculture (1955) and Corresponding Member, French Academy of Sciences (1961); General President, Indian Science Congress (1961); Member, International Congress in Pure and Applied Chemistry, Uppsala and Stockholm (1958); Member, International Soil Science Congress, Paris, Wisconsin (USA) (1960), International Fertilizer Congress, Opatia, Yugoslavia (1961), Soil Science Congress, Bucharest, Roumania (1964).

Professor Dhar was invited to deliver lectures at the Universities of London, Cambridge, Edinburg and Aberdeen in UK; Sorbonne, Toulouse and Biarritz in France; Opatia in Yugoslavia; Bucharest in Roumania; Madrid in Spain and Wisconsin in USA etc.

He was invited to deliver lectures by the UNESCO by Holy Father Pope in the International Symposium on *Organic Matter and Soil Fertility* organised by the Pontifical Academy of Science in the Vatican city at Rome in April 1968. He delivered lectures in almost all the Universities in India. He was invited to deliver Kamala Lectures in 1959 and Khaitan Lectures in 1974 and, Adhar Chandra Mukerji Memorial Lectures twice in the Calcutta University. Professor Dhar delivered Convocation Address at Calcutta and Gorakhpur Universities and IIT, Kharagpur.

DSc Degree (*Honoris Causa*) was conferred upon Professor Dhar by the Calcutta University, Viswa-Bharati University, Banaras Hindu University, Gorakhpur University, Allahabad University and Jadavpur University.

Munificence of Professor Dhar for the Advancement of Scientific Research in India and for Philanthropic purposes

Professor Dhar after constructing his residential building on Beli Road Allahabad in 1927 also constructed another huge building on the same land in the pattern of a Research Institute consisting of two big laboratories, one large central hall, one office room and half a dozen small rooms to be used as stores and staff rooms. The construction was completed in 1934 and was properly equipped in 1935 and was named as Indian Institute of Soil Science. After the demise of his wife Mrs Sheila Dhar in January 1949 (who was a distinguished physical chemist), Professor Dhar, on the advice of his favourite pupil, Dr Iqbal Krishna Taimini, a great theosophist and

Reader in Chemistry Department, Allahabad University renamed the Institute as Sheila Dhar Institute of Soil Sciences. He donated it to the Allahabad University on the condition that the Institute shall be an integral part of the Chemistry Department, Allahabad University and Professor Dhar shall be the Honorary Life Director. He also donated large amount of money to the Allahabad University for the creation of NR Dhar Endowment Fund out of which seven Sheila Dhar Memorial Fellowships of Rs. 200 each per month are awarded to Research Scholars carrying on research in Sheila Dhar Institute for their DPhil and DSc degrees of the Allahabad University. Extension of the Institute building was carried on with the help of a grant of Rs 3 lakhs sanctioned by University Grants Commission. Dr DS Kothari, Ex-Chairman, UGC is a pupil of Professor Dhar. A Green House was constructed with the UGC grant inside the Agricultural Farm of the Institute with an area of 2.57 acres. Professor Dhar also donated a piece of land and a cash of Rs. 15,000/- as a matching grant for the construction of the Sheila Dhar Hostel where research scholars of the institute reside.

Professor Dhar gifted land for building the National Academy of Sciences, India founded by Professor Meghnath Saha, Dhar, AC Banerji and other scientists. He also donated large amount of money for the creation of Acharya PC Ray Professorship of Agricultural Chemistry in Calcutta University.

Dr Atma Ram, a well known chemist was highly impressed by the creation of Sheila Dhar Institute of Soil Science by Professor Dhar and stated : *The foundation of Sheila Dhar Institute of Soil Science at Allahabad was an event which has few parallels in the history of science. There have been cases where amateure scientists of the days gone by, when modern science was beginning, built workshop laboratories of their own for doing experiments and making gadgets but not many of founding a whole research institution out of their hard earned money and nurturing it for nearly half a century while mentioning this, one is apt to be reminded of what Andrew Carnegie said while dedicating Carnegie Institution of Washington. This then is the theory of wealth to earn massively, to live frugally and donate magnificently.*

Professor Dhar donated large amounts of money to Viswa Bharati, Santiniketan for the improvement of agricultural research by the creation of an Endowment Fund out of which research scholars are to be awarded Fellowships. Professor Dhar, donated Rupees one lakh to Chittarajan Seva Sadan for building nurses quarters where his wife Mrs Sheila Dhar was medically treated and died of cancer. Professor Dhar donated his Barlowganj, (Mussourie) House to Ram Krishna Mission Ashram.

Inspired by the high ideals of sacrifice of his guru Acharya PC Ray, Dhar throughout led an austere life denyiny all personal comforts. He invested his hard earned money in buying National Savings Certificates which on maturity doubled, he

then donated this money to the different institutions already described. Thus his donations exceed whatever he earned in his whole life.

Dhar as a teacher

In the words of late Dr Atma Ram *Professor Dhar's emphasis has always been on making the students understand the principle of science rather than on stuffing information into their heads. He has been very fond of demonstrating experiments, more or less on the models of lectures at the Royal Institution, London. A large number of carefully designed experiments used to be arranged and performed with the elegance of a magician. The rapport between the teacher and his pupils was full and complete. I remember even now, one such repeated again and again. Oxidation is an exothermic reaction. Boys ! don't forget and don't commit mistake-oxidations are exothermic reactions. Professor Dhar never followed any syllabus. He wanted to impart education in the real sense and not just teach according to any text book.*

Dr Dhar was an ideal teacher, a great inspirer and a great lover of students.

If anybody wishes to know what his lectures were like, then he should ask some one who had listened to his popular lectures at the annual sessions of Indian Science Congress. They drew large number of eager listeners, who enthusiastically watched him showing experiments. He often spoke on nutrition and emphasized the need of taking more protein especially eggs. Professor Dhar's life was an example of the influence a teacher can exercise on his students. He came under the influence of great patriot scientist Acharya PC Ray. Dhar's patriotism found expression in his passion for India's scientific advancement. He life was a life of complete dedication to science—science for the benefit of all—no secrets, no patents, no royalties. In his frugal style of living he literally typified the tenets of *Ishopanishad*. His life motto had been *Work is worship* in action and not a slogan.

As a research leader, Professor Dhar was a hard task master—no week ends, no holidays. He remained active till the last breath. When he was ninety, Chemical Society of India brought a special issue, in which all of his pupils freely contributed their papers. It was because Dr Dhar happened to be the founder member of the society.

Marriage and Personal Life

Professor Dhar married Miss Sheila Roy in 1930. Sheila was the daughter of Sri Paras Nath Roy, MBBS, IDPH (London), a Chief Medical Officer of Calcutta Corporation, who died of plague, and niece of Dr BC Roy. She was a chemist in her own right and was a very gracious and cultured lady but she did not possess a good health. She travelled along with Professor Dhar in many European countries during his lecture tours. She died of cancer in Chittaranjan Seva Sadan, Calcutta in 1949.

After her death, Dr Dhar married Miss Mira Chatterjee in 1950. Mrs Mira Dhar had her education in Viswa Bharati, Santiniketan and did her MA in London. She is an artist.

Dhar had no issue from either of his wives Dr Dhar used to take long walks usually in the evening, throughout his life. He used to take a balanced and simple diet and he had a good health. He hardly used any medicine. He believed in plain living and high thinking. He used to wear Bengali dress—*dhoti-kurta* on special occasions. He had a great love for his brothers and sisters. He used to manage their expenses and even had to sell off his gold medals to meet the expenses of one of his sister's marriage. However, he did not use costly costumes. During winter he used to wear an overcoat. He never believed in groupisms or politics.

His Last Days

During his last days he was extremely anxious for the continuity of the Sheila Dhar Institute. He requested Professor RP Misra, the then Vice-Chancellor, Allahabad University in April 1986 to shift the MSc (Ag) classes from the Chemistry Department of the Allahabad University to the Sheila Dhar Institute and entrust his devoted pupil Dr Sheo Gopal Misra to look after the affairs of the institute. In a meeting called by the Vice-Chancellor, all the Professors and Senior teachers of the Chemistry Department accepted the request of Professor Dhar unanimously and accordingly the section of agricultural chemistry was shifted to the Sheila Dhar Institute on May 8, 1986. It was a great relief to Professor Dhar to see the institute humming with students and its continuity being thus ensured. Dhar was mentally alert till the last days of his life. Two research scholars—one for DPhil and another for DSc degree were working under him at the time of his death. He used to call them daily to issue instructions for research work and to check their experimental results.

He used to reply numerous letters received from scientists abroad and also from his pupils, admirers and different scientific and academic institutions in India. Professor Victor Kovda of USSR and Lady Eve Balfour, President Soil Association, UK regularly corresponded with Professor Dhar. He did not attend to any administrative duties.

Even a week before his death, he did not give any inkling to anybody that he was not keeping well and the end is nearer. He developed kidney trouble and faced extreme difficulty in urination. While entering to the bath-room at night, he fell down on the floor and was seriously hurt on the head and became unconscious. Eminent physicians were called who applied cathetor for urination. Thereafter, his face and body started swelling and he became extremely restless at night of December 5, 1986. The news of his death broke out like a wild fire. AIR and morning news bulletin, all

newspapers of the country announced his death. Vice-Chancellor, Pro-Vice-Chancellor, Registrar and large number of Professors, teachers and students of the university and many distinguished citizens thronged at his residence at 2-D, Beli Road to pay their last homage to the departed soul. All of them accompanied his dead body to the cremation ground. Thus ended the life of Professor NR Dhar, the doyen of science, a great benefactor of humanity whose great contributions in realm of science, whose donation of hard-earned money to the cause of education and advancement of scientific research, whose fatherly affection and care for his students in building up their career will always be remembered by his countrymen with gratitude and reverence.

SG MISRA

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2. Symposium entitled *Chemistry, Agriculture and Man* on the occasion of 90th birthday of Professor NR Dhar April 24-25, 1982 Souvenir, National Academy of Sciences, India.

3. Reflections on Chemical Education, 1972, for autobiographical data.

Recipients of Doctorate Degree of the Allahabad University under Professor NR Dhar

	Name	Title of the thesis	Degree	Year
1.	NG Chatterjee	Studies in adsorption	DSc	(1923)
2.	KC Sen	Adsorption and stability of colloidal solutions and other properties	DSc	(1925)
3.	AC Chatterji	Studies in Liesegang Rings	DSc	(1926)
4.	Satyeshwar Ghosh	Studies on the phenomenon of coagulation	DSc	(1926)
5.	BK Mukerji	Studies in photochemistry	DSc	(1928)
6.	CC Palit	Slow and induced oxidation	DSc	(1929)
7.	AK Bhattacharya	Studies in photochemical reactions	DSc	(1931)
8.	Satya Prakash	The Studies on the preparation and properties of some inorganic jellies and coagulation and clotting of blood and serum	DSc	(1932)
9.	DN Chakravarti	Some physical properties of colloids	DSc	(1935)
10.	Gopala Rao	Newer aspects of soil nitrification and ammonification	DSc	(1935)
11.	Atma Ram	Some aspects of applied photo-chemistry	DSc	(1935)
12.	WV Bhagwat	Studies in photochemistry	DSc	(1936)
13.	SL Das	Phosphatic nutrition of plants in calcareous soils	DSc	(1937)
14.	SK Mukerji	Fixation of nitrogen and its loss from soil	DPhil	(1937)
15.	SP Tandon	Nitrogen transformations in soil	DPhil	(1937)
16.	Raghunath Mittra	Studies on the formation of periodic precipitate in the absence of foreign gels and some properties of concentrated colloids	DSc	(1938)

17.	**HN Batham**	Studies on nitrogen in relation to soils, plants and waters	DPhil	(1938)
18.	EV Seshacharyulu	Nitrogen fixation and bacterial counts on the application of energy rich substance to the soil	DPhil	(1938)
19.	AK Bhattacharya	Composition of Prussian and Turnbull's blues and of ferric arsenate and ferrous arsenate	DSc	(1939)
20.	HL Dube	Some studies on gel formation and induced and photochemical reactions	DPhil	(1939)
21.	RC Mehrotra	Investigations on hexameta-phosphates, and studies in adsorption indicators	DPhil	(1948)
22.	BR Rao alias BVS Raghvan	Fixation of nitrogen and carbon	DPhil	(1948)
23.	RC Kapoor	Studies on the influence of temperature on nitrogen transformation	DPhil	(1948)
24.	BBL Saxena	Studies in fixation of atmospheric nitrogen with chemically pure substances	DPhil	(1949)
25.	K Bahadur	Studies on the growth of yeast	DPhil	(1949)
		Studies on the growth of yeast	DSc	(1956)
26.	BC Pandey	Studies in colloids	DPhil	(1949)
27.	MC Pant	Studies on loss of nitrogen from soil with different manures	DPhil	(1949)
28.	BG Chatterjee	Studies in the nitrogen fixation in soil with cellulosic substances	DPhil	(1949)
29.	Nand Kishore	Studies in the oxidation of certain metallic hydroxides and photo-chemical oxidation of carbohydrates by passing a current of air	DPhil	(1949)

30.	HL Nigam	Temperature kinetics and other physico-chemical studies of nitrogen loss	DPhil	(1949)
31.	BNP Ghildyal	Transformation of carbon and nitrogen compounds	DPhil	(1950)
32.	CV Suryanarayan	Studies on nitrogen loss in the transformation of different inorganic nitrogen compounds	DPhil	(1951)
33.	CR Narayanan	Studies on the decomposition of ammonium nitrite and other nitrogen transformations	DPhil	(1951)
34.	VP Sharma	Fixation of nitrogen with legumes	DPhil	(1951)
35.	CP Agrawal	Studies on nitrogen transformations	DPhil	(1951)
36.	KS Singh	Studies in alkali soils	DPhil	(1951)
37.	RW Nathan	Studies in photo-chemical reactions	DPhil	(1952)
38.	SK Ghosh	Studies in the formation of nitre beds (physico-chemical investigation on the nitrogen transformation in nature)	DPhil	(1953)
39.	Sudhamoy Bose	Minerals in soils	DPhil	(1953)
40.	SB Sinha	Nitrogen fixation and loss in surface and cultures	DPhil	(1953)
41.	DVP Gaur	Use of straw as manure	DPhil	(1953)
42.	Atharul Hasan	Studies on yeast	DPhil	(1953)
43.	B Ramamoorthy	Physico-chemical studies in the surface colour of virgin soils of India and the significance of this colour for plant growth	DPhil	(1953)
44.	AM Francis	Studies on the fixation of nitrogen	DPhil	(1953)
45.	GKD Roy	Studies in yeast	DPhil	(1954)

46.	GP Gupta	Studies in nitrogen fixation	DPhil	(1954)
47.	SG Misra	Formation of acid and alkali soils	DPhil	(1954)
48.	BK Dhar	Studies in phosphates	DPhil	(1954)
49.	SK Pal	Reclamation of usar soil (alkaline and barren)	DPhil	(1955)
50.	B Bose	Influence of phosphates, molybdates, vanadates and borates on nitrogen fixation	DPhil	(1955)
51.	S Ranganayaki	Studies on the growth of yeast	DPhil	(1955)
		Studies in 2, 3-Butanediol Fermentation	DSc	(1961)
52.	KL Nagpal	Nitrogen transformation in soil with saw-dust and leaves	DPhil	(1955)
53.	Pritam Singh	Nitrogen transformation in soil with clover, sanai etc.	DPhil	(1955)
54.	TN Chojer	Nitrogen transformation with lignite, Assam coal etc. as energy materials	DPhil	(1956)
55.	MS Lal	Nitrogen fixation and nitrogen loss in soils	DPhil	(1957)
56.	K Vadalkar	Studies in yeast	DPhil	(1957)
57.	KM Verma	Studies in titanium and other phosphates and compounds	DPhil	(1957)
58.	AC Gaur	Studies in composing	DPhil	(1957)
59.	D Sharma	Studies in aluminium and other phosphates	DPhil	(1958)
60.	KN Goel	Properties of soils and fertilizers	DPhil	(1958)
61.	GP Ghosh	Studies in complex compounds of phosphoric and other acids and their salts	DPhil	(1959)

62.	SR Hasan	Influence of light on nitrogen fixation and loss	DPhil	(1959)
		Physico-chemical studies on phosphorylation	DSc	(1979)
63.	GN Pant	Physico-chemical investigations of phosphates	DPhil	(1960)
		Physico-chemical investigations of phosphates	DSc	(1966)
64.	GC Shukla	Studies in nitrogen transformations	DPhil	(1960)
65.	VP Gupta	Studies in phosphates : Influence of light and phosphates in the slow oxidation of organic matter	DPhil	(1960)
66.	PSB Naidu	Studies in yeast	DPhil	(1960)
67.	Vimla Yadava	Nitrogen transformations in the growth of yeast	DPhil	(1961)
68.	PN Singh	Studies in alkali soils	DPhil	(1961)
69.	Jotirmoy Sanyal	Influence of light on nitrogen changes	DPhil	(1961)
70.	NK Banerji	Studies in alkali soils	DPhil	(1961)
		Studies on the amino acids in nitrogen fixation	DSc	(1967)
71.	Gulab Singh	Studies in the influence of light in nitrogen changes in decomposing organic matter	DPhil	(1961)
72.	RK Pandey	Phosphates in nitrogen transformation of organic matter	DPhil	(1962)
73.	D K Murty	Physico-chemical investigations on the formation and properties of phosphates	DPhil	(1963)
74.	GP Srivastava	Studies in alkali soils	DPhil	(1964)
75.	GN Bhatt	Studies in nitrogen fixation	DPhil	(1964)
76.	RG Chatterji	Studies on colloids	DPhil	(1964)

77.	RN Tiwari	Influence of phosphates on slow and induced oxidations	DPhil	(1964)
78.	SP Jaiswal	Studies in nitrogen fixation	DPhil	(1964)
79.	AK Rishi	Studies in carbon nitrogen transformations	DPhil	(1964)
80.	AK Dhar	Studies in phosphates	DPhil	(1965)
81.	BS Gupta	Studies in basic slags	DPhil	(1965)
82.	DN Sharma	Studies in nitrogen fixation in soils	DPhil	(1965)
83.	HK Chaturvedi	Studies in nitrogen loss	DPhil	(1965)
84.	PG Deo	Studies in carbon nitrogen transformations	DPhil	(1965)
85.	VK Srivastava	Studies in photo-chemical fixation of nitrogen	DPhil	(1965)
86.	SK Arora	Studies in nitrogen fixation (In presence and absence of basic slags and algae and amino acid formation)	DPhil	(1966)
87.	KS Bhattacharya	Physico-chemical aspects of phosphates	DPhil	(1966)
88.	Smita Chowdhry	Studies on nitrogen fixation	DPhil	(1966)
89.	RC Kapoor	Studies on phosphates	DPhil	(1967)
90.	Gulab Singh	Nitrogen fixation by algae	DPhil	(1967)
91.	Sohan Lal	Nitrogen fixation	DPhil	(1967)
92.	RV Ramana Rao	Studies on phosphates	DPhil	(1967)
93.	KC Srivastava	Studies in basic slag	DPhil	(1968)
94.	MK Fotedar	Studies in phosphoric acid and phosphates	DPhil	(1968)
95.	MM Verma	Studies in phosphates	DPhil	(1968)
96.	PN Kapoor	Studies in carbon nitrogen transformations	DPhil	(1968)

97.	AP Khera	Studies in basic slags	DPhil	(1969)
98.	Ganesh Singh	Studies in phosphates and basic slags	DPhil	(1969)
99.	RS Panwar	Studies in nitrogen fixation	DPhil	(1969)
100.	B Das Gupta	Studies in colloids	DPhil	(1969)
101.	GC Gupta	Studies in soil fertility	DPhil	(1970)
102.	SP Nair	Manufacture of a rich manure containing NPK and trace elements	DPhil	(1970)
103.	SN Singh	Studies in soil fertility	DPhil	(1970)
104.	MK Dhar	Studies in ores, rock phosphates and basic slags	DPhil	(1970)
105.	OP Srivastava	Studies in soil fertility	DPhil	(1971)
106.	AK Sen	Studies in nitrogen fixation	DPhil	(1971)
107.	CK George	Studies in soil fertility	DPhil	(1973)
108.	SS Singh	Studies in saline and alkali soils	DPhil	(1973)
109.	RPS Chauhan	Studies in saline and alkaline soils and their reclamation	DPhil	(1973)
110.	AN Verma	Carbon nitrogen transformations and yield of vegetables	DPhil	(1973)
111.	KR Kushwaha	Studies on nitrogen fixation and nitrogen loss in vegetable production	DPhil	(1973)
112.	PC Agrawal	Studies in induced oxidation and nitrogen loss	DPhil	(1973)
113.	Thomas Vargese	Studies in the slow oxidation of organic compounds	DPhil	(1973)
114.	NK Srivastava	Studies on slow oxidation reaction	DPhil	(1974)
115.	JN Singh	Studies on saline and alkaline soils	DPhil	(1974)
116.	GD Mishra	Studies in phosphorylation	DPhil	(1974)

117.	SC Chaturvedi	Studies in fixation of nitrogen in fats and oils	DPhil	(1974)
118.	Pervez Williams	Studies in horticulture	DPhil	(1974)
119.	SP Rai	Physico-chemical studies on phosphorylation	DPhil	(1974)
120.	G Prasad	Studies in plant growth	DPhil	(1975)
121.	AK Kolay	Studies on physical properties of soil	DPhil	(1975)
122.	DC Srivastava	Studies in soils with reference to the effect of organic matter and phosphates on yield and composition of vegetables	DPhil	(1976)
123.	SP Singh	Studies in nitrogen fixation	DPhil	(1976)
124.	LP Singh	Studies in soil fertility-crop production by mixture of organic matter and phosphate in normal and alkali soils	DPhil	(1976)
125.	VPN Singh	Studies in soil fertility	DPhil	(1976)
126.	SP Srivastava	Studies on crop production	DPhil	(1976)
127.	MB Singh	Organic matter and phosphates in vegetable production	DPhil	(1976)
128.	Paulose TP	Atmospheric nitrogen fixation in the slow oxidation of edibles	DPhil	(1976)
129.	HG Sharma	Soil fertility	DPhil	(1977)
130.	RB Ram	Study in soil fertility	DPhil	(1977)
131.	UK Pati	Nitrogen fixation and nitrogen loss	DPhil	(1977)
132.	NK Shukla	Studies on atmospheric nitrogen fixation in soil	DPhil	(1978)
133.	Shipra Pal	Studies on influence of phosphate in nitrogen transformation	DPhil	(1978)

134.	SW Boaz	Studies in carbon and nitrogen transformation	DPhil	(1979)
135.	RP Sharma	Crop production by the application of organic matter and phosphate	DPhil	(1979)
136.	VK Goel	Use of phosphated compost for the replacement of NPK fertilizers	DPhil	(1979)
137.	A Kumar Singh	Organic matter and phosphate in fodder production	DPhil	(1980)
138.	SS Singh	Nitrogen transformations in the slow oxidation of edibles and other organic substances by air	DPhil	(1980)
139.	MK Singh	Influence of sulphur drugs and antibiotics in the slow oxidation of organic substances by air	DPhil	(1980)
140.	Prem Shankar	Studies on slow oxidation of spices and other edibles	DPhil	(1981)
141.	RD Singh	Production of rich manure by organic matter and phosphates	DPhil	(1981)
142.	Mohammad Kaleem	Effect of organic matter (phosphated and unphosphated) on soil fertility and crop production	DPhil	(1981)
143.	TB Singh	Influence of nitrogenous fertilizers on crop production by a mixture of organic matter and phosphates	DPhil	(1981)
144.	DB Singh	Effect of organic matter and phosphate level on the growth, yield and quality of vegetables	DPhil	(1982)
145.	MR Kulshrestha	Influence of alkali on slow oxidation of organic and inorganic substances	DPhil	(1982)
146.	M Barnabas	Studies on nitrogen fixation and nitrogen loss	DPhil	(1983)

147.	KC Joshi	Value of organic matter plus phosphate in potato production and effect on quality of potato tubers	DPhil	(1983)
148.	SM Khare	Influence of rock phosphate or Tata basic slag with organic matter in crop production	DPhil	(1984)
149.	SK Dwivedi	Study on alkali soil and its reclamation	DPhil	(1985)
150.	SB Singh	Organic matter and phosphate in crop production	DPhil	(1985)

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