Indian Journal of History of Science, 37.4 (2002) 347-365

THE BEGINNING OF BIOCHEMICAL RESEARCHES IN INDIA—A HISTORICAL PERSPECTIVE

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(*Received 3 April 2002 ; after revision 9 August 2002*)

This article is a historical account of the development of biochemistry as a branch of science in India. Mahendralal Sircar's dream Institution, the Indian Association for Cultivation of Science, established in 1876 in Calcutta, initiated lectures on modern chemistry and physiological chemistry, the prerequisites for the study of biochemistry. The biochemical researches however did not take off because of financial constraints and also due to Sircar's isolation from modern medical researches. The outbreak of diseases like plague, cholera and kala-azar signalled the beginning of a new era in medical sciences in India. The first decades of the twentieth century saw the commencement of nutrition research in India. Researches on fermentation for the production of power alcohol, acetone, etc. were initiated at the University College of Science & Technology, Calcutta and at the Indian Institute of Science, Bangalore during the first three decades of the last century. Moreover, acquaintance of a few science graduates with the work of European pioneers of biochemistry like Carl Neuberg, Gowland Hopkins and others influenced them to take up the study of this branch of chemistry, when they returned to India after advanced training from abroad. The establishment of the Indian Institute of Science at Bangalore and the All India Institute for Hygiene and Public Health at Calcutta may be said to have laid the foundation of biochemical researches in India, though these institutes contributed very little to the basic education in biochemistry at that time. It was during the first forty years of the last century we see the establishment of a number of institutions which turned out to be important and well-known centres for biochemical researches in India after Independence.

Key words : Biochemical research, IISc. Bangalore, AIIH&PH Calcutta, Fermentation, Infectious diseases, Nutrition research.

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Biochemistry emerged as a new branch of science in the nineteenth century Europe with the contributions of the pioneers like Lavoisier, Liebig, Wohler, Buchner and others. They tried to decipher the 'Chemistry of life'. Knowledge of modern chemistry, a pre-requisite for biochemistry, was alien to Indians in 1828 when Friedrich Wohler laid the foundation of 'Biochemistry' by synthesizing urea, a substance of biological origin from an inorganic compound, ammonium cyanate. Unlike the fields of botany and geology, the British rulers in India did not encourage investigations in the field of chemistry, as this, according to one school of thought[1], was not conducive to exploitation of natural wealth of this country at that time. Only at the end of the nineteenth century, because of its close association with pharmacy and materia medica, chemistry received due attention at the Bengal, Madras and Bombay Medical Colleges (established during 1835)[2]. In 1899 session of the Medical College, Calcutta, Major L.A. Waddell. I.M.S., in his lectures introductory to the course on chemistry, expressed, 'that the more important advances which have been made in scientific medicine of late years have been chiefly owing to the chemistry methods of research on diseases[3]. Throughout the nineteenth century, India experienced the emergence of modern science imported from Europe. The beginning of the twentieth century, as a result, opened up new horizon in chemical researches and studies. This article intends to highlight the historical events that led to the initiation of biochemical researches and studies in India during the first forty years of the last century.

At the end of the nineteenth century it was felt by Indians like Dr. Mahendralal Sircar, Jamsetji Tata, Acharya Prafulla Chandra Ray and others that the progress of this country depended crucially on researches in science. As a result, the Indian Association for Cultivation of Science (IACS) at Calcutta and Indian Institute of Science (IISc) at Bangalore were established in 1876 and 1911 respectively. In view of his commitment to homeopathy Mahendralal was ostracized by the British doctors of the Indian Medical Association, even though he was fully qualified as a M.D. of the university. He was not invited in the 1894 Indian Medical Congress held at Calcutta. Unfortunately, Mahendralal Sircar was somewhat prejudiced against the new developments in the science of medicine and biology. When the Plague

Research Laboratory was set up in Bombay in 1896 under Haffkine to produce not only anti-plague serums but also anti-cholera vaccination that worked wonders, Mahendralal expressed that he had no faith in Haffkine's anti-plague inoculation. He also had a rather hot discussion with Dr. Barmeimann and Dr. Mackenzie on Haffkine inoculation and vaccination[4]. During 1898 Ronald Ross, while working at Calcutta, discovered the route of transmission of malarial parasite through the agency of mosquitoes. He received Nobel Prize in 1902 for his discovery. However, in Sircar's diary we find no reference to the momentous discovery of Ross. Nonetheless, we notice that he believed in the efficacy of reducing the population of mosquitoes by destroying their breeding areas. Furthermore, he used to say 'that in case of malaria, quinine may be administered straightway and Hahnemann need not be followed'[5]. Mahendralal isolated himself from such modern medical researches and took interest in physical sciences. At this period he was in close contact with Father Lafont of St. Xavier's College. Because of Mahendralal's attitude towards modern medicine, biochemical researches were not encouraged at the IACS though lectures on chemistry and physiological chemistry were initiated by Biman Bihari Dey and Nilratan Sarkar[6]. In this context, it should be pointed out that in Europe medical bacteriology critically influenced the discovery of cell-free fermentation by Eduard Buchner in 1897. The living cell was now to be viewed not in terms of integrated protoplasm but as a membrane-bound bag containing a whole series of defined protein catalysts. Biochemistry began to emerge as a science concentrating on dynamic metabolism and intracellular chemical conversions. In 1901 F. Hofmeister chose to depict the living cell as an enzyme-based machine shop. The same sentiment was expressed by Sir Frederick Gowland Hopkins in Britain before the British Association for Advancement of Science in 1913. This has often been taken as the classic statement formulating biochemistry as a unitary science based on the study of dynamic metabolism mediated through enzymes[7].

In 1898 Jamsetji Tata, the famous industrialist, proposed to the Government of India that he would like to provide a princely donation for the establishment of a 'Research Institute of Science' to be built on the model of the Johns Hopkins University in Baltimore, USA and hoped that the

Government would arrange a matching grant and infrastructural facilities. Mahendralal welcomed Tata's Scheme but wondered why his twenty-year old scheme (the IACS) had been overlooked by the Nation and the Government. However, on the initiative of the Dewan, K. Seshadri Iyer, the Government of His Highness Krisnaraja Wodeyar IV, the Maharaja of Mysore, came forward with an offer of 372 acres of land in Bangalore, free of cost, and promised other necessary facilities. The Maharaja of Mysore laid the foundation stone of the Institute on 24th July in 1911. The first batch of students was admitted to the Department of General and Applied Chemistry under Norman Rudolf. Within two months, the Department of Organic Chemistry was opened. Biochemical Research was initiated in the Applied Chemistry department of this Institute during the First World War when there was a great demand for acetone for manufacturing cordite. During 1908-11, pure culture fermentation trials had been carried out in Boroda, when large amount of alcohol was produced from the well-known indigenous Mohua flower. It was then decided by G.E.C. Wakefield, Director General of Revenue, Hyderabad that Mohua (*Bassica latifolia*) flower might serve as a possible raw material for acetone. There was not a single laboratory in India where acetone could be produced from alcohol by direct fermentation process. Prof. Dixon of the University of Manchester then suggested that Gilbert J. Fowler who had accepted an appointment in the Applied Chemistry Department of the Indian Institute of Science at Bangalore, could conduct necessary experiments in India to produce acetone by direct fermentation of alcohol. However, in the autumn of 1915, a request reached Fowler from the Engineering Agents to the Government of Hyderabad, to obtain a culture of *'Mycoderma aceti'*. This was because they already were able to produce a large amount of alcohol from the well-known indigenous 'Mohua' flower; they now required the Mycoderma culture for fermentation of alcohol to acetic acid and finally, acetone. Fowler met G.E.C. Wakefield, the Director General of Revenue, Hyderabad in 1915 when the latter was in England on leave. An interview took place at the Indian Office where Wakefield brought to the notice of Fowler, the importance of 'Mohua' tree as a producer of sugar from the flower and oil from the seed. It was then arranged that a small consignment of 'Mohua' should be sent to

Weizmann in London for investigation. Very little time was available before Fowler sailed for India but preliminary trials showed that 'Weizmann bacillus' did ferment an infusion of Mohua flower. Fowler visited the experimental plant of the Royal Naval Cordite Factory. The characteristic properties of the bacillus that was used by Weizmann, were explained by his assistant to Fowler at the Lister Institute. A number of culture and spore tubes were supplied and safely conveyed to Bangalore. In mid-February 1916, Fowler arrived at Bangalore. A consultation with the Government of India was then held in Delhi where it was decided that a factory for the production of acetone should be started. Accordingly experiments were carried out at the Applied Chemistry department of IISc, Bangalore under the direction of Fowler for some months in 1916. But as other material was found more satisfactory and cheap as Mohua, its possible use as a raw material for acetone was only partially investigated and attention was directed to its possible use as a source of industrial alcohol and especially of motor fuel[8,9]. Thus, investigations on Mohua oil were the beginning of biochemical research in India. Fowler and his associates took an initiative to solve the demand for acetone by fermentation, a true biochemical process. An experimental plant was afterwards set up at the Applied Chemistry department of IISc in which 800 gallons of mash could be fermented and distilled. Soon Fowler was requested by the Indian Munition Board to investigate the bacterial factors involved in the manufacture of starch. It was concluded after biochemical experimentation that ordinary paddy carried certain resistant germs some of which are allied to the acetone-producing bacillus of Weizmann[10]. Fowler and his Indian associates, Ganesh Vaman Joshi, A.G. Gokhale, M. Srinivasiah, V. Subrahmaniam, Prafulla Chandra Guha and others conducted biochemical researches at the IISc. They worked in the following areas: the biochemistry of Indigenous Indigo dye vat; studies on extensive bacterial oxidation: (a) alcohol to acetic acid, (b) ammonia to nitric acid; studies on the biochemistry of Mohua flower fermentation; the production of power alcohol; paper pulp from waste cellulose materials by enzyme action; the retting of coconut husk; fermentation of toddy to produce alcohol and vinegar; contribution to the scientific study of Lac-industry. At the Presidential Address to the Chemical

Section of the Indian Congress held at Lahore in 1918, Fowler stressed on the importance of 'The training of students in Applied Chemistry'[11]. Later in 1921, the first chair for Biochemistry was instituted at the IISc and was offered to Fowler. It should be noted that the first chair in Biochemistry in England was created at Liverpool in 1902 and it was not until 1914 that Cambridge followed suit. It was first occupied by the celebrated Sir Gowland Hopkins. In the Department of Organic Chemistry, IISc. J.J. Sadborough, H.E. Watson and associates experimented on the splitting of oils by means of castor seed lipase. An article in this connection follows– 'the production in India of a crude glycerin capable of readily yielding a dynamite glycerin on distillation attracted a good deal of notice during the war and our attention having been drawn to the subject by the Munition Board, we carried out experiments...in order to determine whether would it be possible to accomplish this object by means of the well known castor seed ferment. A sample of the distilled glycerin was submitted to the Government Cordite Factory, Aravankadu and the report was to the effect that the sample appeared to be quite suitable for nitration but that larger quantities would be required before a completely reliable opinion could be expressed'[12]. From mid-twenties onwards emphasis shifted however to a wider field when this institute joined hands with the Pusa Agricultural Institute, Delhi for studying the nutritional values of Indian seeds for consumption in which biochemistry played an important role. Although the Department of Biochemistry of the Indian Institute of Science (IISc), Bangalore is one of the oldest department of biochemistry in India, in terms of basic education in biochemistry the department contributed very little during the first four decades of the last century.

The first decade of the 20th century saw the commencement of nutrition research in India. McCarrison and McCay were the pioneers in the field and till 1920 were the only investigators in India actively engaged in nutritional sciences. Both were impressed by the fact that the physique and health of Indians varied in different parts of India. Both of them were convinced that the underlying cause was dietary. McCay devoted his attention to the protein element in nutrition whereas McCarrison's concept of the role of diet was more comprehensive. He planned his experiments

to test the effects of natural dietaries with multiple defects of deficiency and imbalance on the physiological function and structure of body organs. India owes it to McCarrison that he not only founded a school of nutrition research in India but also helped to attract other scientific workers to this field, by his brilliant researches. It would be no exaggeration to say that McCarrison laid the foundation on which the present structure of nutrition research in India has been built up. McCarrison began his researches at Kasauli (Punjab) in 1913-14 on the relationship between the diet and disease under the auspices of the Indian Research Fund Association. In 1918 he moved down south to Coonoor in Tamil Nadu and started his researches on beri-beri. Within a few years the scope of his activities widened and his unit at Coonoor became known as 'Deficiency Disease Inquiry'. In 1926 the Royal Commission on Agriculture recommended the establishment of a central institute for nutrition research. McCarrison took the advantage of this recommendation and proposed to the Indian Research Fund Association that the unit under him be recognized as equivalent to a central institution. From 1929 onwards the unit at Coonoor was known as the Nutrition Research Laboratory (NRL) and was the only institution in India devoted to researches in human nutrition. McCarrison was appointed the first Director of this Institute. W.R. Aykroyd was the Director from 1935 to 1945. Both of them initiated researches on biochemistry dealing mainly with problems related to food and nutrition, soil microbiology, fermentation, enzymology and vitamins[13]. Since facilities available at Coonoor for expanding activities for clinical work was inadequate, NRL was shifted to Hyderabad in 1959.

The three universities of Calcutta, Bombay and Madras were established in 1857. The Applied Chemistry Department of the Calcutta University was another center where a special paper on 'Fermentation' was offered at the time of its inception in 1920. This was due to Hemendra Kumar Sen, Professor at the Applied Chemistry Department, Calcutta. With great zeal, unparalleled devotion and conspicuous ability, Sen set himself to the task of building up the Department of Applied Chemistry from a small beginning. In the early part of his service in the University College of Science, he used to deliver lectures to his students on almost all branches

of chemistry, namely, thermodynamics, biochemistry, organic and physical chemistry, chemical engineering. In his research programme too he did not confine himself to any particular line of study. A variety of problems on chemistry related to both pure and applied including biochemistry were tackled in his laboratory by a body of competent research workers. One special problem attracted his attention; it was eradication and utilization of water hyacinth, which at one time threatened to block all smaller waterways of Bengal[14]. Production of power alcohol by fermentation from a particular type of wood (*Excoecaria agallocha*) found in Bengal, constituted another long range problem of research in his laboratory. This was a case of one man's effort to bring 'biochemistry' to India. In those days most of the Indians who could get a fellowship for higher study usually proceeded to Europe to work at different pioneering Universities. This was also the case with Sen. During his stay in Europe in 1922 he came in contact with Carl Neuberg while working under his guidance at the Kaiser Wilhelm Institute at Dahlem, Berlin. Carl Neuberg introduced the term 'Biochemistry' in 1903 for the first time. Sen worked on certain biochemical problems with Neuberg and shared a patent on a particular process of fermentation with him[15]. During twenties and thirties of the last century, Sen was particularly interested in biochemical and applied chemical investigations. He was especially attracted to fermentation chemistry: the fermentation of alpha-ketocaproic acid by yeast in a phosphate buffer. He worked on biochemical transformation of unsymmetrical dichloroacetone into optically active α, α–dichloro-isopropyl alcohol and water hyacinth as a source of fuel, at the Applied Chemistry department. It was during 1930s that the subject of fermentation was developed into a division of Applied Biochemistry. Later in this department, original investigation on vitamins, nutritional problems, microbial metabolism, etc were initiated. Along with the expansion achieved in this university, the thirties also saw the introduction of teaching and research in biochemistry at a few other places. The Plague Research Laboratory set up in Bombay in 1896 under Haffkine, started a biochemistry section in 1924. At Acharya P.C. Ray's initiative the Bengal Chemical and Pharmaceutical Works started functioning in 1903 at Calcutta. The factory was engaged in the production of sulphuric acid and some pharmaceutical

products described in the British Pharmacopoeia[16]. Later when B.C. Guha joined the Bengal Chemical Works, after his return from England in 1932, he initiated work on the preparation of vitamin concentrates and biologically active compounds from glandular products The Department of Biochemistry was established at the University of Madras in 1933 and studies were initiated on proteins. At about the same time the Food Technology Section (1934) was started in the Department of Chemical Technology of Bombay University. In 1935 and 1936 biochemical researches were initiated at the Bengal Immunity Research Institute, Calcutta and at the National Sugar Institute, Kanpur respectively. The need for biochemical researches in medical sciences as well as industry[17] was felt at the same time.

The history of establishment of the Calcutta School of Tropical Medicine (1920) and the All India Institute of Hygiene and Public Health (1933)—two important centers for biochemical research could be traced from the advent of plague in India in 1896. Plague caused a general awakening in the matter of health and prevention of diseases. It was in 1912 that the Government of India realized the importance of a declaration on sanitary policy and public health. Grants were allowed to local governments to carry out researches on a sound basis. The government then insisted that the candidates for the Assistant Directorships of Public Health should have a British diploma of Public Health. In the resolution it was also stated, '...soon arrangements can be made in India which will enable Indians trained in this country to become health officer of the first class'[18]. Soon Universities of Calcutta, Bombay, Madras and Lucknow initiated specific courses for training in public health. Some preliminary ideas of biochemistry and nutrition were introduced in the course matter. It was in 1914 that the idea of establishing institutes for postgraduate study in tropical medicine and hygiene, was conceived by Sir Leonard Rogers. It was proposed that there should be a School of Tropical Medicine in Calcutta and an Institute of Hygiene in Bombay, and that both of these might be on an all India basis. In 1920, the Calcutta School of Tropical Medicine was opened owing to Sir Leonard Roger's perseverance and enthusiasm. The Governments of India and Bengal and various private benefactors also

contributed generously to the fulfillment of the mission. This Institute combined teaching and research in both tropical medicine and hygiene. Thus biochemical research was introduced to solve medical and nutrition problems. As time went on, public health policy broadened and expanded in almost all Indian provinces. The need was felt for native workers trained with the special requirements for India. At this point of time, W.S. Carter, Associate Director of the Rockefeller Foundation, USA met Major General Sir John Megaw, Head of the Calcutta School of Tropical Medicine. He became deeply impressed with the necessity of establishing an All India Institute of Hygiene. It should be mentioned here that during 1933 decision was taken by the Rockefeller Foundation to encourage the application of physical and chemical techniques to the study of biological problems[19]. Carter grasped the obvious advantage of Calcutta as the location for the Institute of Hygiene and of a site close to the Calcutta School of Tropical Medicine, where the basic subjects would be taught. Finally the Rockefeller Foundation provided the cost of acquiring the site selected. They also contributed to build and equip an All India Institute of Hygiene and Public Health. The building was completed in 1932 and was formally opened by Sir John Anderson, the Governor of Bengal, on December 30, 1932. The Biochemistry and Nutrition Section was opened in March 1933 along with three other sections related to public health and hygiene. H. Ellis C. Wilson as Professor and Bashir Ahmad as Assistant Professor joined the Biochemistry and Nutrition Section in 1934[20]. Chemical or biological techniques for estimating quantitatively the vitamin contents of different food materials were developed only in late 1920s in Europe. Wilson used these techniques for accurate knowledge of the basic composition (including vitamins) of all the ordinary foodstuffs and diet survey of the different classes and communities. In this study he was in agreement with Robert McCarrison (of the National Research laboratory, Coonoor), that it was essential to know the constituents of foodstuffs before any detailed information on the relationship between diet and disease could be obtained. When the Biochemistry and Nutrition Section at the All India Institute of Public Health and Hygiene started to function, McCarrison cooperated with Wilson to solve many nutrition related problems. McCarrison observed

that rats developed urinary stone due to faulty diets. Work based on these lines was taken up at the All India Institute of Hygiene to account for the rarity of urinary calculus in Bengal and its comparatively common occurrence in Punjab. A grant from the Indian Research Fund Association enabled the department to carry out biological assays of vitamins. Bashir Ahmad did considerable research on the vitamin contents of various Indian foodstuffs. He found that the shortage of vitamin C was probably one of the commonest nutritional faults of Indian dietaries. His work on metabolism of hexuronic acid (vitamin C) indicated that the tissues had a considerable capacity for storing hexuronic acid and that even in healthy subjects the depoits were not fully saturated. It seems that the vitamin research that gained momentum in Europe, especially at the Cambridge University under Prof. Gowland Hopkins, had influenced the Indian workers too. An interesting work on the relationship between radioactivity in water (and possibly food stuffs) and vitamin deficiency was carried out by N.K. Chatterjee under Wilson's guidance. These experiments indicated that radioactive spring water from Bengal might prevent and cure early symptoms of vitamin deficiency such as xerophthalmia. But today it is known that it is a case of vitamin A deficiency. At Muir's (of Allahabad University) suggestions, blood proteins, albumin and globulin content in different types of leprosy (cutaneous and nerve types) were investigated by Wilson. He observed that in both types there was a considerable variation in the ratio of the two proteins. The report of the head of the Biochemistry and Nutrition section of the institute could be an indicator of biochemical researches that were taken up during that period, to throw light on nutrition and health related problems[21]. The general work of the Biochemistry and Nutrition section during the first ten years of the Institute could be divided into two main lines: '(*i*) an investigation into the food and nutrition of the community, (*ii*) the prosecution of special problems, namely, food analysis, diet survey and nutritional survey of children from Calcutta'. This section of the Institute was full of activities during 1933-1940 on research related to health and nutrition.

Another institute that initiated biochemical researches was the Institute of Medical Research at Calcutta. It was set up by a group of patriotic

scientists and medical professionals on January 1, 1935. The founder members of this institute were H.N. Ghosh, J.C. Roy, A.C. Ukil and Nabajiban Banerjee. These pioneers were motivated by an indomitable spirit of sacrifice and courageous commitment to the country's needs. It was perhaps the first non-governmental medical research institution in India. It merged with the incorporated the then Pasteur Clinical Laboratory of H.N. Ghosh at 41, Dharmatala Street, Calcutta. The aim of the Institute was to conduct research on biomedical sciences both in their basic and applied aspects. There was a need to investigate health problems of the country and to provide a center for the training of research workers so that the knowledge thus obtained could be applied to practice medicine. The scheme of the project was proposed in 1933 and donations and endowments from public were requested. This not only was a concern for medical persons and scientists but also individuals like Rabindranath Tagore, Madan Mohan Malaviya, A.R. Dalal, G.L. Mehta who signed the first appeal for funds along with acharya P.C. Ray, Dr. Nilratan Sarkar, Dr. Bidhan Chandra Roy and others. Rabindranath Tagore appealed. 'The neglect of national health, one of our greatest national assets, is appalling. Mortality from preventable diseases is colossal....India does not lack research workers of the best training who are ready to devote themselves to these problems, but thus far they have failed to find any place for carrying out this research under proper conditions and adequate equipment. The establishment of such a well-conceived center for medical research depends upon adequate donations and endowments received from the public. Let me entreat my fellow-countrymen for a ready response to this appeal for assistance for this Institution that through their support they may make it a real success.[22]

From its inception the Indian Institute of Medical Research started working on Biochemistry and Nutrition, Bacteriology, Protozoology, Chemistry, Immunochemistry and Chemotherapy. Along with these were a Diagnostic Laboratory and a Clinical Unit. The founders hoped that after the first year, the Institute would be able to support itself from the revenues earned from clinical diagnostic work and the manufacture of standardized vaccines, sera and other products, following the model of Pasteur Institute of Paris. Unfortunately, the target for mobilization of public support did

not materialize and during the first three years only Rs. 10,652.00 was collected. Inspite of difficult and uncertain finances, the Institute's scientific reputation gained steadily. Recognition came as research grants and fellowships from the Tata Trust, Calcutta University, Indian Research Fund Association, Indian Council of Medical Research, National Institute of Sciences, India and even Calcutta Corporation. The Institute started publishing its own journal *Annals of Biochemistry and Experimental Medicine* from 1941, to provide a medium for the publication of original work in biochemistry and allied areas. Earlier Indian research workers had to send their scientific articles to journals edited by British that were often rejected without any valid reasons. When this institute was set up at Calcutta, cholera was a dreaded name in the Gangetic plains of Indian subcontinent, especially, the delta area of Bengal. Therefore, considerable importance and priority were given to cholera research. Under the leadership of Professor H.N. Ghosh, founder-Director of the Institute, a cholera research team initiated investigations on serological characterization of *Vibrio cholerae* strains and biochemical analysis of several enzymes and toxins[23]. From the beginning the institute laid a strong emphasis on biochemistry. This was largely due to the influence of Biresh Chandra Guha. He came back in 1931 from the Biochemical Laboratory, Cambridge University after working for five years under Prof. Jack Drummand and later under Prof. Gowland Hopkins, the Nobel Laureate, famous for his work on vitamins. Guha did pioneering work on B Vitamins in England. He took interest in nutrition research at the Medical Research Institute, Calcutta. Even after he left the Institute to accept the Chair of Applied Chemistry at the University College of Science, Calcutta in 1936, he maintained strong academic ties with this Institute. Scientists from Applied Chemistry Department regularly visited and worked at the Medical Research Institute. The result of this free exchange of thought and experience was the interaction of the disciplines of biochemistry and parasitology: the use of *Leishmania* as a model organism to study biochemical processes, or conversely, to understand the biochemical basis of parasitism. Nutrition research gained momentum under the guidance of B.C. Guha. This was concerned with the protein, vitamin and mineral values of Indian foodstuffs and the metabolism and vitamin C in

human and experimental animals. Later Guha earned fame for original biochemical research on vitamin C. Soon Guha applied himself with zeal to build up an active school of biochemistry at the Applied Chemistry of the University College of Science, Calcutta. The Indian Institute of Medical Research had to work with insufficient and uncertain finances till it was taken over by CSIR in 1956 when it was renamed the Indian Institute for Biochemistry and Experimental Medicine to reflect the activities of the Institute which were mainly biochemistry and microbiology applied to medicine. The name of the institute was later changed to Indian Institute of Chemical Biology (IICB). IICB is now internationally famous for its contribution to researches on biochemistry and allied sciences and for training of biochemists on modern biochemical techniques and studies.

Initiation of biochemical research was possible because there were a number of Indians who after completing Master Degree Course in Chemistry from different Indian Universities went to Europe for advanced studies and came in contact with pioneers of modern science. In this connection we should mention Hemendra Kumar Sen, Nil Ratan Dhar, Biman Bihari Dey, Biresh Chandra Guha and others who contributed to the beginning of biochemistry in India. N.R. Dhar visited France, Germany and Britain to work on physical chemistry. After his return he joined the Muir Central College, Allahabad and engaged himself to work on problems related to photochemistry, colloidal chemistry and finally to biochemistry. He delivered a series of lectures at the Patna University in 1932 in an effort to discuss the general physico-chemical principles underlying animal metabolism[24]. He published a book *New Conception in Biochemistry* which dealt with the chemical aspect of biochemistry that have any bearing on metabolism. The book contains account of contemporary biochemical researches done in Europe. With a series of biochemical experiments Dhar and his associates tried to find out the causes of several diseases. They concluded that exaggerated oxidation of one of the three classes of food materials in preference to the other might have led to the incidence of these diseases. It is worth mentioning here that by 1910 Physical Chemistry had also began to rear its head and claimed a recognized position of its own. The credit should go to N.R. Dhar for being the pioneer and initiator of the

study of this branch of chemistry in India. He also inspired J.C. Ghosh, J.N. Mukherjee, S.S. Bhatnagar and others in its pursuit. J.C. Ghosh later inspired his students to study biochemistry when he got associated with the Chemistry Department of the Dhaka University (now in Bangladesh). One of his students at the Dhaka University, Madhab Chandra Nath wrote, 'J.C. Ghosh inspired me through his kind advice to study books and journals on biochemistry in 1930 and to think of a suitable research problem in biochemistry for the degree of Doctor of Science (DSc.) although there was none in the department to help and guide me in my work[25]. Later Kalipada Basu together with M.N. Basak, H.P. Nath, S.N. Sarkar created a leading school of research in biochemistry at the Dhaka University. Their researches spanned enzymes, vitamins, sterols and bile acids, proteins and endemic dropsy. England's influence through Prof. Gowland Hopkins laboratory at the Cambridge University, played a distinct and important role to initiate biochemical research in this country. A list of Indians who worked in his laboratory during 1930s, clearly indicates his influence and contribution to the Indian biochemistry[26].

Guha, Biresh Chandra (1930-31)—Later Professor of Biochemistry, University of Calcutta.

Sen, Kshitish Chandra (1931)—Staff Member, Indian Institute of Science, Bangalore.

Roy, Surendra Nath (1932-35)—Later Head of Nutrition Section, Indian Veterinary Research Institute, Izatnagar, U.P.

Pillai, R.K. (1935-39)—Senior Scientific Officer, Agricultural Research Station, Coimbatore, Travancore.

Sokhey, Sir Sahib-Singh (1937)—I.M.S., Director of Haffkine Institute, Bombay.

Sreenivasaya, Motanhalli (1937-38)—Head, Department of Fermentation Technology, Indian Institute of Science, Bangalore.

Bhagvat, Kamala (1937-39)—Later Director, Coonoor Nutritional Institute.

Subrahmanian, Vaidyanatha (1939-40)—Head of Biochemistry Department, Indian Institute of Science, Bangalore.

It should be mentioned here that all researches on biochemistry related to medical research, during the first forty years of the last century were possible due to the funds provided by the Indian Research Fund Association. As early as 1911, the Government of India set up the Association with the specific objective of sponsoring and coordinating medical research in the country. It has changed to Indian Council for Medical Research after Independence. It is the apex body in India for the formulation, coordination and promotion of biomedical researches and is one of the oldest medical research bodies in the world. To meet the long felt need of scientists working in the new emerging discipline of biological chemistry, 'The Society for Biological Chemists (India)' was founded in 1930 with its headquarter at the Indian Institute of Science (IISc), at Bangalore. It was registered under the Societies Act in the Princely State of Mysore and the memorandum of registration was signed by the late Profs. V. Subramanian, V. Pattawardhan and C.V. Natarajan, leading figures in the biochemical researches at that time. The original objectives of the Society were to coordinate the work of biological chemists in different parts of India, to hold meetings and symposia for discussions on important topics of scientific and technical interest and for presentation of original papers. In 1931 when sufficient fund was available, the Society started publishing *Annual Reviews of Biochemical and Allied Research* on biochemical researches carried out in India. During the Second World War period the Society played a crucial role by advising the Government on the utilization of indigenous biomaterials as food substitutes, drugs and tonics, on the industrial and agricultural waste utilization and on management of water resources. The other areas of vital interest to the Society in the early years were nutrition, applied microbiology, preventive medicines and the development of high quality proteins from indigenous plant sources. Various laboratories were encouraged to undertake that kind of work.

The early part of the next decade overlapped with the war years and saw little progress in the extension of biochemical activity. During the late forties, however, several new centers of biochemistry were established of which special mention may be made of the establishment of the National Chemical Laboratory (1949) with a full-fledged division of biochemistry,

the Departments of Biochemistry at the Nagpur University (1946) and in the Institute of Science, Bombay (1949) and a biochemistry section in the Chemistry Department of the Poona University (1948). A section for biochemical research was also established in the Christian Medical College, Vellore (1948). We thus see that biochemical research was initiated in India during the first four decades of the last century primarily for two reasons: (1) for fermentation of alcohol to acetone, required for manufacture of cordite during the First World War, and (2) for combating diseases like plague, cholera, kala-azar and malaria that took the shape of epidemics in different parts of this country. Nutrition related biochemical researches were also taken up during that period. It can thus be concluded that during the first forty years of the last century, there was considerable progress in the development of biochemistry which laid the foundation of this branch of chemistry in India. After Independence, particularly in early 1959 University Grants Commission felt it necessary to have a systematic assessment made of the status and standards of teaching and research in biochemistry in India. A Review Committee in Biochemistry was appointed. B.C. Guha, P.S. Sarma and other members of the Committee submitted their 'eighteen points' recommendations for future plans for the advancement of Biochemistry in India. Today Indian biochemists and their research activities attract international attention. But that is beyond the scope of this record which deals with early part of an history.

Acknowledgements

The author is grateful to Indian National Science Academy, Delhi and Asiatic Society, Kolkata for academic support and sponsorship. She is equally thankful to Prof. D.P. Burma, Prof. S.K. Mukherjee and others for kind interest and guidance in the paper.

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