



Chhishna Murti



COIMBATORE RAMADORAI KRISHNA MURTI

(1923 -1990)

Elected Fellow 1971

COIMBATORE RAMADORAI KRISHNA MURTI affectionately known as CRK or CR by his innumerable friends and admirers and Murti by his family members was a well known biochemist and environmental scientist of India. He was very soft spoken, of gentle temperament and had special affection for young and upcoming scientists. He was an erudite scholar, a prolific writer and eloquent speaker who endeared himself to all due to his gentle manners, graciousness and amicable nature.

BIRTH, CHILDHOOD AND EDUCATION

CR Krishna Murti was born on March 3, 1923 in his maternal grandfather's house at Trichur in Kerala State. His father Ramadorai was an MA (Honours) in Economics and was working as an Officer in the Imperial Bank of India to be later known as State Bank of India. His mother Meenakshi was a devout and accomplished housewife. Krishna Murti's fraternal ancestors were from a family of priests who were profound scholars of Sanskrit and well known for their knowledge of VEDAS. Unfortunately, Krishna Murti lost his father at the tender age of two years and as per the Hindu customs his mother returned to her father's house at Thiruvambady, Trichur. His maternal grandfather was the famous TV Kasturi Ranga Iyer, at the Diwan of Trichur. Krishna Murti spent his early childhood and had his early education of his maternal grandfather's house. His mother was a very devout and pious lady who had acquired thorough knowledge of Sanskrit and Indian scriptures by self study. Krishna Murti had great attachment and respect for his mother. She was the source of motivation and encouragement for Krishna Murti for his higher education, love of music and Indian culture, for compassion as well as his overall development.

Krishna Murti received his early education at Vivekodyam School, Trichur which was very close to his house. There was an outstanding English teacher Shri Achuta Menon (who later became the Chief Minister of Kerala State) who inspired CRK most giving proof to his literary taste of English. However, science attracted Krishna Murti most and after passing Matriculation in First division he joined Intermediate Science in St. Thor



College, Trichur with Physics, Chemistry and Mathematics. He passed his Intermediate examination in First division with State rank. CRK cultivated the habit of writing a diary from the age of 15 and his diary of college days reveals his clear goal to become an eminent scientist. He joined BSc. (Hons) in Andhra University where he had eminent teachers like Prof. TR Seshadri for Chemistry and Prof S Bhagvantam for Physics who were his greatest source of inspiration. Around this period (1940-42) the freedom struggle was in full swing and CRK's diaries reveal that he wanted a free India and to work for 'Bharat Mata'. He was a great admirer of Gandhi, Nehru and Rajaji and had feeling of hero worship for them. In science he was greatly inspired by Sir PC Ray, Sir JC Bose and Madame Curie. Together with his academic pursuits CRK also developed a keen interest for English, Tamil and Malyalam literature which kept him busy reading in his spare time. Apart from this, he developed a great taste for Carnatic music and during his summer vacations he made it a point to be at Madras and attend few concerts during the music season.

In April 1942 at the age of 19 CRK obtained his Bachelor of Science degree with Honours and rank fifth specialization in Chemical Technology.

PROFESSIONAL CAREER

At Calcutta : After obtaining his BSc (Hons) degree with specialization in Chemical Technology in 1942, CRK moved to Calcutta to look out for a job in the Pharmaceutical Industry. Calcutta was in those days the headquarters of Pharmaceutical Industry. Krishna Murti's desire at this stage was to become independent as he had depended upon support from his maternal uncles for a long time. At Calcutta he worked in a rubber tyre factory for some time and after some effort he landed up with a job in East India Pharmaceuticals as a chemist making tinctures and liver extract. The period of 1942-43 was of intense freedom struggle and Bengal famine with epidemics and starvation taking large toll of life at Bengal and parts of Andhra, Orissa and Kerala leaving lasting impression on young Krishna Murti and inspiring him to work on problems of human health and nutrition.

At Indian Institute of Science, Bangalore : CRK had an intense desire to do research and on receiving information of his being selected for the award of Rs. 40/- monthly scholarship offered by the Madras Government and tenable at Department of Biochemistry IISc Bangalore, he promptly resigned his Rs. 90/- pm, job at the pharmaceutical company at Calcutta and rushed to Bangalore in Aug., 1943 to join in his own words "the Mecca of Indian Science – The Tata School". The sight of the Institute, its library and laboratories was very impressive for him. The Director of the IISc Bangalore those days was Sir CV Raman. Krishna Murti was received very graciously by Prof. V Subrahmanyam and assigned to develop process for making peptone



pectin. He was advised that these items were urgently needed by the country, in the middle of World War II and as a recipient of a Government scholarship it was his duty to devote wholeheartedly to developmental work. CRK developed method for making pectin and studied their properties under the direct supervision of Dr KV Giri.

After two years tenure of Madras Government scholarship, Prof V Subrahmanyam having been apprised of CRK's disastrous financial plight, appointed him as a Research Assistant on a CSIR scheme on vegetable rennet. he also permitted CRK to supplicate for his PhD degree from Bombay University since IISc Bangalore did not have the status of university at that time. This led to a closer interaction of Krishna Murti with his mentor, he did extensive work on preparation and purification of a milk clotting enzyme from the latex of *Ficus carica* including a patented process. This preparation could be used as a substitute for calf stomach rennet for curdling milk, an essential step in cheese making. Subsequently he was also moved to the Vanaspati Research Unit sponsored by the Ministry of Food and learned the rudiments of nutrition in the rats as well as orphanage children.

Dr V Subrahmanyam had played a very important role in achieving self-sufficiency in biochemicals and under him CRK developed abiding interest in pursuing problems which would yield results of immediate practical importance to the country. While working on enzyme purification he came under the magic spell of Dr PR Venkataraman and was inspired with his total commitment to research. He was also helped and inspired by Dr V Jagannathan whom he called as 'the hand of destiny' to give him some kind of direction to his research efforts.

During his stay at Bangalore CRK would visit Madras often to see his relatives and spend some holidays with them. He was married on August 21, 1946 to Brinda, daughter of Mr Pattabhiraman who was in the Excise department of the erstwhile Madras State.

In 1947 India got freedom. Krishna Murti's sense of patriotism and happiness can be judged from entries in his diary of 16-8-1947, "I live in free India. I breathe the air of freedom. The free skies canopy over me. The free air surrounds and sustains me. Freedom has come to us after a bitter struggle full of tribulations and suffering.....Today I salute you Bharat Mata. I dedicate my life to you. Kindly show me the path I have to tread and do my bit of service to you".

In 1949 CRK obtained his Doctorate degree from Bombay University; Dr V Subrahmanyam was his guide and Dr PR Venkataraman was a close associate who guided him very intimately. In 1949 Dr Subrahmanyam left for Central Food Technological Research Institute, Mysore as Planning Officer and Dr PR Venkataraman left for postdoctoral research in USA. Most of the other colleagues of CRK also left for USA or UK for higher studies. The fellowship of CRK also stopped and by then he had two daughters and his mother and wife to support. But he did not want to go abroad immediately due to his attachment to his family and country.



At Central Drug Research Institute, Lucknow : Dr CR Krishna Murti was amongst the few scientists to be recruited by Council of Scientific and Industrial Research, New Delhi in early 1950 for the establishment of Central Drug Research Institute, Lucknow. He was appointed as a Junior Scientific Officer. In spite of his other relatives opposing his moving to North he accepted the offer and reached Lucknow with his family and found accommodation in Aminabad close to Naaz theatre. CRK was inducted in the Biochemistry Division then headed by Dr DL Shrivastava and got busy with the dedication ceremony of CDRI by Pandit Jawahar Lal Nehru. At CDRI Dr Krishna Murti built an active school of Biochemistry working on the Biochemistry of bacterial pathogens, enzyme inhibition in relation to drug action and utilisation of agricultural and slaughter house waste. In 1962 Dr Krishna Murti became the Assistant Director and the Head of Biochemistry Division. The programmes of the Division were reorganised with major emphasis on Biochemistry of protozoan and helminth diseases, lipids and membranes, molecular biology of development and regulation, and preparation of biochemicals and therapeutic products from biological waste products. He built up active collaboration with KG Medical College, Lucknow working on problems like phototherapy of neonatal jaundice, burns and utilisation of blood and placenta for the preparation of therapeutic products.

Dr CR Krishna Murti received advanced training in Enzymology in UK and was amongst the first few scientist from India to be trained in use of isotopes for biological research at Atomic Energy Establishment at Harwell, UK. In 1964 he visited 11 countries in South East Asia on behalf of the Association of Scientific Workers of India to establish linkage with scientific organisations. He participated in many scientific conferences on behalf of India including the International Congress of Biochemistry at Vienna (1958), New York (1962) and Stockholm (1972). In 1968-1969 he was also invited as a visiting Professor at University of Southern California School of Medicine, Los Angeles, USA.

In 1972 Dr CR Krishna Murti was given the merit promotion to Deputy Director (ScF) in recognition of his valuable contributions. During the stay of Dr Krishna Murti at CDRI he built up active liaison with other Biochemical institutions and Universities. Outstanding students from various institutions in India used to throng to him for doing research. His emphasis on human resource development was exemplary and many graduate employees of the Division of Biochemistry obtained their MSc and PhD degrees and matured as successful scientists. In all 41 students obtained their PhD degree under his supervision at CDRI.

At Industrial Toxicology Research Centre, Lucknow : In September 1975 Dr CR Krishna Murti moved over to Industrial Toxicology Research Centre, Lucknow on invitation from its Founder Director Dr SH Zaidi and got immediately involved with Dr Zaidi in organising the International Congress of Toxicology and formation of Toxicology Society of India. He reorganised the activities of Pesticide toxicology area bringing in considerable amount of mechanistic studies and residue analysis surveys.



In April 1978, on the superannuation of Dr Zaidi, Dr Krishna Murti took over as the Director, ITRC. During his stewardship ITRC consolidated its programmes on occupational health and industrial toxicology and introduced elements of environmental toxicology in a large way. Phytotoxicology, microbial degradation of toxicants, ecotoxicology, and mutagen testing were introduced. Several lines of biochemical research eg. biotransformation, lipid peroxidation, biodegradation were introduced and multidisciplinary approach introduced in toxicology research. A big new campus of SITRC was acquired at Gheru laboratories built up and advanced instrumental facilities acquired. The foundation stone of Gheru Campus was laid by Dr MGK Menon. The Occupational Health Centre was started at Kanpur during his leadership.

Realising the full potential of ITRC, during this phase the participation of Centre in the regulatory activities, through the newly formed Department of Environment, and the Pollution Control Boards also flourished. ITRC was recognised as the reference laboratory for water analysis. Epidemiological studies gained momentum during this period and several nationally important surveys such as Agate workers and food animals as indicators of pollution were conducted. A full-fledged Environmental Monitoring Laboratory was established at ITRC. ITRC interacted with the Central Pesticide Board in a big way and many of the regulatory stipulations and the creation of support facilities were the direct outcome of it. Likewise, the inputs from ITRC for several standards by ISI such as hazardous substance analysis, safety, stocks, raw materials, emanations etc. were phenomenal in this period. Dr Krishna Murti played a key role in listing of hazardous chemicals and suggesting threshold limit values for occupational and community environment. Dr Krishna Murti and his task force made major contributions towards evaluating the consumer safety of non-soap detergents and highlighting the need to set regulatory standards for consumer safety. Under his leadership, an all India coordinated programme on heavy metals in the environment was launched with ITRC as the nodal agency. He also initiated several lines of interaction with institutions like National Institute of Occupational Health, Ahmedabad and a Neurotoxicology unit was established at KG Medical College, Lucknow. He also initiated several international collaborative exercises through ICAR, WHO, IPCS, IRTPC and contributed to many documents. As India's representative to Scientific Committees on Problems of Environment (SCOPE) of International Council of Scientific Unions (ICSU) he contributed towards several documents.

Dr Krishna Murti was keenly interested in the welfare activities for the staff and during his tenure human resource development programmes were carried out leading to over 20 graduate employees of ITRC undergoing MSc training and more than 25 people received their PhD degree under his guidance. Dr Krishna Murti was elected as the President of Society of Biological Chemists (India) during 1978-1980 and also organised 49th Annual meeting of SBC in 1979, which was one of the biggest annual meetings.



All his students and colleagues demonstrated their respect for their mentor, friend, philosopher and guide in a fitting manner by celebrating his 60th birthday on 3rd March 1983 in the form of a symposium presided over by Dr V Ramalinga Swami FRS.

Dr Krishna Murti retired from the Directorship of ITRC on 31.3.1983.

Post-retirement Career; Madras, Delhi and international Scientific Arena : In 1983 after his retirement from ITRC Dr Krishna Murti moved to Madras and settled there with a plan to get involved in Music fully and partly in Science. However, retirement did not result in cessation or any let up in his activities as he was destined to serve science and his motherland to his last day. At this stage he got 'Pitamber Pant National Fellowship in Environmental Sciences' (1983-85) and CRK had to devote his time for this from the Department of Environmental Engineering of Anna University campus at Madras. In between he started the Madras Science Foundation with a few other retired scientists. At the invitation of WHO he participated in several seminars in India and abroad. In Dec. 1984 the Bhopal Gas tragedy took place. The Government appointed him as the chairman of the Scientific Commission to initiate studies on the effects of gas leakage on life systems and lay down guidelines for a scientific base for avoiding future Bhopals. This meant a move to Delhi but Dr Krishna Murti accepted the challenge inspite of his mother's advanced age and his own eyesight being weak. CRK organised the various activities, submitted the report before time and returned to Madras and joined the Cancer Research Institute, Adyar, Madras as its Research Director. He activated and upgraded the activities of Madras Science Foundation and in 1989 he started the programme on the river Kaveri and kept his office just next to his residence at Adyar. In between he published many papers and contributed to several books.

In August 1989 while he was away to Bhopal on a seminar, his mother breathed her last. CRK could not reach Madras in time for the funeral due to disruption of flights and before his return the funeral was over; CRK returned as a very dejected person. During the subsequent period he was keeping himself active with the Madras Science Foundation and completed a number of projects.

On 30th June 1990 he attended his office and even attended music performance at the Mylapore Fine Arts and returned home. Dr Krishna Murti was about to take his dinner that he complained of acute pain on the rear side of his chest. Doctors advised that he be shifted to the nearest hospital for treatment. Even on the way and at the hospital CRK pleaded that life be restored to him, so much was his desire to live and work. Unfortunately at about 22.30 hrs he collapsed and that was the end of a glorious person like Dr CR Krishna Murti, who was true to his name the real image and manifestation of Lord Krishna.



SCIENTIFIC WORK AND SOME MAJOR CONTRIBUTIONS

Biochemistry of Bacterial Pathogens : Dr Krishna Murti developed an active school of biochemistry investigating the metabolic mosaic and enzymatic make up of pathogenic Gram negative bacteria eg *Vibrio cholerae*, *Salmonella typhosa*, *Pasteurella pestis* as well as acid fast *Mycobacterium tuberculosis*. The biochemistry of *V. Cholerae* responsible for human cholera was studied in detail mapping the pathways for utilisation of sugars, amino acids, nucleic acid precursors, oxidative mechanisms to decipher specific targets of drug action. This work was extensively quoted in the WHO monograph on cholera edited by J Pllitzer. He developed a technique for controlled lysis of *V. cholerae* and enteric Gram negative bacteria in the presence of lysozyme and EDTA and the lysate could be used for subcellular fractionation. The gentle lysis yielded the plasma membrane preparations which catalysed electron transport and oxidative phosphorylation while the cytosol had the enzymes of amino acid, carbohydrate and nucleic acid metabolism. His work on biochemistry of bacterial pathogens brought recognition to Dr Murti by election to the Fellowship of Indian National Science Academy (INSA) in 1971.

Mode of action of antibiotics and drugs : During his work at Bangalore Dr Murti had demonstrated the inhibition of thiol-dependent milk clotting activity of papain and ficin by allicin and penicillin. This work on enzyme inhibition by antibiotics proved very relevant for his subsequent work at CDRI. He demonstrated that the mechanism of streptomycin action involved a primary effect on the plasma membrane leading to disturbance in the bioenergetics of streptomycin-sensitive cells, the involvement of metal chelation in the inhibitory action on bacteria by tetracyclin, and the complexing of coenzyme pyridoxal phosphate of mycobacteria by isonicotinic acid hydrazide (INH). He was invited to write a chapter on INH in the book entitled ANTIBIOTICS vol. III edited by Corcoran and Hahn, Springer Verlag, Berlin (1974).

Biochemistry of amoebiasis and helminthiasis : The necessity of studying the biochemistry of parasites as a prerequisite to develop their rational chemotherapy was recognised by Dr Murti and at CDRI much before WHO adopted several protozoan and helminthic infections under. 'Tropical Disease Research Programme'. He constituted an active group of scientists working on biochemistry of amoebae and helminth parasites. Understanding the molecular mechanism of amoebic encystation and excystation holds the key to lasting control of amoebiasis. Since *Entamoeba histolytica* does not encyst *in vitro* in axenic cultures a free living amoeba *Acanthamoeba culbertsoni* was chosen as a model. Conditions for the cultivation and synchronous encystation were developed and the key molecular events in encystation were deciphered. The demonstration of the role of catecholamines in triggering encystation through the agency of cyclic-AMP was the highlight of this work. The molecular mechanism involved the triggering of derepressing factors by cAMP leading to synthesis of cell wall components such as cellulose, glycoproteins and phosphoproteins. He received the Basanti Devi Amir Chan



award of ICMR in 1972 for this work as well as elected to the Fellowship of Indian Academy of Sciences, Bangalore. CRK and his colleagues also found that the failure of *E. histolytica* to encyst in vitro was due to loss of receptor activity to amines and by treatment with bacterial toxins and other triggering agents they obtained relatively dormant precystic stages, closest anyone has come to encystation of this pathogen.

Photodecomposition Of Bilirubin And Management Of Neonatal Jaundice :

Hyperbilirubinaemic newborns face a high risk of bilirubin encephalopathy, death at high plasma bilirubin concentration or subsequent mental retardation if they survive. In view of the limited blood bank facility in our country, exchange transfusion method for managing hyperbilirubinemia cannot be practiced at large scale. Collaborative studies of Dr Krishna Murti conducted at Paediatrics Department of KG Medical College, Lucknow with Prof PC Bajpai spread over 6 years and covering more than two thousand jaundiced newborns showed the usefulness of phototherapy in the management of neonatal jaundice. Studies with mammalian and human skin segments, epithelial layers indicated that skin collagen provides a matrix for binding of bilirubin and a large area to facilitate photodecomposition. This leads to formation of large number of water soluble metabolites which can be disposed by renal route of clearance by passing the as yet undeveloped bilirubin conjugating system. The studies provided a possible mechanism of bilirubin toxicity as well as the rational basis for phototherapy in managing neonatal jaundice. This work was recognised by INSA in 1981 for the award of Sunder Lal Hora medal for outstanding contribution of a sustained nature to the growth of Biological Sciences in India.

Biochemical Toxicology And Related Biomedical Studies : The mechanism of bilirubin toxicity during neonatal jaundice was investigated through its interaction with human erythrocytes. The toxicity involved binding of bilirubin to membrane lipids, derangement of membrane permeability and leakage of hemoglobin and Glucose-6-phosphate dehydrogenase as well altered uptake of nutrients.

Dr Krishna Murti and colleagues also showed that in the reticulocytosis induced by phenylhydrazine, the maturation of RBC comprises changes in the structure and function of reticulocyte membranes. The demonstration of the less of sensitivity to stimulation by epinephrine of membrane bound adenyl cyclase of mammalian reticulocytes during maturation provided guidelines for exploring the development and differentiation of plasma membrane.

CRK and associates also made valuable contribution on the role of non-enzymic lipid peroxidation in tissue inflammation and other toxic manifestations as well as the role of antioxidants like rutin. A cytosol localised pro-oxidant factor was shown to interact with membrane located lipids to produce free radicals and consequently lipid peroxidation as part of the biochemical mechanisms inducing the inflammatory process and tissue degradation. The nature of this factor was elucidated.



Production Of Biochemicals, Utilisation Of Waste Products, Biologicals : Tutelage of CRK under Dr V Subrahmanyam provided to him the necessary enthusiasm and aptitude for applied research of immediate importance to the country and making it self-sufficient in biologicals. He started his research career by developing processes to make pectins from Indian fruits papaya and guava as well as developed methods to prepare a milk-clotting enzyme from the latex of *Ficus carica* which was relatively free from the proteolytic activity and effective in curdling milk an important step in cheese making. The vegetable rennet was also effective in cheese making from vegetable proteins where the rennet from calf stomach was ineffective.

At Bangalore Krishna Murti also learned rudiments of nutrition. His exposure at an impressionable age to the suffering of masses due to famine and the perennial problem of protein deficiency in poor South Indian diet and the resulting kwashiorkar and marasmus in children inspired him to dedicate himself to work on nutrition and protein supplements. The present author has always been intrigued by a picture of a kwashiorkar child which always hung in the office of Dr Murti at CDRI, probably as a constant reminder of his mission. Isolation of proteins and preparation of protein hydrolysates from oil cakes and other protein-rich sources constituted a lasting interest of Dr Murti. Methods for protein extraction, pretreatment to optimise extraction as well as the nature of nitrogenous constituents of oil cakes *vis a vis* their extractability and nutritive value were vigorously pursued. A protein hydrolysate from the distillary sludge was made and evaluated for its nutritional and biological value. Supplementation of the protein hydrolysates with amino acids like lysine, methionine and cysteine were also done to upgrade their nutritive value. The studies on protein nutrition, deficiency and amino acid supplementatic etc. were taken to their logical course by examining the catabolism of amino acids especially histidine. Studies on enzyme induction, enzyme catabolism *vis a vis* protein starvation and amino acid supplementation provided valuable lead on regulation of enzyme level and their activity. Effect of nutritional deficiency on lipid peroxidation and effect of saccharin, cyclamates were also evaluated to understand the response of host to xenobiotics during nutritional deficiency.

Self-sufficiency In Biological Products : The need to achieve self-sufficiency in biochemicals and other biological products was a mission inherited by CRK from Dr V Subrahmanyam. To this end he tried to develop processes to make useful products from agricultural wastes, slaughter house wastes and other easily available biological materials. The processes involved making lecithin, other phosphatides, ubiquinone, tocopherol concentrate etc. from rice bran, preparation of peptone and meat extract concentrate, enzymes from plant latexes, pancreating, pepsin from slaughter house products and lanolin and cholesterol from other waste materials.

In order to meet the demand for human plasma albumin for treatment of shock and injury suffered by our armed forces during the Chinese aggression, Dr Murti and his team at CDRI established jointly with the Command Pathological laboratory, Lucknow



a IOL unit for fractionation of human plasma and purification of albumin, fibrinogen and gamma globulin. The therapeutic value of plasma albumin prepared thus in the treatment of shock was demonstrated in trials on wounded armed personnel at the base hospital, Lucknow. Later he also set up an unit to handle upto 20 pieces of human placentae for the extraction of placental serum albumin and placental serum immunoglobulins. He also served as a consultant to the Industries Development Bank, India on the gamma-globulin project, an Indo-Bulgarian venture financed by IDBI and acted as technical consultant to M/s. Curewell (India) Ltd. Faridabad in implementing the above project.

Plant Biochemistry And Seed Germination : Starting from his initial success in developing a process for vegetable rennet from the latex of *Carica papaya* the plant Biochemistry continued to fascinate CRK. He and his colleagues subsequently discovered several new bacteriolytic enzymes from plant latexes, some of which were purified and characterised to differ markedly from egg white lysozyme. Plant latex as a source of alkaloids, terpenoids, other biochemicals and as a source of energy was also realised.

Seeds and agricultural wastes as a source of protein and other pharmaceuticals was his continuous endeavour. He studied seed germination system and changes in lipid and protein profile etc. with a view to upgrade their nutritional value as well as a model system to understand development and differentiation. The growing seeds of Bengal gram *Cicer arietinum* was used as a model to examine the molecular biology of germination process including the regulation of protein synthesis, action of indole-3-acetic acid, role of cAMP, adenylyl cyclase etc. in RNA synthesis as well as tryptophan catabolism. The germinating seed system was evaluated to examine the effect of metabolic inhibitors, pesticides, toxicants and rapid screening of carcinogens and anti-carcinogens etc.

RESEARCH RELATED TO POLLUTION CONTROL

Safety Evaluation Of Chemicals : With the implementation in late 1970s of the Insecticide Act, it became necessary to evaluate and report on the safety of pesticides and their formulations so that the licensing agency can grant necessary licenses. ITRC under the leadership of Dr Krishna Murti established a Central Facility for Safety Evaluation of Pesticides and formulations and provided the requisite report to the manufacturers. The scope of the facility was later extended to include industrial chemicals. In order to build a comprehensive facility for evaluating the effects of pesticides and chemicals, a new campus was acquired at Gheru and in the Phase I a few labs, an animal breeding centre, a sophisticated analytical laboratory and a model ecosystem including an artificial lake and greenery were built up during 1978-83. The trees and the lake provided conditions favourable for supporting a minisanctuary for birds and terrestrial small animals and a life support system for continuing observations on ecological changes water-soil and air-water interfaces. The facility was used for evaluating the impact



organochlorine pesticides on soil ecology, seed germination and pollen development. Facility for inhalation toxicology were also initiated.

Dr Krishna Murti and his team initiated studies on the residue levels of organochlorine pesticides (DDT, BHC) in wild birds, oils, milk, human tissues including adipose, maternal blood, cord blood, human placentae to evaluate the placental transfer and ill effects on new-borns. Long term exposure of personnel employed by Malaria Eradication programme for spraying insecticides in households and habitations led to macual damage and behavioral changes. Studies on the degradation of HCH revealed rapid interconversion among the isomers and the gamma isomer (Lindane) was found to exert a specific inhibitory effect on the fluxes of potassium in cellular systems. Effects of endosulfan on seed germination and pollen development were examined. The action of endosulfan on seed germination was related to interference with the mobilization of auxins and their triggering of the enzymatic degradation of food stored in the cotyledons for production of substrates for subsequent growth and seedling development. Application of endosulfan by spraying on pollens led to significant suppression of viability pollens and consequent reduction of biomass in mustard and green gram plants.

Dr Krishna Murti led a team of 12 scientists to the Indo-US workshop on Biodegradable Pesticides by National Science Foundation of USA and Department of Science and Technology, Government of India. The background papers of the workshop were later published by Plenum Press, New York & London in 1982 under the joint editorship of F Matsumara, Leadership of US Delegation and CR Krishna Murti. The proceedings of the workshop edited by BS Athri, NL Ramanathan and CR Krishna Murti were published by the Department of Environment, Govt. of India in 1982.

Survey of processed food sold in markets of UP indicated 15-20% use of non-permitted colours like metanil yellow. Biotransformation of metanil yellow to P-amino-diphenylamine, a chemical related to the carcinogen phenylendiamine was demonstrated. The interaction of the dye benzanthrone with skin proteins was examined with a view to understand the dermatits caused in textile workers observed in Rajasthan and Gujarat.

The carcinogenic potential of some heavy metals like Ni and Cr has been of primary concern for their safety evaluation. A mode system based on regeneration of liver after partial hepatectomy of albino rats was used to explore effect of heavy metals on cellular proliferation and differentiation. The metallothionines were also examined in potentiating or modulaing the toxicity of Cadmium in growing rats.

Dr Krishna Murti and colleagues made a survey of different types of non-soap detergents for manual washing of clothes and their effect on housewives. The survey highlighted the urgent need for quality assessment of these products from consideration of health safety. This led to Government decision on the structuring of the industry and making statutory regulatory standards for consumer safety assurance.



In gearing up the activities of the Centre for Safety evaluation of chemicals it became necessary to develop new methods for toxicity testing or adopt known methods to local conditions. The centre had also to take up challenges related to the evaluation of long term safety of chemicals and consumer products necessitating multigenerational studies on rodents etc. All this presented a unique situation and development of expertise turned out to be one of the most essential preoccupations of Dr Murti in the period 1979-1983. Thus the seed germination system was standardised as a short term test for the screening of anticancer activity of chemicals against known carcinogens.

Risk Assessment of Chemicals : Dr Krishna Murti's involvement in safety evaluation of chemicals led him to the area of risk assessment of chemicals in the environment. His services were used by decision takers and policy makers to synthesise information on toxicity of chemicals, to extrapolate data obtained from experimental studies to man, establish interlinks with exposure to chemicals in the work, living and ambient environments, and provide general guidelines for setting national standards for threshold limit values and admissible daily intakes of potentially toxic chemicals.

From 1980 Dr Krishna Murti was continuously associated with the International Registry for Potentially Toxic Chemicals, the International Programme on Chemical Safety cosponsored by World Health Organization, United Nations Environment Programme and International Labour Organization, the Scientific Committee on Problems on Environment under the International Council of Scientific Unions (ICSU) and the Scientific Group on Methodologies for Safety Evaluation of Chemicals. These activities have led to the preparation of number of overviews which have been included as chapters of the SCOPE publications on Metal Cycling, Ecotoxicology and Climate and SGOMSEC publications of Methods for Testing Mixture of Chemicals, Exposure Assessment, Methods to Minimise Injury due to Chemical Accidents.

Ecotoxicological Studies : Employing model microcosms Dr Krishna Murti studied the interaction among the species in aquatic systems polluted by environmental chemicals. The specific response of some of the interacting species of the food chain could also be pursued. Disturbances in the rate of calcium uptake from water by snails turned out to be a sensitive indicator of pollution by non-soap detergents. The contribution by Dr Krishna Murti on safety evaluation of detergents for housewives has been presented in an earlier section.

Another aspect of ecotoxicity studied by Dr Krishna Murti was the misuse of pesticides for suicide in the State of Tamil Nadu, India. A retrospective survey from the records of Forensic Sciences Laboratory at Madras and five district headquarters was made by his colleague who also analysed the results of the medical and toxicological management of the suicide case in the Intensive Care Unit of the Madras Medical College.



The near fatal cases resulting from consumption of carbomates or organophosphates could be saved by treatment with pyridine amino oxime under careful supervision and toxicological surveillance.

An activity coordinated by Dr Krishna Murti in regard to ecotoxicological problems was the study of the health of food animals living in the mining and industrial belts of India. This study involved the collection of 18000 samples of tissues of cattle, sheep and goats from the mining regions of Bihar, West Bengal, Orissa and Andhra Pradesh and their histopathological examination and the analysis of the dust samples collected from the lungs and lymph nodes by X-ray fluorescence spectrometry.

CONTRIBUTION TOWARDS POLLUTION CONTROL

DR CR Krishna Murti evinced a sustained interest in understanding environmental changes in the Indian sub-continent in relation to diverse developmental activities. Specifically he was concerned with pollution by heavy metals and non-biodegradable organic chemicals as a result of industrial growth and modernization of agriculture. He synthesized toxicological information on industrial and agrochemicals and developed multidisciplinary approaches to their safety evaluation.

He was the recipient of the Pitamber Pant National Fellowship in Environmental Sciences (1983-85). Dr Krishna Murti initiated studies on consumer safety of non-soap detergents, their ecotoxicological effects and misuse and abuse of pesticides. He prepared a status report on Residue Levels of Pesticides in Food and Biological Tissues as part of a series of special reports issued by the Indian National Science Academy in celebration of its Golden Jubilee (1984). He also authored a Book entitled 'Man, Environment & Chemicals' published by the Madras Science Foundation in a series of background reading materials for spreading scientific temper in the country.

He evolved an integrated R & D programme on heavy metals and coordinated the same in six centres. This programme envisaged sample survey of Hg, Pb, Cd, Cu, As, Se, Ni, Cr and Mn in water, air, food and levels of Pb and Cd in biological tissues. The report has been completed and published by Tata McGraw Hill Publishing Co. on behalf of the Ministry of Environment & Forests entitled "-Toxic Metals in the Indian Environment".

Dr Krishna Murti developed and coordinated an R & D programme on the ecodevelopment of the Ganga basin in 17 universities located in the vicinity of Ganga. The work included a complete documentation on the water quality of the river and the contribution of the biotic elements of the river to its self purification. A book entitled "Ganga-A Scientific Study" has been completed and published. In connection with



proposal to approach UNESCO for inscribing Ganga in the list of World Heritage of Cultural Property, he prepared the background document "The Ganga—A Cultural Heritage". He had great delight in the writing of this on account of his great attachment to Ganga.

On behalf of the Madras Science Foundation he organised a workshop on the ecosystem of river Kaveri basin and prepared a joint report containing the background information on the pollution status of the river and a programme of research to be carried out in the Universities located in the Integrated Environmental Programme of Research on the river Kaveri sponsored and funded by the Ministry of Environment.

Dr Krishna Murti chaired a Scientific Commission (1985-89) set up by the Government of India to initiate continuing studies on the effects of Bhopal Gas leakage on the life systems and lay down guidelines for a scientific base for avoiding future Bhopals. He set up the Commission and activated an Integrated Programme on evaluating and long term effects of the Bhopal Gas leakage on life systems. The studies envisaged the elucidation of mechanisms of the implicated toxicants and devisal of remedies for their long term effects. A sophisticated Instrument Centre and a multidisciplinary field observation laboratory have been set up in Bhopal to monitor long term effects on the environmental compartments exposed to the toxic gas. A number of reports on the effects of the gas on life systems and creation of a scientific base for prevention and control of accidents was presented by him. Government on the basis of these recommendations identified the Ministry of Environment as the nodal agency to implement a programme of Major Hazards Control to protect the environment and public health.

He organised on behalf of the Scientific Group on Methods for Safety Evaluation of Chemicals (Co-sponsored by IPCS and SCOPE) an International Workshop in New Delhi in Jan-Feb. 1987 on Methods to Reduce Injury Due to Chemical Accidents. Valuable recommendations emerging from this workshop were submitted to the Government. He also coordinated an inter-Ministerial Group on prevention and Control of Chemical Accidents set up by the Government of India. He also presented valuable reports on Contingency Plans for Chemical Industries, Chemical Disaster Management, Emergency Response System.

He designed and coordinated a study on the current practices of industrial waste disposal in India. The study sponsored by the Ministry of Environment, Government of India was conducted by the National Productivity Council and included a survey of some hazardous industries in Gujarat, Maharashtra and Tamil Nadu. A brief report of this was presented to UNIDO sponsored International Workshop. He also contributed background papers on the environmental health aspects of hazardous waste disposal of UNEP/WHO/World Bank manual on Hazardous Waste Disposal Technologies with special reference to Developing Countries.



HONOURS AND AWARDS

Among the many honours and awards he received were his election to the Fellowship of Indian National Science Academy (1971), Fellowship of Indian Academy of Sciences, Bangalore (1973), Fellow of National Academy of Medical Sciences (1978) and Fellow of National Academy of Sciences, Allahabad (1989). He was the recipient of the Basanti Devi Amir Chand award of ICMR (1973), Sunder Lal Hora Medal of INSA (1981) and SICO-ASCI award of Indian National Science Academy (1989). He was the UGC National Lecturer in Biochemistry (1978) and Pitamber Pant National Fellow in Environmental Sciences, Deptt. of Environment, Govt. of India (1983-1985). He was also the Honorary Research Fellow of University College, London and Visiting Professor, USC School of Medicine, Los Angeles, USA (1968-69). He was elected as the President of Society of Biological Chemists (India) (1978-1980), Indian Association of Biomedical Scientists (1983-1985) and International Society of Applied Biology (1985-1990). He was the Chairman of the working group on Ganga basin Ecodevelopment Programme, Department of Environment, Govt. of India, the Chairman of the National Committee of ICSU sponsored Scientific Committee on problems of Environment (SCOPE), Chairman of the Environmental Research Committee of Deptt. of Environment, Govt. of India. He was elected as the Vice President of Scientific Committee on Problems of Environment, ICSU, Paris. He was the Chairman of the Scientific Commission for Continuing Studies on the Effect of Bhopal Gas leakage on life systems and also acted as the Principal Coordinator of Environmental Programme on Heavy Metals sponsored by the Ministry of Environment and the Honorary Project Director of Integrated Environmental Programme of Research on River Kaveri. He served as expert member on various technical Committees concerned with Biochemical Education and Research : CSIR, ICAR, ICMR, United Nations Environment Programme, UNIDO, WHO etc.

FAMILY LIFE AND SOME PERSONAL TRAITS

Dr Krishna Murti was married to Brinda daughter of Mr Pattabhiraman in 1964. He had a very peaceful and happy family life and domestic bliss and harmony were natural to a person of his temperament. Mrs Brinda Krishna Murti was a noble lady who gave him lifelong companionship, understanding and support for his varied scientific and professional interests. She was the most affectionate hostess who would greet all the students and colleagues of Dr Murti to their home with pleasant smile and warmth that left nostalgic memories forever (Mrs Krishna Murti expired on 31st October 1992 after terminal illness). Dr Krishna Murti's mother, affectionately called *Mata Ji* by all of us, was revered as goddess incarnate, and was an ocean of piety, love and compassion who loved and blessed all of CRK's colleagues as her own children and grandchildren and fondly enquired about the welfare of all their family members. CRK's home, like



his office, was open to all at any time. Colleagues would drop in at all times and all his family members were very hospitable to them. Apart science visitors would drop in for consulting him on their personal problems and he would guide them in the best way. He was a real guide, friend and philosopher.

Dr and Mrs Krishna Murti are survived by two daughters and a son, who settled in their careers by the time Dr Murti retired in 1983. The elder daughter Laxmi, an MA in English is a Professor at SIET Women's College, Madras while the younger daughter Shri Devi is engaged in Social service at Bombay. The youngest among three children CK Ramachandran (affectionately called Ramesh) is doing business at Madras. Dr Krishna Murti was very punctual, meticulous and regular in his habits. He will arrive at the Institute an hour before scheduled time (around 9.00 A.M.) and work continuously without any recess till 7.00 P.M. He was very prompt in attending to his office files, letters and correspondence and after attending to his multifarious office duties, he will get busy with bench work, scientific discussion with colleagues and creative writing. He disliked people practising bureaucracy and those indulging in loose talks and gossip. He treated all his staff with utmost courtesy and due respect. He would personally visit all his colleagues on their seats, attend to their problems and guide them most intimately. When in library, he would read and consult literature for all, write down the important references neatly on reference cards and hand them over to the concerned person. This way he inspired all his colleagues and kept them abreast of latest developments in science. He had the most pleasant and congenial temperament and was never seen in rage or angry mood. Even in moments of intense dislike he would remain extremely polite (or become much more polite than usual) and would demonstrate his colleagues the best way to execute a thing.

Not being able to go abroad at an early age for training and research, he had to learn and make a place for himself by his sheer hard work and dedication compared to those with foreign degrees and training. Since he confined all his early work to the areas of nutrition and the neglected tropical diseases, at a time when the fundamental aspects of Biochemistry and Molecular Biology were more in vogue, his work did not receive the due recognition till 1970s when the human health and environment became the focal areas for Molecular biology and Biotechnology.

During his spare time which he had few, CRK had lot of other hobbies, the major being reading and music. In spite of his hectic office hours, he would reach home and get engrossed in reading or music. CRK was associated with many cultural associations at Lucknow and Madras. His house was stocked with a variety of books and the collection of latest records of Carnatic music. CRK was a good singer and at many a times he would entertain his friends with music or clear their doubts about Raga etc. He had translated Ram Charit Manasa and Vinay Patrika of Goswami Tulsidas into Tamil and English. He contributed a number of Tamil articles in leading Tamil magazines which



would explain to a common man in simple language about the theme of the article; these articles were very popularly acclaimed.

Dr Krishna Murti was extremely soft spoken, gentle by temperament and he always had an encouraging word for the young and upcoming. Even at the height of his eminence he remained most friendly, open and accessible to one and all. In his most varied and challenging assignments he synthesized his simplicity, spirituality and knowledge of literature and science into a harmonious excellence yet the most practical means closest to reality. He set high ethical standards for himself and those around him and all through life "he tirelessly stretched his arms, towards perfection" to fulfill his favourite theme from Vedas whose translation reads "The supreme Lord created the intellect, the organs of perception and action, the mind and the vital airs to provide the *Jiva* with a world of experience to perform works, to satisfy their desires in the several worlds and to win release."

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The author had the privilege of working with Dr CR Krishna Murti as a Junior Research Fellow between 1959-1961 and subsequently as a Scientist between 1971-1975 at Central Drug Research Institute, Lucknow. Dr Krishna Murti not only initiated and trained the author in research but served as a source of inspiration and encouragement till the last days. The author interacted with Dr Murti during his tenure at ITRC Lucknow through preparation of status report on biodegradation and initiating the research project on biodegradation of environmental chemicals and plastics and polymers. The author was also associated with Dr Murti in Society of Biological Chemists first as the Secretary of Lucknow Chapter and then as the Hon. Secretary SBC (India) during 1979-1980 when Dr Murti was the President. The interaction of the author with Dr Krishna Murti has been very close as well as from a distance when the author was associated with many different institutions of research and teaching. The reviewer has therefore retained his objectivity and freedom in presenting this biographical memoir of a scientist with intense dedication of science and the country as well as a passion to help and motivate young and upcoming scientists.



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