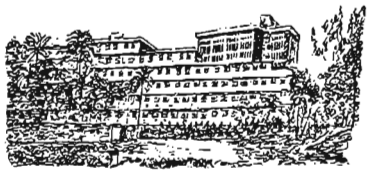
Sixty Fifth Annual Report

APRIL 1996 — MARCH 1997



INDIAN STATISTICAL INSTITUTE

203 BARRACKPORE TRUNK ROAD, CALCUTTA - 700 035

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15. Prof. B.R. Nag, Institute of Radio Physics and Electronics, Calcutta University, Calcutta.

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17. Prof. Prabuddha Nath Roy, Pro-Vice-Chancellor (Academic), Calcutta University.
18. Prof. Ganesh Bhattacharya, Former Professor, DRTC, ISI, Bangalore.

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19. Shri Ajay Ghosh, Representative of the Scientific Workers.
20. Shri Sashi Kanta Mishra, Representative of the Non-Scientific Workers.

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22. Shri Ajoy Kr. Adhikari, Professor-in-Charge, Applied Statistics Division.
23. Prof. Biswanath Bhattacharya, Professor-in-Charge, Social Sciences Division.
24. Prof. S. Bhattacharya, Professor-in-Charge, Physics and Earth Sciences Division.
25. Prof. S. Matai, Professor-in-Charge, Biological Sciences Division.
26. Dr. M.K. Chakrabarti, Professor-in-Charge, Computer and Communication Sciences Division.
27. Shri Anup Majumdar, Head Statistical Quality Control and Operations Research Division.
28. Prof. Atul Sarma, Head, Delhi Centre.
29. Shri B.K. Pal, Acting Head, Bangalore Centre.
30. Dr. P.S.S.N.V.P. Rao, Dean of Studies.

Non-Member Secretary

Shri G.H. Mandal, Chief Administrative Officer

INDIAN STATISTICAL INSTITUTE

Annual Report
April 1996 - March 1997

203 Barrackpore Trunk Road
Calcutta 700035

Editorial Board

INDIAN STATISTICAL INSTITUTE
SIXTYFIFTH ANNUAL REPORT
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BRIEF HISTORY OF THE INSTITUTE

Research in the theory and applications of Statistics as a new scientific discipline began in India in the early twenties through the pioneering initiative and efforts of Professor P.C. Mahalanobis. Soon after his return from England, Mahalanobis began to carry out statistical studies with the help of some part-time assistants. A chance meeting with Dr. Nelson Annandale (the then Director of the Zoological and Anthropological Survey of India) and subsequent interactions with him led to the first scientific paper by Mahalanobis on the statistical analysis of stature of Anglo-Indian males of Calcutta. This was followed by further research in anthropometry, in meteorology and in problems of flood control in North Bengal and Orissa. Gradually, a small group of young scientists were picked up by him in the Department of Physics, Presidency College, Calcutta, where he was a professor. This group formed the nucleus of a laboratory which later came to be known as the Statistical Laboratory.

In the early thirties, realising the necessity for a concerted effort for the advancement of theoretical and applied statistics in India, Professor Mahalanobis together with Professors P.N. Banerjee and N.R. Sen, both of Calcutta University, convened a meeting on 17 December, 1931, to consider various steps to be undertaken for the establishment of an association for the advancement of statistics in the country. It was unanimously resolved that the Indian Statistical Institute be established with Sir R.N. Mookerjee as President and Professor P.C. Mahalanobis as (Honorary) Secretary. The Indian Statistical Institute was registered as a non-Government and non-profit distributing learned society on 28 April, 1932, under the Societies' Registration Act No. XXI of 1860. The total expenditure in the first year was a meagre Rs.238 and the number of workers was only two or three. From such a modest beginning, the Institute grew, under the remarkable leadership of Professor Mahalanobis, into an all-India organisation which now has around 1600 workers, including about 500 scientific workers. The Institute has its headquarters in Calcutta and two other Centres at Delhi and Bangalore and a branch at Giridih. In addition it has a network of service units of Statistical Quality Control and Operations Research Division at Baroda, Bombay, Trivandrum, Pune, Coimbatore, Madras, Hyderabad, Calcutta, Delhi and Bangalore.

From the very beginning, Professor Mahalanobis and his associates who included Professors S.S. Bose, R.C. Bose, S.N. Roy, K.R. Nair, K. Kishen and H.C. Sinha worked with zeal and enthusiasm for the development of statistical theory and methods, and in promoting research and practical applications in different areas of natural and social sciences. *Sankhyā*, the Indian Journal of Statistics, was started in 1933 with P.C. Mahalanobis as its Editor, and received instant international recognition which continues till today. Pioneering research activities were carried out in many areas of statistical theory, especially in the core areas of multivariate analysis, sample surveys and design of experiments. Such activities were strengthened and new directions were opened up by Professor C.R. Rao and many others who joined the Institute in the forties and the tradition continues. The Institute pioneered the development of statistical methods in agricultural research and in the conduct of large scale agricultural enquiries. This led to a large number of research publications and to the introduction of training activities offering short term courses in statistics for officers in government departments and scientific institutions. The scientists of ISI, led by Professor Mahalanobis, helped in introducing the first post-graduate degree course in Statistics in India at the Calcutta University in 1941, and in securing a separate section for Statistics in the Indian Science Congress.

Activities of the Institute gained further momentum from 1938. Professor Mahalanobis started sample surveys to estimate the area under jute crop in Bengal in 1937 as an exploratory work, which later grew to a full-scale survey of the entire province in 1941. Gradually, sample surveys of agricultural crops and other socio-economic surveys became some of the most important activities of the Institute and earned the Institute and Professor Mahalanobis international reputation. After independence, Professor Mahalanobis was appointed Honorary Statistical Adviser to the Cabinet, Government of India, and in 1950, through his initiative, the National Sample Survey (NSS) was started for conducting socio-economic surveys of all-India coverage on a continuing basis. This was the first ever attempt in India to have a data base for various developmental programmes and the five year plans. The ISI group on sample surveys served as the Technical Wing of the NSS from 1950 till it was transferred to the Government of India in 1972.

The ISI was first again to play a pioneering role in starting the Statistical Quality Control (SQC) movement in India by organising a visit of Professor W.A. Shewhart, the father of SQC, to India in 1948 and later by inviting other experts like W.E. Deming for the same purpose. SQC promotional work was gradually spread all over the industrial centres in India under a comprehensive programme covering education and training, applied research and consultancy services.

Research in economics was greatly stimulated when in 1954 Prime Minister Jawaharlal Nehru entrusted the preparation of the draft Second Five-Year Plan of the country to Professor Mahalanobis and the Institute. The "Draft" submitted by Professor Mahalanobis and the planning models formulated by him in that connection have since been regarded as major contributions to economic planning in India. Since then many economists of the Institute have worked in different centres of the Institute on various aspects of national planning and until 1970, were directly helping the Planning Commission in the preparation of the long term perspective plans for the country. Research in other disciplines of Social Sciences was also started in the Institute in the late fifties. Professor Mahalanobis' participation in 1946 in the annual scientific conferences of the Milbank Foundation led to the initiation of systematic studies in India on the growth of population Earlier, the well known Y-sample estimates for 1941 Census population were also derived by the ISI Theoretical and empirical research in sociology using statistical techniques was started in the Institute for the first time in south-east Asia. Similarly, the development and introduction of psychometric tests for selection processes in different organisations was first made by the ISI in India besides carrying out basic research in Psychometry. The studies of the phonetic structure of some major Indian languages have been made on a continuing basis in the Institute under the guidance and collaboration of the famous linguist Djordje Kostic.

The Institute, since its inception recognised the need for development and use of accurate and fast computing equipment for the processing and analysis of data. Professor Mahalanobis strongly believed that to be a good theoretical statistician one must also compute and must therefore have the best computing aids. The Institute has lived up to this tradition from the very beginning. In 1953, a small analog computer was designed and built in the Institute. In 1956, the Institute acquired a HEC-2M machine from the U.K. which was the first digital computer in India. In 1958, a digital computer URAL was received as a gift from U.S.S.R. Since 1956 till mid sixties, the Institute had been serving as a de facto national computer centre for the country. In early sixties, the Institute, in collaboration with the Jadavpur University, undertook the design, development and fabrication of a fully transistorised digital computer, called ISI/JU-1 which was commissioned in 1966 by Shri M. C. Chagla, the then Minister of Education, Government of India

Quantitative analysis in Physical and Earth Sciences was one of the novel ideas of Professor Mahalanobis pursued in the true spirit of the Institute. In addition to evolving some interesting techniques and obtaining some very interesting results from the analysis of directional geological data, the Institute also made a significant contribution by discovering the bones of a 16m (+) long sauropod dinosaur named, *Barapasaurus tagorei*, from the lower Jurassic Kota rocks near Sironcha, Gadchiroli district, Maharashtra, in the sixties. The discovery has helped in understanding the interesting problem about the origin and evolution of sauropod dinosaurs. It, in fact, represents the only intermediate form between the prosauropods and the sauropods, and is called a "missing link" in the evolution of the sauropod dinosaur

The Institute expanded its research, teaching, training and project activities and earned national and international recognition over time. The substantial contributions of the Institute to the quality of theoretical and applied statistical work have culminated in the recognition of the Institute by the Government of India enacting "The Indian Statistical Institute Act, 1959" (No.57) which declared the Institute as an "Institution of National Importance" and empowered it to award degrees and diplomas. None other than Pandit Jawaharlal Nehru, the then Prime Minister of India, piloted the bill in the Parliament. With this recognition, the already existing teaching and training programmes were consolidated and expanded and courses for the degrees of Bachelor of Statistics [B.Stat. (Honours)] and Master of Statistics (M.Stat.) were started from June 1960. The Institute was also empowered to award Ph.D./D.Sc. degrees from the same time. Later on, courses leading to Master of Technology degrees were started in Computer Science and in Quality, Reliability and Operations Research which also received formal recognition from the All India Council for Technical Education (AICTE). Subsequently, a Master of Science programme in Quantitative Economics was also introduced. In recognition of the excellent research work done by the scientists of the Institute in several areas related to statistics, the section 4 of the Indian Statistical Institute Act of 1959 was amended by the Parliament in September 1995 to empower the Institute to award Degrees / Diplomas not only in statistics but also in mathematics, quantitative

economics, computer science and such other subjects related to statistics as may be determined by the Institute from time to time.

The role and importance of ISI in conducting and promoting teaching of statistics has been appreciated by international bodies as well. In 1950, the International Statistical Institute had initiated the International Statistical Education Centre (ISEC), Calcutta, jointly with ISI, to impart training in Theoretical and Applied Statistics to participants selected from developing countries. The centre is run by ISI jointly under the auspices of UNESCO, International Statistical Institute and the Government of India.

Recognition of the Institute by the Act of Parliament provided greater encouragement to research activities not only in statistics and mathematics but also in various branches of the natural and social sciences, without whose live contact, it was believed, the methodology of statistics could not grow to its current level. It is also due to this fact that "Unity in Diversity" is adopted as the motto of the Institute. In view of these, the Memorandum of Association of ISI was first updated n 1976 and subsequently in 1995. The objectives of the Institute as laid down in the Memorandum of Association are :

i) to promote the study and dissemination of knowledge of statistics, to develop statistical theory and methods, and their use in research and practical applications generally, with special reference to problems of planning for national development and social welfare;

ii) to undertake research in various fields of natural and social sciences with a view to the mutual development of statistics and these sciences; and

iii) to provide for, and undertake, the collection of information, investigations, projects, and operational research for purposes of planning and the improvement of efficiency of management and production.

iv) to undertake any other ancillary activities in fulfilment of the objectives i), ii) and iii) above.

From the early days, the Institute has been in touch with many internationally famous scientists in different disciplines from the world over. Some of these scientists have worked in the Institute for several months or even longer. Sir Ronald A. Fisher, a pioneer of modern statistics, was a regular visitor to the Institute and lent it considerable support. Professor J.B.S. Haldane, a geneticist of international repute, was a member of the faculty for several years beginning from 1957. At the inspiration of these stalwarts and other renowned scientists, the Institute began to expand and/or undertake research activities in several areas of natural and social sciences with the hope that collaboration under the same roof would foster the mutual development of statistics and other disciplines. In fact, the Institute stood up to Sir Ronald Fisher who called Statistics a "Key Technology" of the century, in view of its intimate relevance to all scientific endeavours which involve experimentation, measurement and inference from sample to aggregate.

Coming to more recent times, the Institute has continued to pursue its goal of attainment of excellence in the various fields of science. Fundamental research in statistics with its roots in applications has been the bottom line ever since the inception of the Institute. The contributions from the Institute in multivariate analysis, design and analysis of experiments, sample surveys, statistical methods of data analysis and statistical inference have found their places in text books and monographs, and the tradition continues. In addition, probability theory and stochastic processes have also been major areas of research in the Institute. The theoretical mathematicians of the Institute, in addition to collaborating with the statisticians, are also making fundamental contributions in several fields - Topology, Functional analysis, Harmonic analysis, Algebra, Combinatorics, Quantum Mechanics, Game Theory, to name some. The current trend of research in statistics not only carries forward the traditions set up in the Institute, but is also setting new directions, both in theory and applications, in different disciplines.

The Institute has been maintaining its tradition of high quality research and development in the field of computer science. In 1979, a microprogrammed signal processing system using Fast Fourier Transform (FFT) was designed and developed. Keeping pace with the global advances in computer technology, the activities of the Institute in the field of computer science gathered a tremendous momentum in the late seventies, resulting in diversification of research in different areas including Algorithms and Complexity,

Parallel and Distributed Processing, Fault-Tolerant Computing, VLSI, Computational Geometry, Fuzzy Sets and Systems, Cybernetics, Pattern Recognition, Neural Nets, Artificial Intelligence, Image Processing, Computer Vision, etc. In recognition of its contributions in the field of computer science, the Government of India established, in collaboration with the United Nations Development Programme (UNDP), one of the five national Nodal Centres for Knowledge Based Computing Systems (NCKBCS) at ISI in the year 1988. The Institute also has the infrastructure for providing the most modern computational environment with facilities for email, Internet connection, etc.

The different disciplines under the Social Sciences also continued to develop and flourish over time by carrying out basic research as well as inter and multi-disciplinary programmes. In economics, the Institute has come to be known as a specialized centre for its significant contributions in different branches of theory and also for studies on such areas as Demand Analysis, Poverty and Levels of Living, Measurement of Inequalities, Production and Prices, National Income and allied topics, Development and Planning etc. In Demography, Sociology, Psychometry and Linguistics also the Institute maintained its distinctive feature for the focus and emphasis on quantitative aspects. Mention may be made, in this context, about the pioneering theory for teaching and training for the hearing impaired children, developed by Prof. Kostic. Based on this theory the Electronics Unit of the Institute, in collaboration with the Linguistic Research Unit and the Government of Tripura, designed, developed and fabricated a set of instruments for the hard-of-hearing children of the Institute of Speech Rehabilitation, Government of Tripura, Agartala. This has come to be regarded as having a significant impact on social welfare.

Plant and human biology have been the major areas of research in biological sciences. Both basic and applied research are conducted, with emphasis on quantification, statistical design and analysis, and modelling. In the area of plant biology, research has included quantification of natural variability and modelling, animal behaviour, effect of interaction of rice varieties on yield, use of protein extracted from leaves to supplement human food, mathematical modelling of ecological and embryological phenomena, etc. In the area of human biology, researches have included anthropometric, genetic and biochemical studies on population affinities, micro-evolution, studies on utilising data on anthropometric variability in designing car seats, human adaptation to differing environments, human ecology and growth and genetic epidemiology.

With a view to developing innovative methodologies for collection and analysis of quality survey data, interacting and collaborating with organisations like NSSO, CSO, DoS, Planning Commission, RBI, etc., promoting the growth of inter-disciplinary research in statistics and data analysis in the Institute, and disseminating the methodologies (old and new) to the scientific, academic and research organisations, a Survey Research and Data Analysis Centre (SURDAC) has been established at the Institute in February 1997. Such a centre would benefit the planning processes and national development. In 1995, the Plan and Policy Research Unit (PPRU) was established under the Planning Unit at Delhi Centre which has already undertaken several projects of national and international importance.

Over the years, the SQC & OR Division has grown to the size of having ten operating units all over the country and have uniquely served for promotion, education and training and technical guidance in Total Quality Management Methodology, Quality Assurance Systems for the benefit of the manufacturing and service industry over the decades. It has thus, as was intended, played a leading role in dissemination of new concepts, methods and techniques in the areas of Quality and Productivity.

The Central Library of the Institute is located at Calcutta with a network extending to other locations of the Institute. Over the years, the library of the Institute has attained the distinction of being one of the richest libraries in the country, particularly in the fields of statistics and related disciplines. The library has developed a well-equipped Reprography and Photography Unit. The library's gift collections include the personal libraries of Professor P.C. Mahalanobis and Professor Walter A Shewhart. The library has been recognised as the Depository Library for World Bank publications. A separate collection of books and journals in Mathematics, Statistics etc., known as Eastern Regional Centre of NBHM has been developed out of the grants from the National Board of Higher Mathematics. Computerization of library facilities has been taken up which will certainly enhance the facilities for the users. Much more is on the anvil in this direction.

The Professor P. C. Mahalanobis Memorial Museum & Archives, which was inauguarated on June 29, 1993 by Shri P. V. Narasimha Rao, the then Prime Minister of India, has been established in *Amrapali* on the Institutec campus in Calcutta.

The Documentation Research and Training Centre (DRTC) established at Bangalore in 1962 by the late Professor S.R. Ranganathan, a doyen in the field of library and information science, is engaged in research, teaching and training in documentation and information science. The Institute awards post-graduate diplomas in documentation sciences.

An index of the contributions of the Institute is the publication of many books and monographs, in addition to a large number of scientific papers in national and international journals, receipt of national and international recognitions of very high order by the scientists of the Institute in terms of awards, titles, and fellowships, and holding of prestigious positions in various scientific organisations of higher learning as well as in governmental organisations both in India and abroad. With a dynamic group pursuing and guiding research work in some of the most modern topics in statistics, mathematics, computer science, economics and in various fields of natural and social sciences, there exists a close interaction among the scientists from all over the world.

Director's Report

During the year, training in core areas of Statistics, Mathematics, Economics, Computer Sciences and other related fields was in full gear. The scientific and technical workers kept a busy schedule with research activities, project works, case studies both in theoretical and applied statistics as well as in other interdisciplinary areas. Several techniques for exploratory analysis of regression data arising in industrial, socio-economic and biomedical studies have been developed. Non parametric quantile regression techniques developed in this connection led to many interesting and useful results when applied to financial and econometric data obtained from the Reserve Bank of India and the centre for monitoring Indian economy. The class of Steiner Triple Systems (STS) on 3^4 points constructed by our colleagues Dr. S. Bagchi and Dr. B. Bagchi turned out to be more than counter examples, this STS have lots of beautiful hyperplanes and subspaces and these designs closely resemble and approximate to the affine geometry designs without being themselves one such; an interesting step forward towards the settlement of a long unsolved problem.

The Plan and Policy Research Unit (PPRU) established in 1995 under the Planning Unit at Delhi Centre of the Institute with an endowment fund of Rs. 2.00 crores from the Government of India, apart from developing some infrastructural facilities, has embarked, during 1996-97, on several projects of National and International importance which include, impact of Economic Reforms on Productivity of firms specially the steel industry; Inter-regional disparities and growth; Gender bias and differential employment opportunities; Agricultural trades liberalisation and spatial development with focus on rural development; Promoting economic cooperation with ASEAN in the developing environment; and Do environmental regulations promote growth?

The Survey Research and Data Analysis Centre (SURDAC) created in 1996 at the Institute at Calcutta has conducted a successful two day symposium in February 1997 on "Statistics as an Interface in Interdisciplinary Research : Methodology and Data Analysis" with two focal themes - one on "Statistics in Planning and Policy Making" and the other on "Statistics in Environment, Ecology, Wild Life and Natural Resources". The aim of this Symposium was to bring together the policy makers in the Government and other organisations along with the scientists of the Institute, to identify focal areas for immediate consideration for Data Analysis and Development of New as well as innovative Statistical Methodologies in collaboration with these organisations which include Planning Commission, NSSO, CSO, DOS, RBI and others. The SURDAC has also embarked on projects during 1996-97 which include Market Share Models, Social Networks, Soil Resource Potential, Small Scale Industries, Human Uterine Cervix Cancer Data Base and Molecular Epidemiology. It is hoped that suitable endowment funds for continuance of the SURDAC at the Institute on a long term basis will be received from the Government of India and other Governmental Organisations.

The use of Statistical Quality Control and Reliability techniques in controlling loss and cost, and also for improving and augmenting productivity in industries has generated great impetus to the quality control movement in the country. The Institute with its expertise in the Quality movement in the country since 1953 is providing training and consultancy through its SQC & OR units spread over the country in all areas of quality management and quality systems related to ISO-9000 certification. During this year 1996-97 services for designing and implementation of ISO-9000 quality systems were rendered to 60 organisations. The crash programme for training of trainees undertaken as the "Quality Mission Project" during the 8th Five-Year Plan period has been well received by Industry and a five fold increase in the number of participants in in-plant training could be achieved by the SQC & OR Division during this period. A peer group appointed for reviewing its progress and achievements recommended its continuation during the 9th Five Year Plan period with, among others, some changes to focus on training programmes and systems implementation to industries such as Leather, Food processing, Gems and Jewellery, Service Sector, Small Scale Industries; and Quality System Implementation for Financial Services including Banks, Health Management etc. This recommendation has been accepted by the Section 8(1) Committee for 1997-98. Efforts for export of our consultancy services have been initiated. An agreement for providing such a consultancy support for oil and gas industry in Nigeria is in the process.

In Computer Science and related areas, an epsilon stopping time for genetic algorithms has been determined which provides a solution to a long standing problem of evolutionary computation. A new measure called "Roughness of Fuzzy Sets" is provided for handling vagueness and uncertainty in real life problems in stronger soft computing paradigm. A novel confocal laser scanning microscope (CLSM) image processing software has been developed with a view to automatic detection of prostrate cancer. The automatic reading system for printed Bangla has been extended to read Hindi (Devnagari) printed documents. Several new topologies for parallel processing along with efficient parallel algorithms for various applications including numerical analysis, signal processing, image processing have been developed. Several interesting results have been obtained on remote sensing and data analysis in atmospheric and wave propagation.

Important contributions have been made by colleagues in economic theory, international trade, econometrics, macro and growth, industrial economics, planning, environment, dynamical systems, finance, poverty and agricultural economics.

The Institute also undertook several externally funded projects of national importance from different government and non government organisations. These include Genetics of quantity traits of commercial importance of the Silk Worm (CSB),Development of statistical technique as an aid to geological mapping - (CSIR), A study of mathematical techniques in water wave problems - (CSIR), Development of thin film on a rotating disk - (CSIR), A knowledge based computing - (CSIR), A neuro fuzzy image recognition system : Methodology development for forensic applications - (CSIR), Poverty assessment in India - (DOS), Molecular epistasis and the human globin gene clusters with special reference to haemoglobinopathies in eastern India - (DBT), Studies on the PBL dynamics using sodar & tower data - (DST), Development of computer algorithms for recognition & interpretation of sodar pattern - (DST), A knowledge based frame work for diagnosis & therapy planning using multimodality medical imaging - (DST), Large amplitude ion & electron acoustic waves in relativistic plasma - (DST), Development of software package : handling uncertainties for machine interpretation of ill defined structures present in gray level images (DEAL Dehradun), Indepth studies on the levels of development of schedule castes and schedule tribes (Ministry of Welfare, GOI), Rice based cropping systems studies in rainfed regions of eastern Indian plateau (RRI), Development of CAD tools for identification of (i) logical equivalence of library elements and (ii) identification of false path in a switch level network - (Motorola & IIT, Kharagpur), Unsteady surface water waves in ocean - (UGC), Sustainable livelihood studies under environmental stress in eastern plateau of India - (UEA, UK), Change in livelihood trajectories - (UEA, UK), Evaluation of rainfed farming project - (ODA, UK). Survey of the possibilities and problems of small industries in Birbhum district - (Small Industries Corporation, Govt. of West Bengal), Base line assessment study for the district primary education programme - (Government of West Bengal), Gender study for the DPEP - (Government of West Bengal), Efficient VLSI layout design (Motorola India Electronics Ltd.).

In appreciation and recognition of high standard of research and scientific excellence maintained by the researchers of the Institute, several faculty and scientific workers of the Institute received laurels in the form of awards and fellowships from Institutes/Organisations of National and International importance.

Professor K. R. Parthasarathy continues to be with us as INSA C.V. Raman Professor and he won the prestigious Third World Academy Sciences Award for his outstanding research contributions. Professor V.S. Sunder who had been with us till recently (presently at Mat-Science, Madras) was awarded the S.S. Bhatnagar Award of the CSIR for his work done at the Institute. Professor B.L.S. Prakasa Rao received the outstanding Alumni Award from the College of National Science, Michigan State University, USA. Several other colleagues and young faculty members received Young Scientists Award and Fellowships, Associate Awards from Scientific bodies such as INSA, Indian Academy of Sciences, Institute of Electronics and Telecommunication Engineers etc.

It has been a practice for the Institute to share its expertise and its facilities with colleagues and scientists from other institutes, universities, colleges and research organisations. Following this view, various summer/winter schools, seminars, workshops, lecture series and conferences were held during the year to disseminate new results obtained as well as to strengthen the research, project works, case studies and consultancy work of the Institute with fresh ideas.

The Stat-Math. Unit conducted : An International Workshop on "Percolation theory" at Delhi. A winter school on "Logic and computer science" at Calcutta, an International Symposium on "Probability and analysis" at Delhi, workshop on "Optimal experimental design with applications" jointly with Applied Statistics Unit at Sambalpur University, the regional mathematical olympiad at Calcutta and other centres, National Mathematical Olympiad 1997 at Calcutta. The Applied Statistics Unit conducted : A School on "Sample survey" at Calcutta, an UGC Refresher Course for College/University teachers and researchers at Calcutta, a training programme on "Small area statistics" for senior/middle level officers of the DOS (GOI) at Calcutta, a Workshop on "Directional data analysis" at Hyderabad. The Social Sciences Division organised the following : A state level dissemination seminar "On policy implications based on NFHS, West Bengal" at Calcutta by Population Studies Unit with IIPS, Mumbai. A summer school on "Advanced econometric techniques and their applications", a Conference on "Economic reforms in India", and a Special Seminar discussion on "The role of IMF in India and world economy", by the Economic Research Unit at Calcutta. A seminar on "Recent advances in quantitative methods and their applications to indian economic studies" by the Economic Analysis Unit at Bangalore, A symposium on "Item response theory and its applications" by the Psychology Research Unit at Calcutta. A workshop on "Statistical and computational intervention in language in a plural society : The case of India" by the Linguistic Research Unit at Calcutta. The SQC & OR Division conducted a special programme on QS-9000 for participants from various industrial units, a winter school on "SQC & Reliability" at Calcutta.

The Institute invites a distinguished statistician every alternate year to deliver the prestigious Mahalanobis Memorial Lectures here and at our centres at Delhi and Bangalore. These lectures were delivered this year by Professor James Berger, till recently Richard M. Brumfield distinguished Professor at Purdue University and now at the Institute of Statistics and Decision Sciences, Duke University, Durham, USA The main theme of his thought provoking talks was "Bayesian Statistical Analysis". Professor Berger dwelt upon the recent developments in the Conventional Statistical Analysis, focusing mainly on Bayesian hypothesis testing and model selection techniques.

Regarding the teaching and training activities of the Institute, during the year, 9925 candidates applied for admission to various courses offered by the Institute including B.Stat. (Hons.), M.Stat. (M and S streams), Master of Science in Quantitative Economics, M.Tech (Computer Science), M.Tech. (Quality, Reliability and Operations Research), etc.. A total of 5889 candidates finally appeared for the admission tests conducted at 21 different centres all over the country. A total of 424 candidates qualified for interview for final selection. Based on the academic record, performance in the written tests and interviews a total of 218 candidates were offered admission to various courses leading to degrees and diplomas during the academic session under review. It may be mentioned here that encouraged by the recent amendment of the ISI Act 1959 by Parliament in 1995 which empowers the Institute to award degrees and diplomas not only in Statistics but also in Mathematics, Quantitative Economics, Computer Science and such other subjects related to Statistics; as well as to meet some of the needs of the country for development of human resources and research, a two year Master's Course in Quantitative Economics was introduced by the Institute in 1996. Recruitment of faculty, essential scientific, technical and administrative staff based on the minimal needs of the Institute is in progress.

The International Statistical Education Centre (ISEC) is run by the Institute as an associate Body/Institute under the Regulations of the Memorandum of Association of the Institute jointly with the International Statistical Institute under the sponsorship of the UNESCO and the Government of India since 1950. At present the Centre is conducting its fiftieth term with ten foreign trainees. Due to discontinuation of the fellowships by the Government of India under SCAP and ITEC programmes, representations from the African countries is continuously absent during the last three years. The Institute has approached the Government to restore these scholarships as there are requests from UN Agencies and African Government for such a training and recently the Government has agreed to restore the same.

As far as the financial position is concerned, appreciating the new budget control mechanism adopted by the Institute, the Government increased the non plan budget of the Institute for 1996-97 reasonably so far as the salaries and other allowances are concerned. However, the amount approved under the head "non salaries items" is less than the minimum required by the Institute for this purpose. The approved plan budget for 1996-97 is slightly more than that of the earlier year. I am happy to inform that the approved plan budget for 1997-98 is substantially higher than that of 1996-97, so as to enable the Institute to undertake all the important

proposed plan projects/schemes in almost full capacity and for development of infrastructural facilities including computer networking using optical fibre.

Substantial progress on the construction of the new guest house at Calcutta was made and it is expected to be ready in 1997. The construction of 'D' type quarters at Calcutta was completed and allotted to colleagues. An additional floor on the hostel building at Bangalore Centre is being constructed. Residential accommodation at Bombay has been bought for furtherance and strengthening of the Quality Control and Reliability consultancy services. INTERNET connection for research work was installed at Calcutta and Delhi Centre of the Institute and is expected also to be installed soon at the Bangalore Centre of the Institute.

As a recognition of the excellent research work done by the scientists of the Institute in several areas related to Statistics, the Council, the General Body of the Institute, the Government of India, and the Registrar of Societies, West Bengal approved regrouping of the Units of academic, scientific, project and administrative service activities of the Institute into eleven divisions under the new Memorandum of Association (MOA) of the Institute effective from 1996. The Council of the Institute, as per the new MOA, has been formed with effect from 18 September 1996 for a term of two years. In this new environment the Institute has a dynamic role to play for furtherance of the excellence of the Institute in the above and related areas for planning, national development and social welfare.

Our Institute is nationally and internationally recognised as a centre of excellence both for its theoretical contributions to Statistics and related areas as well as applications of Statistics. We all pledge to uphold the standards and keep the banner of recognition high. "WORK IS WORSHIP" AND "UNITY IN DIVERSITY" should be our mottoes.

31 March 1997 **(S. B. RAO)**

1. TEACHING AND TRAINING

Degrees and Other Courses

A brief account of teaching and training activities of the Teaching and Training Division during the period from 1 April 1996 to 31 March 1997 is given below :

During the academic session 1996-97, 9925 candidates applied for admission and were called for written selection tests for the various courses offered by the Institute, viz., B.Stat. (Hons.), M.Stat. (M-stream and S-stream), Master of Science (M.S.) in Quantitative Economics, M. Tech. in Computer Science, M Tech. in Quality, Reliability and Operations Research, Two-year Part-time Post-Graduate Diploma in SQC and OR (Chennai), Research Fellowships in Statistics, Mathematics, Economics, Computer Science and Communication Sciences, Theoretical Computer Science, Physics and Applied Mathematics, Anthropology, Geology, Sociology, Biometry and Statistical Quality Control, and Operations Research, One Year Part-time Course in Statistical Methods and Applications and the course on Operation and Programming of Automatic Data Processing Equipment. Admission tests were conducted at 21 different Centres all over the country. A total of 5899 candidates finally appeared for admission tests and a total of 424 candidates who qualified in the written tests were called for interviews. Based on the performance in the written tests and the interview, 218 candidates were offered admission to various courses during the academic session under review.

Apart from the above, for the course in Documentation and Information Science (DIS), candidates were chosen through an initial screening followed by an interview. Six candidates were finally selected.

The annual examinations for all the regular courses were held in May/June 1996. The 1996-97 academic session commenced on 1st July, 1996.

One hundred and seven candidates received their degrees and diplomas at the Thirty first Annual Convocation of the Indian Statistical Institute held on 31 March 1997. Seven research Fellows were awarded Ph.D. degree of the Indian Statistical Institute. Also during the same year five of the Research Fellows of the Institute obtained their doctoral degree from academic bodies other than the ISI.

The number of candidates admitted to the different degree, diploma and training courses in 1995-96 and 1996-97 and the number of students passed in the annual examinations in 1996 are given below.

Twenty-six trainees in Engineering and Technology from various Universities (Rourkella Eng. College, Jadavpur University, I.I.T. Kharagpur, Birla Institute of Technology, Ranchi, Indian School of Mines, Dhanbad, University College of Engineering, Orissa, Benaras, Malaviya Regional College, Jaipur, Motilal Nehru Regional College, Allahabad, Regional Engineering College, Jaipur, Durgapur) received a six-week practical training in the different Computer Science Units of the Institute, viz., ECSU, CSU, EU, CVPRU, CSSC, MIU, SQC (T and P). Besides 8 MCA and M.Tech. students (from Regional Engg. College, Rourkella, North Bengal University, Assam Engg. College) did their six months project work in the above Computer Science Units of the Institute.

NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES

	Courses	Number of Students		
		Enrolled in 1995-96	Passed in the annual exam. in 1996	Enrolled in 1996-97
	(1)	(2)	(3)	(4)
Degrees				
1.	Bachelor of Statistics with Honours [(B.Stat.)(Hons.)]			
	1st year	36	36	16
	2nd year	27	27	36
	3rd year	10	8	27
2.	Master of Statistics (M.Stat.)			
	1st year (M-stream)	14	14	8
	1st year (S-stream)	34	33	20
	2nd year	30	27	61
3.	Master of Science (M.S.) in Quantitative Economics	-	-	17
4.	M.Tech. in Computer Science			
	1st year	21	19	26
	2nd year	21	21	22
5.	M.Tech. in Quality, Reliability and Operations Research			
	1st year	16	14	16
	2nd year	13	11	13
Certificate/Diploma/ Associateship				
6.	Course on Operation and Programming of Automatic Data Processing Equipment			
	1st year	12	12	15
	2nd year	12	9	12
7.	Part-time Certificate/Diploma Course in Statistical Quality Control and Operations Research			
	Madras - 1st year	6	6	-
	2nd year	-	6	6

	(1)	(2)	(3)	(4)
8.	Course in Documentation and Information Science (Bangalore)			
	1st year	9	9	6
	2nd year	10	10	9
9.	One Year Part-time Course in Statistical Methods and Applications			
	Calcutta	22	16	19
	Hyderabad	33	14	41
10.	Six-month Part-time Course in Statistical Quality Control			
	Bangalore [Jan.-June 1996]	16	15	31
	Bangalore [July - Dec. 1996]	8	8	23
	Hyderabad [Aug. '94 - Jan. 1995]	17	13	-
	Hyderabad [Sep. '95 - Feb. 1996]	25	17	-
	Hyderabad [July '96 - Dec. 1996]	-	-	22
11.	Intensive Course in Programming and Applications of Electronic Computers	6	6	12
12.	(a) Statistical Assistantship [Jan. '96 - Sept. 1996]	13	1	13
	(b) Junior Diploma in Statistics [January 1996]	87	4	42
Fellowships				
13.	Junior and Senior Research Fellows, Visiting Fellows, Post-doctoral Fellows and Research Associates in different discipline	95	12	21
	GRAND TOTAL	593	368	534

Ph.D. Degrees Awarded

(A) Ph.D. Degrees awarded by the Institute :

i)	Anish Sarkar	:	"Some problems of continuum percolation" Supervisor Rahul Roy, ISI, Calcutta
ii)	Samir Kumar Neogy	:	"On some generolisations of the linear complementarity problem" Supervisor : S. R. Mohan, ISI, Delhi.
iii)	Tirthankar Bhattacharyya	:	"Some problems in joint spectral theory" Supervisor : R. Bhatia, ISI, Delhi.
iv)	Arupkumar Pal	:	"On some quantum groups and their representations" Supervisor : K.R. Parthasarathy, ISI, Delhi.
v)	Bimal Kumar Ray	:	"Polygonal approximation and scale-space analysis of closed digital curves " Supervisor : K.S. Ray, ISI, Calcutta.
vi)	Dipti Prasad Mukhopadhyay	:	"On detection and use of reflectional summetry in computer vision" Supervisor : D. Dutta Majumdar, ISI, Calcutta.
vii)	Sundari Maddala	:	"The Fourier transforms of very rapidly decreasing functions on certain Lie groups" Supervisor : A. Sitaram, ISI, Bangalore.

(B) Ph.D. degrees awarded by other Universities to the Research Fellows of the Institute :

i)	Dyuti Prasad Dolai	:	"A study of some problems on propagation and generation of water waves" Supervisor : B. N. Mandal, ISI, Calcutta. (Awarded by Calcutta University)
ii)	Pabitra Banik	:	"Studies on paddy based cropping system under different agronomical practices in Eastern Plateau area" Supervisor : D.K. Bagchi, ISI, Calcutta. (Awarded by Calcutta University)
iii)	Sauren Das	:	"Certain aspects of morphology, anatomy and palynology of some mangroves and their associates of Sunderbans, West Bengal" Supervisor . Monoranjan Ghosh, ISI, Calcutta. (Awarded by Calcutta University)

iv)	Prasanta Chatterjee	:	"Non-perturbative Approach to Solitary waves in Plasma" Supervisor : R.K. Roy Choudhury, ISI, Calcutta. (Awarded by Jadavpur University)
v)	Anjana Sinha	:	"Some Problems in Supersymmetric Quantum Mechanics and Quantum Field Theory in Flat and Curved Spaces" Supervisor : R.K. Roy Choudhury, ISI, Calcutta (Awarded by Jadavpur University)

International Statistical Education Centre (ISEC), Calcutta

The International Statistical Education Centre was established in 1950 and is operated jointly by the International Statistical Institute and the Indian Statistical Institute, under the auspices of the UNESCO and the Government of India. The Centre functions under a Joint Board of Directors of which Professor P.C. Mahalanobis was the Chairman since the inception of the Centre in 1950 until his death in 1972. Since then Professor C.R. Rao has been the Chairman of this Board. During 1996-97 the Board of Directors consists of Chairman : C.R. Rao, Members : D.R. Cox, President, International Statistical Institute, ISI, Netherlands, A. Hawkins (President, IASE), Z.E. Kenessey (Director, ISI), Secretary, Department of Statistics, Govt of India (representing the Govt of India), S.B. Rao (Director, Indian Statistical Institute) and P. Mukhopadhyay (Member-Secretary) of the Indian Statistical Institute.

The Centre provides training in Theoretical and Applied Statistics at various levels to selected participants from the countries in the Middle-East, South and South-East Asia, the Far East and the Commonwealth countries in Africa.

The Centre offers a ten-month (June to March) Regular Course of training every year. The Course is divided into two parts. The first eight months are devoted to training on general statistical methods including six-week training in Official Statistical Systems conducted by the Central Statistical Organisation, Government of India, New Delhi. During the remaining two months, each trainee specializes in one selected branch of applied statistics, like Large Scale Surveys, Data Processing, Economic Planning, Statistical Quality Control and Operations Research, and Vital Statistics and Demography. The course is offered through lectures, practical work and assignments, field visits, and guided reading.

In addition to the Regular Course, a few persons are admitted from time to time, on an individual basis, for Special Courses of varying duration (generally, 3-6 months) and in different fields. Facilities are also available for research work and advanced study by senior visiting statisticians from abroad.

During the year under review, there were 10 trainees in the Regular Course from 3 countries.

Maldives 4, Bangladesh 2, Sri Lanka 4.

Since inception, the Centre has provided training to about 1249 trainees and their countrywise distribution is shown below :

Afganistan	18	Israel	1	Solomon Island	1
Australia	1	Japan	26	South Africa	1
Bangladesh	27	Jordan	1	Sri Lanka	151
Bhutan	26	Kenya	4	St. Christopher Nevis-Angolla	2
Brunei	16	Republic of Korea	41	Sudan	2
Burma (Myanmar)	44	Laos	5	St. Lucia	1
Kampuchea	3	Malaysia	20	Swaziland	4
Republic of China (Taiwan)	5	Malawi	4	Syria	1
Peoples' Republic of China	4	Mauritius	2	Seychelles	1
Ethiopia	7	Maldives	32	Tanzania	36
Fiji Islands	19	Nepal	15	Thailand	53
Gambia	10	New Zealand	1	United Arab Republic	2
Ghana	3	Nigeria	55	Uganda	13
Hong Kong	15	Pakistan	64	UAE (Abu Dhabi)	4
India	241	Philippines	94	Vietnam	19
Indonesia	64	Papua New Guinea	2	Western Soma	2
Iran	21	Sarawak	1	Zambia	31
Iraq	5	Singapore	17	Zimbabwe	1
		Sierra Leone	9		
		Somalia	1		

Majority of the candidates have been supported by Fellowships awarded by the Govt. of India, mainly under the Technical Co-operation Scheme of the Colombo Plan, the Special Commonwealth African Assistance Plan (SCAAP), Indian Technical and Economic Co-operation (ITEC), Aid to Sri Lanka and Aid to Maldives. In recent years, a number of fellowships have been awarded by the *Commonwealth Fund for Technical co-operation (CFTC), Commonwealth Secretariat, London* Since the opening of the CEntre in 1950, altogether 649 ISEC trainees have been awarded Colombo Plan and SCAAP fellowships, 75 ITEC fellowship and 36 Aid To Sri Lanka fellowship.

1996-1997 (50th Term of Regular Course)

		Number of	
Country	Applicants	Candidate offered admission	Candidate joined
Bangladesh	3	2	2
Myanmar	2	-	-
Ivory Coast	1	1	-
LaoPDR	1	1	-
Maldives	5	4	4
Sri Lanka	4	4	4
Total :	16	12	10

The Convocation of the 50th regular course of ISEC was held on 31st March, 1997. All the Regular Course trainees were awarded Statistical training Diploma.

Professional Examinations in Statistics

The Indian Statistical Institute holds Professional Examinations in Statistics in the theory and practice of analysis of statistical data for the external candidates on the basis of some model guidance for the award of following certificates and diplomas :

1. Statistical Assistantship Certificate
2. Junior Diploma in Statistics
3. Senior Diploma in Statistics

*By the decision of the Academic Council of ISI, new registration for Statistical Assistantship Certificate examination were discontinued from July 1995.

These examinations are separate from, and independent of the examinations held for the award of degrees, diplomas and certificates on the basis of training given by the Institute.

The Government of India recognises the Junior Diploma in Statistics as equivalent to a Bachelor's degree in Statistics and the Senior Diploma in Statistics as equivelent to a Master's degree in Statistics.

These examinations are held now-a-days twice in a year usually in or about the months of April/May and November/December at different cities in India (Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras).

The total number of candidates and their results for September 1996 term only of the examinations are shown below. The results for April 1997 term are under process for immediate finalisation.**

Examinations	Number of Candidates					
	Registered		Appeared		Passed *	
	September 1996	April 1997	September 1996	April 1997	September 1996	April 1997
1. Statistical Assistantship Certificate	5	4	5	4	1	**
2. Junior Diploma in Statistics	44	66	22	-	8	**
3. Senior Diploma in Statistics	6	10	4	-	-	**

* Passed in one or more papers only, not necessarily completed the examination.

** April 1997 term just completed and result not yet been published.

Preparation for the next term Professional Examinations scheduled to be held in November/December, 1997, is under way. Preparation of the Model-answer booklet for the compulsory papers in Senior Diploma in Statistics is also under way.

The total number of candidates who have qualified for the award of the Certificates and Diplomas in the Professional Examinations in Statistics including the result of September 1996 term are 486 and 278 respectively.

2. THIRTYFIRST CONVOCATION

Indian Statistical Institute held its Thirty First Convocation for awarding the Ph.D., M.Tech. (Computer Science), M.Tech. (Quality, Reliability and Operations Research), M.Stat., B.Stat. (Hons.) degrees and Diplomas, Associateship etc. on March 31, 1997.

Professor M.G.K. Menon, FRS, President of the Institute presided over the Convocation and awarded Degrees, Diplomas, Associateships and Awards to the students. Professor .S.B. Rao, Director of the Institute, presented annual review of teaching and training activities of the Institute. Dr. C. Rangarajan, Governor, Reserve Bank of India delivered the Convocation address. In his address Dr. Rangarajan highlighted the context and objectives of Monetary Policy in India.

The number of students who obtained Degrees, Diplomas, Associateships and Awards in the Convocation are given below :

Degree/Diploma/Associateship	Number of candidates
Doctor of Philosophy (Ph.D.)	7
Master of Technology (M.Tech.) in Computer Science	21
Master of Technology (M.Tech.) in Quality, Reliability and Operations Research	11
Master of Statistics (M.Stat.)	27
Bachelor of Statistics (Honours) [B.Stat.(Hons.)]	8
Diploma on Operation and Programming of Automatic Data Processing Equipment	9
Associateship in Documentation and Information Science, Bangalore	10
Professional Examinations in Statistics - Junior Diploma in Statistics	4
ISEC Regular Course	10
Total :	107

AWARDS 1996

1. Award of Mahalanobis International Symposium on Statistics prize to the most outstanding M.Stat. student of Statistics of the Institute :

Debashish Goswami

2. Award of ISI Alumni Association Prizes to the outstanding students of the Institute :

B.Stat. (Hons.)	:	Rituparna Sen
M.Stat.	:	Debashish Goswami
M.Tech.(CS)	:	Subhamoy Maitra
M.Tech. (QROR)	:	Sirshendu Biswas

3. RESEARCH AND OTHER SCIENTIFIC ACTIVITIES

The major thrust of the Institute is on research in various disciplines comprising theoretical statistics and statistical methodology, mathematics, undertaking both internal and externally funded projects in diverse fields of applications, consultancy and collaboration with several scientific organisations and industries. For academic and administrative convenience these are grouped in the Divisions listed below. It may, however, be mentioned that scientists belonging to a Division carry out independent as well as collaborative research with scientists belonging to other Divisions.

Theoretical Statistics and Mathematics Division; Applied Statistics Division; Physics and Earth Sciences Division; Computer and Communication Sciences Division; Biological Sciences Division; Social Sciences Division; Statistical Quality Control and Operations Research Division; Library, Documentation and Information Sciences Division. There is also a well equipped Computer and Statistical Services Centre (CSSC) which manages the VAX system, e-mail and internet facilities and provides computing and statistical services to researchers. This supplements to a large extent the computer facilities slowly being developed within the units for easy and quick access. The Institute is planning to have a complete network of the facilities. In view of the growth of some new disciplines, the Council of the Institute reorganised the divisions and also the different units belonging to the respective divisions.

A brief account of the research activities in different divisions and units during the year is presented below :

Theoretical Statistics and Mathematics Division

The Division with units in Calcutta, New Delhi, Bangalore and Hyderabad has a major role in teaching Probability, Statistics and Mathematics in the B.Stat.(Hons.), M.Stat., M.Tech.(CS), M.Tech.(QR & OR) and other courses of the Institute. The Division also conducts courses for 3-4 semesters at an advanced level for research fellows enrolled for Ph.D. degree of the Institute. The unit in Calcutta regularly conducts a weekly colloquium with speakers both from within the unit and outside. The Division regularly conducts workshops, summer/winter schools, refresher courses and conferences with extensive interaction from academics from various organisations both in India and abroad, funded by external agencies as well as by the Institute, the details of which for the year under review are given elsewhere. The research activities of the Division are in Probability theory, Theoretical Statistics, Stochastic processes, Mathematical Stochastic Modelling, various branches of pure mathematics such as Algebra, Functional analysis, Combinatorial theory, to mention some broad areas. Several members also provide statistical consultation to other units in ISI or other organisations.

Some of the areas of research and contributions from various units are given below :

Calcutta Unit

The main areas of research are as follows.

Mathematics

Commutative Algebra, Geometry of Banach Spaces, General Topology, Algebraic and Differential Topology, Topology with emphasis on Function spaces, Equivariant plus construction and acyclic maps, Gromov theory on partial differential relations, Quantum groups, Uncertainty principles on Nilpotent and

Solvable Lie groups, Wiener Tauberian Theorems in Semisimple Lie groups, Equivariant Cobordism, Stochastic Differential Geometry, Descriptive Set Theory, Automata Theory, Theoretical Computer Science, Harmonic Analysis, Ergodic Theory, Functional Analysis, Operator Algebras, Differential Geometry, Spectra of Laplacians, Sediment Transport, Graph Theory, Combinatorics and Construction of Designs, Random partitions, Markov Chain Monte Carlo methods and application to Social Networks.

Probability Theory and Stochastic Processes

Limit theorems, Rates of convergence and expansions, Stochastic Integrals, Markov Processes and Dynamical Systems, Stochastic Differential Equations, Random Walks, Finitely Additive Probability, Probability inequalities and Stochastic majorisation, Martingale theory and Stochastic calculus, Markov chain simulation.

Theoretical Statistics

Asymptotic theory in Statistics, Sequential Analysis, Bayesian Inference, Ranking and Selection, Cramer-Rao type Integral Inequalities, Multivariate Analysis, Non-parametric Inference, Inference in Stochastic Processes, Directional Data Analysis, Optimal Designs and other aspects of Experimental Designs, Survey Sampling, Survival Analysis, Time Series Analysis, Bootstrap, Jackknife and other resampling techniques, Parametric and Nonparametric Regression Techniques and related topics, Bayesian nonparametric statistics and estimation, Bayesian semiparametric inference and Inference with many nuisance parameters, Robust Bayesian Analysis, Reliability theory, Applications of Statistical and graph theoretic techniques to Social and Biological Sciences.

Some major contributions from this unit are as follows.

Mathematics

1. Algebra

Investigated the kernel of a non-zero locally nilpotent R-derivation of the polynomial ring R[X,Y] over a noetherian integral domain R. If R is normal, it is shown that the kernel has a graded R algebra structure isomorphic to the symbolic Rees algebra of an unmixed ideal of height one in R and conversely, the symbolic Rees algebra of any unmixed height one ideal in R can be embedded in R[X,Y] as the kernel of a locally nilpotent R-derivation of R[X,Y]. In particularthe result shows that the kernel need not be finitely generated over R. The question of finite generation of the kernel and its connection with the class group of R is discussed with examples. A necessary and sufficient condition for the kernel to be a polynomial ring, in general, is given. Minimal sufficient fibre conditions for a finitely generated flat algebra over a noetherian domain to be locally A^1, or at least an A^1, fibration and the structure of locally A^1, algebras are being investigated.

2. Harmonic Analysis on Lie groups

A result on a Mathematical Uncertainty Principle on R and the Heisenberg group - appear particularly interesting as it shows a near equivalance of an integral form of smallness introduced by Cowling and Price for a function f and its fourier transform f simultaneously with the classical pointwise estimates.

3. Topology

Hopficity and Cohopficity of certain spaces with group actions were determined.

Grassman manifolds which are nilpotent were also determined.

Function Spaces from Topological, Functional Analytical and Measure theoretic points of views were studied. The intensive study of bounded open topology on $C(X)$, the set of all real valued continuous functions on an arbitrary Tychonoff space, deserves special mention. The importance of the topology vis-à-vis other well-known and well-studied topologies has already been brought out. The study is still continuing and is expected to bring out some surprising results.

4. Functional Analysis

Research was done on the problems dealing with asymptotic norming properties of Banach spaces, tensor product characterizations of smooth spaces etc. These topics are important because they help one to clarify one's understanding of the long-standing conjecture in Banach Space theory that the various asymptotic norming properties and the Radon-Nikodym property are equivalent.

5. Theoretical Computer Science

Work on cellulor automata (CA) continued. The relation of two-dimensional CA with σ and σ^* game has been studied and necessary and sufficient conditions for invertibility have been obtained. An extensive study of multi-dimensional CA has been carried out and interesting results regarding their invertibility and connection with number - theoretic properties have been obtained. CA-based architecture for efficient multiplication and inversion in finite fields have been proposed.

Probability Theory & Stochastic Processes

Probability results (Random Walks; Zero - one laws) in the finitely additive Strategic set up were developed.

Limits of convolutions of probabilities on the space of stochastic matrices were obtained

Vanden Berg - Kesten inequality in continuum (Boolean) percolation model has been obtained

Work on the connections between Stochastic Calculus, (Schwartz) distribution theory and local times continues. One of the outcomes of this research is a precise rendering of the physicist's interpretation of the local time. There are other consequences. Attempts are on to show how the different results on intersection local times obtained by Marcus & Rosen, Yor, Yor & Legall can be viewed in a consistent manner. Work on 'applications of lost entrance times' to reliability and degrading phenomena continues.

New probability matrices are constructed on l_2 with applications to robustness investigations. Work is continuing to show that these matrices topologize weak convergence.

Theoretical Statistics

1. Nonparametric Analysis

Method of Successive Projecting in non-parametric discriminant analysis improves results obtained by Hastie et al (1994). This method serves to achieve better accuracy than other existing classifiers in most of the examples that have been looked at.

2. Design of Experiments & Linear Models

Research work was carried out to obtain Optimal Diallel Cross Designs and Optimal Block Designs

Balanced nested row-column designs, Nested BIB designs and Balanced Bipartite Weighing designs were constructed.

Optimality of block designs, row column designs, designs under non-orthogonal row-column set up were studied.

A study on partitioned linear model and some associated reduced models was made. The coincidence of inferences on the estimated linear parametric functions under full model and reduced model was also examined.

3. Sampling Theory

Work continued on various aspects of Sampling Theory.

4. Applications

Work continued on application of graph theory to social networks. Nonuniform bounds in CLT and some problems related to quality control associated with distribution of measured characteristics are being studied.

Various exploratory data analytic tools for analyzing multivariate data and regression modeling have been developed. These techniques are quite useful in analyzing econometric data as well as data arising from biomedical studies.

II. Projects Undertaken

1. Exploratory Generalized Regression

Exploratory techniques that are applicable to nonstandard regression set-up involving high dimensional data have been developed and studied. The methodology developed is useful in analyzing data sets that arise in biological, physical, psychological, industrial and econometric investigations. Data analytic tools developed include likelihood based and quantile regression based generalization of kernel, nearest neighbour, local polynomial and tree structured techniques as well as some related cross validation procedures. The performance of the procedures when applied to real data has been evaluated critically.

Exploratory regression analysis of high dimensional data using average derivative nonparametric quantile regression has been developed and studied in detail. The technique is useful in survival analysis and econometric studies. Adaptive sequential designing of nonlinear experiments and analysis of dependent sequence of data generated from such experiments have been investigated. Findings are of critical importance in chemical engineering and bio-chemical studies, where one is interested in gaining insights into various reaction mechanisms underlying the chemical and the bio-chemical processes.

In addition to collaborative research among the scientists and the research fellows of Indian Statistical Institute, there has been fruitful collaboration with scientists based in Universities abroad. Several research articles have been published or accepted for publication in internationally well-known journals. Dr. Probal Chaudhuri of the Stat-Math. Unit is the project leader for this project.

2. Robust Multivariate Inference

Nonparametric and robust techniques for analyzing multivariate data have been developed and studied. The techniques developed have been critically evaluated in terms of their breakdown and efficiency properties. Such techniques are potentially useful when there may be outlying observations in the data as well as when the exact form of the true underlying distribution is not known. Statistical performance of the developed procedures have been thoroughly investigated through analytic studies as well as Monte Carlo simulations. Several useful and intriguing statistical results have evolved in course of the investigation.

A number of robust estimates of multivariate location and scatter have been developed and their performance has been critically studied. Some concepts of quantiles for multivariate data based on the geometry of multivariate data clouds have been introduced and investigated. An adaptive transformation and retransformation strategy for constructing affine invariant estimates and tests for multivariate location parameters and regression parameters in multiresponse linear model problems has been developed. The methodology has been applied to data arising from biological and sociological studies and it leads to very encouraging results.

In addition to collaborative research among the scientists and research fellows of Indian Statistical Institute, there has been fruitful collaboration with scientists based in Universities abroad. Several research articles have been published or accepted for publication in internationally well-known journals. Dr. Probal Chaudhuri of the Stat-Math Unit is the project leader for this project.

3. Development of Statistical Technique as an Aid to Geological Mapping (funded by CSIR, Scheme No. 25(0077)/95/EMR-II)

Prof. J.K. Ghosh of Stat-Math Unit is the principal investigator, for this project. Dr. Tapas Samanta of Applied Statistics Unit is the project coordinator and Dr. Joydeep Bhanja is working as research associate of the project.

The project aims at providing a statistical method aiding geological mapping (A geological map is the basis for exploration of a variety of natural resources like rocks, minerals and fossil fuels). A simplified version of the geological mapping problem was considered in the initial stage. The problem was to divide up the area (to be mapped) into "homogeneous" subregions on the basis of the rock types and our object was to provide an automatic Bayesian solution to this problem. A model already set up for the available data (collected earlier in the study area of Bhumaram in the Godavari valley, India) given the subregions into which a given set of boundaries partitions the whole area. Thus our problem of choosing a set of boundaries between "homogeneous" subregions corresponds to selecting one of several possible models. Recently developed automatic Bayesian methods of model selection have been used to solve the problem.

With the available (first stage) observations we obtained the "best" partition which gave bands for the boundaries. More precise location of the boundaries is possible with additional second stage observations for which a sampling scheme is to be developed. We have now taken up this problem of developing a sampling scheme for allocation of optimum number of observation points to most appropriate locations.

4. An impact study on changing social relations -- A social network approach.

A SURDAC - funded project entitled "An impact study on changing social relations: A social network approach" is undertaken jointly by the Stat-Math Unit, Sociological Research Unit and the Computing and Statistical Services Centre from 1 November 1996 with Prof. A.R. Rao and Prof. S. Bandyopadhyay as the project leaders. The project aims at the study of some social relations and their temporal changes in a rural setting. Data collected on some villages of Birbhum district in 1970's by the Sociological Research Unit of ISI is used as baseline data. Several aspects of the social networks are planned to be studied including the temporal changes in them and the main factors influencing these changes.

5. Regional Math Olympiad

The Regional Mathematical Olympiad 1996 for West Bengal sponsored by National Board for Higher Mathematics for class 9, 10 and 11 students was organised on 1 December 1996 at various centres including Berhampore, Burdwan, Calcutta, Kalyani, Kharagpur, New Jalpaiguri and Purulia. This year it was organised by Prof. S.M. Srivastava. Over the years, this has become very popular and led to great interest and enthusiasm in Mathematics in the region.

Delhi Centre

The main areas of research are as follows.

1. Probability and Mathematics

Markov processes. Martingale problems. Stochastic control. Filtering theory. Infinite dimensional stochastic differential equations. The theory of nonnegative matrices, particularly Perron-Frobenius theory and generalized inverses. Matrix and Operator Theory. Inequalities. Stochastic games and Linear Complementarity Problem.

2. Statistics

Optimality of designs under resource constraints. Construction of asymmetric othogonal arrays. Incomplete block designs for diallel crosses. Optimality of block designs and robustness of designs against

missing data. Estimation of a common mean. Nonparametric Density Estimation, Limit theorem for associated random variables, Spatial Statistics. Global Cramer-Rao Inequalities. Reliability Theory, Survival Analysis. Inference and Stochastic Orders.

Bangalore Centre

The main areas of research are as follows.

Probability theory

Applications of large deviations to Information theory, semi-stable measures and processes, diffusion processes.

Statistics

Sample surveys, Large sample theory, Bayesian inference, Bayesian non-parametric statistics, Bayesian non-parametric estimation, Robust Bayesian Analysis, Reliability theory, Optimality and construction of experimental designs.

Mathematics

Groups of exceptional Lie type, Coxeter groups and the Monster group, Combinatorics (Bruck-Ryser type theorems for quasi-symmetric designs and strongly regular graphs), Functional Analysis, Geometry of Banach space, Ergodic theory, Operator algebras and Operator theory, Harmonic analysis, Differential Geometry and Topology, Spectral theory for partial differential operators, Quantum Probability, Finitely additive measures, G-inverses.

Some major contributions are as follows.

Cheng and Bailey(1991) have proved the optimality of a class of designs within the equireplicate and binary class. Attempts are being made to extend this result to the general class. The optimality of a subclass of Cheng-Bailey designs within the equireplicate class has been established and some progress has been made towards removing the binary restriction as well.

Two series of nonorthogonal row-column designs were constructed. The members of one are universally optimal and another are highly efficient.

Attempts are being made to construct s^n experiments with block size st, t prime to s, estimating all but a few higher order interactions. In the case $s=2$, $n=4$ and $t=3$, a balanced design has been obtained with replication numbers 1 and 2.

Specification of the prior probabilty on a given class of curves is one of the main problems of the nonparametric Bayesian Analysis. For the class of increasing (or decreasing) convex (or concave) curves joining given two points a prior was developed. If it is assumed that the image of an object consists of segments of above type of curves joining a finite number of randomly selected points then one is able to place a prior on the image of an object. Using such ideas a method for restoration of distorted images is developed.

Problems in the general area of Chaos Theory and the associated Fractals were studied. The mathematical side of Chaos Theory has been (and is being still) developed only during the past fifteen years. One of the interesting and important family of maps exhibiting typical chaotic behaviour is the logistic family on the unit interval. The fractal nature of the Feigenbaum diagram associated to this family was investigated.

Results concerning transition densities, recurrence, transience and positive recurrence of diffusion processes with oblique reflecting boundary conditions (in domains like half space, orthant/quadrant) were obtained. As an application a "real variable" proof of a result due to Rogers (TAMS' 91) concerning reflecting Brownian motions in a half plane was given; such an approach enables one to exhibit other examples of

recurrent diffusion in R^2 which become transient when confined to half space by stipulating certain reflecting boundary conditions.

Work continued on Geometry of Operator spaces and the space $WC(K,X)$.

It was shown that no vector of norm one can be a point of weak-norm sequential continuity in the unit ball of $WC(K,X)$. In the case of operator space $L(X,C(K))$ it was shown that there are no denting points in the unit ball. By using some results from the M-structure theory it was shown that there are no denting points in the unit ball of $L(l^p)$, extending a result that R. Grzaslewicz has proved for the case of a Hilbert space.

In the case of the dual unit ball of $WC(K,X)$, when K has a dense set of isolated points, a complete description of the points of *weak** - norm continuity was obtained. This extends some recent work of Hu and Smith and complements a classical result of Ruess and Stegall on *weak** denting points. This identification leads one to the conclusion that for a non atomic measure μ, there are no points of weak-norm continuity in the unit ball of the space of Bochner integrable functions $L^1(\mu, X)$.

It was shown that the space of compact operators $K(X, Y)$ is isometric to a continuous function space $C(\Omega)$ iff there are compact spaces Ω_1 and Ω_2 such that X^* is isometric to $C(\Omega_1)$ and Y is isometric to $C(\Omega_2)$ and Ω is homeomorphic to $\Omega_1 \times \Omega_2$. A similar result was obtained for the space $L(X,Y)$ under the added assumption that X^* has an extreme point in its unit ball.

Problems relating to "Uncertainty principles in harmonic analysis" and "The Pompeiu problem" were investigated. Both problems are in the general area of "Harmonic analysis on Lie groups and on R^n"

The quotient module corresponding to a submodule of holomorphic functions vanishing to some finite order on a hypersurface was studied. It was shown that such a quotient module can be realised as a module of vector valued holomorphic functions on this hypersurface.

A product representation, involving two projective representations of $PSL(2, R)$, was established for the characteristic function of irreducible homogeneous contraction. Using this, an explicit formula for the characteristic function of twisted Bergman shifts was given. Further developments led to many new examples of homogeneous operators including an explicit model for all the irreducible homogeneous contractions in $B_1(D)$. Further work in these directions is in progress.

As a continuation of the study of codes associated with finite generalized quadrangles, the dimension and the submodule structure (over the algebraic closure of the field of two elements) of the code associated with a regular generalized quadrangle of even order and its subcodes associated with the classical ovoids of the generalized quadrangle were determined (with the help of Peter Sin).

Harmonic analysis on spheres was exploited to give unified proof of the optimality of a large class of spherical codes, called tight and quasi tight codes. In the process, a significant extension of a theorem of Seidel et. al. on the annihilator polynomial of spherical codes was obtained.

An algorithmic version of Zagier's recent proof of Fermat's two-squares theorem was obtained, thereby settling a conjecture of Shirali in the affirmative. This also led to a new prime testing algorithm.

Applied Statistics Division

Applied Statistics Unit

Applied Statistics Division consists of only one unit viz. the Applied Statistics Unit.

The following are the research and other activities of the Applied Statistics Unit (1996-97).

Scientists of the Applied Statistics Unit (ASU) are involved in multifarious activities related to teaching and training in the Institute. ASU is fully responsible for conducting the course "Intensive Course on Programming and Applications of Electronic Computer". This unit also conducts several teaching/training

programmes like winter/summer schools and workshops. Some members collaborate with other units of ISI on joint projects. Currently, there are collaborative on-going projects with the Theoretical Statistics and Mathematics Division and the Social Sciences Division. The scientists of the unit are also actively involved in the activities of the newly formed SURVEY RESEARCH & DATA ANALYSIS CENTRE (SURDAC)

Research Activities

Biostatistics: Distributional results have been obtained and methods of analysis developed for correlated, repeated observations on a single subject in dealing with skin papilloma.

The use of a Markov chain method is being explored to analyse cancer data specially in dealing with heterogeneity in cell dynamics between animals.

Projection of HIV incidence in Calcutta: A preliminary study based on limited survey information on incidence of HIV in Calcutta has already been completed. Work related to pooling available data and more sophisticated analysis based on extensive epidemiological modelling is ongoing.

Computer Science: Cellular automata (CA) are discrete dynamical systems in which cell values evolve synchronously in discrete time steps according to the combinational logic embedded. On 2-dimensional CA 9-neighbourhood linear rules are studied with special emphasis on their algebraic properties and state transition diagrams. Some interesting mathematical results have been obtained in this connection and others are under investigation.

CA have been used to design cryptographic systems at the hardware level for several data communications; research is in progress for application of CA to the data compression problem.

Design of Experiments, Combinatorial Methods and Their Applications: Repeated measurements designs have been studied under very general models which allow for the residual effects of treatments to persist upto k subsequent time periods, $k \geq 1$ Here k may be chosen according to the needs of the experiment. These models should be practically more useful than the ones currently used in the literature where all residual effects are assumed to die out after just one time period. Moreover, the interaction effects between treatments applied at successive time periods, which one found to be significant from the analysis of live data but are ignored in the existing models, are also considered. Under such general models, using the Kroneckker Calculus tools, some optimum designs are obtained. Moreover, the construction problem of such optimal designs for general k and any number of treatments, is completely solved. It has also been shown that these optimality results remain robust under the corresponding model with random unit effects.

Construction problems of strongly balanced uniform repeated measurement designs, both in the linear and in the circular cases, have been satisfactorily dealt with. Concepts generalising nearly balanced uniform repeated measurement designs and second order RMD's are introduced. Construction problems of such designs have been solved for some general classes of parameters. The problem in its full generality is under investigation.

Routing algorithms of street sweeper vehicles have been considered under multifarious constraints that are involved in municipal street sweeping operations. Interesting graph-theoretic and combinatorial problems are involved in the process of developing efficient solutions. The general problem has been shown to be NP-complete. Various extensions of the algorithms are under consideration and an ϵ approximate algorithm has been developed for mixed graphs. Combinatorial aspects of designs are studied particularly with respect to characterising the well known class of lambda designs. Some characterisations have been obtained under structural and parametric conditions.

Generalized Regression:, Likelihood based non-parametric regression method has been developed in multiparameter and multiresponse situations with some analysis of simulated and real life data. Extension of the methods to longitudinal data is under investigation.

Estimating equation based method has been developed for regression data, assuming only the mean structure and nonparametrically estimating the variance structure using kernel smoothers. The extension of the approach to likelihood based methods is under study.

Minimum Distance Estimates: Progress has been made in developing robust procedures based on minimum distance ideas in i.i.d. situations as well as more general regression set ups. Recent advances include the development of a new class of divergences outside the scope of "disparities" and related inference. Other work includes new weighted likelihood procedures based on minimum distance estimating equations which can be used effectively both in robust estimation as well as in detection of outliers.

Linear Models: Some work that began as part of an ISI-funded (ASSC Division) project was completed during this period. They include the various methods of diagnosing collinearity and dealing with it. Specifically, some diagnostics for the collinearity-influence of groups of observations were developed. The various methods to identify the groups of variables forming collinear relationships were studied, and their inter-relationships were examined. The theoretical question of how well-conditioned a subset of variables can be was studied, and a few methods of identifying well-conditioned subsets were developed. The effect of location-change on collinearity was also studied.

A new approach of developing the theory of Best Linear Unbiased Estimation in the General Linear Model, based on Linear Zero functions, was developed last year. The method yielded several advantages, including simplicity of derivation, and a clear understanding of the singular dispersion case. As a follow-up of this work, the updates in the General Linear Model for data and model changes were examined from this point of view. The new approach led to interesting interpretations of the correction terms, which bring out the uniformity of the underlying principles in the singular and non-singular dispersion cases.

Multivariate Analysis: Significant work was carried out in semiparametric statistical classification and other areas of multivariate statistical inference, neural network, directional data analysis, change point and slippage problems in circular data and optimal test for multiparameter mixture distributions.

Selection theory: The multinomial selection problem is studied for selecting the t "best" cells using a subset of size ($\geq$ t). As a particular case of the result obtained, a long-standing conjecture in the area of multinomial selection theory is settled.

Reliability, Life Testing and Survival Analysis: Studies are being carried out on the analysis of competing risk data with cause of death arbitrarily missing. Estimation procedure using EM algorithms has been worked out. A counting process approach is under study in the context.

Estimation of component life time distributions from data on system life times of a coherent structure has been worked out. The investigation of estimation methods with intermediate observations on the system and its components is under consideration
at present.

Maximum likelihood method for parametric estimation of the member of components in a system of superimposed renewal processes has been worked out. The same is being attempted in a non-parametric set-up.

Sample Surveys: Certain innovations are made in three-stage sampling with unequal probabilities in the context of an actual survey related to rural indebtedness undertaken by the ISI.

Brewer's asymptotic technique has been and is being applied in direct and randomised response surveys in one and two phases covering quantitative data admitting regression estimators and also in developing appropriate small domain statistics. Bayes method in various forms are also being employed in deriving small domain estimators. Measurement error models are studied in estimating finite population totals and variances and small area parameters. Some significant results are reported. The work is still in progress. Estimating functions in response-dependent sampling from finite populations and in sampling using randomised response models have been studied.

Project:

1. Statistical Approach for Evaluation of the Efficiency of PEMF Therapy

Project Leaders: Anup Dewanji, Tapas Samanta

The main objective of the study is to obtain an insight into the effects of PEMF on different human physiological processes in relation to specific pathologies involved in Rheumatoid Arthritis based primarily on the subjective responses on certain specific symptomatology. Data taken from a pilot study have been analysed and attempts have been made to develop statistical methods for examining effectiveness of pretherapy preparation and post application durability.

2. Intergenerational Occupational Mobility among Residents of Calcutta

Project Leader: P. Mukhopadhyay

A field survey covering about 1100 households from among residents of Calcutta has been completed and data on migration, inter and intra-generational occupational mobility have been collected. The final tables have been obtained. Different indices of occupational mobility are being worked out. It is expected that a draft project report will be completed very soon.

3. Small Area Population Estimation for the Districts of Hooghly and Murshidabad

Project Leader: P. Mukhopadhyay

The work of the project started in August 1996. The relevant literature is being studied and preliminary information for forming sampling frames for these two districts is being collected. Sampling design has been worked out and the schedule has been prepared. Data have been collected from sampled households in the urban area of Hoogly district.

4. Development of Statistical Technique as an Aid to Geological Mapping (funded by CSIR, scheme No.25(0077)/95/EMR-II)

Principal Investigator: Prof. J.K. Ghosh

Project co-ordinator: Tapas Samanta

The project aims at providing a statistical method aiding geological mapping. (A geological map is the basis for exploration of a variety of natural resources like rocks, minerals and fossil fuels.) A simplified version of the geological mapping problem was considered in the initial stage. The problem was to divide up the area (to be mapped) into "homogeneous" subregions on the basis of the rock types and our object was to provide an automatic Bayesian solution to this problem.

A model was already set up for the available data (collected earlier in the study area of Bhumaram in the Godavari Valley, India) given the subregions into which a given set of boundaries partitions the whole area. Thus our problem of choosing a set of boundaries between "homogeneous" subregions corresponds to selecting one of several possible models. Recently-developed automatic Bayesian methods of model selection have been used to solve the problem.

With the available (first stage) observations we obtained the "best" partition which gave bands for the boundaries. More precise location of the boundaries is possible with additional second stage observations for which a sampling scheme is to be developed; we have now taken up this problem of developing a sampling scheme for allocation of optimum number of observation points to most appropriate locations.

5. Software Package for Directional Data

Project Leader: A. Sen Gupta

This is an ongoing project on software package development for directional data. So far programmes have been developed for diagrammatic/ pictorial representation as a descriptive statistical tool, robust parameter estimates, and statistical testing procedures, goodness-of-fit tests, model selection etc., in a semi parametric framework for circular data.

6. Application of Two Dimensional Cellular Automata

Project Leader: P. Pal Chaudhury

This project relates to study of cellular automata of various dimensions, particularly in two dimensions regarding the theoretical properties and their practical applications. For a class of 2D cellular automata, several algebraic properties have been established. Application to cryptology have already been reported. Work is in progress to apply 2D automata in areas like data compression, production of fractals, etc

7. Bayesian Analysis of Biomedical Imagery:

Project Leader: , Amita Pal

An attempt is being made to tackle a variety of image understanding problems pertaining to images of biomedical origin. The approach is to some extent application-dependent in the sense that the choice of priors to be used is governed by the problem being attacked. We have started work with photomicrographs of peripheral blood film. Preprocessing problems have been taken care of and algorithms for detecting some types of abnormal blood cells are being developed.

Computer and Communication Sciences Division

The Division comprises Computer Vision and Pattern Recognition Unit, Electronics Unit, Electronics and Communication Sciences Unit and Machine Intelligence Unit. Faculty members of the Division are also engaged in teaching and training in M.Stat., M.Tech.(CS) and M.Tech.(QROR) programs, in addition to their research and project work. Many undergraduate and postgraduate engineering students of Computer Science, Electronics and Telecommunication, Electrical Engineering and students of MCA courses from different universities and institutes undergo their vocational/semestral training under the supervision of the faculty members of this division. Research works carried out in these units are described below.

Computer Vision and Pattern Recognition Unit

1. Mathematical Morphology, Dot Pattern and Cluster Analysis

(a) An efficient approach based on mathematical morphology has been developed to detect circular objects in a scene. Also, mathematical morphology has been extended to detect shape of dot patterns.

(b) The task of shape identification of dot patterns has been considered. A new shape definition called S-shape has been proposed. It has been refined to r-shape which can be computed in linear time while other existing techniques take O(N log N) time.

(c) Generalization of the dot pattern shape identification has been made to take care of patterns with variable density and having line-like extensions.

(d) An improved multi-seed data clustering algorithm has been proposed. It has been demonstrated that the algorithm works quite efficiently. Detection of clusters within a cluster has been worked out

(e) Another problem considered is the clustering of noisy and imprecise data. The problem has been considered in the context of k-means clustering algorithm.

2. Computational Linguistics, Natural Language Processing and Speech Analysis

(a) From a large corpus, statistical analysis of Bangla text is continued. Statistical analysis of phonemic representation of the data has also been done.

(b) Morphological analysis of Bangla words has been started from the linguistic point of view. This includes preparation of suffix list, categorization of compound words, re-duplicated and echo-words, pronominal and other ambiguity categorization, etc.

(c) Work on Bangla verb analysis has been continued and morphological parsing of compound verbs, has been implemented. Work on non-verb words has now been started.

(d) A spell checker prototype has been designed for non-word error detection in Bangla text. A correction strategy has been formulated. It is being extended to take care of some real word error detection.

(e) Computer implementation of grapheme to phoneme conversion rule has been worked out. Work is in progress to produce speech mode output of OCR and spell checker already developed. The work will be useful for the visually handicapped.

(f) Work has been started on limited domain automatic translation between Bangla and Hindi languages. The domain chosen is weather and calamity forecasting.

(g) In collaboration with International School of Dravidian Linguistics, a study has been started on automatic synthesis of Malayalam speech sound.

3. Optical character recognition and document processing.

(a) The prototype Bangla OCR system already developed is being improved to recognize multi-font multi-size Bangla documents.

(b) A system has been developed to segment multiscript documents.

(c) A bilingual OCR stem to Bangla and Devnagari (Hindi) characters is being developed.

4. Preliminary study has been started on South Indian Language OCR like Telugu and Tamil.

(a) Work is in progress for automatic identification of tables and mathematical expressions in a complex document. Automatic merging, appending and restructuring of tables are also being worked out.

(b) Work has been started on hand-printed Indian script recognition system.

5. 3D Digital Geometry and Biomedical Image Processing

(a) The problem of confocal microscopic (CM) image processing has been considered. Multiple layers of CM images have been combined to make a 3D cellular representation. The work has been compared with SNAKE algorithm. The work on cell segmentation has been extended to automatic FISH signal detection.

(b) 3-D binary image thinning and skeletonization algorithms have been proposed. The work has been extended to segment the skeleton into meaningful parts

(c) Work has been started on Medical Image Database Management Systems.

6. Neural Networks

(a) An adaptive method has been developed to update, in an autonomous way, the learning rate of the backpropagation algorithm for a multilayer perceptron. In this context a new concept, namely, the effective value function of the learning rate, has been defined. The new adaptive algorithm has been found to be useful in some real life problems and has produced much better performance in terms of convergence speed than the original backpropagation algorithm. The applications considered are (a) texture segmentation problem which does not consider a feature set and (b) classification of remote sensing imagery.

Also, the robustness of the proposed algorithm is being studied.

(b) A modification of the self-organising neural network model of Kohonen has been proposed. A dynamic version of the network has been developed where the size of the network can grow or reduce during the learning process depending on the data. The dynamic network has been applied for efficient shape representation and a unified approach to skeletonization of 2-D patterns (binary or gray level images or dot patterns) has been proposed. The robustness of the proposed shape representation algorithm in comparison to the existing algorithms for the same purpose, has been established.

Also, modifications have been made so that even the local topology of the network gets adapted (unlike in Kohonen's feature map) on the basis of the input.

(c) A work is continued to see how a redundant multilayer network behaves under component failure both during training and operational phase of the network.

Electronics Unit

During the period 1996-97, the faculty members of the Unit were engaged in research in the field of Computer Science. The research areas include Parallel Algorithms and Parallel Architectures, Network Topology, Interconnection Networks, VLSI Layout Design, Computational Geometry, Logic Synthesis and Design for Testability, and Discrete Event Simulation.

1. Heterogeneous Computing

During recent years, Heterogeneous Computing (HC) has become one of the thrust areas of research in the field of parallel processing. HC involves the use of different types of parallel processors, processing components or connectivity paradigms to maximize the overall system performance, cost effectiveness and development efforts.

The objective of our research in this area consists of the following :

a) We plan to develop a suitable model of computation for a heterogeneous computing environment involving a combination of dissimilar machines. Devising a suitable topology for interconnecting different component processing units is also planned to be studied. Appropriate methods of analysis will also be developed to predict the behavior of such complex systems.

b) Different application problems will be mapped on such an HC environment containing several (5-6) processing nodes having different architectures. The performance of the HC environment in executing different problems of varying size under different connection paradigms and different scheduling policies will be measured through actual experimentation. Then the experimental results may be compared with the theoretical estimations. The best possible computing environment for a given application can be identified from these experimental data. During 1996-97, we have developed some new ideas for scheduling different tasks on a heterogeneous system. These have been simulated on an existing workstation and the results of simulation are being studied for consolidation of the ideas. Along with the above experiments, several

theoretical results have been obtained on the efficient topology for interconnecting multiprocessor systems and also on designing parallel algorithms for solving different numerical and graph theoretic problems.

2. Logic Synthesis and Design for Testability

Logic synthesis and design for testability techniques are indispensable in the VLSI circuit synthesis and testing. A typical VLSI chip may consist of hundreds of millions of transistors, design of which requires specialized design tools. To ensure high reliability, yield and maintainability, these chips must be tested during design, production, and while under operation. Unless the chips are designed with in-built easy testability scheme, testing will be a formidable task, if not impossible. In this project, our objective will be to innovate new design methodology for gate-level logic synthesis and redundancy elimination, targeted to having high fault coverage, in terms of stuck-at faults, as well as robustly testable delay faults.

The results obtained in this area during the period in question are given below :

(i) Logic synthesis with non-scan sequential circuits is of utmost importance in the recent trends of high performance circuit design. Investigations have been done on the redundancy problem in synchronous sequential circuits. Identification and elimination of redundancy have been studied, with a special emphasis on isomorph-redundancy. Several new attributes of such redundancies have been formulated, and their impact on logic synthesis has been studied.

(ii) We have also developed a novel scheme of BIST (Built-in Self Test) technique for detecting stuck-open faults in combinational CMOS VLSI circuits. Efficient BIST design for universal testing of stuck-open faults was an open problem. The proposed scheme is not only robust but also universal. Its hardware overhead is low, and testing time is significantly reduced. In addition, a new technique called adaptive BIST has been developed. The scheme is useful for testing arbitrary CMOS complex cells, and the test sequence is independent of the circuit structure and its functionality.

3. Multi-Mesh Architecture

The Multi-Mesh (MM) architecture, built around 2-D meshes, has newly been proposed by us (Ref. Das and Sinha, Proc. 9th IPPS, pp. 17-21, April 25-28, 1995, Santa Barbara; and M. De, D. Das, M. Ghosh and B.P. Sinha, Proc. HiPC '95, pp. 707-712, held in New Delhi, India during Dec. 28-30, 1995). This architecture provides the following features :

a) The number of processors is $N = n^4$, for some integer $n > 2$. The smallest system can be built with 81 processors.

2) Every processor will have a uniform degree of 4 only.

3) Although the number of links is same as that of an Illiac IV architecture or a 2-D torus, the MM topology provides a diameter of $2n$, i.e., $2N^{1/4}$ in contrast to $2N^{1/2}$ for an Illiac IV topology. This reduced diameter helps to implement the following algorithms very efficiently :

Summation/Average/Maximum /Minimum	: $O(N^{1/4})$ time
Matrix Transpose	: $O(N^{1/4})$ time
p x p matrix multiplication	: $O(p^{0.8})$ time (compare this with $O(p)$ time on a 2-D mesh)
p-point DFT computation	: $O(p^{0.8})$ time
Sorting :	
n^3 independent sets of n^3 elements each	: $O(n)$ time
n independent sets of n^3 elements each	: $O(n)$ time
n^4 elements	: $O(n)$ time
Lagranges interpolation on n^3 elements	: $O(n)$ time

4) The 2-D mesh can also be emulated on this MM topology in constant time. Thus the 4-neighbour adjacency property can also be preserved in a certain sense on this topology.

5) Point - to - Point communication, singe node broadcast and multicast can all be implemented on this network in $O(n) = O(N^{1/4})$ time.

6) Under single node or link failure, the diameter will not increase by more than 6. Other properties will be gracefully degraded with faults.

7) Any existing algorithm on a 2-D mesh or torus can be easily transported to this new architecture and this is still a subject of further study and software development.

Apparently, the proposed architecture will be able to implement a large class of algorithms in numerical applications, image processing and other real-life situations very efficiently without any additional hardware investment over that required for a 2-D mesh.

During the academic year in question, efficient algorithms for i) multicast in O(N) time, ii) complete exchange using wormhole routing in $O(N^{3/2})$ time and also iii) permutation routing on the Multi-Mesh have been developed. The sorting algorithm on the Multi-Mesh has also been further improved.

4. Electronic Design Automation

During the past 10 years, members of this Unit had done extensive research in the area of VLSI Design including synthesis, testing and physical design. New techniques of testable design, partitioning, floorplanning and routing in microchips have been developed. With the advent of high-performance VLSI and ULSI (Ultra Large - Scale Integration) chips, and MCM's (Multi-Chip Modules), efficient EDA tools targeted to achieve high speed and low power design are now in great demand. In the forthcoming years, we would thus like to explore the following emerging areas of research :

A. Performance driven logic partitioning and floorplanning
B. Unified scheme for global and local routing
C. Low power design of VLSI chips

Efficient algorithms for high performance floorplan design and routing in VLSI circuits have been proposed and tested on benchmarks. The results outperform earlier methods both in cost of chip fabrication and turnaround time. In particular, we have addressed (i) the optimal linear placement problem of circuit graph to minimize signal delay, (ii) floorplan-area optimization for custom designed microchips, and (iii) partitioning for improved wire routing based on geometric measures.

5. Applications of Computational Geometry to VLSI Layout

The physical design phase of VLSI (Very Large Scale Integration) circuits involves many problems on partitioning, placement, floorplanning, wire routing and area compaction. Furthermore, variations of layout style, technology, and packaging, e.g., FPGA's (Field Programmable Gate Arrays), and MCM's (Multi Chip Modules), lead to numerous design and optimization problems, the formulation of which needs graph theory and combinatorial optimization. In this project, our objective is to identify various VLSI design problems which can be efficiently solved using the paradigms of computational geometry. We believe that these new techniques, by virtue of their inherent power and novelty of spatial data structures and search methods, will outperform or augment the conventional EDA (Electronic Design Automation) tools. In addition, these techniques will have manifold applications to defence, robotics, database, and pattern recognition.

We have identified many new design problems that arise in VLSI physical design automation and mapped them to computational geometric problems. New algorithms for maximum-empty-region recognition among isothetic/non-isothetic obstacles have been proposed. The algorithms also include recognition of max-width/area empty staircase channels, 3D cuboids etc. We also introduced the shooter location problem and proposed efficient algorithms for solving it. A novel routing-driven partitioning scheme has been formulated.

6. Mobile Computing

Mobile computing refers to the use of portable computers interconnected through wireless networking. It allows the mobile users to effect versatile communication with other people along with continuous access to the services and resources of the land-based computer network. Designing softwares for a mobile computing system is different from that involved in case of a stationary networked system in certain aspects, as mobility induces several new problems.

Wireless communication used for mobile computing system is characterized by low bandwidth channels with high error rates and more frequent disconnections. These factors can increase the communication latency resulting from the requirement of retransmission of data packets arising due to error control protocol and short temporary disconnections. Mobility, in turn, causes wireless connections to be sometimes lost or degraded due to signal weakening, when the users travel beyond the coverage of network transreceivers or enter areas of high interference. Also, the number of devices in a network cell varies dynamically and a large concentration of mobile users at a single place like conventions, may also overload the network capacity.

A mobile computer's net-address changes dynamically. This dynamic feature in mobile wireless networks leads to a problem of keeping track of the topology connectivity. This problem, also known as the location management problem, becomes too complex when the rate of change is high and the network size is large. Thus, an important issue in mobile computation is the design and analysis of the topology management schemes.

New routing schemes are also needed for such mobile networks. Conventional routing protocols are not applicable for networks where the topology connectivity is subject to frequent unpredictable changes. A suitable loop-free routing is desirable for this purpose, since a loop-free routing will minimize the consumption of resources during communication and also the communication delay involved in the process. Routing schemes also need to be developed to tolerate corrupt wireless links.

In a mobile computing environment, all the neighboring base stations are connected to a Mobile Switching Centre or MSC. When a mobile user is about to leave a cell, the cell's base station transfers the ownership of the cell to another base station getting the strongest signal from the mobile user. If a call were in progress at this point of time, then this call should be switched to a new channel (as the old one is not used in any adjacent cell). This new channel assignment is basically done through a switching network.

We have developed a generalized shuffle exchange network, which can be used as an efficient MSC, even when the number of base stations is not necessarily a power of 2. The network offers a very cost-effective as well as fast switching technique for handoff procedure between base stations.The routing algorithm and the fault-tolerance of these networks are currently under study.

7. Microelectronic System Design using FPGAs

Field-Programmable-Gate-Arrays (FPGA'S) are now being extensively used to synthesize complex logic circuits in the laboratory. These IC chips have the following features : (i) high degree of complexity (thousands of gates), (ii) complete programmability to implement arbitrary architectures, (iii) programmability in the laboratory and (iv) a large number of contact pins. In this project, we have two objectives in mind :

An exposure to FPGA's has now become indispensable in a 'VLSI Design' course. FPGA devices can be configured in hours rather than weeks or months. The logic devices as well as routing patterns are pre-fabricated on the chip. Synthesis of an arbitrary architecture can be made by proper logic design followed by programming the FPGA to implement the circuit and routing. This needs:

(i) a hardware platform with FPGA logic card,
(ii) design software
and (iii) FPGA chips which are to be programmed.

Assignments of moderate complexity can be completed within one course. The feasibility of rapid prototyping of systems would encourage the students to undertake more experimental research on realistic problems of larger size.

Optimal logic synthesis and routing targeted for FPGA realization has become an upcoming area of research. In particular, we shall undertake the investigation on logic - partitioning problem in an FPGA environment. Given a complex circuit in terms of interconnection of modules, the problem is to partition it into smaller sub-complexes, such that the overall design and routing on FPGA become optimized.

Synthesis of fault-tolerant systolic arrays with FPGA architectures is being studied. We have also developed a new technique for synthesis of large synchronous sequential machine. The proposed design has less hardware overhead, shorter test application time, and a very high fault coverage. The design can easily be mapped to a FPGA-based architecture.

8. Discrete Event Simulation

Synthesis of very large sequential machine now forms an integral part of high performance ASIC VLSI chips. Typically, such circuit might consist of 30,000 logic gates or more. The circuit is described in VHDL environment ; then steps of partitioning, finite-state machine synthesis, and final logic design need to be performed.

To check the correctness of the design, it is required to have an extensive simulation study. This involves : (i) logic simulation, (ii) fault simulation, (iii) timing simulation, (iv) layout simulation.

If any design error is identified during simulation, it is corrected and the process is iterated.

In this project, we would like to investigate different strategies for such discrete event simulation. Typically, simulation programs run on mainframe for several days at a stretch. New techniques based on circuit partitioning and efficient data structures are to be devised to cope with this rapidly expanding area.

Discrete event simulation is also indispensable in evaluating the performance of a parallel processing system. In our array processor-based system, performance of various computer networks and parallel algorithms are being studied. Study of such designs will also require discrete event simulation in a large scale. Typical examples are job queuing, deadlock, broadcast, message routing protocol, etc.

Various studies on the development of efficient methodologies for discrete event simulations have been carried out. A Parallel Virtual Machine (PVM) environment is also being studied in a UNIX environment run on a Silicon Graphics Workstation. Logic simulation at switch-level is being studied on a PC platform.

Large scale simulation studies have been made in the earlier years to assess the performance of a (64 x 64) baseline switching network with output buffering. It has been observed that the output buffering scheme provides more throughput and manages huge traffic quite efficiently. The traffic rate was varied from 20% to 100% whereas, the number of buffers in a queue within a switch was varied from 1 to 12.

Externally Funded Project

Development of CAD Tools for Identification of Logical Equivalence of Library Elements and Identification of False Paths in a Switch-Level Network (Funded by Motorola India Electronics Ltd., Bangalore).

Date of commencement : January 1997

Duration : 1 year.

Principal Investigators : B.B. Bhattacharya (ISI, Calcutta), P. Palchaudhuri (Intel Corp., Oregon).

Collaborating Scientists : S. Choudhury (B.E. College), I. Sengupta (IIT Kharagpur), S. Misra (Motorola, Bangalore).

Objectives :

i) To develop theory and tools for boolean logic verifier with an objective of recognizing logic functions under permutation and negation of inputs. This is necessary in logic synthesis of VLSI Circuits, and would be useful in replacing a logic module by an equivalent one having better permonfance features, from the cell library.

ii) To extract circuit description from a switch-level netlist, and determine false paths across latches in a sequential circuit. This is necessary to reduce simulation time and to optimize logic and critical delay in high performance VLSI circuits.

Electronics and Coimmunicaiion Sciences Unit

1. Theoretical and Experimental Investigations in Computer Vision, Pattern Recognition, Biomedical Imaging and Image Analysis

Mathemetical morphology : Use of mathematical morphological tools for image processing and analysis are extensively studied. Concepts of digital convexity, ramp-convexity, ortho-convexity are expressed in morphological framework Algorithms for generating relevant convex hulls are suggested. Fast algorithms for computing pattern spectrum are developed. Morphological edge detector is designed and its superiority is established over existing edge detectors. Morpbolocical operations are successfully used in document image segmentation and analysis.

Multisource data integration : Integration of multisource data having various spectral and spatial resolutions is being carried out, so that better interpretation of the object/scene that has been imaged can be obtained from the combined information. One of the major steps is the registration of the preprocessed multisource data. Preprocessing techniques, in this work, include classification of various regions based on higher spectral resolution data and extraction of linear features from higher spatial resolution data using multiscale operator. The techniques are applied on biomedical images as well as remote sensing data.

Analysis of 3D objects : Topology and shape preserving parallel 3D thinning algorithms were developed. A new method is introduced to estimate robustness of a thinning algorithm under random noise and rotation. Topology based segmentation method is proposed for 3D objects and it is shown that the method is quite capable of handling noisy objects.Local topological parameters of 3D objects in tetrahedra representation is studied and the results were reported.

Geometric invariance : Application of Geometric invariance in computer vision includes detection of symmetric contour pairs under non-fronto-parallel viewing condition. This is followed by determination of symmetry line in images subjected to projective object onto image transformation. This is evaluated from the inter-contour reflection matrix.

2. Remote Sensing and Data Analysis in Atmospheric Science and Wave Propagation:

Analysis of Satellite data : The research focus is to first classify the atmospheric images into meaningful subparts of meterological relevance and this is primarily based on its reflectance value. This information are then used to study the motion in a sequence of atmospheric images taken from INSAT. Algorithms were developed to classify the bands concentric to eye of the cyclone in ages. Further works are going on to monitor, track and predict the future course of movement of atmospheric disturbances like cyclone. The two critical aspects of this study are : (a) The shape under investigation is deformable in nature. (b) A set of meteorological factors is involved in formation and deformation of the eye of the cyclone and its encompassing bands. Cloud systems are then modelled through ray tracing.

Analysis of SODAR images : Atmospheric Boundary Layer (ABL) shapes have been extracted from SODAR images. A rule based algorithm was prepared for the interpretation and classification of the SODAR patterns. An algorithm for network driven inferencing mechanism has been developed and it has been applied on SODAR pattern recognition problem. An algorithm for image segmentation based on Fuzzy c-means has

also been implemented for SODAR image. Algorithms are being developed for fractal based study of turbulence on SODAR patterns.

Modelling of Transport Phenomena : Data collected by 30 meter meteorological towers were analysed to understand the dynamics of the Planetary Boundary Layer (PBL). Study of transport phenomenon in the PBL is being simultaneously carried out. A suitable model for transport of scalar in the PBL is under preparation. Validity of the model was continuously checked with the help of tower data.

Study of Atmospheric Boundary Layer : Study of the dynamics of atmospheric boundary layer has been continued during the last financial year. The main aim of the project was to develop a turbuylent transport model for the monsoon period. Substantial work has been carried out towards that goal. Besides this, the objective of the project was to analyse the sodar and tower data available at differemt stations in India with a view to deriving some deeper understanding of the planetary boundary layer dynamics. A number of papers have been published and a few others have been sent for publication.

Fractal algorithm for study of ABL dynamics : In 1996-97 extensive study has been conducted on the application of fractal methods in general and atmospheric turbulence.

In a paper, published in "Indian Journal of Space and Radio Physics", Vol 25, pp 245-248, the fractal nature of semidiurnal variation of radio refractivity index has been studied.

Applicability of fractal decomposition of sodar image technique to study thermal convection in the planetary boundary layer has been studied in a paper, which has recently been communicated to the International journal "Fractal" after second revision.

3. Statistical Studies on Acoustic Phonetic Characteristics of Indian Speech and Musical Sounds with a view to Automated Speech Recognition

Acoustic Phonetic Study : Acoustic phonetic studies on major Indian languages like Assamese are continuing. Investigation on Assamese vowel has been completed and reported in conference. Spectrographic analysis of 360 multisyllabic Assamese words spoken by three male informants provide data for this study. In next phase acoustic phonetic studies of Assamese plosive consonants will be carried out. An elaborate investigation is started to find out acoustic correlates of the nasal and non-nasal distinction of vowels in Bengali language.

Perception : Perception experiment is continued for finding cues for different manner of production. Perception experiment has been completed to detect cues for Bengali unaspirated plosive consonants. Similar experiment will be conducted for a aspirated plosive consonants.

Perception experiment has been set up to find cues to distinguish non-nasal and nasal vowels. Tentative cues have been located and stimuli are prepared from 7 minimal pair of words, one for each vowel of Bengali language using these cues. Elaborate perception experiments will be conducted to find out the sufficiency of the cue.

The perception of illusory note 'ni' in tanpura sound has already been reported. It was also reported that this sensation is accomplished with a appearance of a strong harmonic. A software has been developed for this experiment. This work is being done in collaboration with Sangeet Research Academy.

Word recognition : Work on word recognition using neuro-fuzzy classification technique is going on. Here a pattern recognition scheme, using fuzzy logic and back propagation type neural network is proposed. In another experiment approximate reasoning approach to pattern recognition of vowel speech sounds of major Indian languages has been attempted successfully. Application of this method for Telugu, Bengali and Assamese vowel recognition provides promising result.

Music : A theory based on principle of consonance and categoricity of pitch perception in music mode is being elaborately tested with data from actual vocal performances by maestros. So far this has been tested for raga Iman.

The work on the theory of tanpura string vibration using two-length string vibration model is continuing. So far striking similarity has been observed between the simulated results and the results obtained from actual strings.

Identification of different gharanas in Indian classical music has been taken up. The software already built for pitch detection is being used to detect shruti positions in actual performances of master musicians. These are used for identification.

The research on music is being carried out in collaboration with Sangeet Research Academy, Calcutta.

Machine Intelligence Unit

The objective of the Machine Intelligence Unit (MIU) is to carry out basic research concerning certain aspects of machine intelligence. Machine intelligence signifies the work associated with attempting to make a machine behave like human beings. In other words, it conveys the core concept of pattern recognition and machine learning with the advanced technologies like fuzzy logic, artificial neural networks, genetic algorithms, fractal, rough sets.

The investigation that is currently being done in MIU encompasses both the development of these technologies individually and in an integrated (hybridization) manner, and demonstrating their effectiveness in solving various problems of pattern recognition, image processing, brain modeling, expert system, vision, control etc. related to the design of intelligent systems. Hybridization such as neuro-fuzzy, neuro-rough, neuro-fuzzy-genetic helps in making such systems artificially more intelligent.

Note that these tools are collectively known as soft computing paradigm. They provide the theory of flexible information processing, which can deal with real life ambiguous situations in an efficient manner like human beings, and therefore form the basis of future generation computing systems.

Research work that has been carried out in the aforesaid line is categorized as follows.

I. Pattern Recognition

Genetic algorithms (GAs) have been applied for pattern classification in N dimensional feature space where a fixed number of hyperplanes is used for modeling the decision boundaries of the classes. It has been proved that as the size of the training data tends to infinity, the error probability of the GA based classifier is less than or equal to that of Bayes classifier. The number of hyperplanes required for modeling the class boundaries has also been adaptively evolved from the GA itself utilizing the concept of variable string length. In addition, effectiveness of several other strategies like simulated annealing, linear discriminant functions and learning automata in classifying patterns in IR^N has also been studied. In another investigation, an effect of chromosome differentiation for performing restricted cross-over operation is studied. This helps in accelerating convergence of the GA process. An analogy of the GA classification with MLP is determined. Based on this, an algorithm for optimum network formulation is formulated.

A multivalued recognition system, which minimizes uncertainty in decision making by providing output in four states, has been successfully implemented in identifying ill-defined man-made objects such as airports, seaports, road maps and beaches from IRS image data. Various supervised and unsupervised fuzzy set theoretic models are also examined in this context for SPOT images. Under an externally funded project, a software package is developed on this and is handed over to defence personnel for their use. A modified version of the multivalued recognition system is also used as a medical expert system for diagnosing hepatic diseases.

A minimal spanning tree based criterion for the selection of seed points has been formulated along with its experimental demonstration. A split and merge clustering technique and a metric for higher dimensional data sets have been developed in this regard. A modification in k-means algorithm is suggested

for reducing the computation time. A minimal spanning tree based criterion for finding α for the construction of α -*hull* has been found. A concept of *fuzzy* α- *hull* is also proposed.

A new model for *fuzzy-possibilistic* clustering has been proposed. Unlike existing models, the proposed mixed model can provide us with both fuzzy *membership* values and *typicality* (possibility) values, and consequently can give a much better understanding of the substructures present in a data set. Dempster-Shafer paradigm has also been used to design a classifier.

Electroencephalogram (EEG) reflects the electrical activity of the brain in the various states of sleep and wakefulness. One of the methods for quantifying (qEEG) such activity is calculating the FFT (Fast Fourier Transform) of the EEG waves. Under different conditions of stress and exercise, the qEEG is found to be suitable as input feature to MLP (multilayer perceptron) for discrimination between normal and depressed animals.

For classifying fingerprint patterns, the use of unprocessed gray level images reduces the loss of information (and hence uncertainty) in decision making. Power spectral (1-D FFT) estimate of texture along some (4 or 8) selected directional bands has been found to be useful as input features for MLP based classification. Here the global characteristics (frequency) of fingerprint patterns are utilized. Its comparison with those of fuzzy geometrical features and other directional/textural features is made for various noisy and distorted fingerprints.

The effectiveness of fuzzy geometrical features has been demonstrated for classifying distorted overlapping fingerprints directly from raw unprocessed images. The output is defined here in terms of six classes. Left-loop, Right-loop, Twin-loop, Plain-arch, Whorl and Overlapping. Overlapping (between any two of the above five pure classes) in various degrees and orientations is artificially produced on pure fingerprint images. Distorted patterns are generated for all the six classes, with random noise, cut marks and information loss in certain random locations. The fuzzy geometrical features are found to be the best for classifying these patterns when Bayes', k-NN (with k = 1, 3, 5) and MLP (multi-layer perceptron) classifiers are used.

2. Image Analysis/Processing and Computer Vision

Various efficient smoothing algorithms using isotropic and anisotropic diffusion processes, and coding algorithms using a modified Bezier-Bernstein approximation technique have been developed. Based on the second generation coding technique, an algorithm has been formulated which is seen to yield high compression ratio. A new contour coding scheme using the properties of discrete circle has also been developed. The algorithm is seen to yield high compression ratio for a class of binary images. Various fractal and wavelet methods for image data compression are under investigation.

An attempt is being made to recognize and classify planar polygons using a new set of local shape descriptors, namely *extended angle* and *extended ratio*. These together with a proper measure of the direction of the extended lengths make the feature set translation-rotation-scale invariant and also help in complete reconstruction of the unknown polygon.

A new multiscale morphological edge detector has been developed. The proposed detector has better noise immunity and intensity response compared to other existing morphological edge detectors. Fuzzy control paradigm has been used for image processing. Effective edge detection algorithms have been developed integrating human psychovisual facts with fuzzy reasoning.

The application of spatial/spatial frequency (s/sf) representation (Wigner distribution) for different low and intermediate level vision problems are currently under investigation. A new framework in analyzing the formal mathematical correspondence between quantum mechanics and time-frequency representation of signal is proposed. It is also shown that the joint time frequency distributions (s/sf) have a close link with Heisenberg uncertainty relation if the observables are taken as fuzzy entities. It is postulated that these mechanisms will be of crucial importance in highly fragmented computational structure, such as neural networks as they may exhibit a strong mutual interaction between data and operator.

3. Artificial Neural Networks

A connectionist model, namely, X-tron is developed for perception of mixed object categories. Necessary supervised and unsupervised learning algorithms are proposed. Network models for mixed category perception which is capable of accepting absolute feature values as input are also developed. The principle of X-tron has been used to build a psychologically motivated structured connectionist system, called PsyCOP, for learning and simultaneous recognition of multiple objects. A connectionist system for learning and recognition of linear structures and its application to handwritten character recognition has been developed. Principle of Hough transform is used in this development. The effectiveness of neural networks is studied for thinning in graylevel images. Some efficient algorithms based on cellular neural networks have also been developed for object extraction problem.

The generalizations of Kohonen's LVQ model have been proposed and used in clustering and image processing problems. In this context, relations between LVQ and various c-means type algorithms are established.

Dimensionality reduction using different neural networks has been done. Selection of an optimal feature set for pattern recognition problems has been realized. An algorithm for selection of an optimal/near optimal architecture for a MLP has been developed. Application of NN for time-series analysis is in progress. A MLP based approach for determining the shape of a pattern class from its sampled points is proposed.

A knowledge based connectionist system incorporating domain knowledge has been developed for classification and rule generation. The network is then refined by learning. This helps in speeding up the net other than improving performance.

4. Genetic Algorithms (GAs) and Fractals

Here the investigation involves both theoretical development of GA and its different applications to pattern recognition problems.

A new mutation method called *directed mutation* is developed which accelerates the rate of convergence of genetic algorithms to a great extent. Convergence of GAs with elitism is proved. Attempts are also being made to find the optimal stopping time for GAs.

A new crossover technique, called self crossover has been developed which satisfies the constraint cardinality (number of 1's) of the coded string remains the same" but retains the stochastic and evolutionary characteristics of GA. The method provides better result for problems like traveling salesman problem and feature selection in pattern recognition compared to existing techniques.

An attempt has been made to study the effect of emulating sexual discriminations in artificial genetic algorithms. The results shows a marked improvement over the conventional or asexual genetic algorithm. The schema theorem is shown to hold for the modified methodology. It is also established that in most situations the lower bound on the number of schemata sampled by the modified method is better than its conventional counterpart.

A concept of "age of individuals" so as to decide the 'parenthood' of them is introduced; and this is seen to maintain more diversity in the population. Middle aged individuals are considered to be more fit to produce offspring. In another work, parents' fitness is used as a part to decide the fitness of individuals thereby giving more importance to individuals coming from 'better families'. This gives more directionality towards the goal. GAs are made efficient also by introducing better individuals in terms of fitness function from outside the population or preserving and reintroducing individuals which were dropped out at earlier generations. This promises to increase the general degree of exploration of the search space, thereby improving the performance efforts are also being made to develop some strategies to select mating pairs for the crossover operation.

A concept of search space division by employing a multi population scheme is introduced in GAs. In this scheme a GA divides the whole search space into sub spaces depending on the convergence status of the population and the solutions obtained so far. The scheme helps to prevent premature convergence to local

optima for multi-modal problems. It is shown that for a bi-population real coded GA the scheme can provide local searching capability to genetic search.

A methodology for searching robust solutions (in contrast to the best one) by GAs is developed. The scheme employs addition of noise with the search space parameters, before evaluating the fitness of individuals. The scheme detects stable solutions in contrast to sharp ones and this helps in real life design problems where solutions are expected to be unaltered with small variation of parameters.

An application of GAs for automatic selection of optimal image enhancement operators has been shown. The selection of optimal parameter values of multilayer perceptron and cellular networks has also been made. It relieves multilayer perceptron from using back propagation technique. A GA based model to evolve Hopfield type optimum network architectures for object extraction has been developed. The performance of GAs vis-a-vis simulated annealing for optimization is investigated.

A method has been developed for magnification of digital images using iterated function system (IFS) with the help of GAs. GAs have helped in reducing the search space for finding near optimal transformations for coding. These codes are directly used for image magnification instead of the original images and thus reducing the memory requirements as well as computing time. Further, a mathematical analysis of the reconstructed images using IFS codes has also been carried out. Attempts are being made to develop a hybrid coding system of images incorporating IFS for better compression ratios. IFS and GA based EEG signal compression has been successfully implemented. Moreover, attempts are being made to retrieve the class specific features of EEG signals from IFS codes.

5. Neuro-Fuzzy Computing

Attempts are being made to integrate the merits of fuzzy logic and artificial neural networks for designing an efficient decision making system. Concept of fuzzy sets has been incorporated at various stages (e.g., input, output, learning and neuronal level) of Kohonen's network and multi-layered perceptron to handle imprecise, incomplete or linguistic input data and intractable pattern classes for recognition. Its extension to connectionist expert system for rule generation and inferencing has been made along with applications to real life data. This shows how pattern description in terms of linguistic properties and membership values can be processed by a neural net for fuzzy and crisp classification, and their merits over conventional networks and Bayes' classifier. Utility of such architectures for generating non-convex decision regions is also demonstrated. A generalized framework for integration of multilayer perceptron and fuzziness measures has been developed to design an unsupervised system for object extraction. Implementation of fuzzy set theoretic operators using neural networks and the utility of these networks in pattern classification and rule generation have been demonstrated.

Various ways of integrating fuzzy set theory and connectionist system for feature evaluation have been formulated. The performance of the system has been theoretically analyzed. Currently, attempts are being made to develop a neuro-fuzzy system with unsupervised learning for feature evaluation.

One important project in this area entitled ``Neuro-fuzzy expert system . design and implementation'' has been successfully completed under the Jawaharlal Nehru Fellowship scheme. This project was fully funded by the Jawaharlal Nehru Memorial Fund as part of the Fellowship award.

6. Brain Modeling

The human brain is a much superior information processing machine compared to any artificial device constructed so far. This has led scientists to study in detail the different processes involved in biological neural computation and to incorporate the facts so gleaned into more realistic models of brain function. This enterprise, known as ``brain modeling'', aims to create artificial entities, more ``intelligent'' compared to present-day systems in performing cognitive tasks.

Work has already been carried out in networks of excitatory-inhibitory neural pairs which exhibit chaotic behavior in certain parameter regions. Using variable feedback control, the network was made to converge to any one of a large number of possible periodic patterns. On withdrawal of control signal, the network reverted to the chaotic state.

The phenomenon of state synchronization among elements of a coupled chaotic network has also been studied. A system of three chaotic elements was coupled with each other, such that they competed with each other in phase-synchronizing the network. This work is pertinent in discovering the neural basis of "attention".

In another piece of work, by using decomposition techniques, an m-bit gray level image has been represented as a sequence of m two-tone images and subsequently stored in a suitably modified associative memory model. Good recall performance has been achieved both for noisy and occluded images.

Work is currently being carried out on the application of network of excitatory-inhibitory neural pairs for edge-detection and segmentation of gray-level images. The encouraging results so far indicate a possible extension of these methods for noise-removal and thinning in images.

7. Rough Sets, Logic and Applications

The theory of Rough Sets is a mathematical tool which deals with problems involving vagueness and uncertainty. As Fuzzy Set theory also deals with such problems, there naturally arises a scope of an interplay between the two. We have attempted an integration between these theories, by providing a measure of roughness of a fuzzy set. Properties of this measure have indicated possible applications for handling uncertainties in the field of pattern recognition and image analysis, and we have started investigations in this direction.

On the other hand, as part of our work in the area of logical analysis of rough sets, we have introduced a few algebraic structures and the corresponding formal propositional systems. It is found that these can be imparted a rough set semantics and moreover, respective soundness and completeness of the systems can be established. We have started a study of the relationship of these new entities with other known structures and logical frameworks.

An attempt has been made to integrate rough sets and fuzzy neural networks for designing a knowledge-based system. Rough set-theoretic techniques are utilized for extracting crude domain knowledge that is encoded among the connection weights. Methods are derived to model (i) convex decision regions with single object representatives, and (ii) arbitrary decision regions with multiple object representatives. A three-layered fuzzy MLP is considered. The feature space gives us the condition attributes and the output classes the decision attributes, so as to result in a decision table. This table, however, may be transformed, keeping the complexity of the network to be constructed in mind. Rules are then generated from the (transformed) table by computing relative reducts. The dependency factors of these rules are encoded as the initial connection weights of the fuzzy MLP. The network is next trained to refine its weight values. It may be noted that the optimal number of hidden nodes is automatically determined. The classification performance is found to be better than the conventional and fuzzy versions of the MLP. The model is capable of handling input in numerical, linguistic and set forms, and can tackle uncertainty due to overlapping classes.

8. Fuzzy Logic, Uncertainty Analysis and Control

A new measure of total uncertainty for Dempster-Shafer framework has been suggested. This new measure takes care of uncertainty due to non-specification and randomness and is free from several drawbacks of earlier attempts. An axiomatic approach has been used to define a measure of conflict for Dempster-Shafer framework. Unlike other measures of uncertainty which generalizes Shannon's information measure the proposed one is a generalization of Vazda's quadratic entropy and it considers only the conflictual aspects of total uncertainty that arises due to the randomness in the system. For possibility distribution new metrics have been defined using different measures of non specificity. Properties of iterates of fuzzy circulant matrices under max-min operations have been investigated. Characteristics of determinants of fuzzy matrices under general S-norm and T-norm have been investigated. A shape estimation procedure has been developed with the help of fuzzy α hulls.

Adaptive fuzzy logic controllers have been developed using reinforcement-type learning algorithms. A new concept of rule-dependent/system dependent inferencing has been introduced and its effectiveness for realizing a robust fuzzy controller has been demonstrated.

An extension of the conventional fuzzy reasoning model that can account for incorrect and inconsistent rules obtained from human experts or otherwise has been proposed. The extended model has been used not only for handling inconsistent rules but also for selection of rules for a fuzzy logic controller. The extended model can be used in any other non-control rule based systems including pattern recognition. Algorithms have been developed for realizing self-tuning PI and PD type fuzzy controllers through online tuning of output scaling factors. The striking feature of the scheme is that it is model independent and works excellent even with the most natural and unbiased membership functions (equispaced symmetric triangle with 50% overlap with neighbors) for all linguistic values. Genetic algorithms have been used to design self-organizing fuzzy controllers. A fuzzy neural network has also been used for rule selection. A general purpose neuro-fuzzy tool for realizing fuzzy reasoning with more intuitively plausible properties has been developed. Work is in progress on fuzzy system identification through exploratory data analysis.

International Collaboration

The Institute has an international collaborative project with the College of Engineering, Osaka Prefecture University, Osaka, Japan which was initiated and is being coordinated by MIU. Members of MIU are also involved as co-investigators in the INDO-POLISH collaborative project titled "Reasoning under uncertainty about complex objects/rough set theory and fuzzy set theory". This is coordinated by the Dept. of Science & Technology (DST), India and the Polish State Committee for Scientific Research (KBN), Poland.

Physics and Earth Sciences Division

The division comprises Geological Studies Unit and Physics and Applied Mathematics Unit. Faculty members of the division are engaged in teaching and training in B.Stat., M.Stat., M.Tech. (CS) and M.Tech. (QROR), besides their research and project work. Research carried out in these units are described below :

Geological Studies Unit

The broad areas of research that were carried out in 1996-1997 in the Geological Studies Unit can be placed under five heads : Precambrian, Gondwana, Supra Gondwana, Quantitative Geology/Computer Application and Colloid and Surface Science. In 1996-1997, the unit conducted 17 ongoing and 1 new projects. All the projects remained incomplete by the end of March 1997, hopefully that 11 of them would be completed in 1997-1998.

(a) the Precambrian research in the unit involves the history of the crustal development of the southeastern part of the Indian peninsula, integrating tectonic, stratigraphic, sedimentologic, structural, magmatic and metamorphic studies in the Pranhita-Godavari Valley, Chattisgarh basin, Cuddapah basin, Sonakhan granite-greenstone belt and the Eastern Ghats.

(b) the Gondwana research aims to integrate studies on stratigraphy, palaeontology, climate and sedimentation to work out the history of the Gondwana succession in the Pranhita-Godavari, Rewa and Satpura basins.

(c) empirical-statistical analyses of naturally arising field and laboratory data provide ways of building or evaluating quantitative models of significance in geological problems. Computer applications are done in automation of various techniques commonly employed by the earth scientists.

(d) the research on colloid and surface science has a good potential in its application to studies in environmental science in the national context.

1. Precambrian

The details of the structure and stratigraphy in some key sectors of the Nallamalai Fold Belt (NFB) have been analysed to understand the kinematic framework of deformation in the Proterozoic intracratonic Cuddapah basin. Analysis of structures and stratigraphic data in some key sectors along the western margin of the NFB has been done. On the stratigraphic front, transition from the Proterozoic Nagari Quartzite to the Pullampet Formation within the Nallamalai Group is interpreted in terms of the transgression of the sea punctuated by tectonically controlled increase in terrigenous influx which led to the development of a prograding fan-delta overlying the lower tidilites showing prevalence of easterly ebb currents. Westerly varging mesoscopic and larger folds and thrusts, normal sense crenulations overprinting a slaty cleavage or mylonitic foliation, and on a microscopic scale, asymmetric fibres in pressure fringes suggest development of non-coaxial deformation zones even in the western part of the NFB.

Organized markings on bedding suggestive of fossil worm trails and/or burrows from the basal sandstones of the nagari Quartzite unconformably overlying the granite gneisses (Peninsular gneiss) have recently been discovered from the Cuddapah district. If these markings are indeed fossil worm trails one may raise the question whether the earliest metazoan forms evolved much earlier than the Vendian represented by the Ediacara fauna. The base of the Cuddapah sediments is at least 1555 m.y. old (Crawford & Compston, 1973).

A collisional boundary between the Singhbhum craton and the Eastern Ghats in an area around Rengali, Orissa was documented with structural and petrological data. Numerical experiments were conducted to evolve forward and inverse models for thermal evolution of the Eastern Ghats granulite belt. A new analytical solution to the partial differential equation describing the transient thermal regions in the crust was worked out in the form of the fundamental solution $I = (L/\sqrt{y})$.

An area of about 250 sq. km. was reconnoitered near Sini in Singhbhum Dist., Bihar, to have an idea about its general litho-structural set up. The rock types include varieties of semi pelites locally interlayered with amphibolites. Common presence of bedded rock fragments suggests volcanic ancestry. Present work concentrates on the compression types of crenulations.

Origin of Fe-illite, a group of clay minerals less well understood than their end member counterparts illite and glauconite, has been studied. It has been shown that authigenic illitic minerals form at the expense of detrital feldspar and mica, and progressively change over to Fe-illite and glauconite through different substitutions between exchangeable cations. It is also observed that substrate composition may have strong influence on the composition of Fe-illite. Environmental significance and compositional peculiarities of Proterozoic Fe-illite, collected from different environments in the P.G. Valley, have been analyzed.

Distribution of several exchangeable cations was assessed by running BMDP regression program 6 D. Substitution relationships between different cations like Fe, Al, K and Mg are marked by high correlation co-efficient. A few data points in each plot show wide variation from the normal trend, and have unusually large effect in the estimates of the regression co-efficients. The data points defined as outliers were identified by using BMDP program 2R. Geological interpretation of the outliers has been offered. A manuscript has been completed by Sarbani P. Deb, SRF, jointly with Dr. M. Fukuoka of Hiroshima Univ., Japan.

Work on the development and evolution of the deep water Proterozoic Penganga carbonate platform has been completed. A transgression - regression cycle with an episode of major sea level rise leading to

development of black limestone deposited in anoxic environment has been identified. Trend of transgressive - regression points to a northerly palaeoslope and the existence of a large marine basin north of the P.G. Valley. Joydip Mukhopadhyay, a non-ISI worker, has submitted a Ph.D. dissertation under the guidance of Professor A.K. Chaudhuri of the Unit, on the Penganga carbonate platform evolution, in December 1996.

Field work on the Sonakhan greenstone belt which unconformably underlies the Chhattisgarh succession was continued. The north-south trending belt of volcano-sedimentary succession bounded by two volcanic belts has been identified as a major turbidite basin, developed in front of a rising volcanic chain. Petrographic analysis of volcaniclastic sandstones is in progress.

A short reconnoitary field work was conducted in the Indravati basin.

Reconnaissance maping of about 250 sq. km. around Dewalmari Pranhita-Godavari Valley, suggested revision of W. King's map done more than a century ago. It was found that the Sullavai rocks occupy much less area than what is shown in King's map.

The sedimentary rock sequence in this area comprises a marine limestone-sandstone sequence unconformably overlain by fluvial pebbly arkosic sandstone. Slightly deformed marine sequence is broadly correlatable with the infra-Albaka lithostratigraphic units of the adjacent area. Limestone is stromatolitic and sandstone shale sequence bears imprint of storm and wave-dominated shoreline processes.

The overlying fluvial sandstone bears close resemblance to the Sullavai sandstones of the south-western belt. Remarkable similarity of facies and lithology of the Sullavai rocks in two belts demonstrates the potential of the pre-Silurian alluvial system in spreading sandstone sheets across the basin. A paleocurrent reversal in these rocks lends support to the inferred rift origin to the Sullavai basin.

A number of publications were being prepared on the sedimentology of the Sullavai rocks.

The Triassic and Jurassic sediments of the Satpura basin have been explored extensively. Dinosaur bones and other archosaur bones have been recovered for the first time from the Bagra Formation of the Satpura basin. In the lower Denwa Formation, a Triassic horizon, several parts of dicynodont skull and rhynchosaur skulls have been found. Several temnospondyl amphibian, mainly capitosaurids, have also been recovered.

Study on endothiodont dicynodonts from the Pranhita-Godavari valley was nearly complete. Apart from the known form, a new species of the dicynodont would be described for the first time from this continent. The study would lead to a Ph.D. dissertation for Sanghamitra Ray, SRF, to be submitted soon to the Calcutta University.

Both laboratory and field work on the project was concentrated on the geology of the Triassic deposits in the Damodar Valley of west Bengal. Restudy of the Triassic vertebrate fossils of this area suggested a thorough revision of the fauna of the Panchet Formation. High resolution lithologs and detailed mapping, along with fossil searching operations, have located the Permian-Triassic boundary which is probably the best exposure of such a boundary in India. Considering globally, it can be studied as the type area for Permo - Triassic change-over within continental deposits. Many new fossil taxa have been identified.

A new vertebrate fossil fauna has been identified in the Upper Gondwanas of the Satpura area, Madhya Pradesh. This includes new capitosaurid amphibians, dicynodonts, rhynchosaurs and dinosaurs.

The amphibian fauna has been studied in detail and few new taxa have been erected. An interesting paper on amphibian evolutionary trend has been prepared and sent for publication in a reputed foreign journal.

Western part of the basin around Suk Tawa was examined with special emphasis on the Bagra Conglomerate. A remarkable facies change from east to west within this basin has been observed and it is felt that the Lower Gondwana lithostratigraphy in the western part needs to be established independently.

Sedimentologic and petrographic analysis of Motur and Barakar Formations of the eastern part of the Satpura basin was completed. Motur red clays and interlayered sandstone lenses display evidences of

deposition through overbank sheet-floding, contrary to the earlier interpretation of meandering streams. Sedimentary succession of the Motur Formation in the eastern part of the basin is reinterpreted to represent an anastomosed fluvial system

A write up on the stratigraphy and sedimentology of the Motur Formation is under preparation.

2. Supra Gondwana

The research (Re. Chatterjee and Rudra, 1996, KT events in India, etc. Mem. Queensland Museum, 39(3), 489-532, Brisbane, Australia) on the KT mass extinction (65 million years ago) and the Deccan volcanism suggests that among the various meteorite impact sites that are linked to the same extinction, the prime candidates today are the Chicxulub Crater in the Yucatan Peninsula, Mexico, and the Shiva Crater as identified from the subsurface data at the India Seychelles rift margin. The crucial evidence for the latter comes from the Bombay High field, the giant offshore oil basin and the associated alkaline intrusives within the Deccan Traps. The age of the crater is inferred from its Deccan lava floor, Palaeocene age of its overlying sediments, isotope dating of presumed melt rocks and the Carlsberg rifting event (Chron 29B) within the basin. It is speculated that a 40 km. diameter meteorite crashed on the western continental shelf of India around 65 Ma, excavating the Shiva Crater, shattering the lithosphere and inducing the India-Seychelles rifting. The Deccan volcanism was already on, starting 1 Ma before the KT impact event, but the impact enhanced the rate of lava extrusion to an enormous extent. The origin of the Deccan volcanism is attributed to the Deccan-Reunion hotspot. Though at the early stage of Deccan eruption, sauropods, theropods and ankylosaurs flourished in India, they died out suddenly at the KT impact boundary. Both impact and Deccan volcanism appear to have contributed towards the deleterious environmental consequences leading to the biotic crisis at the KT boundary. However, the impact appears to have played the major role as the killing mechanism.

3. Quantitative Geology/Computer application

Influence of impurity on Quartz CPO . The project on the influence of micaceous impurity on Quartz CPO has been completed. The major findings are a) asymmetry of quartz C-axis fabric, a type I cross-girdle, or a kinked single girdle, is independent of the model mica content in the range 2% to 35%, and b) a negative correlation between model mica content and fabric intensity

A project on the systematic microstructural investigation of naturally deformed quartzofeldspathic (Q-F) rocks has been undertaken with a view to understand the nature of flow in the upper and middle crust. The nature of the aggregate flow law, where both diffusion and dislocation creeps act together on a polyphase aggregate, has been worked out. Some deformed arkoses and feldspathic schist (soda granite) from the Singhbhum Shear Zone has been studied for microstructural details.

4. Colloid and Surface Science

The scope of Colloid and Surface Science is wide since it embraces multidisciplinary areas of research. Of these, the fundamentals and applicabilities of the self organised amphiphiles, viz. micelles and microemulsions, were undertaken for research. The amphiphiles can produce microheterogeneous environments for possessing novel physicochemical properties and research on them has potential in technological applications, e.g., enhanced oil recovery, pharmaceuticals, agriculture, semiconductors, biotechnology, etc. Microemulsions are potential systems for formulating agrochemicals because of their isotropic, thermodynamic stability, indefenite shelf time, small droplet size, transparent and enhanced biological efficacy. Investigations are aimed at the better understanding of phenomena of solubilization in a single surfactant and mixed surfactant microemulsions to improve both the cost competitiveness and the performance of their products. The interesting results on the formulation of microemulsions are reported though these ternary systems produce various complex phases.

Apart from research activities in Physics and Applied Mathematics faculty members of this unit are engaged in teaching various courses of the Institute and other universities and also in guiding research students.

Major topics of research are :

1. Topological field theory, Berry phase, Quantum Hall Effect, Superfluidity, Quantum cosmology, Skyrmions

2. Quantum field theory in flat and curved space time.

3. Quantum Mechanics of Anyons, Supersymmetric Quantum Mechanics, q-deformed Quantum Mechanics, Quantum optics, Confined Systems.

4. Foundational Problems of Quantum mechanics, Quantum field theory by Stochastic quantization approach. Quantum field theory of dissipative systems, Blackhole physics.

5. Extended Electromagnetic Theory.

6. Wolf mechanism and alternate cosmology.

7. Joint distribution functions and Image analysis.

8. Modelling Cerebellum and Cognition Process.

9. Studies in the reported 'Strangeness' abundance in high energy collisions. Large antibaryonic yields related with the QGP signatures in the framework of the standard theory. General aspects of antimatter searches and the several important characteristics of the intermittency phenomenon are now under investigation.

10 Multivariate modelling of the Gamma Ray Burster data from BATSE 3B catalog : Hierarchical clustering analysis of data reveals Kouveliotou effect. Presence of three statistically significant clusters established.

Analysis of Glasgow Laser Interferometric Detector data with the intention to model the non-Gaussian nature of the noise.

11 Solitary waves in plasma, and Dusty Plasma. It has been shown that finite temperature restricts the region of existence of solitons.

12 Rapid distortion theory and Coriolis rotation on a turbulent flow. Modelling of turbulent flows with nonlinear terms, deductive theory for a homogeneous turbulent flow in presence of helicity, acceleration correlation in turbulent flow. Calculations of turbulence energy spectra, pressure spectrum.

13 Hydrodynamic Stability, Fluid flow, Thin Film development. Stretching Sheet, Crystal growth. It has been shown theoretically how a thermocapillary force helps to enhance the thinning rate and can achieve the desired thickness before the skin hardens at all.

14 Water waves, Mathematical methods, Inventory models.

15 Sediment transport, Dispersion processes, Navigation hydraulics, MHD flow and Heat transfer.

16. Blood flow through artery. Two layer model. Hematocrit dependence. Temperature dependent viscosity. Effects of magnetic field. Blood flow in cardiovascular system.

17. Multivariable system and control theory; Design and Analysis of control systems; numerical methods.

18. Pattern forming instabilities. Physics of Granular material. Fluid flows. Dynamical systems and Bifurcation theory.

Teaching activities

1. Scientists in PAMU took part in teaching courses in Physics. Fluid Mechanics and Water waves to research students in PAMU.

2. S. Gangopadhyay took part in teaching courses in M. Tech (QROR). K. Hajra and K. Kumar taught Physics courses to B. Stat (Hons.) Students.

Biological Sciences Division

The Biological Sciences Division is engaged in studying the varied biological processes covering plant and animal kingdoms, including humans. It comprises the following units : Agricultural Science Unit, Anthropology and Human Genetics Unit, Biochemistry Unit, Biometry Unit, Chemistry Unit, Embryology Unit and Plant Chemistry Unit. Faculty members of all units participated in teaching various courses of the Institute and of other organisations. They were also actively engaged in guiding research of Ph.D. students. Activities carried out in these units are described below.

Agricultural Science Unit

Research studies in Agricultural Science Unit are mainly conducted in two distinctly different ecological regions, namely Giridih region of Bihar Plateau and Sundarbans coastal region of South Bengal. Farm based studies are carried out in Giridih Experimental Farm with the focal theme of 'increasing cropping intensities and productivity through rainfed farming. In coastal Sundarbans region, studies are aimed at detailed botanical and ecological work on mangrove vegetation, and cultivation and introduction of oil palm and high yielding coconut cultivars in that area.

The studies included the following eight research projects.

Crop-soil-weather relationship

This project was initiated in 1995 with the following objectives : (i) to establish sustainable cropping systems through utilization of rain water, (ii) to select potential traditional and improved varieties producing stable yield under varied rainfall situation, and (iii) to identify growth stages being affected by occasional draughts both in traditional and improved varieties and identify suitable ones in combating water stress. Long term weather data have been collected from Sekhampur, Birbhum, to identify quantum, distribution and levels of uncertainty in rainfall pattern. The data are now under analysis and will be correlated with rice varietal performance. The study on relationship of weather parameters like temperature, humidity, sunshine, evapotranspiration affecting crop growth and yield is in progress.

2 Crop/varietal performance

This project was initiated in 1989. The main objectives of the study are : (a) to select suitable cultivars of paddy, maize and pigeonpea for rainfed farming, (b) to adopt different management practices affecting yield stability suitable for small and marginal farmers, (c) to find out the optimal date of sowing of the cultivars which affects yield considerably, and (d) to select suitable crop varieties for cultivation in fallow land area of Bihar plateau.

Some results have already been achieved and given in the last Annual report. In addition to that it has been demonstrated that cropping intensities can be increased with management of minimum water harvesting facilities (possible due to large volume run-off water) on mid-up to upland situation. On mid-upland, short duration rice or maize grown between June to early September offers scope of successful sequence with kulthi (pulse) and niger (oil seed) as follow up autumn crops between September-November. It has been established in our farm that totally eroded rocky upland could be restored through afforestation programme within three to four years. Sisoo (timber) and cashewnut have demonstrated their potential in this region.

3. Work on Palmae

The family palmae comprises many economically important plants. It consists of 2779 species growing mainly in tropical climate. The main objective of the project is to conduct indepth studies on different aspects of the family such as, developmental morphology, anatomy, phyllotaxy, ontogeny of endosperms in fruits, palynology, ecology and conservation.

This is an ongoing project. The phase I of this project dealt with morphological and anatomical variations between seedlings and adult palms. Besides these, ontogenetic study of stomata and trichomes of leaves and tracheary elements of roots of some palms were studied extensively. In phase-II, the study aimed to find out whether there is any effect of foliar arrangement (phyllotaxy) on the density and size of stomata and trichomes of leaves. This study revealed interesting variations between left and right spiralled palms. The third phase of work of the project deals with developmental process of trichomes in some palms, ecology and conservation of some threatened palms. The work is in progress.

4. Introduction of oil palm and high yielding coconut cultivars in the Sundarbans area of West Bengal

This is a long term project initiated in 1986 in collaboration with the Department of Agriculture, Government of West Bengal, with the following objectives : (i) to find out the possibility of introduction of oil palm, and (ii) to select the most high yielding coconut cultivars, suitable in the Sundarbans area. Eight cultivars of coconut (five tall cultivars and three dwarf cultivars) and one cultivar of oil palm ('tenera') were transplanted at the District Seed Farm, Manmathanagar, South 24 Parganas, in July 1987. Early growth data, such as number of leaf production, girth at stem base, plant height and flowering at different age points are being collected regularly. Until now about 94% of oil palms and 10-37% of coconut palms started flowering. Since the palms are perennial long duration crop, they will require another six years to show their full potentials and stability in yield. On the basis of stabilized yield data, selection could be made for high yielding coconut and oil palm cultivars.

5. Eco-floristic and anatomical investigations on mangroves of Sundarbans

The project was initiated in 1989, with the objectives of preparing a comprehensive account of mangroves of the Sundarbans in respect of their floristic survey, morphology of seeds and seedlings, anatomy of leaf, stem and root and palynology, towards understanding of their correlation in taxonomic and ecological elucidation of the taxa.

In the first phase of this project, the anatomical work on leaf, stem, palynology and seedling morphology have been completed in 22 true mangroves and seven mangrove associated species. The phase II work of this project includes comparative ecological anatomy of tracheary elements of stems and roots of mangroves collected from different ecological regions of mangrove forests, viz., Sundarbans, Bhitarkonika (Orissa), etc. The work is in progress. Besides these, development process of stomata and non-glandular leaf hairs have been studied in five species of mangroves of Sundarbans.

6. Subsistence farming studies of Bihar plateau region

This project was initiated in 1993 with the following objectives : (i) to locate the status of resource utilization and constraints for technological adaptations, and (ii) to identify and examine the indigenous knowledge systems of the villages while practicing subsistence farming.

A survey work was conducted at the 'Usri' watershed of Giridih area to probe agro-ecological constraints. These included microlevel rainfall pattern as affected by environmental changes, soil resource status, technology adoption by farmers etc. In order to gain intimate knowledge of technology adoption, a complete household survey of three villages was done in the watershed area with varying socio-economic systems, productivity, ecology and technology adoption rate. The data collected in the survey are under analysis. During the year under review an attempt has also been made to analyse the resource data through GIS tools. This will continue in the next year.

7. Weed crop interaction

The project was initiated in 1993 with the objectives of studying types of weeds, their interaction with the crops, and to evolve a composite system to control weed problems in the upland soil conditions of Bihar plateau.

Crop-weed interaction experiments carried out with paddy and wheat in 'Kharif' and 'Rabi' seasons respectively have indicated the usefulness of intensive land use through intercropping of paddy-blackgram and wheat-bengal gram for increasing efficiency in system productivity as also effective weed suppression. Bur clover, a natural winter weed, associated with wheat in this region have shown its usefulness in conservation of soil moisture and sustaining soil nutrient status.

8. Food grain damage by rodents

This is a short term project initiated in April 1995 and has been completed in March '97.

The objectives of the project were (i) to assess yield loss of paddy in the field due to rodents, and (ii) to find out the affinity of rodents to different rice varieties. Some data had been collected on the nature of rodent burrows, their numbers of openings and the quantity of grains hoarded per burrow. This work also continued in the 'Rabi' season of this year. The affinity of rodents to different rice varieties, such as, coarse, medium, fine (scented) etc. have been examined in laboratory condition. Preparation of the report is in progress.

Anthropology and Human Genetics Unit

Faculty members of the AHGU regularly participated in teaching in B.Stat.(Hons.) in Anthropology and M.Stat. in ASDA, SQC&OR under Biostatistics II and M.Stat. in ASDA, BSDA, SQC&OR under Statistical Methods in Genetics courses offered by the Institute. One faculty member is also teaching Anthropology at Calcutta University. Some of the faculty members are also engaged in supervision of Ph.D. theses. One Research Fellow has already been awarded, one has submitted, two fellows are about to submit and 3 fellows are working for their Ph.D.

Faculty members of AHGU are also engaged in active research in different areas of biological Anthropology and Human Genetics. The details are as follows :

Human Adaptability Programme : Within the general framework of this programme, the following plan projects are being conducted

1. Health Status and Labour Productivity

Empirical studies outside India reveal that an individual's health status play an important role in determining his/her labour output. On the basis of this, the objective of the project is to examine the health - productivity relationship in different occupational groups of Oraon labourers of Jalpaiguri district, West Bengal.

Data collected from the Oraon agricultural labourers of Jalpaiguri district, West Bengal, reveal that both fertility and mortality are comparatively lower in this population in comparison with their tea garden counterparts. Less prevalence of hypertension and lung diseases in the Oraon agricultural population compared to the tea labourers.

2. Effects of Microenvironmental Factors on Health in Rural Populations

Data analysed so far reveal that both fertility and mortality have decreased over a short span of 10 years in Chakpota village.

From the data on reported ailment symptoms and treatment it was found that in all the groups and subgroups of Kayastha, Poundrakshatriya and Oraon of South 24 Parganas district, West Bengal, the percentage of adult males not affected by any ailment is higher than that of adult females and the difference is statistically significant. Gender difference in education is marked. In all the groups and subgroups, the percentage of "not attended school" is higher among females than among males, and the percentage of "continuing school" is higher among males than among females. The differences are statistically significant.

3. Psychological Stress and Health of Mother and Child

The overall purpose of the project undertaken was to evaluate the health status of females over their entire life span, divided into phases. In their prime working age urban middle class educated women face both physical and psychological problems resulting from constant exposure to day to day stress and strain. Ageing adds a more difficult dimension to this, as women generally live longer compared to men. Information on biological, psychological and social characteristics of women who are at prime adult working age and who are at post-adult working age (at or about their retirement age) are being collected from the city of Calcutta.

A part of the data collected so far has been analysed, where a comparison is made between a group of college teachers and a group of women secretaries and executives from public and private sector organisations. The executives show higher anxiety scores (33.78±1.99) compared to the college teachers (32.0±2.60), though the difference is statistically non-significant.

As a part of the ongoing project data on socio-economic characteristics and anxiety levels were collected from a culturally/ethnically different group of women, engaged as gazetted officers in different departments of the Government of Sikkim. It is intended to find out whether economic factor, and/or cultural/ethnic factors per se (i.e., independent of the economic factors generally associated with the latter), affect the traits discussed above.

4. A Study on The Determinants of Fertility and Mortality in an Urban Setting : An Anthropological Perspective

The major thrust of the project is to investigate into the correlates of infant and child mortality among the Hindu and Muslim slum dwellers of Calcutta city.

Almost 75% of the work has been completed. The results show that the Muslims have higher fertility and mortality compared to the Hindus, and that the Hindus are economically better off, literacy rate is higher and the overall hygienic condition is better than the Muslims. The results also show that the adoption rate of family planning methods as well as perception levels are higher among the Hindus than the Muslims. The study demonstrates that the desire for additional children is the result of a strong gender preference (son) as well as lower survival prospect especially among the Muslims. The study also reveals that the expectation of life at birth is slightly higher among both male and female Hindus compared to the Muslims. The higher fertility among the Muslims may perhaps reflect the perceived threat of existence of a minority community.

5. Human Biology of Himalayan Populations

The objective of the project is to evaluate the effects of sociocultural factors associated with modernization on the demographic and health status (measured in terms of fertility, mortality; selected biological traits, health perception and health care practices) among the Lepchas of Sikkim Himalaya.

Data collected earlier from the Lepchas inhabiting 3 rural Revenue Blocks of Dzongu area, North Sikkim on anthropometry, blood pressure and behavioural traits (e.g. tobacco use, alcohol use, etc.) have been analyzed. Analysis of the data reveals that while significant effects of age, alcohol intake and triceps skinfold thickness (among the females) on blood pressures exist among the study population; effects of smoking, tobacco chewing, oral contraceptive use on the trait are not discernible. Moreover, a high prevalence of

essential hypertension (males : 30.8%; females : 25.8%) is found to occur. The above finding clearly indicates that compared to many other rural Indian populations, rural Lepchas of Dzongu area have much higher prevalence of hypertension.

6. Genetics of Complex Traits

Research in the area of genetic epidemiology of complex disorders (disorders with variable ages at onset that aggregate in families but do not segregate in a clear Mendelian fashion) is currently an international interest. We have developed likelihood-based methods for determining modes of inheritance of such disorders. We were able to propose and cross-validate a multilocus model using family data on a dermatological disorder (vitiligo) and also study robustness properties of the proposed methods. We were able to establish, contrary to traditional belief, that vitiligo is not a single-locus disorder but is controlled by epistatically interacting recessive alleles at three unlinked autosomal loci.

In collaboration with the Biochemistry Unit, we completed a genetic epidemiological study on blood pressures and lipid and lipoprotein levels among Marwaris living in Calcutta. Using a path model, for familial data, that takes genetic and environmental factors into account, we have found that : (i) the genetic effects on blood pressure are indirect and are perhaps mediated by genetic factors controlling adiposity, (ii) the genetic heritability of HDL-cholesterol level (the so-called "good" cholesterol, higher levels of which are protective for vascular diseases) is about 80%, and (iii) the genetic heritability of Triglyceride level is about 55%. The implication of these findings is that control of body fat by regular physical exercise and lowering the intake of saturated fats and oils can significantly contribute to lowering the risk to cardiovascular diseases. While this conclusion is not novel, quantitative estimates of heritability from populations with non-Western life styles are very few. In fact, this is the first family study conducted India with the explicit objective of estimating genetic and environmental components to lipid and lipoprotein levels.

7. Human Ecology

(i) The changing patterns of resource use and its cultural and biological implications are being studied among a Kuki tribe called Gangte, who are currently living in the hills of Manipur and are undergoing rapid transition from shifting cultivators to the urbanized mode of subsistence.

The results obtained so far suggest general improvement in the economic situationand literacy and reduction in child mortality. A trend of decline in the availability of biological resources and increase in admixture with non-Gangtes is also apparent.

8. Population Structure and Human Variation

(ii) Human impact on biodiversity, (iii) interface between forest dwelling communities and forest resources.

Statistical analyses of different data sets collected earlier, are being pursued. As part of this, we have so far synthesized all-India data on (i) the inbreeding effects on reproductive outcome, and (2) finger ridge count variation of the Indian populations. We have also analysed (1) genetic differences between migrant populations and their parental counterparts, (2) effect of life styles on blood pressure variation, and (3) dermatoglyphic and anthropometric affinities of some local clusters of populations, in the light of ethnohistorical and geographical backgrounds.

9. Dermatoglyphics

Dermatoglyphic data on toe, sole, finger and palm of a large number of nuclear families (500) from five different ethnic groups have been collected and partly analysed. Bilateral asymmetry (directional and fluctuating) is the main emphasis of the project which is considered to be a direct reflection of developmental homeostasis in humans. The study aims to evaluate : (1) genetic and common family inheritance components of plantar dermatoglyphics, (2) genetic component of phenotypic relationship between toe and finger, sole and palm as well as between characters within the plantar and palmar dermatoglyphics, (3) nature and extent of variation within and between ethnic groups; in genetic disorders and on twins.

The study between toes and fingers reveals that (i) the same genetic influences might be exerted on both the dermatoglyphic regions but produces differential effect for different functions in their independent courses of evolutionary specialization, and (ii) laterality may be useful for ethnic comparisons.

10. Human Growth

A cross-sectional growth study on 26 body dimensions on the boys and 9 dimensions on the girls from Calcutta city was undertaken in order to assess their growth performance in the context of the Indian population. The study also evaluates the influence of sociodemographic variables on the growth by univariate and multivariate analysis. Curve fitting techniques have also been used to estimate the biological parameters of the growth process.

Family based study on anthropometrics undertaken in a rural endogamous population of West Bengal has generated intrafamilial correlations and heritabilities of 22 body dimensions.

11. Population Variation Programme

(i) Studies on Rheumatoid Arthritis : Statistical sampling design involves a two-step design. The first stage sampling units are Panchyats and the second stage units are villages within sampled Panchyats. At each stage simple random sampling with replacement was done. We have completed a field survey with this sampling design in Ranaghat Block, Nadia District.

About 3,000 families have been surveyed comprising about 16,204 individuals. Out of these, 90 individuals have been suspected as Rheumatoid Arthritic (RA). Suspected R.A. individuals were clinically examined and their blood was collected for laboratory investigation. Out of 90 (0.56%) suspected R.A. patients only 63 RA patients have examined. Out of 63 patients, 20 (12.6%) patients are clinically positive Rheumatoid Arthritic and by laboratory investigation 11 (6.93%) patients are R.A. factor positive.

The prevalence of Rheumatoid Arthritis in the surveyed area (Ranaghat) is much more than in North 24 Pgs.

(ii) Genetic Variation : A field work was conducted in Varanasi, U.P. About 350 blood samples were collected from four different endogamous populations : Brahmin, Rajput, Chamar & Muslim. In the field Hb% estimations, G-6PD deficient test, ABO, & RHD blood groups have been done. The following biochemical markers have been screened - AK_1, ADA, G-6PD, 6PGD, PGM_1, ESD, Acid Phos, CA_1, CA_2, LDH, MDH, Hb type, Hp, Cp-Tg & Albumin etc. in our Institute.

From the laboratory screening few new variants have been observed - G-6PD (New slow variant), PGM_1 and MDH.

(iii) Two predominant alleles - HbE and HbS of beta globin gene cause haemoglobinopathy among a considerable proportion of populations of India. Molecular character of these alleles are known and these alleles show a wide range of clinical manifestations. Distribution of these alleles are limited to specific populations. Frequency of HbE in some populations has been found upto 85% and HbS upto 45%. Although these alleles are known to be deleterious and these are maintained in populations in such a high frequencies but how it spread through a wide area is not known. Objective of this study is to throw some light on the mechanism of maintenance and spread of these alleles.

(a) spread of HbS in the region due to wide range of migration of the tribes;

(b) excess of homozygotes and prevalence of high frequencies due to practice of consanguinity and random effect among populations;

(c) similar Hb levels and longevity of homozygotes compared to that with normal or carrier individuals observed in the data. This is possibly due to interaction with high frequencies alpha thalassemia in the region.

Study on HbE has been conducted among three subdivided groups of Deshi population in two districts of Malda and North Dinajpur of West Bengal. A total of 521 individuals belonging to three generations were

studied for 17 genetic markers, Hb and haematocrit levels. Information about marriage pattern and marriage distance have been collected. Results reveal that (a) allele frequencies fluctuate between generations of each subpopulation, (b) significant asymmetry exists in marriages between generations in each population, (c) a large difference is observed between estimates of inbreeding level from genetic data and genealogical data, (d) we observed two alleles of two genetic systems - ACP and Tf in one of the three subgroups which are not common among the populations of the region, and (e) a correlation between haematological profile variation and alpha globin content variation was observed.

12. Epidemiological and Clinical studies

(i) Epidemiological profile survey data on "Diabetes" has been collected through family studies on Bengali Hindu population by enumerating the number of persons belonging to a Municipal Corporation/Panchyat Wards in three habitats : Rural (471 families), Industrial (487 families) and Urban (561 families). Analyses of primary data and confirmation of disease status are in progress.

(ii) Surgically incised organs - Appendix, Gall Bladder and Hernial Sac collected on Hindu Bengali individuals have been analysed to study histopathological and genetical changes. Associations of organ tissues with 4-polymorphic (PGM, ESD, Ak and ACP) genetic loci have been studied. Further 6-monomorphic loci (LDH, MDH, 6PGD, G-6PD, CA_1, CA_2) have also been screened for detection of variants. In respect of hernial sac, significant association was found with Esterase D (ESD) and for gall bladder with Acid phosphatase (ACP).

Biochemistry Unit

Cancer Chemoprevention

As an approach towards Cancer Control, the following projects are ongoing on Uterine Cervix Cancer Prevention.

Studies remain focused on women with cervical dysplasias/cancers to investigate several aspects of the role of folic acid in neoplasia. A major question is whether folic acid plays any role in programmed cell death (PCD) (through apoptosis) during the process of normal maturation and differentiation of cervical epithelium versus the abnormal cell proliferation. During 1996-97 we have standardized methodologies for identifying apoptotic bodies in the paraffin sections of formalin-fixed cervix tissues and in the epithelial cells obtained from cervical lavage preparations. Part of this work was presented in an international conference in 1996. A second one has been submitted to another international conference to be held in March 1997.

The project has been approved in Dec. 1996 by the SURDAC. Our objective was to develop statistically designed methodology of appropriate calibration for two new molecular techniques of measurement in the assessment of risk of cancer of the uterine cervix. These are human papilloma virus infection (HPV), and perturbation of the programmed cell death (PCD) apoptosis, pathway. We have standardized the PCR (polymerase chain reaction) protocol for HPV detection in cervical cells obtained as scrapings. Also, we have standardized the TUNEL reaction protocol for detecting apoptotic cells in cervical scrapings. Utilising these two molecular parameters along with pap tests, we have screened 17 samples. Only one sample was found to be HPV+ (high risk HPV-16 infection) and several samples were diagnosed as SIL (squamous intraepithelial lesions) high or low grade, from pap readings. Several of these SIL cases were found to exhibit a disbalance in the cell proliferation/cell-death (apoptosis) phenomenon. Utilising these data, statistical analysis and calibration of the methodology are ongoing.

During the past year, we have standardized the procedure for culturing human lymphocytes. Using these lymphocytes we have been studying the effects of various drugs (mutagenic/carcinogenic) on the apoptotic cell death pathway. When PHA-stimulated lymphocytes were treated with H_2O_2, a dose dependent percent increase in the apoptotic cells was noted, coupled with a drop in the nuclear division index (NDI), an estimate of cell proliferation. But, a pretreatment of the lymphocytes with a tickling dose of H_2O_2, 24h prior to the challenging treatment with H_2O_2, significantly decreased the percent of apoptotic cells with an increase in

the NDI in a dose dependent manner. This kind of response, termed as the adaptive response, appears therefore to involve an inhibition of apoptotic cell-death process. Further studies are in progress.

It is important to understand the response of mamalian cells to oxidative stress because of the involvement of such conditions in various degenerative diseases including ageing and cancers. We have observed that, pretreatment of the rodent cell line, V79, with a tickling dose of H_2O_2 confers clonal growth advantage to these cells upon subsequent exposure to oxidative stress. Also a derivative M5, of V79 cells, resistant to the chemotherapeutic drug methotrexate, exibits similar phenotypic behaviour to oxidative stress, as observed in case of pretreated V79 cells. Our objective is to elucidate, some of the underlying molecular mechanisms of such resistance in M5 and V79 cells. We have been able to establish the involvement of an increase in the glutathione level and inhibition of the apoptotic cell-death process in the resistance observed in case of M5 cells. In case of preteated V79 cells, inhibition of apoptosis coupled with the involvement of glutathione levels and metallothionein (an anti oxidant enzyme) have been implicated.

Semiochemicals

The primary aim of the present phase of this ongoing project is to investigate the chemical nature of the Marking Fluid (MF), the putative source of pheromone of leopard (Panthera pardus) and Cheetah (Acinonyx jubatus). Samples of leopard and cheetah were collected from Rajabhatkawa Reserve Forest, Jalpaiguri, W B and Africat Foundation, Otjiwarongo Farm, Namibia, respectively. The volatile molecules like free fatty acids(C -C), primary, Secondary and tertiary amines, aldehyde and ketones have been isolated and identified by Gas-chromatography (GC) and GC Mass spectrometry. These volatile molecules are made to last longer in nature with the help of some nonvolatile or less volatile lipid fixatives. A thorough chemical analysis of these fixative part were performed to find out the uniqueness, if any. A phylogenetic relationship among those three mammals, tiger (**Panthera tigris tigris** work done in the year 1994-1995) leopard (Panthera pardus) and cheetah (**Acinonyx jubatus**) has to be establishesd finally regarding the pheromonal constituents.

Biometry Research Unit

Fishery Science

Conventional statistical methodologies pertaining to the analysis of longitudinal growth data and directional data are being applied to study carp growth. Autoregression and Finite difference methods are also applied parallely. The results so far obtained indicate the problem area of growth where negative velocity and acceleration of growth pattern were observed. By applying suitable nutrients during those periods of growth; growth promotion is possible.

Carp growth by nutrients and pollutants and the histopathological and physiological changes in the Gastro-Intestinal tract of air-breathing fish exposed to pesticides.

The role of digestive enzymes in different regions of alimentary canals of the freshwater Indian major carps, viz. Catla Catla and Cirrhinus mrigala by treatment of protein enriched supplementary diets has been found to be promising as far as the growth performance of the carps are concerned. The growth of C mrigala is considerably increased in comparison to C. Catla by the application of the protein enriched diet.

Result on longitudinal growth studies of two fresh water Indian major carps. Catla Catla and Cirrhinus mirgala reared in the pond and in controlled laboratory conditions during the early stages of their development have been submitted for publication.

Biomedical

1. Investigation into Fibrocalculous Pancreatic Diabetes (FCPD)

The progress of this work upto this date is quite satisfactory. The data so far have revealed that the disease is not genetically inherited as only 11.2% of the relatives of our patients are found to be diabetic. Since

the patients possess high IgG and IgA. it is presumed that some immunological disturbances might have developed in them. Our HLA studies show that they may be a sub-class of IDDM C-peptide and Insulin assays clearly indicate that nutritional status plays an important role. It is also interesting that 60% of these patients show diabetic retinopathy. A histological study of liver and kidney of FCPD patients are being studied to compare them with that of NIDDM and IDDM.

2. Role of Interleukin -8 (IL-8) on the regulation of some infectious diseases

Interleukin-8 plays an active role in the induction of inflammatory response in some diseases Work on the regulation of IL-8R expression, through which IL-8 activity is manifested, are in progress Uptill now the study has been able to demonstrate that serum activated LPS (Lipo Polysaccharide) at a concentration 10 ng/ml induces expression of functionally active IL-8R by 120% within 30 minutes through denovo protein synthesis. This significant observation shows that stimulation of PMN's with LPS induces IL-84 expression which enhances the IL-8 mediated biological responses and provides evidence for post stimulatory restoration of receptor level on neutrophil surface by proteolytic cleavage of the aminoterminal end of the receptor

Besides this, antihyperglycaemic effects of some medicinal plants are now being studied. At the start Gymnema sylvestre is taken for our experimental study.

Chemistry Unit

1. Distribution and characteristics of allophanic materials in soils of West Bengal

Previous research findings of the unit hinted at the possible existence of allophanic substances in some soils of West Bengal. As these materials are important in modifying some soil properties and its almost decisive role in aggregate formation we took up this project to make our soil studied more comprehensive.

Weakly developed acid soils formed out of basic rocks under forest cover were found to contain appreciable amount of these materials in the clay fraction. Absorptive and other interaction of the isolated allophanic material and nutrient cations were studied. Gelling property of these materials and consequent aggregate size and shape was intensively studied. Allophanes from soils exhibited varying degree of cation enchange capacity and exist in combination with considerable quantity of organic matter.

Two papers have so far been communicated on these aspects. We have also offered an equation connecting the allophane-content and size distribution in soil aggregates.

2. Heavy metals in soil

This project deals with the heavy metal behavior in presence of various soil components. This fledging project was taken with an eye on plant nutrition as well as ground water pollution The latter objects is more in with the present spate of ground water pollution too. One senior research fellow has been carrying out the main bulk of work.

Embryology Unit

The unit has been engaged in carrying out the following ongoing projects.

1. Mathematical and stochastic modelling on cellular growth, differentiation and morphogenesis during embryonic development and carcinogenesis

Mathematical and stochastic models of cellular growth, differentiation and morphogenesis have been constructed on the basis of well recognized experimental observations and biological principles. Application and development of advanced mathematical tools of nonlinear analysis, bifurcation, catastrophy theories,

global stability and control theories, system analysis, probability theories etc. have been made to study the complex biological systems. Mechanisms of carcinogenesis have been further investigated by introducing the idea of activator and inhibitor of mitosis and contact cell inhibition of cell division in the reaction - diffusion nonlinear spatio-temporal mathematical and stochastic models. Genetic contribution on pattern formation has been investigated with the help of one locus, two allele three genotype reaction - diffusion model The results of this model help to distinguish between two animals of the same species. Detailed work is in progress.

2. Intercrop interaction - a mathematical study of Agricultural Ecology

Plants liberate different metabolites through their root system into the soil and such substances may significantly affect the growth of other neighbouring plants. It is suggested that soil sickness problem in agriculture might be due to exudates of crop plants and that rotation of crops could help to alleviate the problem. So, allelopathy can play an important role in agriculture.

Allelopathy is the effect of one plant upon another occuring under natural conditions and exerted by chemical means other than nutritional ones.

The allelopathic interaction between two varieties of rice (Oryza sativa) seedling, namely Subarna and Pankaj, was further studied. The study of the composition and properties of phenolic compounds, amino acids and fatty acid detected earlier in RE (Root exudates) has been further perused. UV spectrophotometer and MS analysis of root exudates (RE) have been carried out and some interesting results have been obtained.

Another line of work deals with the presence of natural chemical retardants or inhibitors in weed that infest uncared lands and cultivated fields. Crozophora rottleri, is a common seasonal weed that grows abundantly in various places. All parts of the weed produce inhibitors as observed by germination experiment with rice, wheat and mustard. Sinapic acid is identified as one of the allelopathic agent in the weed. Another 16-C aliphatic acid with a mol. wt. 362 also acts as an allelopathic agent. This substance requires further study for complete characterization.

We also studied the allelopathic effect of Tamarindus plants. Vegetation under the trees is very sparse. Root exudates and leaf leachate of these plants have been found to have inhibitory effects on germination of rice seeds but in constrast, the brown seed coat extract has been found to be stimulatory suggesting that the extract could be utilised as biofertilizer.

We have perused another line of work dealing with the nature of the fruit pulp. It is well known that the pulp of many species of fruit contains inhibitors of germination. This makes sense in the ecological perspective, for, such inhibitors would not only prevent premature germination of seeds in the fruit still attached to the tree but also of those dropped from the tree and lying below. Delayed germination should be to be interest to the tree because zoochoric agents can remove the inhibitors through their alimentary canal while dispersing seeds to distant points. It is therefore of interest to study the germination-inhibitors or relatively little known tropical species.

Sterculia foetoeda, this Indian fruit is encased in very hard, woody cover and so apprently need not contain any inhibitor. In laboratory experiments, the pulp extract shows inhibitory effect. On paper chromatographic separation, two stimulators, one strong and one slight inhibitor were revealed.

In mangroves, however, seeds germinate when the fruit is still attached to the tree and so the question arises - whether the mangrove fruit pulp lacks inhibitors and/or contains stimulators.

On laboratory experimentation we have found that the fruit pulp of Candelia candel strongly inhibits the germination of standard rice seeds. But on chromatographic separation we have observed that the individual components are much less inhibitory and two or three are even slightly stimulatory. Further investigations are in progress.

3. Mathematical and computer modelling of the cellular and molecular details of how the animal's embryonic body plan is established

The project leader was away in New Zealand and so the project could not be perused.

4. Mathematical Epidemiology

Mathematical and stochastic models of Japanese Encephalitis (JE), measles and other vector borne diseases have been further modified and investigated to see the dynamical behaviour of the systems. Special emphases have been put on seasonal fluctuation and spatial spread of the diseases. An epidemiological model of the dynamics of JE spread coupling the SIRS (susceptible - infective - recovered - susceptible) models of the JE spread in the resovoir population and the human population has been proved and investigated. The development of immunity in the susceptible class by a continuous subclinical infection is a commonly observed phenomenon in many infectious diseases. This important feature has been incorporated in an SIRS epidemiological model with both the rates of incidence and increase of immunity being nonlinear in nature. The local and global dynamics of this model have been investigated. Some work has also been done to obtain the optimal vaccination age for JE. It has been observed that the optimal vaccination age is at the age of school entry. The result also shows that even with optimal vaccination strategy nearly 45% of a cohort would get the infection and the cumulative incidence of death could be reduced to about 4% only. If the vaccination coverage which could be achieved were independent of the vaccination age, there is a local optimum around the age of 4 years. Before, the model can be applied in practice it is necessary to estimate the relevant parameters on the basis of field data and this work is on progress.

5. Diffusional effects on two or more interacting species in community ecology

The importance of differential species mobility by considering spatio - temporal variations in the environment and the biogeophysicochemical influences have been further investigated. The basic question of how the epidemics affect the predators and ultimately the ecosystem itself is also an important problem in ecology. We have tried to say something by considering a simple two-trophic level system, namely, the sound phytoplankton cells (sound prey (susceptible)), predator (or grazer), and the infected cells (infected prey). By introducing the delay term in the growth of infected cells we have observed the local dynamical behaviour of the system around the partial feasible and positive equilibria, we have also established the results of global asymptotic stability of the positive equilibrium. Our approach here makes use of another novel and nontrivial way of constructing proper Liapunov functionals.

Plant Chemistry Unit

1. Screening of local vegetation

Screening studies were done on a semiaquatic plant *Cyperus tegetum* Roxb, a perennial herb growing naturally in marshy lands, and its chemical composition worked out for the potential utilization of the plant. The results of chemical analysis of the stem indicate that cellulose (31-33%), pentosan (24-27%) and lignin (23-27%) are the major constituents of this plant. The ash & crude fat content were in the range of 9.5 to 11.3% and 5.0 to 5.3% respectively. Glucose accounted for cellulose while xylose and arabinose constituted the main hemicellulose fraction in the plant.

2. Microbiology & Technology

For isolation of aeromicroflora in ecologically different zones, deproteinised leaf juice (DLJ), the liquid by-product of LP technology, from cowpea, turnip and radish was used instead of the usual media in order to determine their efficiency as potential growth media for different types of microbes. The four different ecological zones selected for the study were i) Densely populated and industrially polluted Calcutta; ii) Plateau region of Western part of the state; iii) Terai region of North Bengal and iv) Sandy coastal zone of Midnapore district of southern Bengal. The relative abundance and species diversity of microbes were noted. The study indicates that pollution and ecological diversity both play important roles in controlling the above two factors.

3. Nutritional and biochemical studies

Anti-nutritive factors present in thirty two tree species were studied. The presence of alkaloids in the leaves of eight leguminous and six non-leguminous tree species was noted. Tannin contents ranged from 0.19% to 6.28% in the non-leguminous group and from 0.24% to 4.20% in the leguminous one. It appeared that a higher content of phenolic substances seemed to be an inherent and distinct characteristic of tree leaves in which the non-leguminous group exhibited a higher range when compared to the leguminous group.

4. Aquatic weeds and water relationship

A number of ponds around the Baranagar area have been surveyed and two ponds have been selected for periodic sampling. The macrophyte density in the ponds is being estimated primarily from visual observations. Increasing numerical values (0-8) correspond with increasing plant density for density ratings. Taxonomic identifications of different plant species is being made. Plant and water samples are being collected at monthly intervals. Protein content in the floating plants were found to range from 14.6% in *Salvinia auriculata* to 24.4% in *Limnanthemum cristatum*

5. Yield performance

Variety Ramanskaya-06 was sown on 20th Nov, 1996. Nitrogen doses were N_0, N_{60}, N_{120}, N_{180} kg/ha and potassium doses were K_{00}, K_{100} and K_{150} kg/ha. Highest root yield of 56.08 t/ha was given by $N_{180}K_{150}$ treatment closely followed by 55.10 t/ha given by $N_{180}K_{150}$ kg/ha treatment. It is clear from the experiment that nitrogen fertilizer influenced root yield in the range of 120-180 kg/ha. Highest root yield was always given at the last harvest of 150 days for all treatment combination. Sugar concentration in root juice varied from 16-21.5% at 130 days with $N_{120}K_{100}$ and $N_{120}K_{150}$ treatment combination. It has been established from this experiment that higher K doses of 100 to 150 kg/ha with higher nitrogen can check falling sugar concentration at later growth stages.

6 Enzymes from soil microbes

A protease producing streptomycete (*Streptomyces* sp. 1) was screened from alluvial soil of Hooghly, West Bengal. The physiological characteristics of the *Streptomyces* have been worked out. It can use D-glucose, maltose, galactose, mannose very efficiently. It can also use D-xylose, sucrose, L-arabinose as carbohydrate source. It does not produce melanin and H_2S in the media. It cannot decompose L-tyrosine. The Streptomycete very efficiently use peptone, gelatin and asparagine as nitrogen sources for protease production. It liberates 7.32 to 8.58 ug of tyrosine/min per ml of substrate fermented on fourth day of incubation.

Social Sciences Division

The Social Sciences Division includes the following units : Economic Research Unit, Economic Analysis Unit, Linguistic Research Unit, Planning Unit, Population Studies Unit, Psychology Research Unit and Sociological Research Unit. Economic Analysis Unit is located at Bangalore, Planning Unit is located at Delhi, while the remaining five units are located at Calcutta. Faculty members of this Division were engaged in teaching and training activities at various levels, including Ph.D. supervision. The research work done in these units during the year under review is described below.

Economic Research Unit

The faculty members of this Unit were engaged in teaching and research activities, including supervision of Ph.D. students. The faculty, as in previous years, took active part in teaching all economics, econometrics and time-series courses in B.Stat. (Hons.), M.Stat., M.Tech. (QROR), ISEC (both regular and specialization) programmes. With the starting of the new two-year Master of Science (MS) programme in Quantitative Economics from 1996-97, the teaching responsibility of the faculty of this unit has increased

substantially. The research work done during the year under review covered, broadly speaking, different areas of theoretical and applied economics and econometrics. Some of the major areas in which researches were done are given below.

1. Economic Theory

Research works on various areas in economic theory were done in the last year. Some of these areas are : macroeconomic theory, general equilibrium analysis, welfare economics, economic efficiency etc. Research in emerging new areas such as industrial organisations and endogenous growth theory received emphasis.

2. Industry and labour

This unit carried out, in the past, many studies on Indian labour and Indian industry - both large-scale and small-scale. However, this area of research has assumed importance in the context of the current government policy of liberalisation and globalisation. In the last year studies were undertaken to investigate such aspects of small-scale industry as factors leading to high mortality, problems of demand and financial constraints encountered by such industrial units, policies of ancilliarisation and reservation etc. This work concentrated primarily on small-scale shoe-making units in and around Calcutta. Another aspect on which emphasis was placed was the informal sector. Besides undertaking quantitative studies, theoretical analysis of informal sector was also done to investigate various aspects of the functioning of this sector including, in particular, its relationship with the large scale sector and the rest of the economy, and its role in the development process.

3. Economic Development and macroeconomic policy in India

Some analytical works in this area have been completed. These include issues in financial liberalization, role of money, credit and government finance, budgetary policies etc. Studies on the patterns of inter-regional development in India and growth of service sector in India during the period 1960-90 were also undertaken during this year.

4. International trade

Researches are being carried out to examine the effect of foreign investment on output and employment in a developing country like India where the size of the domestic market is large. Some studies on the effect of protection on exports have also been done. These are being further investigated. Mention may be made of studies which focussed on the co-operative and non-cooperative R and D behaviour of competing firms as also of joint ventures, merger and other connected problems.

5. Agricultural economics

A study was undertaken to examine some implications of farm efficiency on the basis of a sample of 597 paddy cultivating farms in West Bengal for the year 1989-90 using the non-frontier profit function technique with translog specification. The method proposed in the study tried to take account of the economic environment of the farmer. The empirical results showed considerable differences in the resource - use pattern of various size groups of farms; but little differences in technical efficiency. Another study focusses on the relation between the agricultural price seasonality and market arrival seasonality of wheat and rice.

6. Studies on consumer behaviour and level of living

The methodological study on the estimation of Engel elasticities of clothing and other items based on NSS 38th round household budget data was continued during the year. Interesting results were obtained by applying instrumental variable method of estimation to last month data with a view to overcoming the difficulties arising due to seasonality and other transitory influences.

As a part of the research project on strategies and financing for human development sponsored by the Government of India and UNDP, some faculty members had taken up a project entitled "Employment, level of living and utilisation of public distribution system".

Work on studying the trends in the extent of inequality, poverty, agricultural growth, rural-urban disparity in the level of living in India, absolute level of living, poverty and deprivation continued during the year.

7. Econometric Methods

Time series econometrics has become very important in the last decade. Keeping this in mind, emphasis is being given to topics related to time series econometrics. During the period under review extensive works have been done on autoregressive conditional heteroscedastic (ARCH) models. In particular, the well known ARCH model has been generalized in which the dependent variable is transformed by the Box-Cox transformations. The ARCH-M model has also been generalised by allowing for time-dependence of the risk aversion parameter. Some works on long-memory models are also being done.

8. Other econometric applications

Some of the areas in which researches were done relate to (a) optimal commodity taxation, (b) employment fluctuation/uncertainty, (c) non-parametric demand analysis and (d) causality between social development and economic growth. The nonparametric exploratory analysis of the form of Engel curve was carried out in great detail using the NSSO data for rural Maharashtra.

Economic Analysis Unit (Bangalore)

The unit was actively engaged in research in the areas of agricultural economics, measurement of poverty, economic policies and econometric methods and applications.

The major topics of research were :

1. Growth, stability and variability of crop yields in India and Ahdhra Pradesh.

2. Agricultural markets integration.

3. A new approach to modelling macroeconomic time series based on expectation of the macroeconomic parameters of the economic agents.

4. Derivation of heirarchy of needs of consumers based on saturation points of commoditywise engel curves.

5. Operational Research approach to planning of Professor P.C. Mahalanobis in the context of current Indian economic reforms.

6. Evidences on production smoothing hypothesis.

7. Exploratory Bayesian analysis of modelling incomes.

8. Tests of heteroscedasticity.

9. A simulation study of the impact of priors on nonlinear parameters.

Linguistic Research Unit

During the period under review, the Unit continued its programme of research in the areas of quantitative Linguistics and Computational Linguistic with special emphasis on Speech Pathology, Psycholinguistics, Sociolinguistics, Syntax and Text Analysis as described below.

1. Quantitative Linguistics

The main aim of this project is to develop methodology for the quantification of Micro and Macro-Linguistic Data by using Statistical and Computational techniques. In spite of substantial application of Statistics in the realm of Linguistics Research, there is no indigenous and integrated method for Statistical-Linguistic analysis appropriate for the Indian situation. For this basic need, we wish to develop methodology covering different fields of Linguistic, Computer Science and Statistics. The areas which are intended to be covered at the outset are lexicology, semantax, sociolinguistics and text analysis.

2. Assessment of articulatory performance in hearing impaired children

The aim of this project was to examine the degree of correlation between the amount of hearing loss of hearing - impaired children and their articulatory performance. Djordje Kostic proposed a classificatory system by which hearing - impaired children are classified into 5 groups depending upon the degree of hearing loss. Fifty children between the ages of 5 to 10 years with Telugu, Hindi and Bengali as L1 were tested in Hyderabad, Delhi and Calcutta respectively using the Kostic - Mitter (1982) test for articulatory evaluation. Analysis showed that the performance of the subjects varied according to the group they belonged to. The age of onset of hearing loss, the criteria upon which the groups were further sub classified was found to be important as subjects with congenital hearing loss had very poor articulation compared to the ones whose hearing was affected during the language acquisition period.

3. Comparative Suprasegmentals of the Slavic, Indo-Aryan and Dravidian languages

Out of the eight branches into which the living Indo-European languages have been arranged (vide Chatterji 1926) the Balto Slavic branch and the Indo-Aryan group display striking similarities in many aspects. This project examines the interrelationships between some of the major languages of the Indian sub-continent with a view to measure the statistical distance between them. The stress patterns of isolated Hindi disyllabic words containing combinations of long and short vowels have already been analysed in order to study whether the length i.e. duration of syllables is a significant one for the presence of stress in Hindi words. A similar study has been done for Bengali and at present the study is being extended to Telugu and Tamil. The data are being analysed on the Visi-pitch (6087DS). The role of juncture in coarticulation and syllable stress have been studied in detail by collecting fresh data from a larger sample size from Telugu, Tamil, Oriya, Hindi and Bengali speakers residing in and around Calcutta.

Planning Unit

The faculty members of the Planning Unit are actively engaged in theoretical and empirical research in economics. We continue to publish in journals that are rated high by international standards. Many of our colleagues are invited abroad to participate in prestigious conferences and collaborate with scholars. Many foreign scholars have also visited our unit to interact with colleagues.

Our collective research continues to be broad, despite the modest size of faculty members. Apart from our strength in game theory and welfare economics, we have worked in international economics, growth and

development theory, finance, environmental economics and poverty and inequality. Those whose main concentration is in econometrics are doing micro and macro econometric studies of the Indian economy.

The new related development is the initiation of several Indian economy related research projects financed by PPRU (Planning and Policy Research Unit). The topics are wide-ranging. One of the objectives here is to widely circulate the research findings among government organisations and departments with the aim of being used for economic policy decision making by the government.

The unit also held its 12th Annual Conference in the second week of January 1997 for three days. Besides our own faculty members, scholars from other organizations in India and from abroad participated in this conference.

In terms of teaching, the new feature of this academic year is the initiation of the M.S.Q.E. program. We taught five compulsory courses to about seventeen students in their first semester. Our aim is to produce the modern quantitative economic analysts.

The following research projects funded by PPRU (Plan and Policy Research Unit) have also been undertaken by the Unit :

i) Impact of economic reforms on the productivity of firms, ii) Inter-regional disparities and growth, iii) Gender bias and differential employment prospects, iv) Does environmental regulations promote growth ? v) Agricultural trade liberalization and spatial development, vi) Promoting economic cooperation with ASEAN countries in the emerging environment.

Population Studies Unit

The main broad areas of research of the unit include demographic transition in India, studies on migration, evaluation of literacy programme. Some of the researches are described below.

1. Agriculture Development, Child Labour and Fertility

This study examines the interrelationship between agriculture development, child labour and fertility. Child labour is defined under several categories such as, wage earning child labour (i.e., work for earning) and domestic child labour (i.e., work in the family farm or household part time or seasonal). A sample of about thousand households were selected at random from rural areas of two blocks respectively from the district of Hooghly and Midnapore in West Bengal for the purpose of the study. Preliminary findings show that the demand for wage earning child labour increases in the household with development and modernisation of agricultural farm but has a negative relation with fertility. However, the household with traditional agricultural management in the farm has a positive relation with domestic child-labour as well as fertility. Supply of child labour in the household with modern farm management comes from the household with no agricultural land or a marginal farmer and fertility is higher among this group.

2. Study of Digit Preference Error : Some Generalisation, Modification and a New Index

This work generalises some existing indices of digit preference error in single year age data from survey or Census. This type of data possesses some unusual peaks and troughs in ages due to preference or non-preference of ending digits in reporting ages. Several indices have been developed from time to time to measure this error such as Whipple's index, Myers' index, preference pattern index and so on. In this study attempts are made to review some of these indexes for their possible shortcomings for further improvement as well as to develop a better index.

3. Women Education and Employment in India, 1951-1991

The study is undertaken to find out the pattern of growth of education and employment of women and the differential rate of growth of sectors over time.

4. Micro-Regional Statistical Surveys in India, 1800-1875 : An Evaluation

Under this project a massive volume of data on population with various classifications and land use and other economic variables have been collected from the reports of the surveys conducted during the 19th century. Writing of the final report is in progress.

5. Populations Dynamics of West Bengal

West Bengal has been facing the problem of rapid population growth during the last five decades. This population growth is determined by its components : fertility, mortality and migration. As migration data are often flawed in the census, these have been ignored in the present study. Recently developed indirect methods have been applied to census data to estimate these parameters and these estimates have been substantiated by the estimates obtained from National Family and Health Survey data.

6. Migration in India with special reference to Nepali Migration

This research is devoted to study inter-state male migration flow, Nepali migration to India in general and to West Bengal in particular, using mainly 1951-81 census data. In recent years, there has been a renewed interest in the history of movement of Nepalese to India in general and to West Bengal in particular. The full fledged migration of Nepalese is believed to have been initiated with the recruitment of Gorkha from a particular region of Nepal into British Army. High concentration of Nepali migrants are found in Assam, Bihar, Uttar Pradesh and West Bengal. The Nepali migration in 1971 have decelerated compared to previous census years reflecting fall in growth rate. But during 1981 the volume of migrants have fallen significantly so that there has been a negative growth rate.

7. Impact of Total Literacy Campaign in the District of Birbhum - An In-depth Study

A study on the Impact of Total Literacy Campaign in the Districts of Birbhum and Bankura of West Bengal (Sponsored by Govt. of W.B.) was undertaken in the year 1993. The report of the Project was submitted to the govt. Now further attempts are being made to study the impact of the programme in terms of behavioural change and to develop method of quick assessment of the programme.

8. Mortality and its determinants in India

The purpose of this research is to analyse SRS data on mortality over the two decades following 1970 at the national as well as regional level. Attempt is being made to study the mortality trends and determinants, and in particular those of infant, child and old age mortality.

9. Item Analysis of Two Newspapers : A Socio-economic Perspective

The role of newspapers in modern world is highlighted as an important yet controversial mass media. Studies are generally undertaken to judge its performance and assess the extent of social responsibility. It is often ignored that a newspaper may be treated as a special type of 'economic good' with primary focus on consumer satisfaction. The newspaper authorities represent a typical industry which target at maximising revenue earnings. A study based on the different items of a newspaper was undertaken to see how these conflicting objectives are considered keeping in mind the social responsibility of this media.

10 Estimation of Volume of Illegal Migrants from Bangladesh

The independence of Bangladesh in 1971 created a vast displacement of population between Bangladesh and India, specially eastern region. Frequent crossing of borders continues to be a political flash point between Bangladesh and eastern region of India. Large number of migrants from Bangladesh tend to hide their identity. Large volume of refugees from Bangladesh, a densely populated poor country, has created political and economic problems in this region of India. Poverty, unemployment, social security and increasing pressure of population on land forces the people to take shelter to other neighbouring places. Still no systematic approach has been made to examine social, economic and political impact of migrants from Bangladesh to eastern region of India. An attempt has been made to estimate the volume of illegal migrants from Bangladesh to West Bengal using Census records.

Psychology Research Unit

The scientific workers of Psychology Research Unit have been carrying out research work in the areas of Entrepreneurial behaviour, motivation to work, primary education etc. Some of these researches are described below.

1. Potential Entrepreneur School Leavers

A scale for measuring entrepreneurship ability is being developed to identify potential entrepreneurs from among the school leavers. The scale is being developed on the basis of data collected from trainee entrepreneurs and established entrepreneurs taking into account some essential psychological characteristics. Psychometric properties of the scale has to be established for standardisation and future applications.

2. Motivation to work for primary level workers

For assessing the motivational level of primary level workers a questionnaire has been developed on the basis of pilot study done on a group of 52 clerical workers. Data from four different groups of workers, for example, clerks, typists, account assistants and factory workers have been collected. Analysis of the data for establishing the psychometric properties of the questionnaire are being done.

3. Attainment level of Primary students at the end of Calss-IV in West Bengal on Non-scholastic subjects

The National Policy of Education put emphasis on the wholesome development of a child's body and mind at the primary stage of education. To achieve the goal a comprehensive curriculum was drawn for the elementary education that includes the following : a) Games, Physical education & healthy living b) Socially useful productive work c) Creative expressions. d) Work based on direct participation and e) Work based on teaching & learning (Scholastic work).

To help children achieve this capacity it is needed to identify the most essential competencies, attitudes and values rather than learning facts and information. The present study examines through a comprehensive assessment in all the above areas whether and how learners have gained through participation in the above activities. The present study would cover all the 18 districts of West Bengal.

4. Gender study for the District Primary Education Pogramme

An indepth gender study for the District Primary Education Programme has been undertaken in three districts, namely. Birbhum, Murshidabad and Coochbehar of West Bengal. Special emphasis is being given to look into the problems of girl students specially minority girls. Observations on gender study in Birbhum district has been prepared.

Sociological Research Unit

The scientific workers of SRU have been carrying out their internal and external research projects in areas which have direct implications in understanding the rubric of social transformation. A brief description of these research projects, both internal and external, are given below.

1. Forest protection and income generation for the tribal poor - evaluation of an organised movement

A pilot survey has recently been carried out in Ilambazar block of Birbhum district which will facilitate the deployment of both the case-study method and the structured 'questionnire-schedule' method for

collecting empirical data in order to assess the relevant impact of (i) land reforms, (ii) decentralised Panchayat-oriented planning process, (iii) literacy movement, and (iv) organisational activities of the local peasant organisations in motivating the Forest Protection Committees in the context of undertaking specific measures to check deforestation of Chaupahari forest and encourage income generation for the poor tribals in the Ilambazar block area of the district.

2. Involvement of people in the decentralized planning process : Experience in West Bengal

This study aims at (i) assessing the extent of involvement of the people right from the planning (at village level) down to its implementation, (ii) gaining an insight into the efficiency of the villagers in utilizing the resources (material and human) and the constraints of full-capacity utilisation, (iii) comparing the efficacies of earlier district plans implemented at village level. Through analysis of data gathered in course of examining relevant documents on Plan-performance gaps etc. as well as field-level investigation, the study seeks to suggest concrete measures which need to be taken to optimally accommodate grass-root level needs in higher aggregate level planning.

3. Scope and constraints of rural women leadership with special reference to experimentations in self-government bodies

Due to long-drawn movements by women for equal status with men, the Constitution was changed to ensure legal sanction for their participation in political and social activities. Our enquiry starts from this point, after reservation of seats for them in self-Government bodies. One third of the total number of seats in each of the tiers of Panchayats has been reserved for women. The 1993 election in West Bengal was held on the basis of this reservation. Three Gram-Panchayats from each of the districts of Midnapore and Birbhum were undertaken. In the first year 1995-96, we conducted the census of all Panchayat members in six Gram Panchayat areas. We formulated the socio-economic and culture profiles of women leaders. Data collection is underway.

4. Interpersonal contacts and social development : A rural experience in West Bengal

In the changing rural scenario it seems that individuality is gaining its strength. Instrumental use of personal relation is very much associated with the process. In this context personal contacts draw special significance. Social development in terms of mobilization of the scarce resources by the individual person is very much likely to be influenced by the nature and context of the personal contact of the individual. Thus, besides other factors, the role of personal contact of the individual, as such, deserves attention. In this study we attempt to understand the role of personal contact in the process of motivating the individual, securing the scarce resources and sustaining it. This study is exploratory in nature and tries to delineate different methods and techniques suitable to comprehend both the structure and personal contact and the process through which it influences the developmental activities.

5. Chamars and Santhals of Giridih

It is generally assumed that the impact of urbanization and industrialization is associated with social change as also with emergence of new type of occupations within umbral zone of such process. The present study examines whether Chamars and Santhals in Bihar who are predominant among the SC's and ST's in the study are influenced by such process, since they have very little to lose by way of social prestige in whatever occupation they engage themselves, being placed in lower rung of the social hierarchy.

Academic activities of Giridih Branch of Sociological Research Unit

In the context of the broad theme of social transformation, since 1958 SRU has been effectively pursuing in Giridih research projects concerning the problems of urbanization, migration, dimensions of integration in rural life, inter-caste and inter-class relationship in Giridih and surrounding villages, controlled measurement of fertility, application of Mahalanobis's D^2 to social science data on intergroup relations, appraisal of household stocks of handicraft and machine-made products in the villages, exploration in Palamau area to measure the impact of development plans on the rural population, eco-systemic programme of work and agro-sociological collaborative study on rain-fed farming. Some of these investigations were taken up solely by