

# INDIAN STATISTICAL INSTITUTE

## FIFTYEIGHTH ANNUAL REPORT

April 1989—March 1990



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# INDIAN STATISTICAL INSTITUTE

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# INDIAN STATISTICAL INSTITUTE

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April 1989 — March 1990

### O. INTRODUCTION

For the Institute, the most important scientific event during the year was the first Asian Congress on Quality and Reliability held during 30 October to 2 November, 1989, at New Delhi, under the distinguished patronage of the Prime Minister of India. Indian Statistical Institute played a leading role in hosting the Congress in collaboration with a few other organizations and in bringing out the Proceedings of the Congress. More than fifty scientific workers of Indian Statistical Institute participated in this Congress and 21 papers were presented from the SQC & OR Division. The Congress was an outstanding success and the delegates strongly felt that the Asian Congress should be held regularly in the future, at an interval of two to three years. The next event may be hosted by China.

The SQC & OR Division of Indian Statistical Institute was associated with another very important event in the history of the Institute. The two-year full-time M.Tech. programme in Quality, Reliability and Operations Research, announced last year, was started during this academic year at Calcutta. This training programme will admit students from two streams, namely, engineering and Statistics, and will turn out students with a strong background in both engineering and various aspects of quality, reliability and operations research. The course would thus meet a long-felt demand of Indian industry. Thanks to the devoted efforts of the faculty in the SQC & OR Division and of the workers of the Engineering Unit, a workshop needed for this course could be made ready within a few months.

Keeping in mind the unprecedented thrust for scientific quality management in the country, the SQC and OR Division is planning to introduce an eleven-month full-time training programme on Quality Management and Technology for engineers sponsored by industries.

The Institute organised two important short term courses during the year. At the request of the Regional Office of Science and Technology, UNESCO, the Institute agreed to organise a Regional Training Course on Microcomputer Based Applications of Statistical Programme Packages for Environmental Scientists of South and Central Asia, during December 1989 in Calcutta. Twelve participants, five from India and one each from Afghanistan, Bangladesh, Iran, Mongolia, Nepal, Pakistan and Sri Lanka participated in the Training Course. A special software package was developed for this course. Dr. Miron P. Derkach of UNESCO has expressed complete satisfaction with the course and has expressed a desire for having more such course in the future. At the request of the UGC, the Institute organised a workshop for teachers in statistics in colleges and universities. This would be the first of a series of such workshops for the UGC.

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<sup>1</sup>Vide Annual Review presented by the Director at the Twentyfourth Convocation of the Institute held on 29 December 1989.

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The Institute's regular courses were going on well. For the academic session 1989-90, a total of 10622 candidates applied for admission to the various degree and diploma courses of the Institute and they were called for written selection tests which were conducted at 14 centres distributed all over the country. A total of 5643 candidates appeared for these written tests, subsequently, a total of 587 candidates were called for interviews, and finally, 350 candidates were offered admission to the various courses like B.Stat. (Honours), M.Stat. (M-Stream and S-Stream), M.Tech. (Computer Science) and M.Tech. (Quality, Reliability and OR).

The Institute operates the International Statistical Education Centre (ISEC), which started functioning in 1950, jointly with the International Statistical Institute under the auspices of the UNESCO and the Government of India. During the year under review, this Centre conducted the 10-month Regular Course of its 43rd Term with 28 participants from 15 countries in South and South-East Asia, the Middle East, the Far East and Commonwealth Africa. The Government of India awarded 23 fellowships to the foreign trainees—8 under the TCS of the Colombo Plan, 9 under special Commonwealth African Assistance Plan (SCAAP) and 6 under Aid to Sri Lanka. One trainee was awarded the CI-TC fellowship. Three Indian trainees and one trainee from Nigeria were supported by their respective governments. Twenty-five of the trainees completed the Regular Course. A special course in Tourism Statistics was organized for a Maldivian trainee of the previous Term who was supported by a Government of India fellowship under the TCS of the Colombo Plan.

Several issues of Sankhyā, Vol-51, both Series A and B were brought out during the year, besides the first and second volumes of Selected Papers of Professor C. R. Rao.

The Institute's statisticians, economists, sociologists and agricultural scientists worked on a number of multi-disciplinary projects taken up at the request of different agencies.

The Reserve Bank of India entrusted the Institute with a project on the Long-term forecasts of fresh Notes and Coins. The study is being carried out jointly by the staff of the Economic Research Unit and the Computer Science Unit. The main task is to develop a stochastic model for determining the aggregate demand for currency in our country as well as the demand for different denominations of currency and to use the model for predicting the demand for currency.

In an innovative project funded by the British Overseas Development Agency (DDA), the Indian Statistical Institute is collaborating with the DDA and the Hindustan Fertilizer Corporation and trying out risk averse strategies for agriculture in the rain-fed villages of West Bengal, Bihar and Orissa. The Indian Statistical Institute considers this as a problem of dynamic control in a social context, and will provide feedback and advice continuously, along with monitoring the progress. The project team includes scientists from Social Sciences, Biological Sciences and Applied Statistics Divisions of the Institute. One challenging task facing this team is to work out the methodology for evaluation the impact of such activities upon the local population.

Work was continued for the project sponsored by Rockefeller foundation on the "Differential Impact of Modern Rice Technology on favourable and unfavourable production environments". This was conceived as part of a network study undertaken

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in several Asian countries and co-ordinated by the International Rice Research Institute at Manila. The main aim is to examine the extent of adoption of modern rice technology in different production environments in West Bengal and also the impact of such adoption on the well-being of the people. A report on the village level data collected in the first phase of the survey yielded interesting results. Steps were also taken for collecting detailed household level data in the next phase of the study.

A third related multi-disciplinary project, funded by the ICSSR, aimed at studying the watershed of the river Usri in South Bihar plateau with emphasis on social, agronomic, ecological and industrial aspects.

It is hoped that these several projects will throw up valuable data for evolution of future policy and also provide scope for new kinds of research.

It may be mentioned in this connection that the Institute's Sociological Research Unit at Calcutta has been collecting a variety of data on villages around Giridih for more than three decades, in an ambitious project to understand the phenomenon of urbanization and growth. A comprehensive report on this study is under preparation.

After extended discussions over a period of more than two years, the Department of Science and Technology approved project on "Production and economic evaluation of leaf protein at village level". This project would run for about 15 months in Phase I in collaboration with the Indian Institute of Technology, Delhi. Work on this project was initiated during the year under review. The project, which has several goals, will explore among other things, the technical and economic feasibility of producing a cheap, acceptable, concentrated protein by a technology adopted for our rural areas.

The Institute's experts continued to be associated with the National Sample Survey Organization (NSSO) in many ways. Some of them were engaged in analyzing the data collected by the NSSO through a pilot study on household income, consumption and savings. Others worked on the development of a generalized software package for editing survey data collected by the NSSO, which would finally be implemented on computers utilized by NSSO.

The Institute's DOE/UNDP sponsored Nodal Centre for knowledge Based Computing System (NCKBCS) Technology and Fifth Generation Computer System Development Project was working well. Among the achievements of the Centre and the Electronics and Communication Sciences Unit (ECSU), the following may be highlighted.

(i) A fractal based criterion was developed to evaluate the performance of digital image magnification techniques.

(ii) A new mathematical theory of 2-D and 3-D shape analysis has been developed and experimentally implemented for a new shapebased object recognition algorithms for computer vision system.

(iii) A Bengali speech sound synthesis procedure from phonetic script typed at the computer console has been developed using a novel approach of speech event concatenation.

(iv) Another achievement was the development and use of an indigenously made SODAR (an acoustic radar system developed at ISI) system for characterising the atmospheric boundary layer (ABL) phenomena prevailing in Calcutta region.

## **Part I. Teaching, Training, Research, Projects and Publications**

### **1. TEACHING AND TRAINING**

#### **Degree and Training Courses**

A brief account of teaching and training activities during the period from April 1989 to March 1990 is given below :

During the academic session 1989-90, 10622 candidates applied for admission and were called for written selection tests for the courses offered by the Institute, viz., B. Stat. (Hons.), M. Stat. (M-Stream and S-stream), M. Tech. in Computer Science, M. Tech. in Quality, Reliability and Operations Research, Two-year Part-time Post-graduate Diploma in SQC and OR (Bombay and Madras), Research Fellowships in Statistics, Mathematics, Economics, Computer Science, Physics, Fluid Mechanics, Anthropology and Geology, One-year Evening Course in Statistical Methods and Applications and the course on Operation of Automatic Data Processing Equipment. Admission tests were conducted at 14 Centres all over the country. A total of 5643 candidates appeared for admission tests, a total of 587 candidates were called for interviews and 350 candidates offered admission to various courses during the academic session 1989-90.

Four foreign applicants who applied directly for admission to our courses were given special admission tests conducted through the Indian High Commissions or Embassies in Paris, New York, Colombo and Dhaka.

The annual examinations for the B.Stat. (Hons.) and M.Stat. courses were held in May/June 1989. The 1989-90 academic session commenced on 4 July 1989.

Eleven trainees in Engineering from various Universities (Jadavpur, Banaras Hindu University, Aligarh Muslim University) received six-week practical training in the Electronics and Communication Sciences Unit and the Electronics Unit.

A new course — the M.Tech. programme in Quality, Reliability and Operations Research was introduced from the academic session 1989-90.

One hundred and twenty-two candidates received their degrees and diplomas at the Twenty-fourth Convocation of the Indian Statistical Institute held on 29 December 1989, and fifty-five candidates who passed the various regular courses of varying duration (one-year or less) received the certificates during the year. Six candidates were awarded Ph.D. degree of the Indian Statistical Institute.

A one-year Evening Course in Statistical Methods and Applications was started at Hyderabad from the academic session 1989-90.

A revision of the syllabi and course structure of the B.Stat. (Hons.) and M.Stat. programmes was undertaken by a committee and the new syllabi were introduced with effect from the session 1988-89.

The number of candidates admitted to the different degree, diploma and training courses during 1988-89 and 1989-90 and the results of the examinations held during the period are given below :

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**NUMBER OF STUDENTS ADMITTED AND PASSED IN DIFFERENT COURSES  
APRIL 1989—MARCH 1990**

Courses	Number of students			
	enrolled in 1988-89	as on March 1989	enrolled in 1989-90	passed in annual examina- tion in 1989
	(1)	(2)	(3)	(4)
<b>1. Degree :</b>				
Courses leading to a Degree in Statistics :				
Bachelor of Statistics with Honours (B.Stat. (Hons)) :				
1st year	16	11	18	10
2nd year	21	14	10	11
3rd year	12	11	21	11
Master of Statistics (M.Stat.) : 1st year (M-stream)	7	6	6	6
1st year (S-stream)	30	30	30	30
2nd year	52	52	25	52
3. M.Tech. in Computer Science : 1st year	17	17	20	15
2nd year	10	10	11	18
4. M.Tech. in Quality, Reliability Operations Research: 1st year	—	—	21	—
<b>5. Diploma :</b>				
Specialised Courses in Applied Statistics leading to Diplomas :				
Statistical Quality Control and Operations Research (One-year)				
	13	12	11	12
<b>6. Certificate/Diploma :</b>				
Course in Operation and Programming of Automatic Data Processing Equipment :				
1st year	13	13	27	5
2nd year	10	10	5	1
<b>7. Part time Certificate/Diploma in Statistical Quality Control and Operations Research : (Bombay and Madras)</b>				
Bombay —				
1st year	4	2	1	1
2nd year	2	2	2	2
1st year	5	5	5	5
2nd year	2	2	2	1
<b>8. Associateship :</b>				
Associateship in Documentation and Information Science :				
1st year	7	4	4	4
2nd year	6	5	5	5
<b>9. Certificate :</b>				
Statistical Methods and Applications				
(i) Calcutta	27	1	65	5
(ii) Delhi	—	—	15	1
(iii) Hyderabad	—	—	10	0
<b>10. Six-month Evening Course in Statistical Quality Control :</b>				
(a) Bangalore				
(i) January-June '89	9	1	—	6
(ii) July-December '89	—	—	13	11
(b) Hyderabad				
(i) January-June '89	—	6	—	6
(ii) July-December '89	—	—	31	3
<b>11. Intensive Course on Programming and Applications Courses in Statistics for Persons in Employment (Jointly with C.S.O.) :</b>				
	30	30	17	3
<b>12. Junior Certificate Course in Statistics</b>				
	21	11	11	11
<b>13. Indian Statistical Service Probationers' Training Courses</b>				
	—	—	—	—
<b>Fellowship :</b>				
<b>14. Junior and Senior Research Fellows, Visiting Fellows in the following areas**</b>				
	80	80	80	—
<b>15. Specialist Development Programme in SQC and OR</b>				
	6	6	6	—
<b>Grand Total</b>	<b>380</b>	<b>376</b>	<b>458</b>	<b>283</b>

\*The course started from the Session 1989-90. †Course not held in previous year

\*\*Statistics, Mathematics, Economics, Physics, Fluid Mechanics, Communication Sciences, Anthropometry and Human Genetics, Computer Science, Embryology, Geology, Biometry, and 2 CSIR Fellowships in Theoretical Physics. The figure includes 16 Research Fellows and Associates at Delhi Centre and 4 at Bangalore Centre.



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### International Statistical Education Centre (ISEC), Calcutta

The ISEC, which started functioning in 1950, is operated jointly by the International Statistical Institute and the Indian Statistical Institute, under the auspices of the UNESCO and the Govt. of India. The Centre functions under a joint Board of Directors. During the period under review the Board consisted of : Chairman—National Professor C. R. Rao, Members—G. Kulldorff, D. Vere-Jones and D. A. Livesley (Ex-officio members, representing the International Statistical Institute); Secretary, Department of Statistics, Government of India, representing the Government of India; J. K. Ghosh and A. B. Raha (representing the Indian Statistical Institute).

Since inception, the Centre has provided training to 1130 trainees from 52 countries.

During 1989-90, the 43rd Term of ISEC, the Centre conducted the 40-month Regular Course with 28 trainees from 15 different countries in South and South-East Asia, the Middle-East, the Far East and Commonwealth Africa. The Govt. of India awarded 23 fellowships for the Foreign trainees—8 under TCS of the Colombo Plan, 9 under Special Commonwealth African Assistance Plan (SCAAP) and 6 under Aid to Sri Lanka and one trainee was awarded CFTC fellowship. Three Indian trainees and one trainee from Nigeria were supported by their respective governments.

The Regular Course started on 1 June, 1989. From June to September the trainees stayed in Calcutta and studied theory and application of Statistics besides Mathematics, Economics and Data Processing. Most of the courses taught in this period were compulsory for all the trainees. During October-November they attended a six-week programme of training in Official Statistical Systems and Procedures at New Delhi and Simla. This part of the programme was conducted by the CSO, Govt. of India. General training in Statistics was resumed at Calcutta around the middle of November and the trainees attended further courses in Statistical theory and applications during November 1989—January 1990. Most of the courses being taught in this phase were optional and the trainees were attending courses chosen by them.

In the last phase, during January—March 1991, five (5) trainees went to Bangalore Centre of ISI to undergo specialisation in SQC and OR and 10 trainees went to Delhi Centre to undergo specialisation in Economic Planning. The remaining trainees specialised in Demography and Data processing at Calcutta. Of the 28 trainees, 25 completed the 10-month Regular Course; 24 of them received the Statistical Training Diploma and one, the Certificate of Attendance.

A Special Course on individual basis in Tourism Statistics was organised for a Maldivian trainee of the 42nd Term. He was supported by a TCS of Colombo Plan fellowship.

Professor D. Vere-Jones, Chairman, Statistical Education Committee, of the International Statistical Institute, and ex-officio, member of the Board of Directors of ISEC, visited this Centre on 11-12 October, 1989, to review the activities of the Centre.

Dr. S. Kageyama of the Department of Mathematics, Faculty of School Education, Hiroshima University, Japan, taught at the Centre as a visiting Professor from November, 1989 to March, 1990.

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### Professional Examinations in Statistics

During the period under report, examinations for the Statistical Assistantship Certificate, the Junior Diploma in Statistics and the Senior Diploma in Statistics were held at Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras, for the April 1989 and October 1989 terms.

The total number of candidates registered and appeared and their results for April 1989 and October 1989 terms are shown below.

Examination	number of candidates					
	registered		appeared		passed*	
	April	October	April	October	April	October
1. Statistical Assistantship Certificate	26	18	14	8	1	2
2. Junior Diploma in Statistics	42	43	25	28	17	13
3. Senior Diploma in Statistics (Old)	6	4	5	4	3	2
4. Senior Diploma in Statistics (New)	7	7	7	5	0	1

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

Three candidates qualified for the award of Diplomas in these Professional Examinations in Statistics during this period.

## 2. RESEARCH WORK

The Research Activities of the Institute are grouped in the following divisions : Theoretical Statistics and Mathematics ; Applied Statistics, Surveys and Computing ; Physical and Earth Sciences ; Biological Sciences ; Social Sciences ; Statistical Quality Control and Operations Research ; and Library, Documentation and Information Sciences. In addition, the Computer and Statistical Service Centre (CSSC) has the responsibilities of management of in-house computer system of the Institute and providing Computing and Statistical Services to Scientific workers.

A brief account of the progress of research in different divisions and units of the Institute during the year under review is given below :

### Theoretical Statistics and Mathematics

#### Calcutta

The Division has the major part of the responsibility of teaching theoretical statistics and mathematics in the B.Stat., M.Stat., M.Tech., Evening Courses, ISEC, JCCS and other courses of the Institute. The Division also conducts a course, lasting

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12-18 months, at an advanced level, for research scholars enrolled for the Ph.D. degree of the Institute. The Division regularly conducts Monday Colloquia with speakers both from the Division and visitors.

### *Main topics of Research*

Asymptotic Theory in Statistics, Decision Theory, Statistical Inference, Inference in Stochastic Processes, Sequential Analysis and Inference, Multivariate Analysis, Discrete Multivariate Analysis, Directional Data Analysis, Robustness, Linear Models, Constructional and Combinatorial Aspects of Designs, Optimality Theory of Designs, Sampling Theory and Surveys, Ergodic Theory, Stochastic Processes, Markov Processes, Stochastic Models, Characterizations of Distributions in Statistics, Limit Theorems in Probability, Inequalities, Application of Statistics in Geology and Human Genetics, Statistical Computations, Statistical and Quantitative Economics.

Descriptive Set Theory, Graph Theory, Combinatorics and their applications to Social Sciences, Functional Analysis, Geometry of Banach Spaces, Measure Theory, Harmonic Analysis, Analysis on Lie Groups, General and Algebraic Topology, Differential Topology, Automata Theory, Computational Complexities, Complex Analysis and Moduli Problems, Complex and Hypercomplex Manifolds, Binary Codes and Finite Geometries, Classical Finite Simple Groups, Sediment Transport and Theory of Dispersion.

*Research work done/published during the period April 1989 to March 1990.*

1. *Probability and Stochastic Processes.* A complete description of Filtrations of polynomial solutions of cold equation was obtained. Martingale representation of Hermite polynomials was established. Study of Prediction.

2. *Inference.* Significant work was done on the following topics : Sequential methods in finite populations, Binomial estimation, optimal estimation in sampling. Third-order comparison of unbiased tests, Comparison of the conditional ratio-test and usual likelihood ratio test, locally asymptotic minimax estimation in non-regular case, higher order asymptotics for the likelihood ratio, Rao's and Wald's tests, Non-additive linear models estimability, squareness and eccentricity, efficient estimation with many nuisance parameters, stopping rules, permutation invariance and sufficiency principle, optimal strategies, majorization.

3. *Design of Experiments.* Several results on universal optimality of block designs with unequal blocks sizes, optimality and construction of row-column designs,  $E$ -optimality of block designs, were obtained. Results on balanced incompletely block row-column designs, analysis of balanced incomplete multiresponse designs, run order of trend resistant 2-level factorial designs, almost saturated  $D$ -optimal main effect plans, were proved. Problems and perspectives of uncertain resources and optimal designs were posed. Results on robustness of group divisible designs, calculus of factorial designs were obtained.

4. *Multivariate Analysis.* Significant results were obtained on : Selecting the  $t$ -test cells in a multinomial distribution, characterization of uniform distribution with Chernoff-type inequalities. Multivariate majorization, multi-stage selection procedures

for Weibull populations, unlinking theorem for symmetric convex functions, multi-dimensional Polya theorem, Rates of convergence to normality for variables with entire characteristic functions, multinomial distribution quantum statistics and  $E-P-R$  like phenomena. Study of asymptotics of circular median, Bahadur representation for circular median, a rotationally symmetric directional distribution, Von Mises-Fisher's matrix distribution obtained through maximum likelihood characterization, estimation of multivariate finite population parameters. Derived results on asymptotic comparison of tests in the general multiparameter cases, these technique are useful in many other situations, for example, for studying properties of conditional tests, superiority of the conditional likelihood ratio test to the usual likelihood ratio test.

5. *Survey Sampling.* Interesting results were proved in survey sampling, in particular, applications of some techniques popular in the theory of optimal experiments to the derivation of optimal strategies under a general correlated modes. Work was done on estimation of multivariate finite population parameters and multipurpose surveys, coherent mixtures of SRSWOR sampling scheme for bounded risk estimation on a finite population mean, optimal sampling for defective detection in case of defective interference. Study of optimal strategies in sampling from a social network—a strategy uniformly better than SRSWOR prescribed was undertaken.

6. *Descriptive Set Theory.* Results on Hausdorff-Kuratowski hierarchy of  $W$ . regular languages and a hierarchy of Muller automata were obtained. Research work in random theorems, in topology was done and published. Interesting new results on random fixed point theorems with domain measurable functions, random extension theory were proved.

7. *Combinatorics, Graph Theory and Group Theory.* Interesting work was done on unitals of nonprime order,  $U(6)$  etc., Infinite series of cyclic Steiner 2-designs with block size 7, construction of infinite series of semi-biplanes, determination of intersection pattern of known ovoids  $B_2(s)$ ,  $s$  even; regular two-graphs versus sporadic simple groups, investigation of modular representation in unnatural characteristic of the Chevalley group  $O(5, q)$ . Finite simple groups of Lee type and their geometries. Binary codes related to the  $O(5, q)$ , generalised quadrangles. Continued work on application of graph theoretic techniques to the study of social networks, especially to study the boundary of reciprocity in a social network. Continued work on degree sequences of graphs with given invariants, totally super compact graphs. Results on Automata in infinite strings and trees, computational complexity were proved.

8. *Analysis, Geometry and Topology.* Study of injective tensor product of Banach spaces with the Mazur intersection property (MIP), Projective tensor products, Extremal structure of the dual ball in the projective tensor products. Investigation of the MIP in Banach spaces in the context of geometric aspects, specially a study of various stability questions and a uniform treatment of several generalisations of this property. An equivariant notion of local coefficient system has been introduced. A cohomology theory with such coefficient system has been formulated for spaces equipped with the action of a finite group  $G$  and using his equivariant, obstruction theory for  $G$ -filtrations has been developed. Study on parametric homotopy principle for a class of partial differential relations, existence of contact forms on closed manifold was made. Work was done on completely bounded modules, extremal

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problem, Curvature in-equality, and  $SV(n, 1)$ -invariant operators and discrete representation. A new insight on the Stone-Weierstrass theorem and Dini's theorem, construction of regular spaces which are not completely regular, abundance of spaces which are not completely regular, abundance of spaces akin to  $S_\omega$  were proved.

### Delhi

The faculty members of the unit have worked on several important areas in Mathematical Statistics, Probability, Stochastic Calculus, Linear Algebra, Operators and Algebra and Game Theory.

The specific topics in which the work lead to significant results, and is reported in publications listed later are linear Statistical Models and related problems : unified theory of matrix partial orders through generalized inverses and its applications. Designs and Analysis of Experiments, optimality, Robustness of designs, parametric and nonparametric inference specially in the context of stochastic processes, Two-stage shrinkage estimation, functional equations in probability theory, identically distributed stochastic integrals and semi-stable processes, stochastic difference equations and Martingale problems associated with the Boltzman equation, Discrete and continuous time quantum stochastic flows and Schrodinger equations, Theory of generalised harmonic oscillators in quantum probability, Markov processes as commutative quantum diffusions, Theory of diffusions with unbounded generators.

Perturbation of roots of polynomials and of matrix functions and inequalities for operators. Significant Geometric characterization results for  $N$ -matrices similar to  $P$ -matrices, transversals of latin squares, constructions of Hypergroups of matrices.

*Research Interests :* Design and Analysis of Experiments, Linear Statistical Models (related problems of Linear Algebra including generalised inverses), Multivariate Statistical Analysis, Asymptotic Statistical Theory, Stochastic Processes (theory and applications), reference in Stochastic Processes, Stochastic differential equations, Functional equations and Fourier and Laplace transforms in Probability Theory, Quantum Probability and irreversible processes, Perturbations of linear operators, Operator algebras, Game theory, Univalent mappings theory, Optimization, Mathematical programming, Reliability theory and scheduling problems, Nonnegative matrices, Permanents, Hypergroups of matrices, Finitely additive probability, White Noise theory, Non-linear Filtering, Combinatorics.

### Bangalore

Research was carried out in the following areas of probability theory, statistics and mathematics :

Probability theory : Theory of large deviations, semi-stable measures and processes, diffusion processes ;

Statistics : Sample surveys, Large samples theory, Bayesian Inference, Reliability theory ;

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Mathematics : Functional Analysis, Geometry of Banach space, Operator algebras and Operator theory, Complex analysis, Riemann surfaces, Harmonic analysis, Differential Geometry and Topology, Finitely additive measures,  $G$ -inverses.

### *Teaching activity at the unit :*

During the year '89-'90, there were two second year M.Stat. students and three Research Fellows (the latter three being all funded by NBHM fellowships), so there were courses taught correspondingly.

In addition, for the major part of the academic year, there was an additional research student, C. V. Ramji, (currently engaged in a Ph.D. programme at the University of Hyderabad) who was informally visiting the unit so that he could have consultations with S. Ramaswamy and T. S. S. R. K. Rao ; his visit seems to have been fruitful and he is said to be submitting his thesis shortly.

### **Applied Statistics, Surveys and Computing**

The Applied Statistics, Surveys and Computing Division consists of two units : Computer Science Unit and Biometry Research Unit. Research activities in the Division include both theoretical investigation of methodology and application of existing methods to the solution of practical real life problems. The scope of the Divisional research work is broadly in the areas of applied statistics, computer science and biometry.

#### *Computer Science Unit*

*Design of Experiments :* A class of row-column designs have been defined and constructed and its optimality property proved. Optimality of certain classes of known block designs has been established. The designs in the first set have replication number ( $r$ ) smaller than the square root of the number of treatments ( $v$ ). The ratio  $rv$  is bigger in all the existing optimal row-column designs in the non-regular setting. In practice, a small design accommodating many treatments has obvious practical advantages. Attempts are being made to reduce  $rv$  even more.

*Genetics :* A two-locus genetical model of prelingual deafness has been proposed. The model fits family data. Strategies for mapping a two-locus recessive disorder have been suggested. Anthropometric data on tribes and castes of India have been analysed using multivariate statistical methods. No "racial" clustering of populations was detected.

*Econometrics :* A general index of growth has been obtained starting from a set of axioms. This can be used to measure growth from single-valued time series data.

*Sample Surveys :* A theoretical model to estimate the number of tourists in an area (city/town/district), especially the number visiting a particular spot, has been developed using on-the-spot survey data. This method is less costly and has high degree of efficiency. Further work is being carried out to see whether this model could be applied in other similar situations, and whether some conditions could be relaxed.

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*Biometry* : Biometry Research Unit is engaged in various research activities in the areas of Medical Statistics including computer simulation of biomedical problems. This will lead to greater insight into human metabolic tracts as far as their activities in normal and diseased conditions are concerned. Effects of malnutrition on the prevalence and onset of diabetes mellitus are being studied with the collaboration of the Metabolic Disease Ward, School of Tropical Medicine, Calcutta. Continued study on growth modelling of fresh water Indian Carps is being pursued. The significance of this study lies in probing the genetic marker enzyme, lactate dehydrogenase, as the probable indicator of the Carps adaptive power against an adverse pond-ecosystem.

### *Externally Funded Projects*

1. *Growth Modelling of Carps* : A project on the growth modelling of fresh water Indian Carps has been sponsored by the Directorate of Fisheries, Government of West Bengal. Report of the pilot study has been submitted and the sponsor has requested continuation of the study. Accordingly, a scheme has been submitted with some addenda to the original programme.

2. *Oil and Natural Gas Commission Project* : In a project undertaken for the Oil and Natural Gas Commission, theoretical models have been developed for the purpose of predicting discovery and production of hydrocarbon along with the associated costs and these models have been tested with data collected for the Cambay basin. The final report is under preparation.

3. *Fish Farmers Development Agency (FFDA) Project* : At the request of the Directorate of Fisheries, Government of West Bengal, a sample survey project was conducted covering four districts of West Bengal, to evaluate the impact of a number of World Bank schemes that have been sponsored by the Fish Farmers Development Agency (FFDA). The impact is to be judged from the point of view of increase in fish yield rate and better management of water bodies for fish farming.

Data have been collected from FFDA beneficiaries and from an equal number of non-beneficiaries. Sampling scheme adopted was two-stage stratified PPS/SRS mixed. Data have been computerised for all four districts, and are being cleaned.

4. *Differential Impact of Modern Rice Technology (DIS) Project* : Studies of Differential Impact of Modern Rice Technology have been undertaken in a number of countries in South and South East Asia under the auspices of IIRI with funding from the Rockefeller Foundation, USA. The project taken up by ISI (in collaboration with the University of Kalyani) is one of these studies. Its objective is to investigate the adoption and impact of modern rice technology (HYV seed, irrigation, mechanized farming, fertilizer, insecticide-pesticide etc.) in West Bengal. An important aim is to examine the factors behind the relatively slow progress in adoption of modern rice technology utilizing data at two levels—village level and household level. The village level data have been collected and analyzed and a report, "Technological Change and Labour use in Rice Agriculture : Analysis of Village-Level Data in West Bengal" has been presented at the IIRI Conference at Manila during March 26-28, 1990. As

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a preparation to the Intensive Household Survey to be conducted in 1990-91, a benchmark Survey of about 3000 sample households was conducted in January-February 1990, with a view to getting a broad idea of variation across villages and across households within selected villages.

### *Internally Funded Projects*

Computer simulation of human metabolic functions is a current research interest. Already some headway has been made in simulating human glucose homeostatic functions. The essence has been published. The goal is to have a close insight into human glucose metabolic functions. Visco-elastic properties of blood is envisaged to be traced. This has got some diagnostic value as far as the onset and prevalence of human catabolic diseases is concerned.

The project, "An investigation into the young Insulin-Dependent Malnutrition related Diabetic Patients" is being carried out with the collaboration of the Metabolic Disease Ward, School of Tropical Medicine, Calcutta. The results reveal that hypercholesterolemia and hypertriglyceridaemia are common in about 68% of malnutrition-related diabetics, whereas a few (about 20%) possess risk level of high density lipoprotein in their blood. Also, bacterial/viral infection are suspected to be manifested by the high level of immunoglobulin G in their serum immunological profiles.

### *On-Going Projects*

Estimation of fish yield rates of FFDA and non-FFDA water bodies and other related work is in progress. Data collection has been completed and processing work is in progress. This project is being continued from 1988-89. But no headway could be made due to want of the rheo-viscometer. The machine reached our laboratory early this year. Necessary standardization is being made before the actual experiments can be done.

### *Training Course :*

A UNESCO-sponsored Regional Training Course of Microcomputer based Applications of Statistical Program Packages for Environmental Scientists of South and Central Asia was held from 4 to 22 December 1989. Fourteen Candidates participated in this training programme. Topics covered were : Operation of IBM-PC ; EASE Software Package ; Techniques of Data Collection ; Data Summarisation ; Regression Analysis ; Analysis of Variance ; Discriminant and Cluster Analysis ; Analysis of Categorical Data ; MINITAB Software Package.

### **The Computer and Statistical Service Centre (CSSC)**

The Computer and Statistical Service Centre (CSSC) is responsible for operation and maintenance of the VAX-8650 Computer System allocated to the centre and to provide the following services to users with special arrangements for students : (a) Statistical and computational consultancy ; (b) Assistance in choosing and using software available at centre ; (c) Assistance in computer programming and debugging of programs ; (d) Training in systems software, application packages and programming languages ; (e) Bulk data transcription service and (f) Data archival service.

The CSSC provided computational facilities to about four hundred users. National Sample Survey Organisation, Government of India, was also using the computing facilities available at the centre.



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The CSSC has started Data Archival Service. Data of 38th round of the survey conducted by the National Sample Survey Organisation is currently available with the CSSC.

The CSSC organised the following courses for the users :

- (a) Orientation Programme for VAX-8650
- (b) Introductory lectures on Statistical Packages
- (c) VAX Fortran
- (d) VAX C
- (e) RDB (Relational Data Base)

To meet the increasing demand, ten additional terminals have been connected with the system.

### Physical and Earth Sciences

The Division comprises the Chemistry Unit, Electronics Unit, Electronics and Communication Sciences Unit, Geological Studies Unit, Physics Unit. Researches carried in these units are described below :

### CHEMISTRY

1. *Study of Soil Rhizosphere* : Plant roots being the habitat for the development of symbiotic and nonsymbiotic micro-organisms the soil rhizospheres permeated by them is the zone of vigorous activity. This attributes to the rhizosphere properties and composition different from those of the bulk soil. The soil in this zone along with the elaborate root system in it are in a state of constant interaction. Preliminary investigation on the system has established striking differences in the form and quantity of organic and total nitrogen between the rhizosphere and the bulk soil. Experiment has been carried out in soils of different textures and organic matter content each with two different plants. Root-length, volume and area have been determined along with their exchange capacity. Excess nitrogen in the root zone has been found to bear a direct correlation with both the root-area and root-volume. Correlation with root area has been found to be much more prominent. This highlights the importance of the enzymatic action at interfaces in the rhizosphere.

2. *Distribution and characteristics of allophanes in Soils of West Bengal* : Allophanes or non-crystalline inorganic materials present mainly in the clay fractions are of utmost importance in determining the mechanical properties of soil. They are associated with organic materials and inorganic nutrients. Their amounts properties and effect in Indian soil have been investigated very little. The work has been recently undertaken to fill this gap.

North Bengal soils studied so far have shown significant amount of allophanes. They have been characterised by cation exchange capacity, specific surface area and water holding capacity. Gelling capacity of these materials effective in forming aggregates have been studied. Nutrient content in the allophanic separates are being measured.

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3. *Adsorption at solid-solution and Solution-air Interfaces* : Adsorptive interaction between clays, feldspars as well as rock particles and organic substances have been investigated.

## ELECTRONICS

### A. *Digital System Research*

1. *Parallel Algorithms and Parallel Architectures* : Studies on tree-type architectures and their suitability for parallel processing have been carried out. Performance of simple tree-type architectures is severely limited by the constraint imposed by the data communication bandwidth of the root processor. To get rid of this bottle-neck, suitable modifications on the simple tree architectures have been proposed.

Methodology for testing bilateral bit-level systolic arrays have also been developed.

Extensions of earlier algorithms and architectures for fault-tolerant binary arithmetic, design of an efficient parallel algorithm for ternary multiplication with its implementation on a systolic architecture and design of a testable binary multiplier are currently under study.

2. *Network Topology* : Studies have been carried out on the quantification of network reliabilities. A stochastic model of fault in the network has been developed to define the meaning of 'Reliability of Network' and also an algorithm has been developed to compute it. Different properties of circulant graphs in connection with diameter, routing, fault-tolerance etc. are also being studied.

3. *Interconnection Networks* : Multistage interconnection networks play an important role in determining the extent of parallelism attainable in a multiprocessor system and are worth of extensive study. Using the concept of conflict graphs, an optimal graph coloring algorithm has been developed to find out the optimal number of passes for a set of permutations.

Different properties of MIN's such as the permutation capability, routing, equivalence, fault-tolerance etc. are currently under study. Benes network, being a rearrangeable, MIN, can realize any arbitrary permutation in a single pass. Fault tolerance of Benes networks in presence of single fault as well as multiple faults have been studied. It has been found that in presence of a single fault, two passes are always sufficient to realize any arbitrary permutation, which results in an exponential order time delay reduction compared to extra stage fault-tolerant MIN's. The number of double faults and multiple faults tolerated by the network have also been found.

4. *System Diagnosis* : An efficient algorithm for diagnosis of faulty units in a multiprocessing environment has been developed. Graph theoretic modelling has been adopted and several interesting results have been obtained.

5. *VLSI Layout Design* : A new concept of inherent nonslicability in VLSI floorplanning has been proposed and defined. The neighborhood graph for inherently nonslicable floorplan with minimum number of vertices and edges has been identified

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and a family of other such floorplans has also been discovered. A hierarchical decomposition of the floorplan topology has been introduced; it helps in breaking all directed cycles in the channel graph efficiently and thus transforming nonslicible floorplans to slicible ones. In the placement area, efficient algorithms for optimal circular placement of modules has been developed. A new  $O(n \log n + R)$  algorithm has been designed for identifying the maximum empty rectangle on a chip floor with  $n$  modules and  $R$  maximal empty rectangles. This algorithm has the best complexity known so far.

6. *Data Structures to Support VLSI Layout Tools* : A data structure similar to MAGIC has been implemented in Turbo PASCAL on PC/AT. This algorithm works on the corner-stitching data structure and is suitable in a VLSI environment. Software for drawing and editing of a floorplan has been implemented. Another interactive tool for transforming nonslicible floorplans to slicible ones has been developed. The implementation of hierarchical decomposition of floorplans based on strongly connected components of the channel digraph has been completed.

7. *Testability, Test Generation and Fault Simulation in VLSI Circuits* : An efficient method of transforming a gate-level circuit description of a single output combinational circuit to an equivalent design with DCVS has been formulated. The method is based on a novel modelling of DCVS circuits using binary decision (BD) graphs and logic partitioning of supergate structure. This design also yields a circuit with good testability. The proposed method has been successfully implemented in PASCAL on a PC/AT. Results on benchmark circuits are under study.

### B. Theoretical Physics

1. *Quantum Mechanics, Field theory and Plasma Physics* : Using the results of Supersymmetric Quantum Mechanics exact eigen values of for some important potentials have been obtained. It has also been established that SU(2) symmetric Hamiltonians which allow partial determination of their spectrum are also supersymmetric. A bosonic string model in curved space has been studied. In quantum field theory Gaussian effective potential method has been applied to several finite temperature field theoretical model including  $\phi^4$  and Sine-Gordon solutions. A shifted  $1/N$  expansion method has been developed for the Dirac equations and for the first time eigen values for the relativistic screened coulomb potential (Mehta Patil type) has been obtained by this method. In plasma physics formation of double layers has been investigated in both magnetized and unmagnetized plasma. It has application in astrophysical plasma.

2. *Quantum Phenomena and multinomial distribution* : The characterization of Bose-Einstein statistics by multinomial distribution raises interesting possibilities to look into the foundation of quantum mechanics. The recent experiment like double coil resonance experiment has been reanalysed within this frame work. The Einstein-Podolsky-Rosen like phenomena has also been studied from the point of view of 'Information theory'.

3. *Stochastic Geometry and Quantum Gravity* : The random zero point field induces a probabilistic aspect in the geometry itself. It raises new possibility to study cosmological models as well as help us to construct Lorentz invariant Markov process in Minkowski space.

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4. *Topological Aspects of Particles and Their Interactions* : The internal symmetry of hadrons has been investigated from the point of view of holomorphic quantum mechanics and twistor geometry highlighting the topological features of elementary particles. The role of these topological features in various interactions with special emphasis to the unification scheme is being investigated.

5. *Stochastic Field Theory, Supersymmetry and Superspace* : The realisation of supersymmetry in stochastic quantization procedure as well as in stochastic field theory has been investigated. The relevance of superspace in nonlinear sigma model, skyrme solitons, Polyakov string and membranes are being studied.

6. *Stochastic and Geometric Quantization* : The equivalence of stochastic and geometric quantization has been studied in details with special reference to coherent state basis. The formulation is now being investigated to study dissipative systems and measurement problem. The relevance of quantum geometry in quantum field theory is also being studied with special reference to renormalisation problem.

7. *Topological Features of Quantum Field Theory, Anomaly and Berry Phase* : Topological features of quantum field theory has been investigated to study the topological origin of chiral anomaly. This formulation has also been extended to study SU(2) anomaly for Weyl fermions, conformal anomaly for Polyakov string and gravitational anomaly. The relationship of anomaly and Berry Phase is being investigated.

8. *Quantum Gravity Supergravity and Quantum Cosmology* : The role of quantum geometry in gravitational phenomena has been investigated. The relevance of torsion in quantum gravity and supergravity has been studied and a gauge theoretic formulation of torsion has also been investigated. The cosmological constant problem and the wave function of the universe has been investigated from this quantum geometry. Quantum field theory in curved space from this view point is being studied.

9. *Polyakov string, Ising Model and superconductivity* : The equivalence of Polyakov string with a three dimensional Ising system has been investigated. This formalism is now being utilised to study superconductivity, and antiferromagnetic systems.

10. *Stochastic Field Theory and Statistical Systems* : The Kadanoff-Wilson formalism of block variable in terms of renormalization group equation in quantum field theory in the framework of stochastic field theory has been investigated. This formalism is now being investigated to study  $Z_n$  gauge theory, XY and XYZ model.

11. *Nuclear Physics and Many-Body Problem* : The microscopic theory of collective behaviour is being studied from the solitonic feature of nucleons. Also the static properties of baryons as well as the origin of proton spin is being studied from this viewpoint. The  $K$ -harmonics method is being utilised to study the two and three baryon-antibaryon pair states.

12. *Quantum Fluids, Superfluidity and Condensed Matter Physics* : Topological aspects of  $H^1$  and  $H^2$  are being investigated on the basis of solitonic features of liquid drops. Also a gauge theoretical formulation of continuous media with topological defects is being studied.

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### C. Fluid Mechanics

1. *Effect of strong vertical vortices on river beds* : A vertical vortex occurring in river was simulated by rotating a perforated hollow circular cylinder, with its axis vertical, in water contained in a large reservoir, over a bed of loose or semi-consolidated sand.

When the cylinder was rotated at 1400 r.p.m. in water over a bed of loose sand, it was found that the sand particles began to move and within a minute or so the sand surface attained a dynamically stable shape of an inverted cone with its axis along the axis of rotation. The movement of sand particles agreed with the velocity distribution obtained theoretically for turbulent boundary layer over a conical surface.

Experiments performed over semi-consolidated sand surface showed that even a strong vortex could not make any dent on the semi-consolidated surface. But remarkable results were obtained when loose sand particles were added to the rotating flow to simulate natural conditions obtaining in river. It was found that loose sand rotating with water had the effect of grinding and in a short time, a neat hole was formed on the semi-consolidated surface of sand.

It was inferred that, in a river, if the vortex generated was strong enough to form a conical surface on the loose sand bed so that the apex of the cone reached the semi-consolidated layer below the loose sand, it is possible for the vortex to scour a cylindrical hole in the bed.

Moreover, it seems, in sediment transport problems in rivers and channels the concentration and velocity of suspended sediment should be taken into consideration for treating scouring problems.

2. *Blood Flow in cardio-vascular System* : Normal blood flow in the cardio-vascular system is sometimes disturbed by the abnormal and unnatural growth in the arteries due to deposition of proteins from blood. The most important work done in this field is the study of erythrocyte effect on the flow characteristics. From the physiological point of view, it is necessary to study this effect on the flow characteristics in an indented blood vessel.

3. *Stratified Turbulent Flow* : The study of stratified turbulent flow is considered important from geophysical point of view. In describing the small scale motion of homogeneous stratified turbulent shear flow, different terms e.g., energy transfer term, buoyancy or heat-flux term and the turbulence energy production term have been modelled by invoking gradient diffusion assumption. Analytical expression for the three dimensional energy spectrum is worked out. One dimensional energy spectra i.e., the energy spectra corresponding to horizontal and vertical turbulence velocities are determined from the three dimensional energy spectrum. Such spectra are compared with the data of field measurements.

4. *Effects of rotation on turbulence* : The effects of rotation on turbulence is worth investigating as far as the turbulent motions in turbo-machinery and some industrial apparatus are concerned. Energy spectra are determined first in the simple

case of homogeneous turbulent shear flow subjected to a rotation. Investigation of more complicated cases is under progress.

#### 5. Water Waves

(a) *Scattering of water waves* : Problems on water wave scattering by obstacles of various shapes and related boundary value problems in surface water waves have been studied by the application of the theory singular integral equations and other methods. A simplified perturbational analysis applied directly to the governing partial differential equation and boundary conditions has become very successful to handle water wave scattering problems involving nearly vertical barriers. This technique appears to be a significant addition to the existing mathematical methods available in the literature to handle various water wave problems.

(b) *Waves due to small oscillations of a floating or submerged body* : When a floating or submerged body undergoes small oscillations, it communicates its normal velocity to adjacent water particles so that a wave motion is set up in the fluid region. Evaluation of the wave amplitude for the radiated waves at infinity is of some physical significance. For a submerged vertical plate, Green's integral theorem is used in a suitable manner to obtain the wave amplitude at infinity. Particular results for roll and sway of the plate and for a line source in the presence of a fixed vertical plate, are deduced.

(c) *Generation of water waves at an inertial surface* : Problems of generation of surface waves in a liquid with an inertial surface due to an explosion above or within the liquid can be formulated as an initial value problem within the framework of linearised theory of water waves. Several problems in this class have been considered. Use of Laplace's transform reduce these initial value problems to boundary value problems which are in turn solved by using Green's integral theorem. Approximate form of the inertial surface in each case is evaluated by using asymptotic methods. Further work in this line is going on.

#### D. Mathematical Methods

(a) *Integral equations* : Singular integral equations occur in a natural manner in many water wave diffraction problems. Very few of them can be solved in a closed form. However, approximate solutions can be obtained in most cases. Approximate solution of some integral equations occurring in water wave diffraction problems has been considered.

Fredholm integral equations of second kind are usually solved by numerical methods. However there exists an important class of Fredholm integral equations with some special type of kernels for which explicit solution can sometimes be obtained. One such class is considered for explicit solution wherein the known solution of a Carleman integral equation and the function theoretic method have been utilized.

Dual integral equations involving special functions of various types as kernels arise in many mixed boundary value problems of elasticity, elastodynamics etc. Some dual integral equations with Bessel functions, Legendre functions as kernels have been considered for solution.

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(b) *Integral transforms* : Development of some integral transforms involving associated Legendre functions as kernel has been considered. They seem to have applications in elastostatic problems involving conical and toroidal regions.

### E. Operations Research

(a) *Inventory models* : A number of deterministic EOQ models have been developed incorporating various assumptions concerning the consumption rate, production rate, nature of the item, with or without shortage etc. The EOQ in each model has to be obtained by solving certain nonlinear equations. This is achieved by employing the usual numerical techniques for solving nonlinear equations. Also it is shown that the criteria of profit maximisation and cost minimisation in general do not produce the same result for the models. Numerical illustrations resembling real life situations have been considered. Consideration of other mathematical models is in progress.

(b) *Boundary value problems in queueing theory* : Queueing problems can be cast as boundary value problems somewhat similar to those arising in continuum mechanics. During the last few years application of singular integral equations in handling queueing problems have gained momentum. Surprisingly, some boundary value problems which arise in continuum mechanics also arise in queueing theory. They can be handled by function theoretic method which is commonly known as the method of Riemann-Hilbert problem. Some ground work to study queueing problems within the framework of Riemann Hilbert-problem has been made. Further study in this line is in progress.

### PROJECTS WORK (On-going projects)

#### *Externally Funded Projects*

(a) *Water waves and related mathematical methods* : This project is sponsored by the Third World Academy of Sciences, ICTP, Italy, with B. N. Mandal as the principal investigator, and it is being administered through the Calcutta Mathematical Society.

This project concerns with further mathematical work in the linearised theory of water waves. A number of problems on the theory of water waves have been considered under this project so far. They involve generation of water waves due to small oscillations of a thin vertical plate submerged in deep water, due to rolling of a nearly vertical partially immersed curved plate, diffraction of water waves by nearly vertical barriers, by submerged slender bodies etc. Special emphasis has been given to the associated mathematical methods.

(b) *Integral transforms, integral equations and applications* : This project is sponsored by CSIR with B. N. Mandal as the principal investigator, and it is being administered through the Calcutta Mathematical Society.

Integral transforms with kernels involving various special functions such as associated Legendre functions, spheroidal wave functions, parabolic cylinder functions etc. are being developed and their basic properties are being studied in this project.

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Their applications to appropriate problems of continuum mechanics such as elastodynamics, fluid mechanics and problems of electromagnetic theory etc. are being considered. Theory and methods of integral equations including singular integral equations, dual integral equations, are also being considered. Some progress in the area of integral transforms and dual integral equations involving associated Legendre functions has already been made.

### *Internally Funded Projects*

1. Supersymmetric Quantum Mechanics and SUSY breaking at finite temperature in string theory. Work on determination of eigenvalues has been completed. Some work on string at finite temperature has also been done.

2. Gaussian approach to field theory in  $(1 + d)$  dimensions. Work has been completed on the existence of solitons at  $T \neq 0$  in several models including sine-Gordon model. This method has also been applied to study symmetry behaviour in curved space.

3. Application of algebraization technique and the shifted  $1/W$  expansion method in relativistic and non relativistic quantum mechanics. Several relativistic problems have been studied using this method including some Screened-Coulomb potentials.

4. 'Flow of a thin film of liquid on a rotating surface' : In spin coating process, so far, the researchers have advanced to understand the process itself, mainly through experimental procedures. Analytical theories were based on typical crude hydrodynamical approximations. A new approach has been developed which will explain the experimental observations from a different angle.

## ELECTRONICS AND COMMUNICATION SCIENCES

Activities of the Unit include :

(i) Investigation for the methodology and algorithms development of various problems in the application area of computer and communication sciences with relevant instrumentation/software backing.

(ii) Teaching/training of some of the courses in B.Stat (Hons.), M.Stat., M. Tech. (Computer Science) and the newly introduced M.Tech. (Quality, Reliability and Operation Research) programme and vocational training supervision to external engineering/technological students of different universities and IIT's, and

(iii) Work associated with externally funded projects.

During the period under report, research activities were carried out the following areas with satisfactory progress toward targets.

### A. *Studies on Pattern Recognition, Pattern Classification, Feature Evaluation and Learning Algorithms.*

(i) Existing feature extraction methods deal with a 2-class problem. Extension of the existing techniques with some new methodologies have been developed and tried for application in 3-and-more multiclass pattern recognition problems.



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(ii) Nearest neighbour rules have been successfully applied in nonparametric pattern classification problems, specially in handwritten numeral classification and these would be studied/developed involving feature-space of high dimension.

(iii) The objectives of these projects are to help automatic diagnosis of malignant cells from various parts of human body, and to find algorithms for abnormal cells of cancer etc. Studies related to the effect of thourcea on brain neuro-secretory of *Periplaneta americana* have been done and would be extended to the mamalian (human too) neuro-secretory cells and chromosome. In another experiment, some work on histological section grading for cancer has been done and statistical techniques have been applied in cytological problems dealing with two types of thyroid cancer—follicular adenoma and follicular carcinoma. Normally, these two classes and indistinguishably visible in cytological smears but their discrimination have been attempted through morphological, photometric and textural features obtained from each cell of specimen through image processing.

(iv) As a part of man-machine interaction, a computer-based system for recognition of well formed handwritten/printed scripts would be developed. Preliminary work on feature selection and ordering necessary for overall recognition strategy within the restricted data sample has been undertaken. Finally, a prototype reader will be developed for printed scripts.

### B. *Development of methodologies for Image Analysis, Shape Analysis, Image Understanding and Computer Vision Technology.*

(i) A recoverable type of two-tone thinning algorithm has already been developed in the extraction of structural features of two-tone image and this technique could be fruitfully utilized for data compression purpose. Gray scale thinning was also attempted after removal of certain drawbacks of algorithms of segmented image and was tested with real life data. In another project computer graphic techniques were used in data compression algorithms for binary/gray images.

(ii) Extension of shape parameters like convexity, elongatedness, straightness, surroundness etc. of two-tone objects also be possible in gray tone object. Fitting algorithm, by optimizing an error of fit, can be efficiently implemented to fit rectilinear/curvilinear figures and also their 3-D versions. Using certain characteristic planes, algorithms for normalization of size and orientation of single 3-D objects were developed. Shape distance of these objects have metric properties which can be utilised in classification of unknown 3-D shapes. On the basis of characteristic planes that provide plane of symmetry, detection of symmetric/near symmetric 3-D objects are possible. Algorithms for 3-D versions have been tested with generated image data.

(iii) For suitable texture analysis efficient algorithms of extrema detection and gray level ranking with moving window have been developed. Current emphasis is given on segmentation and classification of textured images and also object of continuous gradation from textured to non-textured image. Based on Parzen's method of pdf estimation, a new segmentation algorithm has been developed for efficient application of segmentation of textured images.

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(iv) The Ultimate aim of processing technique for any computer-based vision system is of human visual system (HVS) and hence model development of this HVS is an important task for low level processing of a computer vision system. An automatic thresholding technique of edge detectors was developed and the effects of background window size, their sizes, types of transformation used etc. were studied on the quality of extracted edges. Criteria of selection for transformation function based on the measurement of contrast enhancement by fuzzy entropy, fuzzy perimeter, and fuzzy compactness have been developed. In an other scheme, a computer vision algorithm based on concept of differential geometry on a set of local features of the shapes has been developed to locate/recognize partially occluded 2-D/3-D rigid objects of a given scene. Based upon matching of local features of objects in a scene with cognitive data base were verified for best possible recognition. Implementation of these algorithms would be done in a prototype robot model.

### C. *Digital Communication, Microwave Propagation, Signal Processing and Atmospheric Studies.*

(i) Some anomalous propagation characteristics, in three colocated centres in and around Calcutta, were observed from a thorough investigations of the propagation phenomena of Bangladesh TV signal (channel VII, 189 MHz) transmitted from Satkhira station, 75 kms. away from Calcutta over a line-of-sight path. By proper considerations of atmospheric conditions prevailing at that time, those anomalous characteristics have been nicely explained and correlation studies of propagation behaviour have been continued. Extension of this project to a farther station like Khulna, which is 175 km. away from Calcutta, and transmitting VHF signal is under consideration. This beyond-the-horizon propagation would provide information about scattering phenomena and earth's diffraction effect and also propagation data useful to microwave link designers.

(ii) Work on characterising atmospheric boundary layer (ABL) prevailing in this region has been continued with the indigenously made sodar system developed at ISI. Daily, monthly and seasonal behaviour of the lower atmosphere within 1 km. have been recorded and subsequently studied. Observations on ABL dynamics have been performed and modelling of the same is in progress. For detailed observations and studies of aerosol size and distribution in the atmosphere, scattering experiment by Laser beam would be of immense importance. Commissioning work of Laser system will be undertaken in near future.

(iii) To study the effect of rain, fog, haze and terrain characteristics in the propagation path of m.m. wave signal under the joint scheme of a collaborative project among different institutes and universities, are being planned to develop the digitised modulation and demodulation (MODEM) system for inclusion in the proposed 35 GHz propagation link between ISI and IRPE, Calcutta University. Literature survey and some preliminary work of MODEM have been completed. The goal is to correlate the propagation data with the radio-climatological data.

### D. *Speech Analysis and Synthesis, Music Analysis and ASR research.*

(i) Acoustic-phonetic studies on Bengali and Telugu speech are continuing to meet several requirements : (a) the throwing up of reliable acoustic-phonetic data

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for computer recognition and speech synthesis of major Indian languages, (b) establishment of statistical data-base, and (c) assistance to the efforts for standardisation of phonetic quality needed for educational and cultural use of voice media. So far, the acoustic analysis of Bengali vowels and nasal consonants have been completed from the 350 spectrograms of Bengali words uttered individually by 3 male and 3 female speakers.

(ii) A programme for synthesis of Bengali speech sounds has been continued. Using a novel procedure of speech event concatenation, Bengali sentences are being generated and are now produced from phonetic script typed over the console. To make synthesised output more natural, the prosodic and stress patterns are to be incorporated in the system in near future. This system will have immense application in industry, aids for blind and dumb people communication. In another work, a semi-automatic procedure for synthesising vocal music has been continued and four lines (*asthai* and *antara*) of a Bengali song have been generated.

(iii) In-depth study of octaves, note including 'shruti' position for different North Indian classical music with regard to cues of nasality in musical sound and automatic transcription of music into notation and identification of Indian ragas have been performed and are to be continued.

(iv) The project on development of large Bengali lexicon for ASR system includes studies of the properties of large lexicon particularly with respect to different levels of distinctive features of phonemes. Some software packages for handling large data for lexical analysis has been completed. A manner-directed ambiguity driven lexical tree for word hypothesis verification and disambiguation related to ASR is under consideration with collaboration of Dept. di Informatica, Universitat di Torino, Italy.

(v) Development of expert system for specific tasks in man-machine interaction like speech-mode communication, script and sketch for interaction and acquiring of a suitable knowledge engineering environment for the purpose of collaborative programme with Universitat di Torino, Italy, has been continued.

### E. Artificial Intelligence and Expert Systems Methodologies

(i) Test generation, minimisation, design for testability, logic fault simulation etc. for IC's and IC-boards are computationally intensive tasks. Current need of CAD engineers/users is to have one integrated CAD package that should analyse relative trade-off automatically in helping to arrive at the design of best IC chips/board. In meeting the challenge of this project, basic theoretical research in AI problem-solving trick may provide cues. Automated testing and design verification/evaluation using front-end vision and imaging techniques will be a step forward in the direction of reliable, robot-controlled inspection systems for electronic logic boards. At present, 45 rules have been knowledge-engineered into the knowledge base and implementations of the actual expert system is in progress.

(ii) Morphological analysis of Bengali word structure has been done with a temporal matrix formalism for identification of sequences of actions. A lexicon of Bengali words with its parts of speech and other markers have been generated in a PC-based system.

(iii) Present fuzzy resolution principle provides a powerful tool for logic programming in uncertain environment. The fuzzy resolution depends on the concept of linguistic variable, composition rules of inference, approximate reasoning and plausible reasoning. Fuzzy resolution principle was initially considered for propositional logic and then extended to first order logic.

*F. FGCS activities in New Computer Architecture for Signal Understanding and Intelligent Interfacing.*

(i) In order to obtain a continuous digital line in a digital image, a method for joining isolated line segments has been devised by employing the single linkage clustering algorithm based on three features viz length, centre of gravity (c.g.) and the angle made with X-axis. A new algorithm for detecting corners in a digital images has also been developed by taking the zero-crossings of those second differences of X-and Y-axes separately as possible corner points excluding those points correspond to the digital nature of a straight line or a curve. In another project, a model driven scheme for recognition and localisation of planar objects in complex industrial scene has been developed and implemented. In the model data base all triangles formed by triplets of the corners of any object is preserved. Unknown or partially occluded objects are allowed to exist in the scene. After recognising the objects their c.g. and principal axes are used to localise them. In a recent extension we have allowed the objects to change scale, considering the ratio of the side to the perimeter of each of such triangles. In another project, algorithms for extracting global features like length of major axes, minimum width, area, centroid of 2D objects and local features like position, orientation etc. have been considered for computing higher moments of the object with input information of run-length coded chain code only.

(ii) After implementing an edge extraction scheme using several Gaussian masks and also been authenticated by the use of an existing (prior) technique, recent works started on (a) the development of a method to judiciously combine (optimally) the edges extracted by symmetric operators of different resolutions, (b) the development of a scheme to selectively choose the appropriate resolution of the operator based upon the local conditions in an image region. Another project on connectionist models for object recognition has two parts : (a) global features based object recognition that considers the relative priorities of the features and adaptively evaluates them either in supervised or in non-supervised mode to recognise the object class, (b) local feature based object recognition with an efficient scheme for representing the local features of the object is being designed. The ultimate goal will be to design suitable learning scheme for capturing the important features of an object as well as recognising multiple objects (possibly occluded).

(iii) High level vision involves symbolic processing of knowledge and hence needs a suitable knowledge structure adequate to represent the physical characteristics of visual object. This is minimal in space requirement and completely supports the task of the object matching through inferences. Some smart inferencing techniques using a modification of VIKNET (knowledge-structure) has been devised. VIKNET needs to be extended to a knowledge processing environment for efficient handling of the task of object matching. As a man-machine interface aid to the user of the environment, a graphic-based solid modelling tool is nearing completion. This software outputs the solid model in a format simply interfaceable with VIKNET's internal

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data structure, ensuring the preservation of the minimality condition imposed on the representation structure.

(iv) As a continuation of the work of a class of recursive learning, a method of automatic selection of threshold has been developed and with respect to this mean square error (MSE) of the learning method is minimised. Under the assumptions of unconditional distribution of the feature vector, distribution-free estimators of the thresholds have been obtained. The above mentioned tools of PR has been successfully applied in the Remote Sensing field. The feature subset selection is the process of selecting the best subset of 'm' features by optimising any criterion functions over all subsets of size 'n'. By using fuzzy measures, a criterion function for evaluating feature subsets has been developed to implement it in Satellite data treating the bands as separate features. Different aspects of 4 bands (blue, green, red and infrared) of image data have been clustered in 4-dimensions by producing various classes of pixels in the image. Investigation on the discriminatory powers of 4 bands with an aim to design classifiers for classifying unknown pixels and study of error rates of these classifier are under consideration.

(v) An attempt has been made to highlight and isolate curvilinear, line-like structures, objects or patterns of roads/small streams etc. present in remotely sensed image data taken from IRS. To enhance curvilinear patterns, we convolve the image with a set of  $5 \times 5$  size operators totaling to 40 such operators covering all possible directions in the digital domain. In another scheme, works on the algorithm development for the extraction of (linear) structural information from the satellite image data has been completed and recent motivation is to improve these algorithms to obtain greater accuracy.

(vi) Geometrical and topological properties of an object are fruitfully applied in image analysis and computer vision system. Recently mathematical morphology plays an important role in dealing with shapes of objects in an image and geometrical/topological properties of image signal would be appropriate to derive and compute in terms of mathematical morphology that treats images as ensemble of sets rather than as signal. Operations of mathematical morphology are defined in terms of interaction between an object and a structuring element. A mathematical morphological algorithm has been developed to separate the images of overlapped objects.

(vii) The goals of the PCB verification and inspection project have been successfully completed with respect (a) to devise a practical PC-bed inspection-cum verification system for PCB's and (b) to develop a crisp theory for automatic verification of a specified PCB. Combination of demonstrable software environment for creation, editing, connectivity extraction, model matching of PCB etc. forms a comprehensive verification package. A front-end imaging system for capturing and digitising images of real PCBs for subsequent processing and display is under consideration.

(viii) The project of expert systems for cancer detection and diagnosis was launched jointly with Mishanti Engineers Pvt. Ltd., as an experiment in designing production-quality problem solvers in the medical domain. Using expert systems technology two packages are under development, (a) CAN-SCAN : an expert system for use by a woman for early detection, self-examination and counselling services in

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the domain of breast cancer. Good progress has been achieved. (b) ONCO-AID : an expert assistant to an oncologist for diagnosis and treatment planning and protocol management of breast cancer patients. This will be considered after completion of (a).

### *Externally Funded Ongoing Collaborative Projects*

1. The National Centre for Knowledge Based Computing System (KBCS) has been established at ISI, Calcutta, with Professor D. Dutta Majumder as Principal Coordinator-cum-Project Director for Fifth Generation Computer Systems (FGCS) Programme of UNDP and Govt. of India (DOE). A part of the project on 'Some Applications of Artificial Intelligence in Developing Expert System' is successfully continued with following programme :

(a) Development of algorithm for industrial inspection system with special attention to occluded 2D-3D scene recognition,

(b) Parallel architectures and algorithms for image processing, pattern recognition, and computer vision,

(c) Model studies for high level vision system (HLVS),

(d) Application of HLVS in remote sensing studies,

(e) Algorithms for middle level vision system (MLVS) for geology and natural resources management,

(f) Simulation of lower level vision system (LLVS) for geological application,

(g) Acquisition of state-of-the art computing resources and the setting up a well-equipped machine vision laboratory.

2. Defence Grant-in Aid Scheme Confidential Project entitled 'Systems and Algorithm Development for Pattern Recognition and Shape Analysis for Object of Defence Interest' is being carried out in collaboration with DRDO, Dehra Dun. It involves the identification of objects (of defence interest) from its shape in some direction using principal component analysis and various filtering and transformation techniques.

3. Under the national programme of MONTBLEX (the Monsoon Trough Boundary Layer Experiment) the centre is engaged in a DST-funded project entitled 'Studies on the Tropical Boundary Layer Meteorology Using Monostatic Sodar'. The aim of this project is to predict the behaviour of monsoon pattern from eastern to northern part of India by studying the dynamics of lower atmosphere through three observing centres at IIT-Kharagpur, BHU-Varanasi and CAZRI-Pillani. In this collaborative project, the DST (as a part of the measuring system for atmospheric parameters) entrusted to ISI the responsibilities of designing a portable sound radar and installation of the same at BHU in April-May 1990. The progress of the work is satisfactory. The atmospheric data provided by sodar will be correlated with the tower data for modelling the atmospheric dynamics during the monsoon months.

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4. In a project just started entitled 'Application of KBCS (AI and ES) to the Oil and Gas Exploration Problems' (funded by ONGC) attempts will be made to develop KBCS approaches for application in this field with the evaluation of Bengal Basin as the case study.

### GEOLOGICAL STUDIES

Research was undertaken in the following broad areas during the year 1989-90 :

Tectono-stratigraphic studies of the Delhi Supergroup, Rajasthan ; Tectonics, stratigraphy and sedimentation of the Proterozoic rocks of the Pranhita-Godavari Valley ; Gondwana geology and palaeontology of the northwestern Pranhita-Godavari Valley ; Studies on late Cretaceous dinosaur fauna from the Lametas in Maharashtra ; Evaluation and description of late Cretaceous fish faunas ; fossil amphibians of the Satpura Gondwana basin ; Stratigraphy, fossil and geological relationship of the Lameta beds, Jabalpur ; An empirical statistical study of preferred orientation of line in three-dimensional space—applications in geology ; Experimental study on the development of large-scale vertical scour holes through action of stationary vortex.

The most significant findings of research work in some of these broad areas are highlighted below.

*Delhi Supergroup* : The basement—cover contact along the eastern flank of the Delhi basin in Central Rajasthan was previously (Heron, 1953) interpreted as the surface separating the gneissic country from the metasedimentaries to the west. This work suggests that what Heron recognised as the contact is actually a chemical buffer separating the migmatites from the undigested metasedimentaries to the west. No true pre-Delhi structure has yet been recognised within the gneissic country mapped by SenGupta.

*Proterozoic geology of the Godavari Valley* : A significant break-through in the sedimentological studies of the Proterozoic sequences has been made. A new mode of origin of glauconite has been recognized. In contrast to the prevailing ideas, it is now found that the glauconites have formed through selective replacement of potash feldspar in both shallow, agitated and deep, quite water environments. The composition of glauconite shows systematic variation with the depositional environment.

The late Proterozoic Sullavai sandstones are inferred to have formed in an extensive fluvial braid plains and aeolian sand sea. The identification of continental processes that led to the deposition of extensive sheet-like sandstones is new in India and it has an important implication on the origin of similar types of extensive Proterozoic rocks in different basins of the Indian craton. The study recognized the presence of an extensive desert sequence, an erg, in India for the first time.

*Gondwana stratigraphy and palaeontology* : Detailed mapping and study of the fossils and their distribution have revealed four late Triassic vertebrate faunas from the Gondwana of the Pranhita-Godavari Valley. This makes a total of at least seven vertebrate faunal zones from this succession, giving it a unique and important position in the correlation of the Permo-Triassic continental sediments of the world.

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An interesting find is a nearly complete skull of a crocodile from the lower Jurassic Kota limestone in the Pranhlita-Godavari Valley. Preliminary study indicates that the animal might be a new species of Teleosauridae.

*Maestrichtian fish faunas and dinosaurs* : Examination and laboratory preparation of new fossil fish material from the Lameta Beds of Maestrichtian age (Central India) was continued. The results of investigation are being compiled into a research paper. The study of these early percid fishes from India gives an interesting new insight into the early evolutionary history of Acanthopterygian fishes.

New titanosaurid dinosaur fossils of Maestrichtian age from India are under examination. Laboratory work has made a considerable headway. These dinosaurs are poorly known anywhere in the world, except in Argentina. Careful comparisons are being made between the Indian and the South American materials. The study is expected to throw light on the faunal relations and possible migratory route of these dinosaurs.

*Lametas, Jabalpur* : Preliminary mapping in and around Jabalpur indicates a major revision of the existing worked out Phanerozoic stratigraphy of the area. A new site that yields scores of dinosaur egg-shells, nearly complete to broken, has been discovered. Abnormality in the egg-shells may throw important light on the aspect of dinosaur extinction during the K-T transition that happened in the course of the Lameta sedimentation.

*Quantitative Geology* : Variation in the nearest neighbour density estimates in C-axis fabric in some quartz tectonics has been investigated. An exponential function apparently compatible with monoclinic point group symmetry has been and is being examined for its suitability in describing the observed preferred orientations in natural samples.

## PHYSICS

The research activities of the Physics Unit have focussed on problems of 'Bioengineering and Medical Physics' and during the period from April 1989 to March 1990, the Unit worked mainly on the following topics :

(i) Sorption-desorption studies of skin made by measuring the skin impedance, hydration state and the transepidermal water loss. The studies have thrown light on the hygroscopicity and the water-holding capacity, the two mutually competitive processes, of the skin and also on the skin barrier function so as to explain the characteristics of dry and scaly skin-disorders like psoriasis and ichthyosis vulgaris. A statistical model has been developed in this regard.

(ii) Skin pH-mapping—A complete mapping (pH-mapping) of skin has been made by determining the surface pH of skin at 21 cardinal points in all the age groups from 0 to 70 years. The interaction of skin pH with the distribution of sweat glands, sebaceous glands and the normal flora has been established.

(iii) Dermatological iontophoresis—Iontophoretic application of drugs on certain skin disorders (e.g. hyperkeratosis) has shown spectacular results and is being continued.



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(iv) Skin characterisation—Quantitative characterisation and an objective evaluation of skin quality have been made by studying a number of biophysical parameters such as skin surface pH, hydration state, sebum level, high frequency electrical conductance, hygroscopicity, water-holding capacity, skin friction etc. all *in vivo*.

### Biological Science

The Bio-Sciences Division is engaged in studying the varied biological processes covering plant and animal kingdoms, including human, comprise the following units : Agricultural Science Unit, Anthropometry and Human Genetics Unit, Bio-Chemistry Unit, Embryology Unit, Leaf Protein Unit and Entomology Unit. Research activities carried out in these Units are described below :

### AGRICULTURAL SCIENCES

#### Research Activities

In all, there were six research projects of this Unit, of which three were related to improvement of crop productivity through water management and cropping systems under rainfed farming in lateritic soils of Bihar Plateau at Giridih Experimental Farm, while the other three projects were on the adaptation of coconut and oil palm, numerical anatomy and morphology of the family Palmae Arecaceae and floristic study on the mangroves in the saline tracts of Sundarban region. During the period under review (April 1989—March 1990) the following interesting findings were obtained in these on-going projects :

1. Crop sequence studies under mid-upland situation revealed that : (i) Among the winter crops barley seemed to be the best followed by linseed, toria, mustard and lentil. (ii) Mustard seemed to be an ideal drought escaping crop whereas barely and linseed were noted to be drought tolerant ones. (iii) Percentage of soil moisture depletion seemed to be at a faster rate after February. (iv) Local Mussoric rock phosphate appeared to be quite efficient in increasing paddy yield and was noted to be effective in releasing P even at later sequences such as maize and paddy in the second season.

2. Intercropping studies indicated that : (i) Pigeon pea and groundnut seem to be well suited for this soil type in both combinations as sole and intercrops. (ii) Residual beneficial effect of legumes on soil fertility was indicated though not significantly, through post Kharif soil test values and yield of succeeding mustard/wheat crop.

3. Studies on the performance of different potential crops revealed that : (i) Short/medium duration upland varieties of paddy showed better yield performance when cultivated by transplanting methods than by direct (broadcast) sowing. Yield potential of the following four varieties of rice was the highest : Mohan IET-4786, IET-7627 and IET-2233. (ii) Varietal trial of other crops revealed the following cultivars as the highest yielders and most suited to this agroclimatic region : Vijay composite (maize) ; BARC-PKV-24-6, BARC-PKV-8-13 and Sonalika (wheat) ; TG 17 (groundnut) ; PS-10 (mung) ; UPSA-120 and T-21 (arhar) ; Pant G-114 (gram) ; BR-25 (lentil) and Subhra and Neela (Linseed).

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4. In exploratory work on *Palmae*, some data have been collected on the number of stomata and epidermal cells per unit area and their size from left and right halves of lamina of both left and right spiralled area seedlings grown at the nursery of the Institute. It is intended to compare the data of left spiralled plants with that of right spiralled ones as there exists an association between spirality and yield of the plant.

5. Studies on the trials on coconut and oil palm indicated well the suitability of these plantation crops for the Sundarbans region, based on the preliminary growth data collected during the last two years.

6. On eco-floristic and anatomical investigations of mangrove vegetation of the Sundarbans, palynological work on 30 mangroves was completed along with epidermal structural studies of leaves of 24 species. Studies on the anatomy of roots, stems, leaves and tracheary elements are in progress.

### Externally Funded Projects

*On Going Projects :* ICSSR, Govt. of India funded a project entitled "Perception, performance and potential of development in Usri Watershed area of Bihar plateau—au ecosystemic approach". Work started in January 1990 in collaboration with the Sociological Research Unit of ISI. Presently, secondary data are being collected.

## ANTHROPOMETRY AND HUMAN GENETICS

*Human Adaptability Programme :* The Human Adaptability Programme (HAP) was undertaken in 1976 with a view to (i) evaluating the nutritional and health status of, especially, the rural, remote or otherwise disadvantaged groups; (ii) identifying the physical, environmental and socio-economic determinants and consequences of such disadvantaged status; and eventually, (iii) determining human adaptability, i.e., limits to adaptation. The methodology essentially involved studying the states of, and strategies for, human survival and perceptions of well-being under varied environmental stresses.

The following projects are being conducted under the HAP : (1) 'Health status and labour productivity'; (2) 'Effects of microenvironmental factors on health in rural populations'; (3) 'Psychological stress and health of mother and child'; (4) 'Sociocultural characteristics and community health status of the Lepchas of Darjeeling district, West Bengal'; (5) 'Impact of altitude on human population : Determinants and consequences of human health and activity pattern on the mountain ecosystem', and (6) 'A study on the determinants of fertility and mortality in an urban setting : An anthropological perspective'. Phase-I of projects 1 through 4, and Phase-II of project 5, have been completed; field work on project 6 has recently begun.

The salient findings of these projects are as follows :

(1) *Project 1 :* The health status of tea labourers do not seem to affect their productive output, measured in terms of the amount of tea leaves plucked per head per day; (2) *Project 2 :* Very small socio-cultural differences which may occur among

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the High, Middle and Low economic subgroups of a single caste population inhabiting the same village may have conspicuous health effects; (3) *Project 3* : middle class working women of Calcutta who must split their time and energy between home and work place and therefore, supposedly, suffer from a role conflict, do not, however, have a higher anxiety level or worse physical health status compared to their non-working counterparts; (4) *Project 4* : Socio-cultural factors, e.g., rural/urban habitat, religion and economic developmental status, do affect some health traits, but all three factors do not affect all the traits, among the Lepchas and, contrary to popular belief, Lepchas are not a declining population in their own opinion; (5) *Project 5* : the high altitude (above 10,000 ft) environment does not constitute a unique ecotone with unique health effects in case of the Sherpas, a Himalayan population, unlike in case of experimental animal populations and some Andean highlanders.

### *Population Variation Programme :*

*Biochemical Markers* : The human variation programme was initiated with an idea how and why the contemporary human populations differ in physical or biological characteristics, i.e., frequencies of biological traits, both visible and invisible, for which genes are mainly responsible. It is interesting to study the micro-evolutionary dynamics of human population in the Indian sub-continent, where thousands of endogamous groups exist having a wide range of social, cultural and biological variation.

*Genetic survey of some endogamous groups of Eastern India* : Specific objectives of the study were : (i) to examine the nature of distribution of various biochemical and serological markers in blood amongst various tribal groups in Orissa, Madhya Pradesh and Maharashtra, namely, (1) Maria, (2) Muria, (3) Dhurwa, (4) Kisan, (5) Bingham, (6) Deshi Koud, (7) Raj Gond (Orissa), (8) Savara, (9) Kuvi Kond, (10) Konda Dora, (11) Paroja, (12) Godaba, (13) Raj Gond (Maharashtra), (14) Maria Gond, (15) Halba, (16) Bhatra; (ii) to study various Immunoglobulin level (IgG, IgA, IgM) in the population groups, (iii) to examine genetic variation within and across population groups; (iv) to measure the distances between population groups and to build up phylogenetic tree; (v) to study quantitatively the extent of various ethnic components in the population groups; (vi) to study the relationship between genetic proximity and geographic distances of the populations. About 1700 blood samples were screened from the above populations.

*Dermatoglyphics* : Studies on Dermatoglyphics in population variation based on their ethnographic and geographic proximities, confirmed that the general presumptions (a) that dermal traits, in general and palmar characters, in particular, do help in understanding the biologic/ethnic affinities among different groups both at macro and micro levels, (b) that different types of traits, which are likely to be influenced by different genetic/environmental factors give rise to different clustering patterns, and (c) quantitative methods of palmar pattern ridge counts (PPRC) and sole pattern ridge counts (SPRC) have been developed for the first time in the field of dermatoglyphic research. A project on Plantar dermatoglyphics has been carried out, and data collection from different districts of West Bengal among 4 caste groups, namely, Brahmins, Mahishya, Padmaraj, Muslims and 2 tribal populations, Lodha and Santal, were completed. Data were collected from 100 individuals of each sex. Dermatoglyphic prints of finger, palm, sole and toe have taken and, in addition, 24

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anthropometric measurements have been taken. Scoring of prints is nearly completed and statistical analysis will be started shortly.

*Growth* : The study of 110 families for 28 anthropometric characters in an endogamous caste population (Mahishya) of 24 Parganas district in West Bengal was completed. Analysis of data revealed 15 probable familial correlation for height. In addition, the coefficient of heritability ( $h^2$ ) for this trait has been estimated as 0.56. Further analysis is in progress.

### *Genetic Epidemiology Programme :*

*Genetic Epidemiology of Blood Pressure* : The aims of the study are : (i) to identify the determinants (both genetic and environmental) of blood pressure, (ii) to measure the magnitude of the risk factors involved, and (iii) if blood pressure is found to have a significant genetic determinant, to undertake a linkage study with a number of biochemical markers. The following biological characters were studied : (1) (1) Physiometry, (2) Anthropometry, (3) Blood biochemistry, besides extensive socio-cultural and ecological information was collected. About 60 Marwari families, both nuclear and multigenerational living in Barabazar area of Calcutta, covering about 400 individuals, have been surveyed for blood pressure, anthropometry and blood biochemistry, including lipid profiles. The study is continuing and an attempt has been made for preliminary analysis of the data.

## BIOCHEMISTRY

*Distribution of intestinal parasites in West Bengal* : The study is being conducted to observe the variation and prevalence in different ecological zones, dietary and socio-economic and cultural patterns of populations from different regions in West Bengal. Analysis of previous data indicates some interesting findings : Thus, due to some geophysical causes it is seen that the (tubewell) depth of available sweet water for drinking purpose is too small in the coastal zone (Digha) and consequently, the coastal village has a typical type of intestinal parasite of the highest order in comparison to other five villages in the same area.

*Genetic epidemiology of blood pressure* : To study the relative influence of the determinants hypertension along with anthropological and demographic data is being collected in the study. Different biochemical parameters on blood/serum with special reference to lipid metabolism are being estimated among affluent vegetarian sedentary population in the first stage.

Blood pressure with related informations recorded in 92 families includes 600 subjects and estimation of lipid profile have been conducted. The study is being done in collaboration with Department of Biochemistry, Post Graduate Medical Education Research, S. S. K. M. Hospital, Calcutta.

From a preliminary analysis of the data studied on this population, it appears that cholesterol : HDL cholesterol ratio is well within the risk factor limit with a few variations. The above finding leads to the concept of some repressor gene which may be responsible for the blockage for breaking down the edible triglycerides into glycerol

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and fatty acids/or enters into the path of arachidonic acid while the "Atheroma" fats are being metabolized.

*Epidemiological study on Rheumatoid Arthritis* : Rheumatoid arthritis is generally a disease of connective tissues but of unknown aetiology. Genetic influence, environmental condition, psychological stress may be the causative factors for the disease. National Institute of Orthopedic and Handicapped (NIOH) (Under Ministry of Welfare, Govt. of India) and I.S.I. has undertaken this collaborative project to obtain information so that the magnitude of the problem could be assessed. The data would be helpful to formulate any possible preventive measure for this disease and to help any rehabilitation programme (by the Govt. of India). Field investigators have screened about 450 families with test schedule to procure demographic data by tracing the pro-band (Known Rheumatoid disease patient) as detected by NIOH.

Analysis of various biochemical and serological parameters of blood and synovial fluid (where needed) are being carried out on the subject of SRA (Suspected Rheumatoid Arthritis patients) to find new probands.

*Cancer chemoprevention : An approach toward Cancer Control :*

*a. Dietary Risk Factor(s) and cervical Preneoplastic and Neoplastic diseases.*

In order to identify any dietary risk factor(s) for its association with uterine cervical dysplasias and early cancers of the cervix, two case-control studies (one population based and one hospital based) have been designed with the incorporation of dietary epidemiologic questionnaire. A dietary food record with simultaneous blood determination of several vitamins and then respective plasma binding proteins (if any) will be determined.

*The population based registry for mild and moderate uterine cervical dysplasias* has been initiated at Domjur Block in Howrah District of West Bengal. Total numbers of villages are 55 with total population 2,17,000 (PHC-estimate ; 2,07,000-according to 1981 census). The male-female ratio is 48 : 52 and Hindu-Muslim is 60 : 40. The health care delivery system is mostly done through a primary Health Centre with its 22 (14 effectively working) Sub-centres. There is one ICDS Centre with more than 100 sub-centres. The dysplasia detection screening has been started since June, 1990.

*The Hospital-based registry* has been initiated at the Calcutta Medical College Centre (Gyn.Jobs Dept.). Almost 100 women with varying degrees of dysplasias have been put into a cohort as 'potential' cases. *Standardization* for the biochemical assays for vitamins C and folic acid in blood are in progress.

*b. Development of In Vitro model for Human Uterine Cervix.*

There has been a need for a model system to be used in the proposed biological and clinical researches. While differentiated cell types of Uterine Cervical Cells in culture seems to be ideal, the development of such a system has not been satisfactory because of inherent difficulties. The proposal laid down in here has taken into consideration of several of these inherent difficulties in order to establish a cell culture model

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system. Should such cells in culture be developed, the immediate objective is to investigate the nutritional/hormonal influences in order to understand the mechanism of Cancer Chemoprevention. The ultimate goal is to use these cells in various biotechnological/biomedical applications, such as raising antibodies (monocloval/polycloval) for therapeutic purposes.

### EMBRYOLOGY

#### 1. *On-going Research Projects :*

*Pheromones of tigers and other mammals :* As an extension of the study of embryonic informational molecules, investigation of molecules responsible for chemical communication in the tiger had been undertaken in this unit. A number of such molecules has been detected in the tiger, two or three of which are highly interesting and unusual substances. Some of these are shared by the plant world. A possible extension of this line of work may include the study of signalling chemicals in root exudates of crop, another topic undertaken by this unit.

*Mathematical and stochastic modelling of cellular development, differentiation and morphogenesis during embryonic growth :* Deterministic and stochastic reaction-diffusion models using the principles of cell to cell information transfer have been further developed and explored analytically using advanced mathematical and probabilistic tools. Systems in their nonequilibrium states have been extensively studied. Spontaneous emergence of spatial dissipative structure far from the thermo-dynamic equilibrium leading to biological prepattern formation and morphogenesis has been observed. New methods for treating the nonlinear biological control systems have been explored to investigate the mechanisms of regulated cellular growth in normal cells and those of the unregulated cellular proliferation in carcinogenesis.

*Intercrop interaction—A mathematical study in agricultural ecology :* Intercrop and intervarietal interactions in different crops and different varieties of the same crop have been studied both experimentally and mathematically. Statistical analysis of the experimental data yield significant results. Mathematical modelling and analysis of the interaction mechanisms are now being attempted.

### LEAF PROTEIN

1. *Screening and agronomic studies on fodder crops, weeds and tree leaves :* Promising aquatic weeds (eleven) and tree leaves (twelve) were screened based on nitrogen extractability and nitrogen percent in their leaf proteins.

2. *Microbiological aspects of leaf protein research :* It deals with the chemical characterization of the two wastes of leaf protein production plant, the screening of viable and culturable aeromicrobes on deproteinized leaf juice media from different ecological belts of West Bengal and the removal of organic load by harvesting fungal biomass and fruit bodies of edible mushrooms out of the wastes.

3. *Biochemical and nutritional studies of leaf proteins extracted from water weeds and tree leaves :* Based on chemical, anti-nutritive factors and digestibility studies,

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five aquatic weeds were found to be highly promising. Standardization of methods for analysis of water samples (where the weeds are found to grow) is being done. The anti-nutritive factors of promising tree leaves is also being done.

4. *Technical and economic feasibility of leaf protein (LP) production*: The project is mainly formulated to transfer the technology from lab to land and to convince the Government and public about its feasibility and merits. It is aimed at improving the nutritional and economic status of the weaker section of our society. Observations of the second pilot survey with the Kharias (the scheduled tribe) of upper Barakamra region, Simlipal forest, Orissa has been conducted. Data was collected on total population of the caste, their monthly income, food habit and education, the average caloric intake and common diseases prevailing among them.

5. *Conditions to achieve maximum yields of tops and roots in sugar beet (Beta vulgaris L.) crop*: Complete utilization of all the parts of the crop to produce ethonal, pectin, leaf protein and animal feed economically was done. Various trials were rendered with different doses of nitrogen and potassium to maximize leaf protein content of the shoot root yield and sugar percentage in root juice and gross sugar yield of the crop.

## ENTOMOLOGY

Continued research on "Influence of some physical factors in the swarming of mosquitoes. Observations on the size of swarm in relation to swarming has been made.

## Social Sciences Division

The Division includes the following units : Economic Research Unit, Economic Analysis Unit, Planning Unit, Population Studies Unit, Linguistic Research Unit, Psychometric Research and Service Unit and the Sociological Research Unit. The Economic Analysis Unit is located at Bangalore, the Planning Unit is located at Delhi, while the remaining five units are located at Calcutta. The research work done in these units during the year under review are described below :

## ECONOMIC RESEARCH

The Economic Research Unit continued to be engaged in teaching and training at various levels and in research work covering different areas of theoretical and applied economics and econometrics.

1. *Teaching and Training*: Members of the scientific staff shouldered the responsibilities of teaching economics, economic statistics and econometrics in the degree and research courses in economics as well as in other courses conducted at ISI, Calcutta. Several faculty members participated in the teaching programmes of other Universities also. There were, in addition, a number of research fellows working for the Ph.D. degree under the supervision of faculty members of the Unit.

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2. *Research Activities* : The research activities of the Unit during the period under review covered fields like economic theory, national and regional economic planning, issues in development economics, industrial economics, demand analysis, income distribution, level of living and poverty in India, optimal taxation, economics of informal sectors, agriculture, besides other investigations in applied economics and methodological studies in econometrics.

3. *Project Work* : The members of the Unit have undertaken a number of projects. These projects are described in brief.

### (a) *Inter and Intra-Occupational Differentials in Income and Level of Living*

The project was undertaken in 1987 with the objective of analysing inequality in income and level of living within and between different occupation groups. For this purpose, a sample survey was conducted among supervisory and clerical office workers employed in a number of organisations, e.g., banks, the Life Insurance Corporation, Central Government Services, West Bengal State Government Services, the organised private sector and the unorganised private sector, located within the Calcutta Municipal Corporation area. The important results are :

(i) There is a rather weak correlation between income level and standard of living. It appears that beyond a critical level of income consumption expenditure is not so much dependent on income as on other factors like taste, culture, customs, habits and so on.

(ii) Employers in some parts of the public sector seem to pay much higher salaries to their employees than employers in the private sector.

(iii) The public sector seems to provide more of fringe benefits to their employees than the private sector.

(iv) Within the public sector, autonomous bodies like banks and LIC are more generous with these benefits than the Central and State Governments.

(v) Within the private sector, employees in the corporate sector are way above employees in the non-corporate sector not only in the matter of salaries but also in the matter of service conditions and fringe benefits.

(vi) The officer-assistant disparity is higher in the non-corporate private sector than in the corporate sector as well as in the public sector.

(vii) In the smaller firms in the private sector, both corporate and non-corporate, the assistants are more discriminated against in the matter of wages/salary as well as other service conditions than in the larger ones.

Five papers reporting the results of the study have already been published in different issues of the *Economic and Political Weekly*.

### (b) *ISI-ONGC Collaborative project*

This project was undertaken by ISI in collaboration with Oil and Natural Gas Commission (ONGC) with the main objective of developing a methodology for the



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estimation of discovery and production cost of hydrocarbon taking into account the uncertainty involved in the process of exploration and discovery. The major stages of the work are now completed and a number of presentations have already been made at ONGC, Dehradun, reporting the results of the research. Two types of models have been developed—econometric and statistical. The econometric approach seeks to forecast on the basis of the certain discernible behaviour observed through an analysis of the past. The statistical approach, on the other hand, deals with the uncertainty by explicitly specifying probability distributions for the relevant variables and obtaining solutions by simulation methods.

The report is now being finalized and is expected to be submitted within a few months.

### (c) *Long-Term Forecasts of the Requirements of Fresh Notes and Coins (RBI project)*

The Unit is engaged in a study sponsored by the RBI on the long-term forecasts of the requirements of fresh notes and coins in India. The study is based mainly on the secondary data available from different official sources. However, some data have also been collected through a modest-sized sample survey of currency transactions of commercial banks in and around Calcutta. The study is being divided up into two inter-related parts. First, it would try to estimate the required amount of the total currency. Next, it would attempt to estimate the required amount of currency of each denomination, separately, by figuring out the 'right' denominational mix.

### (d) *Linguistic Analysis of the Complete Works of Rabindranath Tagore based on Complete Statistical Counts*

One team comprising linguists, statisticians and computer scientists has been engaged in a statistical-linguistic analysis of Tagore's works. This project is being conducted in collaboration with the Institute for the Study of Languages and Cultures of Asia and Africa (ILCAA), Tokyo University of Foreign Studies, Tokyo. ILCAA has been transferring Tagore's works to computer tapes and preparing and publishing word-counts and concordances for individual poetical works. The team in ISI has been carrying out various types of analyses starting either from the computer outputs supplied by ILCAA or from the texts themselves. These include finding the relative frequencies of Sanskrit Bengali, Bengali, *Mishra* and *Videshi* words, studies on compounds, compound verbs, pronouns, verbal roots, suffixes and prefixes, adjective-noun relations, syntactical analysis (mainly SOV patterns), patterns of syllable composition (V, CV, VC, etc) word-length, sentence length etc. A report on *Gitanjali* is nearing completion.

One member of the project team (Sm. Tandra Rao) has developed a Bengali word processor which can be used for transcribing Tagore's works at ISI, Calcutta.

## PLANNING (DELHI)

### 1. *Research Activities :*

The members of the Unit continued research in a number of fields in both applied as well as theoretical economics, regional planning and analysis of social movements.

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Research in applied economics included diverse topics such as planning, problems in estimation of poverty, estimates of labour force and unemployment, foreign trade and economic development, health and family planning, amongst others. Work was continued on the development and application of macroeconomic models for analysing policy issues. Research in economic theory revolved around game theory and its applications, economic inequality, industrial organization, models of unemployment and the design of contracts and mechanisms.

### 2. Project Works

Various members of the Unit have been working on a number of projects. The topics covered include :

- (i) A study on provision of basic social services in rural areas of Haryana and Rajasthan.
- (ii) Conflict, structure and change.
- (iii) Autonomy-seeking movements in Punjab and Darjeeling.
- (iv) Resource inventory for planning.
- (v) Perspective plan model for economic development of Assam.
- (vi) Disparities in household income and level of living within and between various occupation groups in Delhi.
- (vii) Land systems analysis for the evaluation of resources at micro level.

## ECONOMIC ANALYSIS (BANGALORE)

### Research :

The following projects were continued :

1. *Studies in Poverty and Inequality : Regional Dimension* : A comparative study of pre-revised and post-revised salary structures of technical and non-technical workers at Bangalore Centre of the Institute was undertaken and the results corroborated the hypothesis that the revision has indeed had a favourable impact on the lower categories in terms of pay as well as the Dearness Allowances.

A discussion paper, "A Note on the Distribution of Salaries : A Case Study" was prepared based on the investigations of milk consumption in Karnataka.

2. *Impact of socio-economic factors on income distribution* : Another study was undertaken to analyze the impact of socio-economic factors in income distribution. This began with a survey of relevant literature and the preparation of an annotated bibliography of articles on consumer expenditure published in national and international journals made further progress.

The Economic Analysis Unit launched a Summer Course in Quantitative Economics for the benefit of research scholars, college teachers of various universities in India, and state government officers, and this course evoked wide interest and attention.

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### LINGUISTICS

During the period under review the Linguistic Research Unit continued its programme of research in fundamental and applied linguistics. The main topics of research are as follows :

I. Studies on the phonetic structure of major Indian languages and application of the results in the areas of (a) speech pathology, (b) second language acquisition and (c) cultivation of mother-tongue.

II. Studies on socio-cultural and psycho-linguistic aspects of bilingualism.

III. Application of statistics in linguistic problems.

IV. Instrumental analysis of comparative intonation patterns of Indo-Aryan and Dravidian languages : Work continued throughout the year on the unit's on-going schemes. Fundamental research on the supra-segmentals of Bengali, Hindi and Telugu is in progress with appropriate instrumentation for objective analysis.

Studies are in progress on :

(a) Language acquisition of the pre-school age child between 2 to 4 years of age.

(b) Relevance of contextual parameters in the measurement of bilingualism.

(c) Academic achievement of hearing-impaired children attending general schools with normal hearing children.

(d) Comparative studies on prosodic elements in Indo-Aryan and Dravidian languages are being carried out with the Visi-Pitch. Studies on intensities of speech sounds have been initiated. Comparative studies on intonation patterns are planned between languages belonging to the broad Indo-European group.

#### *Project Work*

*Project I : Study of the Supra-segmentals of the Hindi language :* Fundamental analysis of the data is in progress. Data were spectrographically recorded at CEERI, New Delhi, and at the Electronics laboratory of the Physics Dept. at Aligarh Muslim University and some analysis has been made with the Visi-Pitch system, in the Linguistic Research Unit, ISI, Calcutta.

*Project II : Study of the suprasegmentals of the Telugu language :* Data on Telugu words and sentences are being analysed with the aid of the Visi-Pitch system. Pitch and intensity measurements, syllable stress and intonation patterns of data collected in the subsequent phase was analysed. There has been extensive field work at Hyderabad in this regard.

*Project III : Survey of the articulatory norms in Bengali speaking children of pre-school age :* Collection of data has continued throughout 1989-1990. Progress is limited by certain restrictions as spontaneous utterances of small children have to be recorded.

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*Project IV : Educational problems of hearing-impaired children attending schools for normal children :* Scholastic achievement of hearing impaired children attending normal schools is being examined and recorded as data. Problems in specific subject are being assessed with a view to examining actual requirements of language habilitation.

*Project V : The role of contextual factors in language use and language assessment :* Natural language samples through observations and recordings of verbalisations and conversations in different contextual settings were collected during the current year. Existing pre-school language tests were evaluated through a pilot survey for their adaptability in the present study.

### POPULATION STUDIES

#### *Research Activities :*

##### *A. Plan Projects*

1. *Child Mortality and Environmental Differentials in a Newly Industrialised Indian City—Durgapur in West Bengal (A Collaborative Project with the School of Oriental and African Studies) :*

The central purpose of this study was to investigate the degree of duality that emerged between the various social and environmental sectors of this new industrialised town.

The message obtained was that, using child mortality as an index, the city was strongly divided in ways that affected the child survival apart from being divided in general welfare terms—for example, in access to basic amenities of life like sanitation.

Two reports have been submitted to : (1) Leverhulme Trust, London and (2) International Development Research Centre, Ottawa, Canada. A draft of the booklet entitled, "Child Mortality in a Steel Town : A Study in Durgapur", has been completed.

2. *Estimating Future School Enrolment in Districts of West Bengal (1981-2001) :*

The study has the following objectives :

(i) to project the general population at state and district levels by rural-urban and age-sex categories :

(ii) to derive population exposed to risk of enrolment and estimate functional ratios ; and

(iii) to estimate student population at primary, middle and secondary stages by districts and to investigate the rural-urban and sex differentials in these estimates.

Considerable progress has been made in the development of methods for estimation of relevant parameters.

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### 3. *Some Determinants of Child Mortality and the Latter's Impact on Fertility :*

The main objective of the study is to understand the phenomenon of high infant/child mortality and its effect on fertility through a comprehensive study of level of living including dietary habits and nutrition, education, fertility, morbidity, access to medical facilities etc.

The tabulation of urban sector data of the project is in progress. The rural sector data are being scrutinised after transfer from ORG Disc to tape of 1600 B.P.I. The preliminary tabulation of rural data is likely to start by July next. The entire data are, however, expected to be ready for analysis by the end of 1990.

### 4. *A Study on Educational Wastage (Stagnation and Drop-out) at Primary and Middle School Levels :*

The objectives of the study are :

- (a) to estimate the expected student life, a problem of methodological interest ;
- (b) to find out educational wastage differentials by various demographic, socio-economic and other related factors, and
- (c) to identify and evaluate various factors as determinants of educational wastage.

The sample survey conducted for the study canvassed three schedules—one for schools, one for teachers and another for students' households. The field work for rural areas has been completed. Processing and analysis of field data are in progress. The second phase of the field work, i.e., the urban area survey, has been taken up. Sampling and other preliminary jobs are completed. About 60% of the school schedules have been filled up.

### 5. *Content Analysis of Some Leading Regional Newspapers :*

Allotment of space for various topics in any newspaper is generally guided by the intention of the management of the paper concerned. The objectives of the study are to examine the proportion of space allotted to different topics such as news, advertisement, articles, economic reviews, editorials etc. and also to assess the seasonal variation, if any, in its contents.

The tabulation of data collected is in progress.

## *B. Non-Plan Projects :*

### 1. *Perspectives on the Population Ageing in India :*

The study focuses on statistics concerned with the phenomenon of ageing in India, using data mainly from the United Nations and national census series. It examines the dynamics of changes in the population age composition over the period 1950-2025, and discusses population ageing as a socio-demographic topic with specific attention to its prospects for India.

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Some of the issues addressed in the study are the basic concept and measurement of ageing, worldwide trend of the process, threshold of old age, patterns and trends of mortality for the elderly and health aspects of this sub-population. The study has been published in a book entitled, "Population Transition in India", edited by the IASP.

### 2. *A Study on the Demography of West Bengal :*

The present study was undertaken at the initiative of the Government of West Bengal, which made available all facilities for the purpose. It involves the task of finding the trends of the various elements of population dynamics through a long period of time, resulting in possible changes in the growth and age structure of the population. As one of the components of growth, the issue of migration has been considered in detail. The study has been completed, and the report submitted. This will form a part of a book on West Bengal to be published by the State Government.

### 3. *Population Projections by Marital Status, India 1981-2001 :*

The object of the study is to prepare population projections by marital status for all India Females 1981-2001. Cohort component method has been used for the projections. Some consistency criteria as relevant to population projections by marital status for both sexes have also been discussed. A paper has been published in a book entitled "Population Transition in India" edited by the IASP.

### 4. *Estimation of Adult Mortality from Widowhood Data : Districtwise Analysis :*

An investigation on the use of widowhood data for investigation of mortality differentials in W. B. has been neatly completed. The analysis is carried out separately for different districts.

### 5. *A Survey of Working Children in Calcutta :*

A survey of working children below 14 years of age has been conducted in several establishments in and around Calcutta covering aspects like economic conditions, working conditions and work environment, occupational hazards etc. Preliminary findings of the survey were presented at the Conference on Child labour held at Bhubaneswar on 12-13 February 1990, at the Tribal & Social Welfare Research Centre, Bhubaneswar.

### *C. Teaching and Training :*

In addition to research work, the Population Studies Unit participated in the teaching and training programmes at ISI, Calcutta, shouldering the responsibilities of teaching demography and related subjects in various degree and other courses, including the Specialization Course in Bio-statistics and Demography in the M.Stat. 2nd year. The faculty members also guided Ph.D. students and participated in teaching programmes of other universities/research institutions.

## PSYCHOMETRY

### *Research and Project Activities*

1. *Personality Pattern of Different Occupational Groups :* The objective of the study is to develop personality profiles of different occupational groups based on Indian population.

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The different aspects of personality would be measured through a standardised personality inventory. Five different occupational groups of individuals, viz. (i) Executives, (ii) Sales representatives, (iii) School teachers, (iv) Doctors and (v) Artists, are the subjects of the study. About 500 individuals, 100 from each of the five groups, are being studied. 16 Personality Factor Questionnaire of Cattell is being administered on the subjects of this study. Data collection has been started. So far data have been collected from 75 Teachers, 21 Doctors, 20 Artists and 10 Executives.

2. *Consequences of Social and Economical Deprivation on Academic Achievement* : The objective of the study is to investigate the effect of socio-economic deprivation upon the scholastic achievement of school-going children. Several psychological and environmental factors which are expected to be related to scholastic achievement are also brought under the scope of the study.

Subjects are the students reading in Class X in different schools of West Bengal. The intelligence level, achievement motivation and prolonged deprivation of the subjects are being measured with the help of standardised tests.

Such a study may throw light upon the problem of school drop-outs in our country and the results of the investigation may be utilised in re-orienting the educational system in the light of our requirements specially in rural areas so that the whole system becomes more effective.

Data have already been collected from 64 schools located in both rural and urban areas of West Bengal, covering 1508 cases from 16 districts. Data collection is complete and the analysis of the data is going on.

3. *Development of an Intelligence Test for Hearing-Impaired Children* : The aim of the study is to develop an intelligence test for hearing impaired children when they come for admission to school. The development of the scale is complete after proper revision through item analysis. Reliability, validity and age norms etc. are available. The test is ready for publication along with a detailed examiner's manual.

4. *Predictive Validity of the Forced-choice Scale of Managerial Skill* : The objective of the present study is to find out the predictive validity of the Forced-choice scale of managerial skill. The scale already developed, measures five types of managerial skill, namely, decision making, leadership, human relations, communication and conceptual skills. At the time concurrent validity of the scale has been developed. Now, the predictive validity of the scale has to be established. It has been decided that the scale will be validated against ratings made by peers and supervisors on the above five dimensions. Data from about 100 middle and lower level managers from different parts of India and their peers and supervisor's rating have been collected. Analysis and report writing is going on.

5. *Intelligence and Personality Pattern in some Social Groups of West Bengal based on some Dermatoglyphic and Anthropometric Variables* : The objective of the present investigation is to find out whether intelligence and personality pattern varies with the variation in the dermatoglyphic and anthropometric variables. Data from about 100 families belonging to different social groups (for example, groups formed

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on the basis of castes and tribes) residing in different parts of West Bengal are being collected. Data collection is nearly complete. Analysis of the data and report writing will be done.

6. *Assessment of Minimum Learning in Primary Education* : During the period data were collected from 1650 pupils of Class I reading in 57 sample schools of Hooghly district. Besides the written, the group taking the special test also appeared for oral examination.

### *Service project :*

A selection test was conducted on 2nd July 1989, for the admission of students to the B.Lib. (Sc.) Course for the Calcutta University.

## SOCIOLOGY

### 1. *Research Activities*

1.1 The faculty members of the Unit collaborated with scientists of Theoretical Statistics and Mathematics Division of ISI on a study including the following stages : (i) Identifying boundaries of social interaction by graph-theoretic method ; (ii) decomposition of reciprocity in a social network among the villagers by their various primordial and new characteristics like caste, community affiliation, class, etc. ; and, (iii) obtaining measures of reciprocity in weighted di-graph of a social or economic network as in case of volume/value of flow of goods between rural-urban regions within a country/between various countries like in international trade, or, frequencies or rates or intensities of interaction among villagers in different dimensions.

1.2 The faculty also collaborated with the Bio-Sciences Division and the Theoretical Statistics-Mathematics and Applied Statistics Divisions on : (i) Identifying and studying parameters of rain-fed farming system in an east Indian plateau region ; (ii) vulnerability of rain-fed farmers and their strategies of survival including their risk adjustment strategies ; (iii) conditions of development of sustainable agriculture in mono-crop rice villages of eastern India including explorations of endogenous sources of change and development in local cropping practices ; and, (iv) evolving methodology of evaluating the degree of impact of exogenous inputs for induced development while these activities are going on.

1.3 Data collected in a study on "Value system and social change" are being processed through computer for a detailed multivariate analysis. The results of analysis show a high correlation between value-orientations and the daily behaviour in rural society. A monograph on the pilot survey is available in the Unit. Two papers have been accepted for publication. Detailed analysis of the entire data is under progress.

1.4 An analysis of data collected from rural Giridih concerning the aged people raises doubts regarding empirical validity of "disengagement theory" in explaining their behaviour.



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1.5 Another series of investigations included (i) the collection and analysis of data related to continuity in peasant uprisings in Bengal since the introduction of the colonial rule ; (ii) explication of the impact of popular upsurges during the terminal years (1945-47) of British rule leading to the transfer of power in the subcontinent ; and (iii) stresses and strains in the communal situations in contemporary India—their variations and the process of historical evaluation of these variations.

1.6 Study of people's perceptions about risks and development, carrying capacity of land in terms of human population and grasping the on-going changes at the grass-root level, are the central areas of another enquiry.

2. *Social ecology of the minority/marginal groups of eastern India* : Only an exploratory enquiry could be conducted with regard to this project due to the pre-and post-election disturbances in Bihar. One of the tentative findings of the project is the emergence of social polarization over and above the economic differentiation between castes of different strata.

3. *Potentialities and constraints of development : A socio-ecological approach* : The area under study is Simlipal forest range in the district of Mayurbhanj, Orissa. The field survey has been completed. A preliminary report on some aspects of studies is available and the final report is under preparation.

4. *Socio-ecology of Sundarban* : The field survey has been completed. Materials collected are being used for writing a book entitled, "The desperate delta", dealing with the social ecology of the Sundarbans.

5. *Ageing of population in India* : The studies undertaken so far covered the following dimensions of gerontology :

- (i) Health and medicare survey of the elderly persons ;
- (ii) opinions about the elderly persons, and
- (iii) human ageing in rural-urban Bihar.

The data collected on these aspects have been partly processed and three papers have been published and another sent for publication.

6. *Peasant movements during the early phase of colonial rule in Bengal* : Collection of data from the State Archives and records preserved in the District Collectories of West Bengal is being completed. Three papers have been published and three papers have been presented in seminars.

7. *New pattern of leadership and social action : An exploratory enquiry* : The final report is under preparation. A paper was contributed to the Asian Studies Conference in U.S.A.

8. *Child labour : An exploratory enquiry in Giridih, Bihar* : Data collection work has been completed and the report is under preparation.

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9. *A study of educational wastage (stagnation and drop-out) at primary and middle school levels (in collaboration with the Population Studies Unit) :* The field work has been completed for both rural and urban areas. Data are being tabulated and analyzed.

10. *Tribal economies : Trends and perspectives :* The review of literature was completed. A technical note has been prepared.

11. *Conditions of self-sustained development in rain-fed agriculture :* This research has been undertaken in collaboration with scientists in the Agricultural Science Unit in three tribal villages near Giridih town, Bihar. This study is in pursuance of the recommendations regarding "Farming to Village to Farm Communication" made by ISI Council's Committee on Giridih. The Soil Conservation Division of DVC is also actively associated with this project.

A technical report has been prepared. Three research papers have been prepared and presented in an international seminar organized by the Indian Society of Agronomy. Two papers were also contributed to a conference on Economics of Land and Water-Resources in India.

12. *Application of reciprocity measure as an indicator of balance in international trade by countries and commodities :* This research has been undertaken in collaboration with the scientists of Theoretical Statistics and Mathematics Division of ISI. A paper is under preparation.

13. *The study of registry marriage and the impact of legislation in West Bengal :* This project attempts to study the changing character of the institution of marriage and the roles played by marriage legislation in effecting the change. It seeks to identify the groups involved in it, expose the socio-economic, cultural and psychological forces at work, and examine the nature and extent of post-marital adjustment. Analysis of the survey data is under way. The findings of the data analysed upto now show that the benefit of the Special Marriage Act has been mainly enjoyed by the so-called upper socio-economic stratum of the population and registered marriages seem to be less popular among the communities who occupy ritually lower positions with little or no education.

### *Institutional collaboration :*

Since 1988, the Sociological Research Unit has undertaken a programme of "Guidance and Consultancy Services in Data Processing" at the request of the Indian Council of Social Science Research, New Delhi. During the reporting year, four Ph.D. students from the Universities of Kalyani, Calcutta and Buriwan received the benefit of such guidance.

### *2. Project work : Externally funded projects :*

2.1 *Evaluation of rain-fed farming (ODA) (UK) sponsored and HFCL funded Project* (Sponsored by the Overseas Development Administration (ODA) of Government of UK, the Hindusthan Fertilizer Corporation Ltd. (HFCL), in consultation with the Overseas Development Group (ODG) of University of East Anglia at Norwich (UK),

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has undertaken a project on how to promote and stabilise participatory sustainable agriculture under rain-fed conditions in east Indian plateau regions. With this aim in view, they are carrying out projects in villages located in six districts of three states in eastern India—West Bengal, Bihar and Orissa.

As requested by IIFCL/ODA, ISI has agreed to evaluate the impact of these activities as well as evolve appropriate methodology in this regard. For this purpose, ISI is engaged in doing the following :

- (i) a base-line survey (BLS) ;
- (ii) first year annual monitoring and evaluation (AME) ; and,
- (iii) preliminary enquiries related to in-depth studies (IDS).

For this purpose, a multidisciplinary team consisting of scientists from social sciences, biological and applied statistics Divisions has been formed. Field work of the project is in progress.

*2.2 Perception, performance and potential of development in Usri water-shed area of Bihar plateau.—An eco-systemic approach (ICSSR funded project) :* Bihar, although immensely rich with natural resources, is considered one of the poorest states in India with near stagnation in terms of growth rates of gross domestic product and agricultural productivity. Again, when the focus is on Chhotanagpur plateau constituting 46% of the state's geographical area, the picture turns further dismal.

The proposed study would be taken up on the watershed of Usri flowing through Giridih district in the eastern part of Chhotanagpur (Bihar) plateau. As a component of agro-ecosystem, it represents a major part of the plateau. It is mostly inhabited by tribals.

This study intends to explore linkages between cropping system and ecology in an area, generally held as socially and economically backward and suggest ways and means for improving upon man-environment relationship in accordance with the perception and involvement of the people of the area.

Finalization of questionnaires, check lists, etc., are going on. Physical inspection of the area of study, drafting of schedules for pretesting and preparation for staff recruitment have been completed.

### 3. Teaching and Training :

All the faculty members of the Unit took part in the teaching of sociology and sociometry in the B.Stat. (Hons.) Course including one-week field work in Bihar. The Unit also participated in "Farmers Training Camp" which was sponsored by D.V.C., and organised in collaboration with the Agricultural Science Unit of ISI.

Sm. Indrani Chakrabarti obtained her Ph.D. degree from the University of Calcutta for a dissertation entitled, "The pensioners in Calcutta : A gerontological Study. She completed this work after leaving the unit but the unit provided her all facilities needed for its completion.

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### Statistical Quality Control and Operations Research

#### 1. *Introduction :*

The SQC and OR Division was started in 1953. Over the years it has grown to 11 Operating Units scattered throughout the Country. They are located at Bangalore, Bombay, Baroda, Calcutta (2 units), Coimbatore, Hyderabad, Madras, New Delhi, Pune and Trivandrum. The SQC and OR Division is engaged in diverse types of activities in the fields of Quality Control, Operations Research, Reliability and also in computer software development in the field of Quality Control. The Division renders assistance and expert advice to manufacturing industries, and takes up project assignments in the field of quality control and related areas.

It has a planned programme for promotional activities for propagating the concept of quality control and operations research through seminars and plant visits and through training of technologists and engineers to motivate them in disseminating these ideas for improvement of product quality and productivity. The specialists of the Division also take up regular teaching assignments in degree and diploma courses of ISI, in the ISEC programme and in evening courses of the Institute in different Centres/cities.

Besides teaching and professional work, the Division is also engaged in theoretical as well as applied research in the fields of Quality Control, Operations Research and computer applications.

#### 2. *Consultancy Service and Projects :*

During the period under review, 90 organisations were availing themselves of the services of the Division. 24 organisations were taken up for service, 86 training programmes were organised.

Project involving SQC and OR methods were carried out in various organisations involving various types of problems. Some of the areas of work are, computer applications in Quality Management, general purpose computer software on simple statistical tools, design and analysis of mixture experiment, an utility package for disc screen management, optimal control of conductor dimensions for tele-communication cables, sampling scheme for carrick detonator, evaluation of outgoing quality and development of system of control for foils, control of cabinet shrinkage in PU foam process, energy conservation in plant.

#### 3. *Teaching and Training :*

In-plant training programmes for Executives, technologists and other production personnel including operators were continued during the period under review. The training programmes for executives of BHEL at various levels were continued including the one-year special program at Madras. It is proposed to replace this programme by a six-month intensive programme, on Quality Management, Concepts and Tools including computer applications, from May 1990.

During the period under review, 1915 managers and technologists were given training in SQC methods, and 143 trainees at post-graduate/post master degree level

## INDIAN STATISTICAL INSTITUTE

underwent training at Calcutta, Delhi, Bangalore and Madras, and in part-time certificate courses in Hyderabad and Bangalore. In addition, 8 SDP Fellows were trained during the period.

The Division shouldered fairly heavy load in teaching in the different courses of the Institute, at all the centers. The faculty members of the Division have taken bulk of the courses prescribed for, Diploma in SQC and OR and M. Tech. (Q, R and OR) at Calcutta, Diploma in SQC and OR at Madras and Bombay (part-time). The Division also assisted and/or taken full course in the following programmes :

- (a) M. Tech. in Computer science,
- (b) B. Stat. (Hons.) and M. Stat. courses,
- (c) Part time certificate course at Bangalore and Hyderabad,
- (d) ISEC programme at Calcutta and Bangalore,
- (e) Part time course on Statistical Methods at Calcutta, Hyderabad and Delhi,
- (f) One year special programme at Madras for BHEL,
- (g) Junior Certificate Course at Calcutta,
- (h) Training of SDP Fellows.

#### 4. Research :

Applied and theoretical research were carried out in different areas. Some of the areas of work are :

Bayesian three decision acceptance sampling plans, continuous sampling plans, sampling plans under stratified random sampling, sampling schemes for in-process inspection, Fuzzy goal programming in acceptance sampling, Optimum investment in drilling, approximations of doubly non-central  $Z$  distribution, strongly balanced uniform measurement design, Life testing experiment and minute analysis, parametric design and global optimisation, trim-loss problem, optimisation of fuel injection system, Linear complementarity problem with  $N$  and  $N_0$  matrices, characterisation of  $P$ -matrices, optimum allocation of parallel-series and series-parallel systems, Optimisation of bi-criteria quasi-concave function, control of rotor-stator gap.

During the period under review, 13 papers were published, 17 papers were accepted for publication, 12 papers were sent for publication, 32 papers read at conference and/or to be published in conference proceedings, 1 technical report published and 11 manuals prepared.

#### 5. Promotional Activities :

Introductory visits were paid to 70 factories for promotional work ; 31 surveys and/or pilot projects were carried out and 23 promotional reports were sent. The surveys covered various types of industries. They include : textiles, printing press, aluminium, dry battery cell refractory, aluminium foil, textile machineries, explosives, telephone cables, automobiles, antibiotics, electronics, heavy machinery, machine tools etc.

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The specialists of the Division delivered 342 lectures and talks to various organisations/institutions on different aspects of Quality Control and Operations Research, including Quality Management.

The specialists from the Division attended 41 seminars in the field of quality control and relevant statistical techniques/theories. During the period under review, 20 seminars were organised by the various units of the Division.

### Library, Documentation and Information Sciences

#### DOCUMENTATION RESEARCH AND TRAINING CENTRE (DRTC) BANGALORE

The activities of DRTC have been organised into : (1) Research Programme ; (2) Advisory service programme ; (3) Extension programme ; (4) Publication programme ; (5) Educational and Training programme ; (6) Employment Information Programme ; (7) Continuing Educational and Training programme and (8) Faculty Development programme.

The following is the report of the activities of DRTC during the period April 1989 to March 1990 :

#### *Training in Documentation and Information Service :*

*Course leading to ADIS Award :* Under its Educational and Training Programme, DRTC conducts a course of 24-month duration leading to the award "Associateship in Documentation and Information Science" (ADIS).

There were six students selected for the academic session 1987-89 (24-months). They appeared in the final examination in 1988 after completing their formal residential part of the course of 12 months. After that, they were engaged in their respective guided research projects. They submitted their dissertations in August 1989. The results of their course performances were declared in October 1989. All of them declared passed. Five of them obtained First Class and one, a Second Class. Of the six students, two were women and four were men.

For the academic session 1988-90 (24 months), eight students were admitted. They joined the course on 1st September 1988. After one month, one of the students left the course because of personal problems. The remaining seven students completed their formal residential part of the course in August 1989. All of them appeared in the final examination held in 1989. They are now engaged in their respective guided research projects. They have to submit their respective dissertations, by August 1990. Of the eight students, two are women and six are men. The list of the students of the 1988-90 batch was furnished in the DRTC Annual Report (1988-89).

The academic session, 1989-91 (24 months), commenced on 2nd September 1989. There were ten students selected for this session. One of the students left the course by the end of September 1989 ; and another by the end of October 1989. Currently, eight students are continuing with the course. Of the eight students, two are women and six are men.

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*Short-term Course on Computerized Information Work and Service* : Under the sponsorship of the National Information System for Science and Technology (NISSAT) forming part of the Department of Scientific and Industrial Research (DSIR), Government of India, New Delhi, DRTC has been conducting a six-week course on "Computerized Information Work and Service (CIWS), since 1988. Normally, two such courses are conducted during each financial year. During the period, April 1989 to March 1990 the seventh and eighth courses were conducted.

The seventh course was conducted during the period of 7th August 1989 to 15th September 1989. For the seventh course, 15 candidates were admitted. All the candidates completed the course by meeting all its requirements.

The eighth course was conducted during the period 6th November to 15th December, 1989. 14 candidates were admitted. All of them completed the course by meeting all its requirements.

*Educational Study Tour by ADIS Students, 1988-90 and 1989-91* : According to DRTC policy, the students of each academic session are provided with opportunity of visiting Information Centres, Data Centres, Information Analysis and Consolidation Centres, etc., for the purpose of carrying out observational studies of information work and services in action.

The Educational Tour Programme for the students of 1988-90 and 1989-91 batches was fixed up for the period 24 December 1989 to 5 January 1990. The Educational Tour was conducted by Prof. M.A. Gopinath. For the purpose of Educational Tour, the students were first taken to Jaipur to attend the 17th All India IASLIC Conference organised by the Indian Association of Special Libraries and Information Centre (IASLIC) was held at Rajasthan University, Jaipur during 27-30 December 1989. The theme of the Seminar was "Manpower Planning for Library and Information Systems in India". The theme was of special interest to the students of DRTC.

For the purpose of observational study, the students were taken to Delhi on their return journey. In Delhi, the students carried out observational studies of Secondary Information Work and Services in the following Information Centres : (1) Indian National Scientific Documentation Centre (INSDOC) ; on 1st January 1990 from 10 a.m. to 1 p.m. ; (2) Defence Scientific Information and Documentation Centre (DESIDOC) ; on 1st January 1990 from 3 p.m. to 5 p.m. ; (3) National Informatics Centre (NIC) ; on 2nd January 1990, from 10 a.m. to 3 p.m. ; and (4) British Council Library, Delhi ; on 3rd January 1990, from 2-30 p.m. to 5 p.m.

3. *Research Activities* : The main areas of research in which the different members of the DRTC Faculty were engaged during the period of the report are : (1) Preparation of the State-of-the-art report on the "Methodology of Constructing Vocabulary Control Devices", such as Schemes for notational depth classification, Theauri and Classauri, (2) The preparation of a Manual for the construction of a Classaurus, (3) The designing of a "Classaurus for the depth indexing of micro subjects going with the base, Agriculture and related Sciences and Technologies",

## FIFTYEIGHTH ANNUAL REPORT : 1989-90

(4) The demonstration of the use of the above mentioned Classaurus, (5) The application of the "Colon Classification, Ed. 7", for the purpose of (a) arranging documents; and for (b) documentation work and service, (6) The designing of a "Multi access Thesaurus", (7) The study of the varieties of "Thesaurus-Structures/Formats" from the point of view of their impacts on information retrieval, (8) The study of various methods of knowledge representation, such as, semantic nets, frames, and predicate calculus; and of their related features, to ascertain their co-relations with the classificatory language of colon classification, (9) The designing and development of Notational depth indexing classification schemes, Thesauri and Classauri for the depth of micro subjects going with various disciplines, (10) The application of Modern Scientific Management Techniques to the Planning and Management of Information System, Centres and Services, (11) The study of the methodologies of Information Analysis and Consolidation, (12) The preparation of a state-of-the-art report on "Performance Standards in the field of Secondary Information Work and Service", (13) The development of bibliometrics measures for evaluating the use of Library and Information Services, (14) The preparation of guidelines for developing soft-ware and application packages for house keeping operations of information centres, such as, Circulation Control, Serial Control and Acquisition Control, (15) The development of a Computerized tutorial for CDS/ISIS (Mini, Micro Version), (16) The development of a Computerized Manpower planning model for Information Centres, (17) Restructuring of curricula and syllabi specially for the advanced courses on information science including documentation and library science with a view to accommodate essential contents pertaining to the appropriate advances in information technologies.

### 4. *Project Work :*

*Advisory Service Programme :* DRTC offered advisory services to the following Institutions : (1) the National Law School of India, Bangalore on computerization of information work and services; (2) SNDT University Centre for Women Studies, on the installation of the CDS/ISIS soft-ware package for rendering information services

## CENTRAL LIBRARY

The Institute maintains a Central Library at Calcutta. With the addition of 878 books and 875 journals to the stock, the total collection of the Library rose to 1,91,452.

*Acquisition :* The Central Library accessioned 878 books during the period under report, out of which 525 were purchased and 343 were received as gift, 8 titles were received on exchange basis. The Unit also accessioned 2 Ph.D. theses. It also acquired 368 books for the Circulating Library.

*Periodicals :* The Central Library received 1,339 periodicals out of which 222 were received as gift, 629 against subscription and 464 on exchange arrangement with national and international organisations. The Unit also acquired 13 new journals under NBHM grant. 11 new journals were subscribed during the period. It accessioned 804 journals and completed the technical processing of 875 journals.



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*Circulation and Stock maintenance :* The Library issued 40,993 books and journals to the users on loan and reference. The total membership of the Library was 1352 (after the introduction of New Library Rules from May 2, 1988) out of which 75 memberships were withdrawn. The total membership includes ISI staff, research scholars, project assistants, B.Stat., M.Stat. and M. Tech, students, ISEC trainees etc. as well as outside students and institute members. 446 readers were given special permission to use the Library for short periods. 50 books and journals were borrowed from other libraries and 38 books and journals were loaned to other libraries under the inter-library loan arrangement.

*Reports & Records :* The Library accessioned 490 titles and processed 500 titles. 1434 titles were issued to the borrowers during the period.

*Special Materials :* The Library accessioned 49 titles and transliterated 60 titles. 89 titles were classified and catalogued and released for circulation.

*Technical Processing :* The Library classified 325 books and catalogued 698 books.

*Reprography and Photography :* The Library provided 3,69,582 xerox prints for the users during the period under report.

922 frames of photographs of different natures, 1180 prints of photographic enlargements, 750 frames of microfilming from drawing books, charts, journals etc., 402 frames of lecture slides and 2,67,750 off-set prints were made during the period under report.

*Circulating Library :* The workers' Circulating Library acquired 381 new titles bringing the total collection to 34,160. It issued 33,052 books to the members.

## BANGALORE CENTRE LIBRARY

### 1. Additions :

During the period (April 1989 to March 1990), 376 books were added to the library by purchase. 388 volumes of journals were bound. Among the current titles received in 1989, 3 titles were cancelled and 24 new titles were subscribed to in 1990

### 2. Stock Position :

The total stock position as on 31 March 1990 is as follows : books 10,954 ; books on gratis 608 ; bound volumes of periodicals 4,135 ; number of periodical titles subscribed 284 ; number of periodical titles received on gratis 22.

### 3. Technical Work :

About 768 books were classified and 356 books were catalogued during the year. Nearly 1080 catalogue cards were filed.

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### 4. Circulation Statistics :

During the year, library facilities were availed by 120 persons, out of which 83 availed the lending facilities. 12 visiting professors were also provided with the lending facilities. A total of about 8500 books and 2500 periodicals (including loose issues) were circulated by the library. The inhouse use of books and periodicals was around 27,900. About 140 inter-library loan transactions were registered.

### DELHI CENTRE LIBRARY

During the period April 1, 1989 to March 31, 1990 the Delhi Centre Library was busy performing following activities :

1. *Acquisition* : Only 270 new books could be purchased and added to the stock during the period. Received 91 publications as gift from various sources and agencies. More than 489 sets of loose issues of periodicals after getting duly bound have been added to stock, thus raising the stock to 28,577.

Acquisition section also helped the students and researchers by way of procuring 50 publications for their personal use.

Besides, more than 100 reprints/technical reports have been received in the library during the above period.

2. *Periodicals* : During the period under review 275 current issues of the periodicals, both foreign as well as Indian, were received in the library. Out of this number, 256 were against subscription and 19 as complimentary and exchange. 490 bound volumes of periodicals after getting loose issues duly bound have been added to the library stock.

3. *Membership and Circulation* : During the period in question 297 persons enjoyed the library membership with 175 as temporary members availing themselves of the reading facilities only, whereas 114 as permanent members availed themselves of the lending facilities, 8 Visiting Professors were also given all the lending facilities. Approximately 7767 publications were circulated during the period among the members.

Under the Inter-library Loan program, about 109 publications were lent out to the neighbouring Institutes and about 98 publications were borrowed from other libraries for use by I.S.I., Delhi Centre Library members.

4. *Reprographic Services* : Requests for providing photocopies of more than 60035 pages were received during the period and complied with. Xeroxing facilities have also been provided to outside research scholars at nominal rates for taking photocopies of the articles available in library sources.

5. *Documentation Services* : An Annual issue of 'List of Additions' listing the new books added to the stock during the period from January to December 1989 has been brought out.

6. *Other activities* : As in other years, Library Trainees with remuneration were appointed. Each trainee was given an experience certificate at the end of such training.

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### 3. Symposia, Seminars, Lectures and Conferences

Among different conferences, symposia, seminars, workshops and lectures organised by the Institute mention may be made of the following :

#### 3.1 *Symposia, Conferences, Workshops etc.*

The First Summer Course in Quantitative Economics was organised by the Economic Analysis Unit at Bangalore Centre of the Institute from May 8 to June 2, 1989. About 40 participants attended the course including around 30 research scholars and college teachers with financial support from the University Grants Commission. The focus of the programme was on Agricultural Economics, Income Distribution, Planning Techniques, General Equilibrium/Agricultural Modelling, Industry and Productivity, Poverty studies, and Regional Economics.

A UGC-sponsored Refresher Course in Statistics was held at the Indian Statistical Institute, Calcutta, during the period 12-30 June 1989, for the training of teachers at undergraduate and post-graduate level. Twenty-three applicants attended the course.

The Stat-Math Unit of ISI, Bangalore, conducted a three-week Workshop on 'The Atiyah-Singer Index Theorem' during April 10-29, 1989. About twentyfive young research workers in the area of Differential Geometry from all over India attended the workshop.

A three-week Workshop on 'Vector measures and geometry of tensor product spaces' was held in December 1989, and was attended by about ten participants. The Workshop was held at ISI, Bangalore Centre.

A four-week Summer School on Statistics was conducted by the Stat-Math Division of ISI for about 25 young college/university teachers and research scholars at ISI, Bangalore Centre, during May 15 — June 10, 1989.

A Summer School on Microcomputer-based Statistical Methods for Biologists was organised by the Indian Statistical Institute at Calcutta during 22 May — 2 June 1989. Ten participants from universities/institutes participated. The following topics were covered : Operation of IBM-PC ; Techniques of Data collection ; Summrisation of Data ; Regression Analysis ; Discriminant and Cluster Analysis ; Analysis of Variance ; Analysis of Categorical Data.

A Regional Seminar on Biomedical Library and Information System was organised by DRTC in collaboration with the National Information Centre, New Delhi, the Institute of Information Studies, Madras, and the Department of Medical Education, Government of Karnataka, at Bangalore during 19-20 June, 1989.

The 24th Annual Seminar on DRTC was held during 12-14 March 1990. The theme of the seminar was 'Information Economics'. There were 24 papers accepted for presentation in this seminar. The primary objective of this seminar was to take note of the principal economic factors associated with the secondary information work and services as practised in the different kinds of information centres. About 85 participants attended the seminar.

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The First Asian Congress on Quality and Reliability was held during 30 October - 2 November, 1989, at New Delhi under the distinguished patronage of the Prime Minister of India. Along with a few other organisations, the Institute played a leading role in hosting the Congress and in bringing out the proceedings. The theme of the Congress was "Quality for Progress and Development". The SQC and OR Division of ISI also played a major role in organising post-Congress Conferences at Bangalore and Calcutta. It is an indication of the success of the Congress that delegates expressed the view that the Asian Congress should be held regularly in future, at an interval of two or three years. The next event may be held in China.

At the request of the Regional Office of Science and Technology, UNESCO, the Institute organised a Regional Training Course on Micro-computer Based Applications of Statistical Programme Packages for Environmental Scientists of South and Central Asia, during 4-22 December 1989, at Calcutta. Twelve participants, five from India and one each from Afghanistan, Bangladesh, Iran, Mongolia, Nepal, Pakistan and Sri Lanka, participated in the training course. A special software package was developed for this course. Dr. Miron P. Derkach of UNESCO has expressed complete satisfaction with the course and has expressed a desire for having more such courses in future.

The 17th General Conference of the Indian Association for Research in National Income and Wealth (IARNIW) was organised by the Indian Statistical Institute (ISI) jointly with the Bureau of Applied Economics and Statistics, Government of West Bengal, and was held at ISI, Calcutta, during 8-10 February 1990. The Conference was intended to be inaugurated by Shri Jyoti Basu, Chief Minister of West Bengal. However, due to some urgent unforeseen engagement, he could not attend the Conference. In his absence, Dr. Asim Das Gupta, Minister of Finance, Government of West Bengal, read out his written address at the inaugural ceremony. Dr. A. K. Ghosh, Member, Planning Commission, Government of India, also attended the Conference. More than fiftyfive experts from all over the country participated in this Conference. Forty-seven papers were presented in the five sessions of the Conference.

A Workshop on Statistical Methods in Dermatoglyphics was held at ISI, Calcutta, during 1-4 February 1990. About 15 delegates participated in the Workshop including 5 from abroad (West Germany, Netherlands, Yugoslavia and Iraq).

The Planning Unit of ISI Delhi organised the Fifth ISI Conference on Economic Theory and Related Mathematical Methods, held between 8-10 January, 1990. Selected papers from the first four conferences held so far will be published in a volume.

Dr. S. R. Ranganathan's birthday (9 August 1989) is being celebrated every year by DRTC at Bangalore Centre by organising a Seminar on one or more of the contributions of Dr. S. R. Ranganathan. This year the theme of the seminar was : 'The relevance of Ranganathan's contributions in the context of the modern developments in library and Information Centres'. The leading presentation was made by Professor A. Neelamegham, Honorary Professor, DRTC. Professor G. Bhattacharyya presided over the Seminar. All other members of the DRTC faculty spoke on different aspects of the theme. About 40 participants attended the Seminar.

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A Seminar on Library Automation was held on 5 September 1989 in the Lecture Hall of DRTC at Bangalore Centre. The leading presentation was made by Dr. (Ms) Rosaling Miller, Professor, Library Media Education, Georgia State University, Atlanta, Georgia, USA. About 50 participants attended the Seminar.

*Five Laws Lectures* : This series of lectures is organised by DRTC every year in collaboration with the DRTC Alumni Association. It was held on 27th September 1989 (to mark the death anniversary of Dr. S. R. Ranganathan). The lecture series has been named after the Five Laws of Library Science enunciated by Dr. Ranganathan, which are regarded at the most seminal contribution of Dr. S. R. Ranganathan all over the world. The 1989 lecture was the 17th in the series and was held at the Institute of Information Studies, Bangalore. It was delivered by Dr. F. J. Devadason, and the theme of the lecture was 'Data Bases and CD-ROM'. About 60 participants attended the lecture.

A Seminar on Library Automation was held on 20 November 1989 at DRTC, Bangalore Centre. The leading presentation was made by Professor S. Parthasarathy, Director, Institute of Information Studies, Madras. About 55 participants attended the Seminar.

A Seminar on Knowledge-based Information Management was held on 26-27 February 1990 at DRTC, Bangalore Centre. The Seminar was based on leading presentations made by Professor David Alasdair Kemp, Information Scientist, Institute of Electrical Engineers, London. Professor Kemp's presentations covered several aspects of the theme, e.g., the objectives of information systems; consideration of user's information needs; design of the document retrieval system, and the role of the Expert Systems in this context. About 65 participants attended the Seminar.

A One-day Seminar on Taguchi Methods of Quality Engineering was organised by SQC Unit, Bangalore on 1 June 1989.

A Two-day Post Asian Congress on Quality and Reliability was organised by SQC Unit, Bangalore, alongwith other organisations during 6-7 November 1989.

A Two-day Seminar on 'How to improve the value of yarn in market' was organised by the SQC Unit, Bangalore during 13-14 March 1990.

A One-day Seminar on 'Heater Open Problem in TV Gun assembly' was organised by the SQC Unit, Bangalore on 17 March 1990.

A Three-day Symposium on Fuzzy Statistics and its applications was organised by the SQC T & P Unit, Calcutta, during 12-14 July 1989.

A One-day Symposium on Human Resources Development for Quality Improvement and Cost Reduction was organised by the SQC Unit, Hyderabad on 21 April 1989.

A One-day seminar on World Standard—Global Q Accreditation was organised by the SQC Unit, Madras on 14 October 1989.

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Five Workshops on Total Quality Management (3 of one day and 2 of two days duration) and a Symposium on Project Selection Strategy and Approaches to Improvement was conducted by the SQC Unit, Madras during the year.

### 3.2 Lectures and Seminars

The following lectures/seminars were arranged during the period :

#### *Applied Statistics, Surveys and Computing*

Shri Sukumar Ganguly (13.7.89) : 'Semiuar of Dr. B. R. Chatterjee, Director, Leprosy Field Research Unit, Jhalda, Purulia'.

Shri Pabitra Pal Chowdhury (24.4.90) : How to identify efficiently the faulty machines in an ensemble of faulty and good machines.

#### *Anthropometry and Human Genetics*

Dr. B. M. Reddy : "Workshop on Dermatoglyphic Methodology", the Workshop was held during 12-16 June 1989 at ISI. 15 scientists participated in the Workshop.

#### *Population Studies*

Dr. Moni Nag, Population Council, USA (26.4.89) : Fertility Experiences in Kerala and Punjab.

Dr. Richard Palvnoc Jones, University of East Anglia, Norwich, U. K. (12.5.89) : Minor Irrigation in Bengal some Myths and realities.

Dr. Radheshyam Bairagi, Senior Scientist, ICDDR (B) (12.7.89) : Effects or Parental Sex Preference on Child Mortality Dynamics in Rural Bangladesh.

Dr. Nisel Crook, School of Oriental and African Studies, London (11.8.89) : Effect of Social and Environmental Factors on Child Mortality—Case Study in Durgapur.

Dr. Bikas Sinha (15.3.90) : Statistical Methods for Combining Expert Opinions.

#### *Economic Research*

Dr. Madhusudan Datta, Kalyani University (19.4.89) : Measurement of the volume of services rendered by the Commercial Banks.

Dr. Sarbajit Sengupta, University of Southern California, USA (26.4.89) : Vertical Integration and Asymmetric Information.

Dr. Somdeb Lahiri, IIM, Ahmedabad (3.5.89) : Redundancy of Additional Alternative and Solutions to Bargaining Problems.

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Dr. Somdeb Lahiri, IIM, Ahmedabad (10.5.89) : Coalitional Fairness and Distortion of Utilities.

Dr. Madhusudan Datta, Kalyani University (24.5.89) : Exploration of the Growth of Distributive Trade in India, 1950-51 to 1983-84.

Dr. Somdeb Lahiri, IIM, Ahmedabad (31.5.89) : Bargaining in a Variable Population for Games with a Reference Point.

Dr. Sugata Marjit, Jadavpur University (7.6.89) : Obsolescence in a specific factor model of production with a Continuum of Capital goods.

Dr. Sharmila Banerjee, Calcutta University (14.6.89) : Dumping and Trade Policy under the Condition of Demand Uncertainty and Technological Inflexibility.

Dr. Bibhas Saha, University of Southern California, USA (5.7.89) : Wage Bargaining under Asymmetric Information.

Dr. Madhusudan Datta, Kalyani University (12.7.89) : Tertiary Sector and the Net National Product : The Indian Economy during 1950-51 to 1983-84.

Dr. Ramprasad Sengupta, Jawaharlal Nehru University, New Delhi (17.7.89) : Integrated Energy Model and Planning for the Electricity Sector.

Dr. Abhijit V. Banerjee, Princeton University (1.8.89) : Growth and Distribution.

Dr. Asant Sarkar, University of Illinois (2.8.89) : Joint Provision of Public Goods.

Dr. Prabirjit Sarkar, Bangabasi College, Calcutta (6.9.89) : Transfer Burden of Third World.

Dr. Anup Sinha, Centre for Economic Studies, Presidency College, Calcutta (13.9.89) : Economic Development, Capabilities, Conscience and Change.

Rabindranath Mukhopadhyay, ERU, ISI, Calcutta (20.9.89) : Spatial Pattern of Indian Agricultural Development : 1980-81.

Dr. Bhaswar Maitra, Centre for Economic Studies, Presidency College, Calcutta (27.9.89) : On Keynesian Equilibria in a Two Sector—Two Input Model of a Small Open Economy with Fixed and Flexible Prices.

Dr. Amita Majumdar, ERU, ISI, Calcutta (4.10.89) : Optimal Commodity Taxation in India.

Dr. Brahmachari Ananda, Ramkrishna Mission Vidyamandir, Belur (1.11.89) : Generalized Measure of Concentration.

Dr. Amit Bhaduri, Indian Institute of Management, Calcutta (15.11.89) : Macroeconomics of Social Democracy.

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Dr. Sanjoy Banerjee, Jadavpur University, Calcutta (22.11.89) : Lobbying in a Keynesian Framework.

Dr. Mihir Rakshit, Presidency College, Calcutta (6.12.89) : Trade money and Economics.

Dr. Ashok Rudra, Visva-Bharati, Santiniketan (13.12.89) : Luxury Led Growth Strategy in India.

Dr. Madhumati Dutta, New Delhi (20.12.89) : Standardization and Technical Change in 19th Century U.S. Industry with special Reference to Cotton Textiles.

Dr. Santi K. Chakrabarti, Government of Kenya (27.12.89) : Price Determination in Kenya : An Empirical Investigation.

Dr. Parkash Chauder, ISI, Delhi Centre (28.12.89) : Incentives in Public Good Economics.

Dr. Sugata Marjit, Jadavpur University, Calcutta (3.1.90) : Technology Transfer and R and D of the late Course—A Non-cooperative Framework.

Dr. Ambar Ghosh, Presidency College, Calcutta (10.1.90) : Allocation Investment between Industry and Agriculture in Developing countries.

Dr. Richard Nolan, University of New South Wales (12.1.90) : Entropy and Economics.

Dr. Ronald W. Jones, University of Rochester, U.S.A. (17.1.90) : Optimal Tariff for a Small country with a Foreign Monopolist.

Dr. Nripesh Poddar, University of New South Wales, Australia (24.1.90) : On the Measurement of Tax Progressivity.

Dr. Manas Ranjan Gupta, Jadavpur University, Jadavpur (7.2.90) : International Migration and Welfare.

Dr. Bhaswar Maitra, Centre for Economic Studies, Presidency College, Calcutta (14.2.90) : Sectoral Disparities in Unemployment Regimes : Fiscal Policy in a Dependent Economy with Multiple Inputs.

Dr. Dilip Mukherjee, ISI, Delhi Centre (24.2.90) : Decentralised Exchange and Efficiency with Moral Hazards.

Dr. Subhas C. Ray, University of Connecticut, U.S.A. and ISI, Calcutta (28.2.90) : Measuring the Rate of Technical Progress from Profit Function : An Application to U. S. Manufacturing.

Dr. Shubhashis Gangopadhyay, ISI, Delhi Centre, (7.3.90) : Simultaneous Vs. Sequential Move Price Game.



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Dr. Chiranjib Neogi, ERU ISI, Calcutta (14.3.90) : Structural Changes in Indian Industry : An Empirical Study of Private Corporate Sector, 1951-1980.

Dr. Robin Mukherjee, ERU, ISI, Calcutta (21.3.90) : Some observations on the Development of Small Scale Industries in India.

Dr. Nityananda Sarkar, ERU, ISI, Calcutta (28.3.90) : On Linear Regression Models with Multicollinearity—An Approach Combining Sample and Non-Sample Information.

#### *Economic Analysis (Bangalore)*

Professor P. R. Brahmaunda, ICSSR National Fellow and Honorary Visiting Professor, ISI, Bangalore Centre (8.9.89) : A Report on the recent International Economic Congress, Athens, Greece.

Dr. A. Vaidyanathan, Madras Institute of Development Studies, Madras (21.9.89) : Current Research in Irrigation and Agriculture.

Professor N. S. Iyengar, Economic Analysis Unit, ISI, Bangalore Centre (9.11.89) : Asymptotic Variance for Iyengar's Elasticities—Two Examples.

Dr. P. Gajapathi, Economic Analysis Unit, ISI, Bangalore Centre (23.11.89) : Statistical Methods in Kalecki's Theory of Economic Dynamics.

Professor Charles Lindblom, Yale University, USA, (27.11.89) : The Present State of American Democracy.

Professor N. S. S. Narayana and Ms. B. P. Vani, Economic Analysis Unit, ISI, Bangalore Centre (14.12.89) : Determinants of Consumer Expenditure.

Mr. N. Balasubramanian, Economic Analysis Unit, ISI, Bangalore Centre (28.12.89) : Workers' Savings in Kaleckian Framework.

Dr. Pulapre Balakrishnan, Madras Institute of Development Studies, Madras (26.12.89) : Industrial Price Behaviour in India—An Error Correcting Model.

Dr. V. Rajendra Prasad, SQC & OR Unit, ISI, Bangalore Centre (11.1.90) : Time-Cost, Trade-off in Transportation Problem.

Dr. M. R. Narayana, CSIR Pool Officer, Economic Analysis Unit, ISI, Bangalore Centre (25.1.90) : A Method for Estimating Welfare Gains from Fiscal Equalisation in a Two-Region Federal Economy.

Professor U. L. Gouranga Rao, Dalhousie University, Canada (7.3.90) : Estimation from Undersized Samples : A Monte Carlo Study.

In addition to the above Professor S. Bose, Economic Analysis Unit, ISI, Bangalore, Centre gave a series of twelve bi-weekly lectures from August 16, 1989 on the Economics of Kalecki.

**FIFTYEIGHTH ANNUAL REPORT : 1989-90**

***Statistical Quality Control and Operation Research***

Shri K. A. Anand : Gave a seminar on 'Quality Management' at Kirloskar Brothers.

Shri M. V. Lakmansamy (17.11.89) : Packaging QC criteria for sampling and sampling plan for Variables and Attributes.

Sri K. G. Ramamurthy (10.7.89) : Use of social choice theory for some problems of reliability.

Shri V. Gopalan (10.7.89) : A Case of Regression Analysis for evaluations of Energy Saving.

Sd. Md. Ibrahim (11.7.89) : Analysis of Process Capability through Experimental Design and Regression.

Shri R. Sett (11.7.89) : Evaluation of Testing facilities for receiving target production of Locomotives.

Shri S. Adhikary (11.7.89) : Development of Strategy for selected Assembly of Ball-bearing and Estimation of Size-wise requirement of balls through simulation.

Shri S. A. Bandyopadhyay and T. K. Dutta (11.7.89) : Regression Compiler.

Shri A. Majumdar (11.7.89) : Mixture design software and its application.

Shri S. A. Bandyopadhyay and S. Adhikari (11.7.89) : Statistical Graphics.

Shri A. Bandyopadhyay (11.7.89) : Quality information system for Incoming material.

Shri T. K. Chakraborty (14.7.89) : Services for Management decision.

Dr. S. K. Bhatta (23.11.89 and 27.11.89) : (i) Mathematical Programming, (ii) OR Education in North America.

Dr. P. K. Dey (21.3.90) : Project Management and Net Present Worth.

Shri Arup Das (25.8.89) : Control of Rejection in chrome plating shop.

Shri S. M. Subhani (12.3.90) : Bulk Sampling.

Shri A. L. N. Murthi (26.2.90) : Mr. Phadke's treatise on Quality Engineering.

Shri A. K. Chakraborty (1.9.89) : The role of Software Reliability in Software Engineering.

Dr. T. S. Arthanari : Flow Shop scheduling with special reference to Amenable cases.

--- : Simulated Annealing—Its Applications in Parametric Design.

## INDIAN STATISTICAL INSTITUTE

### 4. PUBLICATIONS

The following publications were brought out during April 1989-March 1990 :

(i) Sankhya : The Indian Journal of Statistics and the official organ of the Indian Statistical Institute.

Series A : Vol. 51, Parts 2 & 3

Series B : Vol. 51, Parts 1, 2, 3

(ii) Twentyeight technical reports from the Statistics-Mathematics Group have been issued during the period.

(iii) Selected Papers of Professor C. R. Rao., Volume I & II.

### 5. SCIENTIFIC PAPERS AND PUBLICATIONS

#### SCIENTIFIC PAPERS PUBLISHED

##### Theoretical Statistics and Mathematics

Calcutta

1. Bagchi, B. (with Bagchi, S.) (1989) : Designs from pairs of finite fields—I, cyclic unital  $U(6)$  and other regular Steiner 2-designs. *J. Combin. Theory, A*, 52, 51-61.
2. --- (with Sastry, N. S. N.) (1989) : Intersection pattern of the classical ovoids in symplectic 3-space of even order. *J. Algebra*, 126, 147-160.
3. Bhandari, S. K. (1989) : Selecting the  $l$ -best cells in a multinomial distribution. *Communications in Statistics (Theory & Math.)*, 18(9), 3313-3326.
4. Chandra, T. K. (1989) : A stochastic representation of logarithms of  $P$ -values and related results. *Sankhyā, A*, 51, 205-211.
5. --- (1989) : Multidimensional Polya's theorem. *Bull. Cal. Math. Soc.*, 81, 227-231.
6. Das, Ashish (with Dey, A.) (1989) : A note on balanced block designs. *J. Statist. Plann. Inf.*, 22, 265-268.
7. --- (with Dey, A.) (1989) : On some  $E$ -optimal block designs. *Metrika*, 36, 269-278.
8. --- (with Dey, A.) (1989) : A generalization of systems of distinct representatives and its applications. *Cal. Stat. Assn. Bull.*, 38, 57-63.
9. --- (with Dey, A.) (1990) : Optimality of row-column designs. *Cal. Stat. Assn. Bull.*, 39, 63-72.
10. --- (with Dey, A.) (1990) : A note on construction of Gracco-Latin square of order  $2n+1$ . *Jour. Ind. Soc. Agril. Stat.*, 42, 247-249.

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11. Dasgupta, R. (1989) : Some further results on nonuniform rates of convergence to normality. *Sankhya* (A) 51(2), 114-167.
12. Das Gupta, S. (with Kunte S. and Rattihalli, R. A.) (1989) : Fixed Volume Parallelopiped of maximum probability content. *Jan. Indian Statist. Assn.*
13. Goswami, A. (1989) : On a martingale representation theorem of M. H. A. Davis—a Markovian approach. *Stochastic and Stochastic Reports*, 28, 3.
14. ——— (1989) : On a conjecture of Frank B. Knight—two characterisation results related to prediction processes. *Seminaire de Probabilités*, Strasburg, XXIV.
15. Mukherjee, Rahul (1989) : Third-order comparison of unbiased tests : a simple formula for the power difference in the one-parameter case. *Sankhya* (A) 51, 212-232.
16. ——— (with Huda, S.) (1989) : *D*-optimal measures for fourth-order rotatable designs, *Statistics* 20, 353-356.
17. ——— (with Sengupta, S.) (1989) : Optimal estimation of finite population total under a general correlated model. *Biometrika*, 76, 789-794.
18. ——— (with Gupta, S.) (1989) : Efficient non-equireplicate designs obtained by merging treatments. *Computational Statistics and Data Analysis* 8, 29-37.
19. Mukherjee, Rahul (1990) : Optimality of balanced designs for minimum norm quadratic unbiased estimation of variance components. *Metrika* 37, 181-188.
20. Narasimha Sastry, N. S. (with Misra, G.) (1980) : On completely bounded modules. *J. Functional Analysis*, 91, 213-220.
21. ——— (with Misra, G.) (1990) : Bounded modules, extremal problems and a curvature inequality. *J. Functional Analysis*, 88, 118-134.
22. Roy, A. K. (with Rao, T. S. S. R. K. and Sunderssen, K.) (199) : Intersection properties of balls in tensor products of some Banach spaces. *Mathematics Scandinavica*, 64, 2.
23. Saha Roy, R. (1989) : Optimality of some block designs, *Cal. Stat. Assn. Bull.*, 187-194.
24. Samanta, T. (1989) : Local asymptotic minimax estimation in non-regular cases. *Sankhya* (A) 51, 3.
25. Sinha, B. K. (with Sengupta, A. and Goswami, A.) (1990) : Optimal strategies in sampling from a social network. *Sequential Analysis*, 9, 1-18.
26. ——— (with Mukherjee, R.) (1990) : Almost saturated *D*-optimal main effect plans and allied results. *Metrika*, 37, 301-307.
27. Tripathi, T. P. (1988) : A generalized method of estimation in double sampling. *J. Indian Stat. Assn.*, 26, 91-101.
28. ——— (with Singh, H. P. and Upadhyay, L. N.) : Improved estimators for population mean based on double sampling. *J. Indian Stat. Assn.*, 27, 89-99.

**INDIAN STATISTICAL INSTITUTE**

Delhi

1. Balasubramanian, K. (with Beg, M. I.) (1990) : Distributions determined by conditioning on simple order statistics. *Metrika*, 37, 1, 37-43.
2. Bhatia, Rajendra (with Holbrook, J. A. R.) (1989) : A softer, stronger Lidskii theorem. *Proc. (Mathematical Sciences) Ind. Acad. Sci.*, 99, 75-83.
3. ——— (with Choi, M. D. and Davis, G.) (1989) : Comparing a matrix to its off-diagonal part. *Operator Theory : Adv. Applics.*, 40, 151-164.
4. ——— (1990) : On the singular values of a product of operators. *SIAM Jour. Matrix Analysis Applics*, 11, 272-277.
5. Dey, A. (with Das, A.) (1989) : A note on balanced block designs. *J. Statist. Plann. Inf.*, 22, 265-268.
6. ——— (with Nguyen, N. K.) (1989) : Computer-aided construction of  $D$ -optimal  $2^m$  fractional factorial designs of resolution V. *Austral. J. Statist.*, 31, 111-117.
7. ——— (with Das, A.) (1989) : On some  $E$ -optimal block designs. *Metrika*, 36, 269-278.
8. ——— (with Das, A.) (1989) : A generalization of distinct representatives and its applications. *CSA Bull.*, 38, 57-63.
9. Karandikar, R. L. (with Dettaan, L.) (1989) : Embedding a stochastic difference equation into a continuous time process. *Stochastic Processes and their applications*, 32, 225-235.
10. ——— (1989) : On Metivier pellumail inequality, Emery topology and Pathwise formulae in Stochastic Calculus. *Sankhyā (A)* 51, 121-143.
11. ——— (with Horowitz, J.) (1989) : Martingale Problems associated with the Boltzman equation. *Sem. Stochastic Processes (E. Cinlar et. al. eds.)*, Birkhauser, Bosten, 75-122.
12. Mitra, S. K. (1989) : Block Independence in generalized inverse : a coordinate free look. *Statist. Data Analysis Inf. (Y. Dodge, Ed.)*, North Holland, Amsterdam, 429-443.
13. Parthasarathy, K. R. (with Lindsay, J. M.) (1989) : Cohomology of power sets & applications in quantum probability. *Commun. Math. Phys.*, 124, 337-364.
14. ——— (1989) : Quantum Ito's formula. *Rev. Math. Phys.*, 1, 89-112.
15. ——— (1989) : A remark on spin correlations. *Sankhyā (A)* 51, 192-195.
16. Parthasarathy, T. (with Sinha, S.) (1989) : Existence of stationary equilibrium strategies in nonzero sum discounted stochastic games with uncountable state space and state independent transitions. *Int. J. Game Theory.*, 18, 189-194.
17. Ramachandran, B. (1989) : Two remarks on vague convergence. *Sankhyā (A)* 51, 2, 233-235.
18. Prakasa Rao, B. L. S. (with Kulperger, R. J.) (1989) : Bootstrapping a finite state Markov chain. *Sankhyā (A)* 51, 178-191.

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19. Sinha, K. B., (with Accordi, L.) (1989) : Stop-time Algebras. In *QP IV Voh*, LNM, Springer Verlag, 1396.

Bangalore

1. Misra, Gadadhar (with Sastry, N. S. N.) (1990) : Bounded modules, Extremal problems and a Curvature Inequality. *J. Funct. Analysis*, 88, 118-134.
2. Nag, Subhashis (1989) : Canonical measures on the moduli spaces of compact Riemann surfaces. *Proc. Amer. Math. Soc.*, 99, 2, 103-111.
3. --- (with Verjovsky, A.) (1990) : Diff ( $S^4$ ) and the Teichmuller spaces. *Commun. Math. Phys.*

Applied Statistics Surveys and Computing

1. Bagchi, Sunanda (with Bagchi, B.) (1990) : Designs from pairs of finite fields. A cyclic unital U(6) and other regular Steiner 2-designs. *J. Comb. Theory (A)*, 52, 51-61.
2. --- (with Shah, K. R.) (1989) : On the optimality of a class of row-column designs. *J. Statist. Plan. Inf.* 23, 397-402.
3. Ganguly, Sukumar (with Sarkar, Samir Kumar, Atanu Bhattacharya and Subrata Kumar Basu (1989) : Study on genetic marker enzyme (LDH) in different inland and exotic carps. *Jour. Ecobio.*, 1, 56-65.
4. --- (1989) : Tissue specific isozymes of lactate dehydrogenase in some tissues of *Channa Punctatus* (Bloch). *Jour. Ecobio.*, 1, 51-55.
5. --- (1989) : Lactate dehydrogenase as genetic marker isozyme in fish *Tilapia mossambica*. *Ind. J. Experimental Bio.*, 27, 913-914.
6. Gupta, Sanjib Kumar (with Roy, Sampra) (1989) : Immunological response in young insulin dependent malnutrition related diabetic patients. *Ind. J. Physiology and Allied Sci.*, 43, 16-19.
7. Krishnan, T. (with Katre, U. A.) (1989) : Pattern recognition with imperfect supervisor. *Patt. Recogn.*, 22, 423-431.
8. Majumder, Partha Pratim (1989) : On the genetics of prelingual deafness. *Am. J. Hum. Genetics*, 44, 86-99.
9. --- (1989) : Strategies and sample size considerations for mapping a two-locus autosomal recessive disorder. *Am. J. Hum. Genetics*, 44, 412-423.
10. --- (1989) : Anthropometric variation in India : A statistical appraisal. *Current Anthropol.*, 31, 94-103.
11. Pal, Monoranjan (with Vasulu, T. S.) (1989) : Size and shape components of anthropometric differences Among the Yanadis. *Ann. Hum. Bio.*, 16, 449-462.

The Computer and Statistical Service Centre (CSSC)

1. Nandy, Subhas (with Sarkar, S. S. & Chatterjee, A.) (1989) : Cluster Analysis Revisited : A case study from Bihar Mica Belt Granites, Eastern India. *Indian Minerals*, 43, 2, 128-135.

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2. ——— (with Chatterjee, A., Sarkar, S. S. and Saha, A. K.) (1989) : A Quadratic Programming Approach for solving Petrological Mixing Problem. *Ind. J. Earth Sci.*, 16, 2.

Physical and Earth Sciences

*Chemistry*

1. Ghosal, D. N. (with Bhattacharyya, K.) (1989) : Cation exchange capacity of soils as a function of soil texture and organic matter. *Indian, Agric.* 33(3), 171-177.

*Electronics*

A. *Digital System Research*

1. Deogun, J. S. (with Bhattacharya, B. B.) (1989) : Via minimization in VLSI Routing with Movable Terminals'. *IEEE Trans. on Computer-aided Design, CAD-8*, 8, 917-920.
2. Bhattacharya, B. B. (with Seth, S. C.) (1989) : Design of parity testable combinational circuits. *IEEE Trans. on Computers*, C-38, 1580-1584.

B. *Theoretical Physics*

1. Bandyopadhyay, P. (with Bhattacharya, B. and Ghosh, P.) (1989) : Stochastic Field Theory at Finite Temperature and Equilibrium States in Quantum Statistical Mechanics. *J. Math. Phys.* 30, 1359.
2. ——— (with Ghosh, P.) (1989) : Twistor Geometry, Spinor Structure and Nature of Superspace. *Int. J. Mod. Phys. A.* 4, 1111.
3. ——— (with Ghosh, P.) (1989) : Extended Conformal Group, Supersymmetry and Geometrical Properties of Hadrons. *Int. J. Mod. Phys.*, A. 4, 3791.
4. ——— (with Ghosh, P.) (1989) : A Lie Group Framework for Composite Particles and Harmonic Oscillator Mass Spectrum. *Int. J. Mod. Phys. A.* 4, 4069.
5. Bandyopadhyay, P. (with Ghosh, P.) (1989) : Holomorphic Quantum Mechanics, Conformal Reflection and the Internal Symmetry of Hadrons. *Int. J. Mod. Phys. A.* 4, 4449.
6. ——— (with Ghosh, P. and Hajra, K.) (1989) : Stochastic Field Theory, Holomorphic Quantum Mechanics and Supersymmetry. *J. Math. Phys.* 31, 212.
7. ——— (with Mahalanobis, J.) (1989) : Some Remarks on the Anomalous Nuclear Enhancement in large Transverse Momentum Hadron Production. *Phys. Rev. C*.
8. ——— (with Roy, A.) (1989) : Topological Aspects of a Fermion and Chiral Anomaly. *J. Math. Phys.* 30, 2366.
9. Bhattacharyya, S. (1990) : Properties of hadronic interactions at high energies and the nature of the cosmic muon charge ratio. *Phys. Rev. D* 41(3), 863.

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10. ——— (with Das Ghosh, A. C.) (1989) : New Tangles in TeV physics : an outline and some comments. *Nuovo Cimento*. 12C(4), 501.
11. Hajra, K. (1989) : Equivalence of Stochastic and Hydrodynamical Quantization. *Int. J. Mod. Phys. A*, 4, 3163.
12. ——— (1989) : Stochastic Interpretation of Position-Momentum Uncertainty Relation. *Mod. Phys. Lett. A*, 4, 1460.
13. Roy, P. (with Roy, B. and Roychoudhury, R. K.) (1989) : Partial algebraization of spectral problems and supersymmetry. *Phys. Lett. A*, 139, 427.
14. Roy, P. (with Roychoudhury, R. and Sengupta, Manasi) (1989) : Gaussian approach to finite temperature  $\phi^4$  theory a curved space. *J. Phys. Class Quantum Gravity*, 6, 2037.
15. Roy, P. (with Roychoudhury, R. and Varshni, Y. P.) (1989) : Gaussian approach to sine-Gordon theory at finite temperature. *J. Mod. Phys. A. Lett.* 4, 2031.
16. Roychoudhury, R. (with Sengupta, Manasi) (1989) : Gaussian approach to  $(1+1)$  dimensional solitons at finite temperature. *Z. Naturforschung*, 44a, 524.
17. ——— (with Varshni, Y. P.) (1989) : Relativistic  $1/N$  expansion for the Dirac Equation. *Phys. Rev. A*, 39, 5523.

C. *Fluid Mechanics*

1. Danda, et. R. S. (1989) : On the nonlinear stability of Ekman boundary layer on a porous plates. *Bull. Cal. Math. Soc.* 81, 270-277.
2. ——— (with Gupta, A. S.) (1989) : Flow and heat transfer in a viscoelastic fluid over a stretching sheet. *Int. J. Nonlinear Mechanics*, 24, 215-219.
3. Mandal, B. N. (1989) : 'A note on Havelock's generalization of Fourier cosine expansion. *Int. J. Math. Educ. Sci. Technol.* 20(1), 179-181.
4. ——— (1989) : 'A note on Havelock's cylindrical wave maker problem'. *Revue Roumaine des Sci. Techniques Mecanique Appliquee*, 34(2), 185-190.
5. Mandal, B. N. (1989) : 'On some relevance of the contribution of B. B. Datta in Applied Mathematics'. *Ganit Chartram*, 8(1) & (2), 79-80 (in Bengali).
6. ——— (with Chakrabarti, A.) (1989) : 'A note on diffraction of water waves by a nearly vertical barrier'. *IMA j. Appl. Math.* 43, 157-165.
7. ——— (with Ghosh, N. K.) (1989) : 'Waves generated by disturbances at an inertial surface in an ocean of finite depth'. *Proc. Ind. Nat. Sci. Acad.* A55(6), 908-911.
8. ——— (with Kundu, Krishna) (1989) : 'A note on the cylindrical wave maker problem in a liquid with an inertial surface'. *Int. J. Engg. Sci.*, 27(4), 483-488.
9. ——— (with Kundu, Krishna) (1989) : 'A cylindrical wave maker in a liquid of finite depth with one inertial surface'. *Ind. J. Pure Appl. Math.* 20(5), 505-512.
10. ——— (with Kundu, P. K.) (1989) : 'Transmission of obliquely incident surface waves through a narrow gap'. *Int. J. Math. Math. Sci.* 12(4), 741-748.



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11. ——— (with Kundu, P. K.) (1989) : 'Incoming water waves against a vertical cliff in an ocean'. *Proc. Ind. Nat. Sci. Acad.* A55(5), 649-660.
12. ——— (with Kundu, P. K.) (1990) : 'Diffraction of water waves by a nearly vertical plate'. *SIAM J. Appl. Math.* 50(5).
13. ——— (with Kundu, P. K.) (1990) : 'Incoming water waves against a vertical cliff'. *Appl. Math. Lett.* 3(1), 33-36.
14. ——— (with Mukherjee, S.) (1989) : 'Water waves generated at an inertial surface by an axisymmetric initial surface disturbance'. *Int. J. Math. Educ. Sci. Technol.* 20(5), 743-747.
15. Mandal, B. N. (with Phaujdar, S.) (1989) : 'A note on inventory models with stock dependent consumption rates'. *OPSEARCH*, 26(1), 43-46.
16. ——— (with Phaujdar, S.) (1989) : 'An inventory model for items with variable rate of deterioration and stock-dependent consumption rate'. *J. Operational Res. Soc.* 40(5), 483-488.
17. ——— (with Phaujdar, S.) (1989) : 'Some EOQ models under permissible delay in payments'. *Int. J. Management and Systems.* 5(2), 99-108.

#### Electronics and Communication Sciences

1. Biswas, S. N. (with Chaudhuri, B. B. and Dutta Majumder, D.) (1989) : A new and efficient method for curve drawing using circular arcs and straight line segments. *JIETE*, 6(5).
2. Chaudhuri, B. B. (with Uma Sankar, B.) (1989) : An efficient algorithm for extrema detection in digital images. *Patt. Recog. Lett.*
3. ——— (with Shiller, H.) (1989) : A color video image coder at 64 kbits for picture telephony. *JIETE*.
4. ——— (with Shiller, H.) (1990) : Efficient coding of side information in a low bit rate hybrid image coder. *Signal Processing*.
5. ——— (1990) : An efficient algorithm for running window pel gray level ranking. *Patt. Recog. Lett.*
6. Das, J. (with De, A. K. and Dutta Majumder, D.) (1989) : VHF propagation characterization during atmospheric disturbances. *Int. J. Remote Sensing*.
7. Datta, A. K. (1989) : Manner-based phonetic levelling of speech signal from amplitude information. *J. Acous. Soc. India*, XVII (3-4), 319-322.
8. ——— (with Ganguli, N. R. and Mukherjee, B.) (1989) : Bengali nasal sounds : A spectrographic study. *J. Acous. Soc. India*, XVII (1-2), 219-223.
9. ——— (with Shidhar, R.) (1989) : Manner-driven ambiguity directed organisation for large lexicon. *J. Acous. Soc. India*, XVII (3-4), 323-326.
10. De, A. K. (with Ganguli, A., Dutta Majumder, D. and Das, J.) (1989) : Application of acoustical techniques in sensing atmospheric boundary layer. *J. Acous. Soc. India*, XVII (3-4), 265-268.

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11. ——— (with Ganguli, A., Dutta Majumder, D., Das, J. and Sen, A. K.) (1990) : Sodar structures of inversion characteristics over Calcutta. *Ind. J. Phys.* 645(4), 22-23.
12. Dutta Majumder, D. (1989) : Neural network modelling for speech and other pattern recognition problems. *J. Acous. Soc. India*, XVII (3-4), 49-57.
13. ——— (with Chanda, B. and Mali, P. C.) (1989) : Mathematical tools for image restoration and data compression. *JITEE*, 35(2), 120-135.
14. Ganguli, N. R. (with Kundu, R. and Mukherjee, B.) (1989) : Acoustical and perceptual study. *J. Acous. Soc. India*, XII (3-4), 327-330.
15. Ray, S. (1989) : On a theoretical property of the Bhattacharyya co-efficient as a feature evaluation criterion. *Patt. Recog. Lett.* 9(6), 315-319.
16. Ray, S. (1989) : On looseness of error-bounds provided by the generalized separability measure of Lissac and Fu. *Patt. Recog. Lett.* 9(6), 321-325.
17. Ray, K. S. (with Dutta Majumder, D.) (1990) : Recognition and positioning of partially occluded 3D objects. *Patt. Recog. Lett.*

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1. Bandyopadhyay, S. (1989) : The mammal-like reptile *Rechnisaurus* from the Triassic of India. *Palaeont.* 32(2), 305-312.
2. Chaudhuri, A. K. (with Dasgupta, S. and Fukuoka, M.) (1990) : Compositional characteristics of glauconitic alterations of K-feldspar from India and their implications. *Jour. Sedim. Petrol.*, 60, 277-281.
3. ——— (with Dasgupta, S. and others) (1989) : Stratigraphy of the Penganga Group around Adilabail, Andhra Pradesh. *Jour. Geol. Soc. Ind.*, 34, 291-302.
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*Physics*

1. Gupta, A. B. (1990) : Skin friction : A simple device for measurement. *IADV and L Abstract*, 18(8).
2. ——— (1990) : Hygroscopicity and water-holding capacity of ichthyotic skin. *IADV and L Abstract*, 18(12).
3. ——— (with Mukherjee, Soma) (1989) : Age-related changes in thermal sensory thresholds of skin. *Ind. J. Dermatol. Venereol. Leprol.*, 55, 290-293.
4. ——— (with Mukherjee, Soma) (1989) : Responses to thermal stresses in psoriasis of hand. *Ind. J. Dermatol. Venereol. Leprol.*, 55, 25-29.

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5. Mukherjee, Soma (with Gupta, A. B.) (1989) : Iontophoretic treatment of hyperkeratosis with sodium salicylate. *Ind. J. Dermatol. Venerol. Leprol.*, 55, 22-24.

## BIOLOGICAL SCIENCES

### Agricultural Sciences

1. Bagchi, D. K. (with Banerjee, A. and Sasmal, B.) (1989) : Studies on plant growth and pod development in winged bean, *Psophocarpus tetragonolobus* (L.). *Tropical Agriculture*, (U. K.), 66(3), 240-242.

### Anthropometry and Human Genetics

1. Bharati, P. (1989) : Variation in adult body dimensions in relation to economic condition among the Mahishyas of Howrah district, West Bengal. *India. Ann. Hum. Biol.* (London), 16, 529-541.
2. Ghosh Dastider, M. (with Gupta, R.) (1989) : Age changes in anthropometric characters among the Sherpas of the eastern Himalaya : Altitude effect. *Jour. Ind. Anthropol. Soc.*, (Calcutta), 23, 232-241.
3. Karmakar, B. (with Malhotra, K. C. and Narain, P.) (1989) : Palmar dermatoglyphic distance analysis among 20 Dhargar castes of Maharashtra, India. *Anthropologie*, 27., 13-27.
4. Majumder, P. P. (with Uma Sankar, B., Basu, A., Malhotra, K. C., Gupta, R., Mukhopadhyay, B., Vijayakumar, M. and Roy, S. K.) (1989) : Anthropometric variation in India. *Current Anthropol.* (Chicago), 31, 94-103.
5. Malhotra, K. C. (with Karmakar, B. and Narain Prem) (1989) : Palmar dermatoglyphic distance analysis among 20 Dhargar castes of Maharashtra India. *Anthropologie*, 27(1), 13-28.
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