

INDIAN STATISTICAL INSTITUTE

FIFTYFOURTH ANNUAL REPORT

April 1985—March 1986



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INDIAN STATISTICAL INSTITUTE

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

1. TEACHING AND TRAINING

A brief account of teaching and training activities of the Institute is given below :

Degree and Training Courses

During the period under review, 7068 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, One year Post-Graduate Diploma in SQC and OR, 2-year part-time Post-Graduate Diploma in SQC and OR (Bombay and Madras), Research Fellowships in Statistics, Mathematics, Economics, Electronics, Electronics and Communication Sciences, Physics 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 12 centres all over the country. A total of 3913 candidates appeared for the admission tests and a total of 379 candidates were called for interviews for final selection for admission to various courses during the academic session 1985-86.

There were two foreign applicants who applied directly for admission to our courses. The candidates were given special admission tests conducted through the Indian High Commission or Embassies at France and Ghana. They did not, however, qualify for admission.

Two separate sections for the M.Stat. Course, 1st year, were started in Calcutta in 1985-86 for those having Mathematics and Statistics respectively as the main subject in the Bachelor's degree.

The annual examinations for B.Stat. and M.Stat. courses were held in May/June 1985. The 1985-86 academic session commenced on 8 July 1985.

One hundred thirty three candidates received their degrees and diplomas at the Twentieth Convocation of the Institute held on 10 December 1985. One hundred thirty one candidates who passed various regular courses of varying duration (one year or less) received the certificates during the year. Three candidates of the Institute were awarded the Ph.D. degree of the Indian Statistical Institute. Seven Ph.D. theses were submitted to the Institute/other universities during the period.

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The One-year certificate course on Operation of Automatic Data Processing Equipment was upgraded to two years and the course content was revised. The course title was changed to certificate and diploma courses on Operation and Programming of Automatic Data Processing Equipment. This decision of the Council is being given effect to from the academic year 1986-87.

Three UNDP fellows from Sierra Leone have undergone special training courses for 10 months during the period. Three Afghan UNDP fellows had undergone a short orientation course in Demography and Sampling. One UNDP fellow from Nigeria undertook research work in Statistics during the period from March 1985 to February 1986.

Three trainees in Engineering from Banaras Hindu University and two trainees from Jadavpur University received six-week practical training in the Electronics and Communication Sciences Unit and the Electronics Unit.

The number of candidates admitted to the different degree, diploma and training courses during 1984-85 and 1985-86 and the results of the examinations held during the period are given in the following pages.

International Statistical Education Centre (ISEC), Calcutta

The centre was opened in 1950 and is operated jointly by the International Statistical Institute and the Indian Statistical Institute, under the auspices of the UNESCO and the Government of India. The Centre provides training in Theoretical and Applied Statistics at various level to select participants from the countries in the Middle-East, South and South-East Asia, the Far East and from the Commonwealth countries in Africa.

The Centre functions under a joint Board of Directors. Directors represent International Statistical Institute, Indian Statistical Institute and the Government of India. Professor P. C. Mahalanobis was the Chairman of the Board of Directors since its inception in 1950 until his death in 1972. Since then Professor C. R. Rao has been the Chairman of the Board.

Major training programme of the Centre is a 10-month Regular Course. In addition, Special Courses of varying duration are also organised. Facilities exist for research work and advanced study by senior visiting statisticians from abroad. Since inception, the Centre has provided training to 1031 trainees from 52 countries.

The last convocation was held in 1983 at the end of 36th term. During 1983-84, the process of replacing the Certificate of Merit by a Diploma started. Approval was obtained at the end of 38th term and the Certificate of Merit was renamed as Statistical Training Diploma. Twenty-seven trainees, from 13 countries, of the 37th term and 27 trainees, from 13 countries, of the 38th term received Statistical Training Diploma.

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NUMBER OF STUDENTS ADMITTED AND PASSING IN DIFFERENT COURSES

Courses	No. of students					Number passed in annual exam. in 1985
	1984-85		1985-86		Approved at the annual exam. in 1985	
	Enrolled	As in Nov. '84	Enrolled	As in Nov. '85		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. <i>Course leading to a Degree in Statistics :</i>						
1.1 Bachelor of Statistics with Honours (B.Stat. (Hons.))						
1st year	29	14	31	18	12	12
2nd year	14	14	12	12	11	11
2nd year	14	13	12	12	14	13
1.2 Master of Statistion (M.Stat.)						
1st year	27	25	31	30	19	19
2nd year	26*	26	20	20	26	26
1.3 Junior and Senior Research Fellows, Visiting Fellows/Research Associates	80	73	71*	71	—	—
2. <i>Specialised Courses in Applied Statistics leading to Diploma</i>						
2.1 Statistical Quality Control and Operatives Research (One-year)	25	16	14	13	15	14
2. <i>Courses in Statistics for persons in Employment (Jointly with C.S.O.)</i>						
2.1 Junior Certificate Course in Statistics	16	16	11	11	16	15
2.2 Indian Statistical Service Probationers' Training Course	34	34	30	30	34	34
4. <i>Evening Course</i>						
4.1 Statistical Methods and Applications (One-year)						
Calcutta	50	20	31	26	18	18*
Delhi	—	—	—	—	—	1*
4.2 Two-year Post-graduate Diploma in Statistical Quality Control and Operatives Research (Bombay and Madras)						
Bombay—1st year	++	++	5	5	++	—
2nd year	5	5	++	++	5	4
Madras—1st year	17	13	10	10	12	12
2nd year	12	12	13	13	12	11
4.3 Six-month Evening Course in Statistical Quality Control (Bangalore and Hyderabad)						
Bangalore : July-Dec. 1984	25	0	—	—	0	7
Jan-June 1985	15	15	—	—	0	4
Hyderabad : July-Dec. 1984	30	30	—	—	7	—
Jan-June 1985	24	24	—	—	7	5
5. <i>Electronic Computer Courses</i>						
5.1 M.Tech. in Computer Science :						
1st year	16	16	13	13	16	16
2nd year	18	18	13	13	17	15
5.2 M.Tech. by dissertation	—	—	—	—	—	5
5.3 Introductory Course on Programming and Applications	35	35	36	36	27	35
5.4 Course on Operation of Automatic Data Processing Equipments	9	9	13	13	8	8
6. <i>Associationship in Documentation and Information Science</i>	8	8	9	9	+++	35****
Total	531	445	384	364	296	321

Note : Blank space in some cols. above indicate that the corresponding figure are not readily available.

*including number continuing from previous year.

** no students was admitted in 1984-85 (1st year) and 1985-86 (2nd year)

*** results of batchwise 1978-80, 1979-81, 1980-82 and 1981-83.

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A total of 53 candidates from 23 different countries were recommended by respective National Selection Committees for admission to the Regular Course, of them 33 were offered admission and 32 from 17 countries joined. Twenty-three trainees were supported by fellowships awarded by the Government of India under the Technical Cooperation Scheme of the Colombo Plan, Special Commonwealth African Assistance Plan, and Indian Technical and Economic Cooperation Scheme. Remaining 9 trainees received support from agencies of the United Nations, respective employers and governments.

Five trainees from 3 countries were offered admission to Special Courses during 1985-86. Four trainees from 2 countries, who had completed the 38th term of the Regular Course, joined. Two of them continued receiving fellowship awarded by Government of India and the other 2 from Commonwealth Fund for Technical Co-operation.

A micro-computer acquired during this year with financial assistance from the International Statistical Institute, the Indian Statistical Institute, and the Applied Probability Trust has been used for training, particularly, those who specialized in Data Processing.

Forty-one staff members of the Indian Statistical Institute at Calcutta and 43 Statistical Officers of the Government of India participated in teaching during the year. In addition, there were 3 guest speakers.

All 4 Special Course trainees completed their training. Of the 32 Regular Course trainees, 3 have been recommended for the award of Diploma and the remaining 2 for Certificate of Attendance.

Professional Examinations in Statistics

The holding of Professional Examinations in Statistics for external candidates on an all-India basis has been an important activity of the Institute since 1938. These examinations are based on well organised syllabi to reach high professional standards and lead to Certificates and Diplomas.

During the period under report, the Statistical Assistantship Certificate, Junior Diploma in Statistics and Senior Diploma in Statistics examinations were held at Bangalore, Bombay, Calcutta, Delhi, Hyderabad, Lucknow and Madras centres during April 1985 and at Bangalore, Calcutta, Delhi and Madras during October 1985 terms respectively.

The total number of candidates and their results for April and October 1985 terms of the examinations are shown below.

examinations	number of candidates					
	registered		appeared		passed	
	April	October	April	October	April	October
Statistical Assistantship Certificate	18	29	9	11	4	7
Junior Diploma in Statistics	37	32	24	19	5	5
Senior Diploma in Statistics	9	10	7	7	5	3

*passed in one or more papers only—not necessarily completed the examination.

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The total number of candidates who have qualified for the award of Certificates and Diplomas in the Professional Examinations in Statistics including the results of October 1985 term are 476 and 239 respectively.

2. RESEARCH WORK

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

Theoretical Statistics and Mathematics

Calcutta : The Division of Theoretical Statistics and Mathematics bears the bulk of the teaching of theoretical statistics and mathematics in the B.Stat., M.Stat. and other courses of the Institute. Besides this, the Division runs a two-year course at an advanced level for doctoral students to prepare them for research.

Nature and description of work done during the current year :

1. *Probability Theory* : The accuracy of Boot-strap procedures for the standard as well as some dependent models was studied. Berry-Essen bound for the maximum likelihood estimators in the Ornstein-Uhlenbeck process using the Ito formula were obtained. It is anticipated to study the performance of the boot-strap in self-normalized statistics and dependent models in general and discuss the rate of convergence of the m.l.s. in general diffusion processes. A thorough analysis of rays of charges was done. A Blackwell space which is not strongly Blackwell was constructed under CH. Further research is continued.

2. *Descriptive Set Theory* : During the current period some new selection theorems were obtained. Work on Hierarchy of R -sets was pursued. The scale and uniformization properties at each level of Hierarchy of R -sets were established. Work on the BP -sets and R -sets is being continued.

3. *Analysis and Topology* : In the theory of Teichmüller spaces, parametrizing Riemann surfaces, it was proved by completely new methods that the Teichmüller spaces are complex Banach manifolds. The Ahlfors-Weill sections were generalized and Bers-type reproducing formulae were deduced for holomorphic functions. Complex analytic coordinates for Teichmüller spaces using Schiffer variation were obtained. It is anticipated that research in the infinite-dimensional cases will continue. In hypercomplex analysis, quaternionic and octonionic functions and manifolds were studied. Research towards a differential geometric characterization of hypercomplex manifolds is in progress.

During the year under review, extension of the Gromov's theory to closed manifolds was given and lie groups with left invariant metric in terms of scalar curvature were characterized. It is further anticipated to study Immersion Problems of Graessmann manifolds in Euclidean space and classifications of contact structures on closed manifolds.

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Hilbert module and their resolution by Šilov modules and curvatures and Representations were studied. Further work is anticipated in the area of Dilations of Hilbert space operators and k -spectral sets.

Intersection properties of balls in Banach spaces were investigated and it is proposed to make an intensive study of Banach spaces with the Randon-Nikodym property and their associated Asplund spaces. In the field of Harmonic Analysis on Euclidean Spaces, work will continue, specifically, around weighted norm inequalities. In Point-set Topology, Dini's Theorem, Integral Representation and Pseudocompactness were considered and work is in progress on S_∞ -like spaces and covering properties and their relationship with closed projections. In the area of Ergodic Theory, the 'spectrum' of the unitary operator has been studied and some spectral questions on Ergodic Actions of OZ_2 were posed.

4. *Statistical Inference* : During the current year, work has been done on residual median process, the relationship between the variance of the mvue in the multiparameter exponentials and the limit of the Bhattacharya bounds with applications to reliability theory, Edgeworth expansion of smooth statistics, asymptotic theory of estimates for the change point in a hazard rate, Bayesian duality argument for the Bartlett correction to the likelihood ratio statistic. Results were also obtained on problems of local asymptotic minimax estimation and analogues of the Bernstein-von Mises theory for the non-regular cases were obtained. An invariant SPRT was used for an identification problem of multivariate populations. Also selection of the Normal distribution having the largest mean (common variance being unknown) was studied. For a very large family of test statistics, the local superiority of the efficient score statistic was established. Further work is in progress.

5. *Design and Analysis of Experiments* : Research work has been done in the following areas during the current year : rotatable designs, repeated measurement designs, optimality in block designs, factorial designs and other designs, variance component estimation, certain parametric relations for variance balanced block designs, balanced arrays of strength t and related incomplete block designs, efficiency comparisons of variance and efficiency balanced block designs and block union and intersection methods of construction of block designs. It is anticipated to continue work in these areas.

6. *Sample Surveys* : New regression type estimators were obtained using multiple auxiliary information. Efficiency of a new PPS estimator where the selection probabilities are modified was examined. Use of auxiliary information in the case of stratified sampling in double sampling was considered. Completeness of certain estimators and problems of domain estimation were studied. Applications of unbiased ratio estimators in the theory of construction of price index numbers were discussed.

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It is planned to study the problems of analysis of data from complex sample surveys and construction of more efficient estimators when multiple auxiliary information is available.

7. *Multivariate analysis* : The classification problem when the response variables are subject to error was studied. Noting that the usual t test fails to diagnose the differential effect, a new rule to test this effect of a drug was developed. Optimum allocation of response variables in incomplete multiresponse experiments was discussed. The concepts of Lorenz dominance, multivariate majorizations were studied in detail. Work on categorical and Directional Data Analysis continued.

8. *Graph theory, group theory and combinatorics* : In the area of Coding theory, it was proved that any finite inverse plane admitting a transitive automorphism group is necessarily classical. Codes associated with generalised polygons were used to construct a family of one-step completely orthogonalizable codes. Work in this area, especially on modular representation is continuing.

In the area of applications of Graph Theory and Statistics to Sociology, work on a measure of reciprocity continued. The problems of decomposition of over-all reciprocity and identification of boundaries for a social choice are being studied. Further work on harmonious marked graphs and consistent nets and their applications to signed social networks is continuing. Development of theory of association schemes with applications to group theory and design of experiments is anticipated.

Delhi : Nearly forty papers have been either published and accepted or submitted for publication, covering several important branches of statistics and probability and some key areas of mathematics like functional analysis, topology and linear algebra. It must be mentioned that the areas of mathematical investigations conducted at the Centre have strongly influenced developments on the applications of advanced mathematical technique in the field of mathematical physics, econometrics, operations research and control theory.

The already published papers and those which have been accepted for publication in the most reputed journals in the relevant areas show the significant progress that has been achieved during the year in the following topics : Algorithms for optimal integration multiple surveys, interplay between game theory, reliability theory and operations research, functional limit theorems for stochastic processes and their applications to diverse problems of estimation and inference, white noise calculus and non-linear filtering problems of control theory, Fock space calculus and stop time theory in quantum stochastic processes, spectral variation problems for operators in finite dimensions and their numerical analytic investigations, low dimensional manifolds and theory of free groups.

Bangalore : Research was carried out in the following areas of mathematics and probability theory : harmonic analysis, functional analysis, diffusion processes, large deviations theory, geometry and probability in Banach spaces and combinatorial limit theorems.

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Applied Statistics, Surveys and Computing

The activities of the Division during the period from April 1985 to March 1986 were on the following heads : 1. Teaching and Training, 2. Research Activities, 3. Projects, and 4. Statistical and computing consultancy.

1. *Teaching and training* : Members of this Division participated in teaching B.Stat.(Hons.), M.Stat., M.Tech. in Computer Science, Operation of Automatic Data Processing Equipments, Intensive Course on Programming and Application of Electronic Computer Junior Certificate Course in Statistics (for Govt. officers), ISS(P) and ISEC Courses.

In addition, members supervised students of other universities placed at the Institute for Practical Training.

2. *Research activities* : Research activities included both theoretical investigation of methodology and application of the existing methods to the solution of practical real life problems. New results were obtained in the following areas.

Computer Science : Unified approach with quantitative data in randomized response surveys. Replicated sampling with or without replacement. Admissibility in finite sampling. Domain estimation in finite population.

Type I optimality of some GD designs. Type I optimality of MBGDD under mixed effect models. Optimality under non-orthogonal incidence structure of different directions. Construction of some generalized Hadamard matrices and repeated measurements design.

Discrimination with misclassified initial samples. Estimation connected with log-normal distribution. A new derivation of Jordan Decomposition of a matrix. Properties of locally optimal tests in curved and non-exponential families. Tests on generalised variance under ordered restrictions.

Reliability and validity studies of soft and hard data.

Consumption of public services in West Bengal.

Likelihood analysis of pedigrees and studies in Familial aggregation.

Performance of parallel processing systems. Design of a T-fault repairable multiprocessor system.

Distance transitive graphs. Arc transitivity in graphs and an extension of a lemma of C.C. Sims.

Biometry : Time series data collected from the malaria endemic areas of Jharkh, West Bengal and Tatanagar, Bihar were analysed. Some interesting findings have been submitted to the Genetic Epidemiology in the form of a paper.

Studies on the impact of common oral antidiabetic drugs at the immunoglobulin and heptaglobin levels were continued. Significant findings have been published in a paper and others were being compiled in the form of a technical report.

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Estimation of different fractions of dietary lipo-proteins and cholesterol responsible for coronary heart disease was carried on MRC strain rats. Important findings have been published in two papers and another was presented at the National Conference of Physiological Society of India.

Computer simulation of blood glucose homeostasis continued. Significant findings, in the form of a paper, has been presented in the Third Annual Conference of the Indian Society for Medical Statistics.

3. *Projects* : The Division mainly executes various projects at the request of Government/Semi-Government Organizations. During the year under review, following projects were executed and were in various stages of completion.

A. *Externally funded projects* :

(i) *Foreign tourists in India* (Funded by the Ministry of Tourism and Civil Aviation, Govt. of India) : Regional analysis. Data Processing was completed.

(ii) *Consumption of iron and steel in the small-scale manufacturing enterprises : Calcutta Metropolitan District, 1983* (Funded by Steel Authority of India) : The project was undertaken by ERU and CSU of I.S.I., Calcutta. A report on this came out in July-August, 1985 under the joint authorship of ERU.

(iii) *An optimization model for the allocation of available resources of ONGC* : I.S.I. entered into a collaborative research project with ONGC. The divisions of I.S.I. involved are at present Applied Statistics, Surveys and Computing, Social Sciences, SQC and OR. The project consists in developing suitable models for discovery cost and production cost estimation, and an optimization model for the allocation of available resources into the three major areas of ONGC activities, viz., exploration, development and extraction. The project is expected to be completed within a total span of two years.

(iv) *Techno-social-economic survey of Fishermen in West Bengal* (Funded by the Directorate of Fisheries, Government of West Bengal as a part of a Central Government Study) : Project was accepted in May 1986.

Objective of the study was to investigate techno-socio-economic condition of fishermen in five districts and coastal areas of West Bengal. Of the six-populations, data collection work was completed in four populations; of the remaining two, seventy-five per cent had been investigated in each.

Computerised data analysis programme is ready and tables have been generated for one population.

(v) *Social attitudes towards air pollution in Calcutta proper* (Funded by the Department of Environment, Government of India) : For promoting public co-operation in ensuring safe air quality in the city, it is necessary to know the minds of the public on the issue of air pollution in Calcutta. For this purpose, a sample

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survey of Calcutta residents chosen randomly from 56 different NSS Urban blocks was conducted. This project was sponsored by the Department of Environment, Government of India, and it aims at assessing people's attitudes toward and concern for air pollution. Door-to-door house-listing of 56 Urban blocks of Calcutta proper was almost completed. A pilot study based on a sample of 124 respondents living in and around Baranagore was completed. On the basis of this pilot study item analysis of different attitudes and value scales had been running. The questionnaire for the core sample was also finalised. The actual survey will start from the middle of May, 1986.

(vi) *Positive/negative effects of family planning* (Funded by the Indian Council of Medical Research, New Delhi): This pilot project is aimed at studying people's perception of the benefits and losses resulting from the adoption of family planning. Till 31st March, 1986, a total of 214 interviews have been canvassed from sampled respondents residing in seven villages of Hooghly District. Data collection for this project will be over by the end of May, 1986.

B. Internally Funded Projects :

(i) *Pilot Intensive Rural Employment (PIREP)* : The Indian Statistical Institute conducted a survey for evaluation of Pilot Intensive Rural Employment Project (PIREP) in the Nayagram Block of Midnapore District at the request of the Ministry of Agriculture and Irrigation, Government of India, in the year 1975-76. As a follow-up study, it was decided to revisit the Block and collect information regarding the current socio-economic condition, long-term impact of the PIREP project etc. For comparison similar information was also planned to be collected from Gopiballavpur Block, which though a non-PIREP Block but similar in other aspects. Information was collected from households through household survey as well as through in-depth interviews for assessment of some project workers. Household survey as well as the in-depth interviews (partly) were completed in March 1986. Data collected is now being analysed.

(ii) *Survey on a socio-economic evaluation of education in English Medium and Vernacular Schools, Calcutta, 1985* : Field work covering 77 schools in Calcutta and 8 schools in Bolpur and 711 students (and their guardians) in Calcutta and 50 students (and their guardians) in Bolpur was completed. Most of the tables needed to present a report on the survey was also completed. But some further analysis is required to be done before the report may be prepared.

The survey comprised with a supplementary survey on the same topic extended to Bolpur.

(iii) *Survey on a socio-economic classification of medical, engineering and post-graduate students, Calcutta, 1986* : Field work had been carried out to get the roll strengths of various departments covering the outgoing students shortly to take the final examinations. A pilot survey had been started with an aim to cover a sample

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of 100 students with representative from various departments and campuses. A plan is to follow it up with a second pilot covering 100 more students so that the questionnaires and plans may be revised before undertaking the final survey aimed at covering about 600 more students.

(iv) *Development of a Block Plan* : During the period under report two schedules of enquiries (One health conditions—successfully completed for 381 households and another on Agricultural income—successfully completed for 400 households) were canvassed.

Data processing for all the schedules is under progress and is expected to be completed during 1986-87.

(v) *Development of field research for tropical diseases on the basis of epidemiological techniques with four profiles : Socio-ecological, economic, nutrimeric, biochemical and immunological profile to prevent, control and eradicate tropical diseases* : There are some definite indications that the blood cholesterol level has got some linkage with some other biochemical and immunological parameters estimated in a tribal population from a malaria-endemic region.

(vi) *Estimation of different fractions of dietary lipo-proteins and cholesterol responsible for coronary heart diseases* : This project was undertaken in collaboration with Department of Cardiology, R. G. Kar Medical College, Calcutta.

This is an on-going project which has been widely discussed and approved by the DCSW/TAC meeting of the Applied Statistics, Surveys and Computing Division.

(vii) *Design of multiprocessor system based on 8086 microprocessors* : The system will be utilised for reducing job turn around time by exploiting parallelism. A microprocessor system and some peripheral devices have already been purchased for this purpose.

(viii) *Studies on the impact of common oral antidiabetic drugs at the Immunoglobulin and Heptaglobin levels and their roles in the long term control of the diseases* : The project produces some significant results which were summed up in the form of a technical article. The paper has been sent for publication in the Indian Journal of Medical Research.

(ix) *Computer simulation of blood glucose homeostasis* : The mathematical model, developed earlier was tested by developing careful validation strategy. The Physiology Department, Indian Institute of Chemical Biology is interested in the project.

Research is being continued to develop Computer model to explain the glucose homeostatic process. A paper has been read in ISMS Conference and submitted for publication in the proceedings of ISMS.

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(x) *Attitudes of scientists and professionals towards environmental pollution in Calcutta* : As a part of the activities of the Survey Research Group, a pilot project had been undertaken to assess the perception and attitudes of various professional groups towards environmental pollution in Calcutta. A mailed questionnaire has been finalised for this purpose based on some pre-testing and it is currently being circulated to the members of faculty of ISI, Calcutta University, Jadavpur University, Saha Institute of Nuclear Physics, BARC and All India Institute of Hygiene and Public Health.

(xi) *New statistical software packages* : A new statistical tabulation package, viz., CENT-41 "combining" the features of COCENT and X TALLY has been acquired. Negotiation is still going on with the Computer Centre, New Delhi for getting a tape copy of 'CLUSTERS' a survey variance analysis package.

4. *Statistical and computing consultancy* : Statistical and computational help had been provided by the members of this Division to a large number of research workers needing such help.

Physical and Earth Sciences

CHEMISTRY

Study on colloidal system : Unit's earlier investigation on the adsorption behaviour of clay colloids had been diversified to relatively complicated situations. Adsorption of surfactant molecules with polynuclear aromatic head and more than one hydrophobic chains were introduced to elicit further information on the relative contribution of ionic and hydrophobic bonding on the overall adsorption of such molecules.

Study of soil-humus : Contribution of organic matter and texture to the exchange properties of a limited group of high altitude soils in Darjeeling District of West Bengal was worked out. Regression analyses were used to correlate organic matter, inorganic components and cation exchange capacity.

A comparative study of the forms of organic matter in hill and foot-hill soils, were completed during the period. Characterising the organic matter by sixteen well-defined parameters the two groups of soil humus were quantitatively compared and a striking difference revealed. Attempt had been made to account for these differences on the basis of temperature, precipitation, vegetation and cultural practices.

ELECTRONICS

a. *Digital Systems Research*

Research on Computer Science : Theoretical research works were under progress in the following areas.

(1) *Fault tolerant computing* : Methods for generating test sets for fault detection in combinational and sequential circuits were derived. Detection of multiple faults for such circuits was also under study. Development of suitable diagnosis schemes for modular digital systems and microprocessor was under investigation. Sophisticated graphical models were developed which could take care of short circuits and bridging faults as well.

(2) *Design for testability in LSI/VLSI* : Testability considerations in LSI/VLSI circuits were examined from a completely new angle. Research papers reflecting new design rules for inducing testability in LSI/VLSI circuits for detecting of stuck-at and bridging faults were published. Methods like random testing, syndrome testing, were developed so that these could be used more efficiently for testing large digital logic circuits. The study of inadmissible class of faulty functions in logic circuits were undertaken, the knowledge of which aids the design for testability. Testable design of CMOS/VLSI for detection of hard faults like "stuck-open faults" had also been proposed.

(3) *System Diagnosis* : Some studies were made in the area of systems diagnosis e.g., techniques for designing optimal self-diagnosable systems etc.

(4) *Graph Theory and Combinatorics* : Several theoretical work on different problems of graph theory and combinatorics were undertaken. In particular, the graph isomorphism problem, the forbidden clique problem, Pascal graph, combinatorial problems involving Stirlings number of the 2nd kind, Fibonacci numbers and their engineering applications, were worked out.

(5) *Heuristic Search* : The recent techniques of heuristic search algorithms were successfully implemented for solving some difficult problems of message routing in a distributed computing network environment. Many interesting properties of Mobius graphs, De-Bruijn graphs, were explored regarding their suitability as computer networks. Admissible heuristic estimates can then be assigned to each processor node, which settle the optimal message routing problem in polynomial time complexity. Fault tolerance of these networks is currently under investigation.

(6) *Parallel architecture and parallel algorithms* : Parallel realization of numeric, non-numeric and graph theoretic algorithms were under study. In particular, the numeric power evaluation problem, the sorting problem, and the diameter evaluation problem in a symmetric graph, were implemented. Parallel architecture for improving speed of a FFT processor had also been proposed.

(7) *Network architecture* : Design methods for realizing suitable interconnection structure for computer networks were under study. Properties such as extensibility, fault tolerance, routing under faulty and fault-free conditions were being investigated. A number of interesting structures had already been obtained and reported. A new cost-performance measure for evaluating network architectures were obtained.

b. *Theoretical Physics*

During the period, the main areas of research undertaken were as follows.

(1) *Particle physics*: The role of conformal group and conformal reflection in the generation of the internal symmetry had been studied. The study of discrete symmetry and disconnected gauge group in various interactions were undertaken.

(2) *Supersymmetry and supergravity*: The role of conformal spinors, extended conformal group and supersymmetry was studied. The implications of supersymmetry as well as supersymmetry breaking in the context of stochastic field theory was explored both at $T = 0$ and $T \neq 0$. The mathematical formalism of twistor geometry was applied in complex manifold to study the nature of spinor structure and superspace. The role of complex manifold and De Sitter space had been explored to study supergravity. Also the $SL(2, 0)$ gauge theory of supergravity was formulated. Besides the role of stochastic geometry in supergravity was studied.

(3) *String model and Liouville field theory*: The geometry of superstring fermionic and bosonic string was investigated in the context of Polyakov metric and Liouville field theory. The role of nonlinear σ -model in string theory has also been studied.

(4) *Skyrmions*: Stochastic quantization of a fermi field was studied and it has been shown that the skyrme term in the nonlinear σ -model appears as a manifestation of quantum condition. In this formalism fermions appear as solitons.

(5) *Stochastic Field Theory and Quantum Statistical Mechanics*: A formulation of equilibrium condition in quantum statistical mechanics and finite temperature quantum field theory was developed in terms of stochastic field theory. In this formalism finite temperature quantum field theory appears as an extension of the $T = 0$ case.

(6) *Ising Model and Quantum Field Theory in 1+1 Dimension*: The equivalence of Sine Gordon solitons with massive Thirring fermions is being studied in the context of non-Abelian fields. Besides the equivalence of 3 dimensional Ising model and fermionic string has also been explored.

(7) *Nuclear Physics and Heavy Ion Collisions*: A generalised Baryon-Baryon potential was developed from the viewpoint of the structural consideration of hadrons. The role of rearrangement was studied to explore the scaling violation in the backward region in heavy ion collisions.

(8) *Quantum Fluids*: The equivalence of hydrodynamical and stochastic quantization was studied. The hydrodynamical quantization procedure so developed is now being applied to the problem of superfluidity.

(9) *Plasma Physics*: The effect of inhomogeneity and temperatures on ion-acoustic waves were studied. Using the stretched co-ordinates introduced by Asano

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a modified KdV equation for an inhomogeneous plasma with negative ions was derived. Two papers were published where these results had been described. Ion-acoustic solitary solutions in both relativistic and non-relativistic plasma is under study.

(10) *Dynamical Symmetry and Quantum Mechanics*: Substantial work was done on the eigenvalue problem of the Schrodinger equation with the exponential Cosine Screened Coulomb potential. Variable scaling method was successfully applied to Stark effect in hydrogen atom. One research scholar submitted her thesis entitled "Application of dynamical groups and scaling variational method to Perturbation problems of Quantum Mechanics" to Jadavpur University for Ph.D. degree. At present work on Hulthen and Screened Coulomb potential using shifted $1/N$ expansion is in progress.

(11) *Supersymmetry and Field Theory*: An important conjecture viz. 'if Supersymmetry is broken then ground state is non-degenerate and the excited states are degenerate' was shown to be not always true. Using Barbour's theorem it was shown that another equally important conjecture viz. 'if Supersymmetry is unbroken then ground state is unique while the excited states are degenerate' was always true. SUSY Quantum Mechanics in three dimensions was also studied. Presently supersymmetry phenomenology especially application of supersymmetry in Cosmic ray spectrum is being actively studied. Another field of present investigation is the effect of curvature of SUSY breaking. One research scholar has submitted his thesis on Supersymmetry to Jadavpur University this year.

(12) *High Energy Collision Processes*: Characteristics of the many particle production in high energy hadron-hadron, hadron-nucleus collisions and nucleon-nucleon collisions were being probed continuously from a specific viewpoint and the theoretical results thus obtained were being compared with the other existing models as well as with the experimental findings. The interesting findings and the results arrived at are being applied to interpret and reinterpret some problems and puzzles of the cosmic ray physics. This apart, some alternative approaches to understand the nature of the high energy collisions of the particles are also under active consideration.

c. *Fluid Mechanics*

(1) *Study of Flow Field in a Hydrocyclone*: The laminar boundary layer on the conical surface of a hydrocyclone was studied when fine suspended particles are present in the liquid flowing through the cyclone. The equations of motion for the fluid as well as those for the suspended particles were treated by the method of Karman-Polhausen. The resulting equations are being solved numerically.

(2) *Study of Flow due to Standing Vortices in an Opposed Jet*: Stabilization of flame by opposed jet due to the appearance of standing vortices is a highly complex problem. The study of the cold flow problem involving stability of the vortices was completed.

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(3) *Simulation of Human Finger Prints by Potential Flow*: The whorls, loops and arches which are common in human finger prints were simulated by potential flow fields generated by placing circular/elliptic cylinders or aerofoils in a flow with circulation. It was intended to find simple parameters for identifying any finger print. This might simplify the process of searching and identification of finger prints.

(4) *Statistical Theory of Turbulence*: The small scale turbulent motions related to atmospheric and oceanic environment were investigated. A spectral model was developed for thermally stratified turbulent flows with and without shear. This model was applied for the case of weak interaction between the mean and turbulent fields in such stratified flows. The three dimensional energy spectrum as obtained was found to obey certain decay laws which have been observed in the upper tropospheric and lower stratospheric region of the atmosphere. Horizontal and vertical component spectra as determined were compared with that of some recent measurements in the oceanic environment. The agreement in this case was found quite satisfactory.

The work of developing a general model describing weak, neutral and strong interactions between the mean and turbulent fields in stratified turbulent flow is in progress. Besides study of the behaviour of turbulent exchange coefficient or spectral eddy viscosity has been undertaken.

(5) *Hydrodynamic Stability*: Thermohaline convection has attracted a steady interest among the researchers in this field for many years. Most of the workers in this field have neglected both Soret and Dufour terms and a few consider the case where the Soret term is retained but the Dufour term is omitted as negligible. Only recently convection has been examined by a very few authors where both Soret and Dufour terms are retained. In this general model, no approximation is being made a priori regarding the relative magnitudes of thermal coefficients. The model of liquid ^3He - ^4He mixture is more appropriate for Soret-Dufour problem because the thermal diffusion ratio is large near the lambda point and tricritical regions of the (c, T) plane ensures that neither the Soret nor the Dufour contribution can be neglected. On this ground, a study on finite amplitude Benard convection in a ^3He - ^4He mixture was made under the project of "Hydrodynamic Stability and Thermohaline Convection".

Apart from this, the dispersion of a solute in the unsteady input and the thermocapillary flow was studied. The shape of the free surface was also investigated.

(6) *Study of Dynamics of Extra-tropical Cyclone*: Theoretical study of the problems related to storm surge on a continental shelf was investigated by considering the coastal geometry provided with sloping bottom and vertical wall extending to infinity in the horizontal directions. In this analysis the linear model of the system of equations was considered together with Coriolis force and bottom friction. The main result obtained in this theoretical investigation is the analytical expression for the sea surface elevation on the continental bed.

(7) *Study of blood flow through cardiovascular system* : The abnormal and unnatural growth, usually called stenosis in the lumen of an artery disturbs the normal blood flow through the artery and is a frequent result of arterial disease. The effects of the shape of stenosis on the resistance to blood flow were investigated by using blood as a power-law fluid. The problem of oscillatory blood flow through a rigid tube with mild constriction under simple-harmonic pressure gradient to study the effects of stenosis on the flow field using blood as a Newtonian fluid is in progress.

ELECTRONICS AND COMMUNICATION SCIENCES

Research activities in the Unit include both theoretical investigation of methodology development and applications of the existing methods to the solution of practical real life problems. The scientists participated in the M. Tech. (Comp. Sc.) and M. Stat. (ASDA) teaching programmes of the Institute. More than 35 research papers have been published this year in Indian and International Journals, Conferences Proceedings by the research workers of the Unit. During the period under review research was conducted in the following broad areas.

1. *Development of methodologies for image analysis, shape analysis, image understanding system and computer vision technology* : Following new work in this area were carried out. (a) A generalised line segment code and a compression technique by the method of folding have been completed and published. (b) The methods of generation of geometric drawings in discrete grid were studied. (c) The shape of a set of points in 2-D planes were found by quadtree decomposition technique have been published. (d) Results of feature extraction using different transformation techniques such as Hotelling, Walsh-Hadamard, Discrete-Cosine, Haar and Slant have been published. (e) Some new methodologies for image restoration and enhancement applying cybernetic approach of human visual system and a modified Wiener Filtering has been published. (f) While investigating shape discrimination problems four new shape distance functions were developed and reported for different uses with open and closed curves. (g) Work on the development of a formal basis for digital plainmetry is in progress.

2. *Studies on automatic speech recognition and speech processing* : Works on phoneme structure of some Indian languages and their application in ASR were under investigation along with syntactic approach in ASR. Studies on the properties of large lexicon using Bengali language were undertaken. A new statistical discriminant function was evolved which while cutting down the computation time appreciable provided recognition score better than the maximum likelihood methods. Research on clustering and stochastic learning of speech recognition system is in progress. The study of acoustic phonetic structure of Bengali language had been taken up. Studies on musical acoustics with particular emphasis on North Indian classical music was continued in collaboration with Sangeet Research Academy.

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3. *Studies on cybernetics and system theory* : Research on application of fuzzy set theoretic approach in Management Science and other socio economic system was developed and reported. Further work is in progress. A new method was developed applying fuzzy clustering method and branch and bound technique for management science application such as resource allocation problem. The work has been widely appreciated abroad. A work on Fuzzy linguistic approach for decoupling of a large multivariate system in the reference of power plant operation had been under consideration. Fuzzy correlation between membership functions was defined and its application is being investigated. Theoretical investigation on Non-Von Neumann Computer Architecture in the light of next generation of computing systems were undertaken and several papers on diverse aspects such as Pattern Recognition, Computer Vision, Image Understanding Systems and Artificial Intelligence were communicated/presented in conferences. A paper on musical acoustics was awarded Sir C. V. Raman Award by Acoustical Society of India as the best paper in five years and a book "Fuzzy Mathematical Approach to Pattern Recognition" was adjudged for 1st prize by the Seventh World Book Fair because of their original contribution.

4. *New computer architecture for signal understanding* : Attempt had been made for rule-based automatic problem-solving know-how (for signal understanding) which provided means for capturing and refining human expertise and are proving to be commercially viable. Rule-based systems (RBSs) constitute the best currently available means for codifying the problem-solving know-how of human experts. In this context the proposed computer architecture has got the four essential elements, e.g., rules, interpreters, translations and explanations.

5. *External collaborative projects* : (i) The Unit completed the work on a project entitled 'Development of continuous nonfading patient monitoring system' sponsored by Electronics Commission, Govt. of India. The final report was submitted.

(ii) The collaborative research project between IRI and Sangret Research Academy (SRA) on Hindusthani Raga Sangret and on Indian stringed instruments was continued during the year under review.

(iii) The joint project entitled 'Statistical studies on the tropospheric propagation for VHF/UHF and microwave link' has been sanctioned by the Department of Science and Technology (DST) for 3 years and the work for this project were started and is giving very interesting results.

(iv) Project of Electronics Commission entitled 'Application for pattern recognition and image processing techniques to geological mapping and mineral detection' has been sanctioned and is in progress.

(v) Research project under Defence Grant in Aid Scheme, entitled 'System and algorithm development for Pattern Recognition and shape analysis of objects of defence interest' has been sanctioned.

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(vi) Fifth Generation Computer System/Knowledge Based Computer Systems (FGCS/KBCS) Research—Electronics and Communication Sciences Unit is a nodal agency (National Nodal Centre) with Prof. D. Dutta Majumder as Co-ordinator cum Project Director in the fields of pattern recognition, artificial intelligence, image processing and computer vision for Fifth Generation Computer Systems Programme of the Govt. of India.

GEOLOGY

Geological research progressed in the following areas :

1. *Structural Geology* : (a) Proterozoic tectonics around Somanpalli, Godavari Valley; (b) Structural and stratigraphic study of the deformed Proterozoic rocks of Rajasthan.

2. *Sedimentology* : (a) Geological controls of arkose formation in marine and continental environments; (b) Facies analysis of the Maleri Formation; (c) Sedimentology of the Upper Gondwana sequence of the Pranhita-Godavari Valley.

3. *Stratigraphy and Sedimentology* : (a) Stratigraphy and sedimentation of the undeformed as well as deformed sequence of the Pakhal and Sullavai Groups; (b) Stratigraphy and sedimentology of the Albaks sequence and its comparison with the Pakhal sequence.

4. *Stratigraphy and Palaeontology* : (a) Geology and Palaeontology of the N. W. Pranhita-Godavari Valley; (b) Fossil vertebrates from the Denwa beds of the Satpura Gondwana basin and their bearing on the Stratigraphic relationship of the Denwa beds; (c) Morphological analysis and stratigraphic position of trace-fossils from the Proterozoic sediments around Ramgundam, Andhra Pradesh.

5. *Palaeontology* : (a) Study of the Triassic Yerrapalli vertebrate fauna; (b) A Triassic reptile from the Tiki beds of the Son-Mahanadi Valley, India; (c) Fish remains from the Lower Jurassic Kota Formation and Cretaceous sediments; (d) Lower vertebrates from the Upper Cretaceous sediments; (e) Dinosaur remains from the Infra-trappean (= Lametas) sediments (Padiara and Dongargaon); (f) Trace fossils and stromatolites in the Kota Formation of the Gondwana sequence, Pranhita-Godavari Valley.

6. *Special Project* : (a) Empirical-statistical study of orientation of lines in 3-dimensional space-applications in geology; (b) Glaciomarine deposits of Permian-Carboniferous age of India.

PHYSICS

1. *Teaching activities* : During the year 1985-86, the Unit gave one full semester course to the Second Year B.Stat. Honours students and the course contents included : Thermodynamics, Statistical Mechanics, Special Relativity and selected topics of Atomic and Nuclear Physics.

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3. *Research activities* : (a) *Progress under plan activities* : In accordance with the schedule of the plan projects for the year 1965-66, the Physics Unit carried out research activities in the following fields. (i) An electronic device 'thermoceas' was developed to measure quantitatively the cutaneous thermal sensory thresholds (TST). The TST's of 100 normal subjects, comprising both sexes, in the age range 10-65 years had been determined and their changes with age, sex, location, ambient temperature, relative humidity etc. were studied by multivariate analysis and the correlations also determined.

Studies of the thermal sensory loss in cases of Hanseniasis (leprosy) of various types from one end of the spectrum to the other, that is, indeterminate, tuberculoid tuberculoid, border line tuberculoid, borderline lepromatous, polyneuritic etc. were made on 220 subjects so far. The work is continuing and the quantum of sensory restoration (thermal) on medication is being evaluated by following up the patients.

(ii) The skin surface pH in normal population was measured with a high precision pH-meter (SMT pH-90) using a specialised flat surface gel-filled microelectrode and the data so far obtained analysed statistically. The preliminary findings show that the mean values of skin surface pH (forehead) are 5.5 and 5.7 for the male and female respectively. The dependence of the skin surface pH on age is not significant. The male skin is slightly but significantly more acidic than the female one and also the exposed skin is more acidic than the unexposed one.

(b) *Other researches* : Apart from the plan project, the Unit is continuing investigation on the various physical modalities that could be applied on dermatological disorders. Investigation into hydroxia-excessive sweat secretion from the sweat glands—utilising the principle of iontophoresis is in progress.

Biological Sciences

ANTHROPOMETRY AND HUMAN GENETICS

1. *Study of physical growth of Bengali children* : (a) Analyses and statistical evaluation of the data on 25 anthropometric characters of about 1000 urban boys were completed. A few research reports were brought out. (b) Measurement of about 500 urban Bengali girls had been made for the second occasion. Analyses of the data were in progress. (c) Anthropometric survey of the rural Bengali boys in Kalpi block, D.H. Subdivision, South 24-Parganas District was in progress.

2. *Pattern of fertility and reproductive outcomes by parity and Social class* : Collection of data on about 8500 births delivered at the Diamond Harbour Sub-divisional Hospital, South 24-Parganas District, was completed. Primary analysis of the data was made to examine problems of low birth weight among the rural mothers of West Bengal.

3. *Health status and labour productivity* : Collection of anthropometric data on adults and children (approx. 1000 individual each) was completed. Analyses of demographic and anthropometric data are in progress.

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4. *Variation in health status in relation to spatial, economic, social, rural/urban, ethnic, etc. factors in some populations of eastern India. I. Effects of micro-environmental factors on health in rural populations* : Collection of anthropometric data on adults and children (approx. 300 and 400 individuals, respectively) was completed. Reanalysis of dietary data was completed.

5. *Variation in health status in relation to spatial, economic, social, rural/urban, ethnic, etc. factors in some populations of eastern India. II. Psychological stress and health of mother and child* : Collection of data on household census and socio-economic status and individual reproductive performance was made on 125 working and 70 non-working women. Further data collection is in progress.

6. *Social characteristics and community health status of the Lepchas of Darjeeling District, West Bengal* : Analyses of dietary, demographic, anthropometric (adult) and haematological data were completed. Analyses of child growth data are in progress.

7. *Impact of altitude on human population, Phase II* : Reanalysis of dietary and high altitude demographic data was completed. Writing up of a comprehensive report is in progress.

8. *Bioanthropological study of migrant African group, the Siddis of India* : The field work was completed and most of the analysis was over.

9. *Relationship between carrying capacity, level of technology, size and social composition and dispersion of human settlements in Western India* : All the contemplated data were collected and are being analysed.

10. *Biology of fluctuating and absolute dermal asymmetry in man, and its relationship with longevity* : The project started in 1985-86 and during the period under question dermatoglyphic prints from a family series from Andhra Pradesh were collected. A scoring of the prints was over and the design of analysis is being worked out. Besides, prints of 23 Dhangar castes were also scored and analysed.

11. *Genetics and diversity in dermatoglyphics of Chimpanzee* : A series of prints were obtained from Primate Research Centre, Tempe, Arizona and kept at the Dept. of Anthropology, University of Arizona, Arizona, USA for analysis.

12. *Indo-German collaborative study* : In collaboration with Bremen University a genetic survey was conducted to study 10 endogamous groups in Assam, 2 in Manipur and 3 in Karnatak during 1983-84 for various biochemical and serological markers. About 1500 blood samples were collected in the survey and all the laboratory tests were completed during this period. Laboratory tests and the statistical analysis of the results are in progress.

13. *Indo-Soviet collaborative anthropo-genetic survey* : Survey in South Indian populations : This survey was conducted in 1983 jointly with Soviet Academy of

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Sciences, amongst 14 population groups belonging to high caste low caste and tribes spread over Karnatak, Kerala, Tamilnadu and Andhra Pradesh. Statistical analysis was completed and two research papers were prepared.

14. *Genetic epidemiology of blood pressure* : A pilot survey conducted in the fishermen community in Digha, West Bengal covering about 50 families comprising about 350 individuals, during December 1935. The analysis of the data is in progress.

15. *Biostatistical study on vitiligo, a skin disease* : Epidemiological, familial aggregation and pedigree data were collected through vitiligo patients. Analysis of data and preparation of report continued.

ВІСНОВКИ

1. *Detection and isolation of lycopene in Daucus carota, red variety* : The presence of lycopene in fairly large amount was detected in *Daucus carota*, red variety (common red carrot). It was totally absent in regular orange yellow variety of carrot. The presence of lycopene had been identified by TLC and absorption spectrum. The lycopene had been isolated in pure crystalline form from red carrot and its properties compared with authentic sample of lycopene.

2. *Correlation of cyanomethaemoglobin and oxyhaemoglobin levels in adult human beings* : The study shows that the males have on an average higher haemoglobin values than females. There is a significant decrease in the values of haematological traits with advancing old-age among males; but the pattern among females seems to be inconsistent. The correlation between cyanomethaemoglobin and oxyhaemoglobin is higher in all cases than that between cyanomethaemoglobin and haematocrit or between oxyhaemoglobin and haematocrit. Thus with the help of regression equation cyanomethaemoglobin can easily be estimated from oxyhaemoglobin without losing much accuracy.

3. *Distribution of intestinal parasites in West Bengal* : For the detailed survey of the types and prevalences of these infestation, the area of West Bengal has been divided into six ecological zones considering temperature, humidity, rainfall, soil-types etc. following the National Atlas Organisation map.

From these zones, the sandy coastal zone was selected as the first study area. Five villages were selected in this zone using statistical sampling techniques. All households with name of head of family and number of adults and children in each household had been listed in each study village. Fifteen percent of the households in each study village were statistically sampled for the investigation of intestinal parasites. Collection of informations in relation to living condition, toilet habit, dietary pattern, water supply, medical facility, attitude towards diseases etc. have been collected in each sampled household for this survey.

4. *Genetic epidemiology of blood pressure* : This study was conducted in collaboration with Prof. B. N. Mukherjee (AHGU) and Dr. P. P. Majumder (CSU).

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A pilot field survey was conducted in December 1985 among the fishermen in the coastal area Digha; measurement of blood pressure, body height, weight and skin-fold thickness were done. About 350 individuals of both sexes were measured. The study is in progress.

BOTANY

(i) *Crop improvement* : The aman rice variety *Subarna*, developed and improved by Botany Research Unit from indigenous germ plasma, was put to performance trial with different density levels at ISI experimental farm in Giridih to determine the optimum density level for best expression of yield potential.

It was observed that at medium density level *Subarna* gave highest grain yield (54.12 Qntl./ha), at high density level it gave highest biological yield (124.69 Qntl./ha) with slight decline in grain yield. At low density level *Subarna* gave poorest yield in both grain yield (45.89 Qntl./ha) and biological yield (96.75 Qntl./ha). Biological yield increased and harvest index decreased with increase in density level. From a comparative assessment of yield performance it was found that *Subarna* at high level of fertilizer gave equal to *Pankaj* but higher than the two local selections and seven other high yielding dwarf/semi-dwarf rice varieties in grain yield and lower biological yield than IET-3257 but higher than the rest. It was further observed that all the eleven varieties tested were positively responsive to higher dose of fertilizers but there existed inter-varietal difference in yield expression. However, a clear variation in the response behaviour to higher fertilizer dose was found in respect of straw yields of the varieties studied. It was observed that straw yield of *Subarna* remained unaltered, IET-3257 showed highest positive response, *Aulkoil* (local selection) showed small but positive response and *Mulasail* (local selection) showed negative response to high fertilizer dose.

Harvest index of these eleven rice varieties showed that the poorest grain and biological yielding varieties had highest ranks of harvest index and those having high yields of grain and straw, had very low harvest index. It appears that harvest index is negatively correlated with both grain and biological yields. These findings raise a serious doubt as to the validity of use of harvest index as a tool for selection of rice in a rice breeding programme.

In addition to these field trials, multidirectional performance trials of *Subarna* were also conducted by the Department of Agriculture, Government of West Bengal at different state farms, by the College of Agriculture, Calcutta University at its Experimental Farm in Baruipur, 24 Parganas and on the farmer's fields under different agroclimatic conditions with an aim to determine its adaptive behaviour. The results are yet to be obtained after harvest in December 1985. The maintenance of fifty six indigenous gram plasma lines and eight dwarf high yielding rice varieties continued.

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(ii) *Intra-specific and inter-specific interactions in crop plants*: (a) *Intra-specific mixture effects in rice, wheat and gram*: Eight mixed planting experiments on rice varieties, one on wheat varieties and one on gram varieties were conducted at ISI experimental farm in Giridih. Land equivalent ratios (LER) of grain yield of the varietal mixtures in rice were computed which indicated an overall yield advantage in four combinations, neutrality in two and disadvantage in two combinations. It was further observed that the short duration exotic rice varieties such as IET-4084, IET-2815 etc. faced serious competition in mixture with *Subarna* and *Jaya* was almost wiped out in mixture with *Subarna*. The two varieties of wheat and gram studied in mixture showed disadvantage in respect of seed yield as compared to that in pure stand.

(b) *Inter-specific mixture effects in crop plants*: Eleven inter-cropping systems were studied at ISI experimental farm in Giridih during the reference period. It was found that in two oat/lentil inter-cropping systems lentil was exposed to competition and so is oat in certain mixture types. Nine cereal/pulse intercropping systems out of eleven tested showed distinct but variable degrees of advantage over monoculture of the components. Some cereal/pulse intercropping systems, wheat (NP 710)/gram (BR 77), wheat (UP 262)/gram (BR 77), oat (kent)/lentil (C 31) and maize (*vijay*)/cowpea showed mutual reproductive stimulation of the component crops leading to increase in grain/seed production as compared to their monoculture.

These results clearly suggest existence of a scope for utilization of properly tested cereal/pulse inter-cropping systems for increase in yield per unit of cropped area.

CROP SCIENCE

1. *Exploratory work on the family palmaceae (Arecaceae)*: Work on anatomical studies on roots, stems and leaves of different species of palms e.g., *Phoenix sylvestris*, *P. paludosa*, *Areca catechu*, *Cocos nucifera* etc. continued. Data on stomatal frequency of leaves of young and adult palms were analysed.

Morphological studies on juvenile palms of different species e.g. *Nypa fruticans*, *Phoenix sylvestris*, *P. dactylifera*, *P. rupicola* and *P. pusilla* have been carried out. Data have been collected on the use of wild data palms.

The work on the estimation of minerals and other nutrients of the tender coconut shells (Pericarp) is in progress.

2. *General problems of levo and dextro-rotatory situations in plants and animals*: Data on the yield of left and right-spiralled *Areca catechu* palms were analysed. Some more data were taken on the stomata and epidermal cells present in the leaves of left and right-spiralled seedlings of *Areca catechu*.

3. *Introduction of oil palm (Elaeis guineensis) and improvement of coconut (Cocos nucifera) production through introduction and selection of high yielding cultivars*

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in the Sundarbans of West Bengal : This is a project in collaboration with the Government of West Bengal. Final plan and experimental lay out of the project was approved by the Government of West Bengal and land of about 1.25 hectares was made available at the State Seed Multiplication Farm, Manmatha Nagar, Sundarbans area, for the purpose. The land was made suitable for the plantation of coconut and oil palm along with the renovation of a irrigation canal. About 200 seedlings of 'tenera' Cultivar of oil palm have been raised in our nursery beds at our experimental garden at Baranagar. These are to be planted at the State Seed Multiplication Farm, Manmatha Nagar, in this coming rainy season.

4. *Histopathological study on the mango (Mangifera indica) malformation and their correlation with insects and mites* : Some more samples of leaf and stem galls of mango were collected and the anatomical studies were continued. A batch of the causative insects had been sent to the Zoological Survey of India for the necessary identification.

EMBRYOLOGY

1. *Embryology of Loligo* : Work on the developmental biology of *Loligo* in collaboration with Laboratoire Arago, France was further continued. Biochemical marker of embryonic maturity, namely proline was detected. By microinjecting proline into yolk they could also shed light on embryonic nutrition. With the help of radioactive proline and another amino-acid, arginine, microinjected into the yolk the rate of transference of this amino-acid into free pools and proteins in the embryonic tissue could be more accurately determined.

2. *Mathematical and stochastic modelling of cellular development, differentiation and morphogenesis* : The mechanisms of embryonic development, differentiation and morphogenesis were studied with the help of mathematical and stochastic models. The epigenetic system i.e. DNA synthesis and enzymatic activation followed by transcription and translation were mathematically modelled and analyzed. Stochastic analysis was also carried out. Computer simulation had been simultaneously conducted to check the validity of the analytical results. The practical output of all these studies was the revelation of the physical mechanism underlying the process of differentiation and subsequent pattern generation, during embryonic growth. The mechanism of formation of the primary layers of differentiation, e.g. endoderm, mesoderm and ectoderm was found out. Stability and bifurcation analysis of the spatially heterogeneous solutions were carried out with the ultimate view of shedding some light on the mechanism of carcinogenesis. Further investigations on these mathematical and stochastic models are in progress to explain self organisation in biological systems.

ENTOMOLOGY

1. *Investigations on the breeding of Anopheles spp. in two suburban localities (Baranagar and Dum Dum)* : Malaria-carrying species of *Anopheles* (e.g. *A. stephensi*,

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A. annularis and *A. barbirostris*) are rare and found during the late monsoon and autumn. *A. subpictus* which is not a malaria-carrying species can breed throughout the year in the stagnant water of the open concrete drains.

2. *Ecological investigations on the filarial mosquito Culex pipiens fatigans*: The chief diurnal resting place of this mosquito is the septic tank. In the evening mosquitoes come out of these tanks giving the appearance of a cloud.

LEAF PROTEIN

During the year research work was conducted in the following areas:

1. *Selection of hopeful LP yielding plants from water weeds and species grown on marshy land in the Sundarban region*: In the first phase of the study, sixteen local aquatics were studied regarding a number of parameters (e.g., total nitrogen extractability percentage, protein content of the leaf protein concentrates, their digestibility percentage, etc.) in order to evaluate their potential as source material for leaf protein production. *Limnanthemum cristatum*, *Ipomea reptans*, *Pistia stratiotes* and *Asolla pinnata* were found to be the most promising.

In the next phase, the chemical composition of the dried aquatic plants were analysed by standard methods to see if these could be used as feed or fodder purposes. On a dry weight basis, many of these plants were found to have protein concentrations comparable to those of conventional dry forages.

2. *Studies on nutritional aspects of various components from water weeds, by-product leaves and other promising non-conventional plants*: After completion of chemical analysis in 18 water weeds—their nutritional parameters had been taken up. Analysis included estimations like—total and available lysine, methionine, digestibility, β -carotenes, polyphenol—(total and free) etc. This is to be followed by feeding trials in rats.

Work on antinutritional factors was taken up.

15 LPC were prepared from wild plants and were studied for chemical, nutritional and anti-nutritional factors in collaboration with Dr. R. Carlsson, Lund University, Sweden.

3. *Studies on the effect of nitrogen, phosphorus and potassium on the head yield and LP yield of cole crops*: In 1964-65, spacing-cum-nitrogen trial on cauliflower (a.v. Snowball-18) demonstrated that with a combination of 120 kg/ha nitrogen dose and 45 x 60 cm head yield of 282 Qn/ha and LP of 241 kg/ha could be obtained from by-product leaves. This combination was significantly the best of all the treatments. Nitrogen concentration as also percentage protein nitrogen extractability of 51%, together with a good amount of dry fibre yield suggests this as a promising crop for multipurpose use.

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4. *Studies on the performance of different winged bean (w.b.) cultivars and their potential as high protein crop in this agroclimatic region* : In 1983-84 and 1984-85, 15 cultivars were put on trial and salient features of promising ones are given below.

(i) Few cultivars like UPS 90, UPS 31, Lucknow 1, Burma-1 and IC 114273 were found to be extremely promising as cover crops for better vegetative top growth with good protein content (21.8 to 24.2% in dry wt.).

(ii) All the cultivars produced higher pod yields with support excepting Lucknow-1 where no difference was noticed.

(iii) For green vegetable pods (like cowpeas and beans), UPS 90, MT-3, IC 114273, IC 26940, Laos-5 and Binhminh were found to be promising, yielding about 800 to 1000g pods per plants with a protein content of 28.8 to 31.4% on dry weight.

(iv) Seed yields ranged from 200 to 350 g/plants in promising cultivars like IC 26940, MITA 969, IC 26949 and Binhminh. Protein contents in these cultivars ranged from 33.5 to 37.2% on dry weight.

(v) Cultivars seemed to produce higher tuber yields when harvested after vegetable pod stage than after harvests of matured seeds.

Varietal trials will be conducted in Giridih farm of ISI in 1986-87 and 1987-88 for noting their performances in lateritic soil.

Pot trials are envisaged to be taken up with two promising cultivars to study the nitrogen fixing capacity and their use as green manure on succeeding crops.

5. *Microbiological aspects of leaf protein research* : The deproteinized leaf juice (whey) left after heat coagulation of protein, was exploited for streptomycin production. *Streptomyces griseus* was the organism used in the study.

S. griseus produces 25.5 mg streptomycin/ml of cowpea whey. For better biosynthesis of antibiotic, the basic substrate is further modified with additional carbon and nitrogen sources.

Seven carbon sources such as glucose, sucrose, wheat flower etc. were used separately to investigate the effectiveness of carbon source in relation to antibiotic synthesis. Among the seven carbon sources tried, the performance of glucose was found to be the best (80 µg/ml).

In the semimodified cowpea whey (cowpea whey+0.5% glucose) medium, effectiveness of different nitrogen sources has been worked out. Out of four inorganic nitrogen sources the performance of ammonium nitrate was the best (80 µg/ml). Among the eleven amino acids tried, histidine gave most satisfactory result (80 µg/ml). Streptomycin synthesis remained in the peak when cowpea whey was substituted with 0.5% glucose and 1% soyabean meal (125 µg/ml).

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The effect of temperature, aeration, pH and inoculum size in relation to streptomycin production has been shown in a number of experiments and the maximum yield was obtained at pH 7.0. The optimum temperature and period of incubation were 28° C and 5 days respectively. The optimum volume of inoculum for 40 ml medium was 5 ml of a 24 hours old culture containing 5×10^8 cells/ml.

Deproteinised juice from *Limnathemum crestatum* was exploited for biomass production by four different fungi such as *Aspergillus flavus*, *A. japonicus*, *Penicillium chrysogenum* and *Fusarium moniliforme*. The effect of glucose and sucrose as the additional sugar sources and NaNO_3 and $\text{NH}_4\text{H}_2\text{PO}_4$ as extra nitrogen sources had been worked out in relation to biomass production.

Fusarium moniliforme and *Penicillium chrysogenum* reacts highly to the method M_2 (whey with 1% of glucose+0.1% $\text{NH}_4\text{H}_2\text{PO}_4$) M_4 (whey+1% glucose+0.1% NaNO_3) and M_5 (whey with 1% sucrose+0.1% $\text{NH}_4\text{H}_2\text{PO}_4$) in order of values slightly less than 0.8000. On the other hand, *Aspergillus flavus* reacts with all the methods having the values of order about 0.200 or so.

Chemical composition of fungi biomass obtained during formation studies. Digestibility, polyphenol values for harvested biomass. Soil screening programme for cellulose producing organisms. BOD and COD removal of whey. Bioconversion of sugarbeet to ethanol by solid phase fermentation using *Zymomonas Mobiles*/ *S. Cerevisiae*.

8. *Screening and other studies on tree leaves, which are used as feed, as a source material for LP* : A preliminary list of available and worthwhile trees have been drawn up. Preliminary screening work has begun.

At least 20 trees, selected from their preliminary data available will be screened in usual way for P extractability. Nutritional parameters will be worked out. Detailed study of LP (Cyto) will be done.

7. *I. Conditions to achieve maximum yields of tops and roots in sugarbeet crop ; II. Complete utilization of all the parts and working of economic aspects in comparison to the conventional practice ; III. A pilot plant to produce ethanol, pectin, leaf protein and animal feed* : Project has been initiated in the winter months of 1985-86. For agronomic studies 4N doses (60, 120, 180 and 240 kg/ha) earthing/non-earthing practice and spacing at 30×30 cms have been tried. Samples of the tops and roots were analysed for L.P. and sugar respectively at 75, 90, 106 and 120 days. Preliminary results indicated that LP extractability continued to be very good till 120 days which was 55-75% and sugar content varied between 12-18%. Rough yields of about 45 tons/ha in 160 days of roots was recorded. Detailed analyses are taken up and work on fermentations has begun.

8. *Transfer of the technology* : DST has sanctioned the project on the adaptation of leaf protein in rural India to work out technical and economic feasibility of the technology. The project will be taken up in collaboration with the I.I.T., Delhi.

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Social Sciences

DEMOGRAPHY

Research activities during the period of report were on the following :

A. Plan Projects :

1. *Evaluation of Y-sample age tables and reconstruction of 1931-41 population age structure and life tables for India* : The purpose of this plan project was to reassess and rebuild the Y-sample age tables in the light of the recent analytical advances. Further, as a pre-requisite of the life table construction, attempt was made to rebuild the age structures of 1931 and 1941 Indian population.

Several methods such as UN method, transitional age structure model, stable population model and a few others were considered and the best estimate for the adjusted age distribution was worked out after examining the consistency of the estimates. Brass logit linear model was used for the construction of life tables for the period 1901-1981. The series extended to 2001.

2. *Socio-economic and demographic trends since 1951 with specific reference to disparities across social groups* : This plan project was taken up jointly with the Economic Research Unit of the Institute. The object was to study demographic imbalance which has resulted in social tension, economic hardship and ecological mismanagement in selected regions of Eastern India (e.g., Manipur, Tripura and Greater Calcutta). The study aimed at evolving a general framework for analysing the underlying factors responsible for discontent and social tension in several regions of India. Interrelation between demographic parameters and socio-economic variables was studied by using multivariate analysis and recursive path analytic model. Such a study by social groups is likely to highlight the possible dimensions of tension.

3. *Educational development survey in rural Bihar* : This survey was taken up to study the educational development and other socio-demographic aspects of the rural population around Patna. It was observed that the scheduled caste Hindus who are least beneficiaries of planned development are mostly labourers in rural Bihar. Lower enrolment was found for scheduled caste Hindus compared to other Hindus for both sexes in rural Bihar.

4. *A study of educational wastage at primary and middle school levels* : The project was continued with the objective of estimating expected life of a student and finding out educational wastage differentials by various contributing factors on the basis of follow up studies of a number of student cohorts obtained from records of sample schools (primary and secondary) in 100 sample villages in the District of 24 Parganas of West Bengal.

The field work comprised of collecting necessary data from school records and through interview of teachers, parents of students and students using three different

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schedules. Analysis of school schedule data has been taken up and preliminary report is expected in July, 1988.

5. *Some determinants of child mortality and the latter's impact on fertility*: The study was undertaken in order to understand the phenomenon of high infant and child mortality and its effect on fertility in rural and urban areas of Hooghly District in West Bengal.

B. Non-Plan Projects :

1. *Urbanisation in India*: Urbanisation in India has been studied from the point of view of degree, tempo, concentration and components of urban growth. All India picture of degree of urbanisation in terms of percentage urban and urban-rural ratio maintains a steady increase over last 3 decades. Maharashtra secures highest position followed by Tamil Nadu and Gujarat in respect of degree of urbanisation. The speed of urbanisation has increased during 1971-81 compared to 1961-71 for most of the Indian states. Concentration Index reflects systematic and steady rising trend over last 3 decades for all the major Indian states.

2. *Growth of urbanisation in India*: Urbanisation growth rate over 1961 to 1981 has been examined in this study. The growth of urbanisation has been decomposed into 3 components—natural increase and net rural-urban migration. Concentration in urban agglomerations and towns has been examined by Gini Concentration Ratio and Index of Concentration. Urban population of India have been projected upto 2021 under two alternative assumptions.

3. *Perspective on demographic data collection in India*: This research study considers some of the issues raised for discussion on the new dimensions of the statistical system in the 21st century. The main focus of the study is on the new areas for data collection as well as on improving quality of data. Alternative approaches for estimating demographic parameters are suggested in the study.

4. *Distribution of households by family size*: Role of health and household occupation for nuclearization of households have been examined in this research study. More than 75% of households are either nuclear or lineal joint. Ratio of nuclear and lineal joint family households are 3:2, 2:1 and 2:3 in rural areas around Calcutta, away from it and around Patna in Bihar respectively.

5. *Occupation distribution in rural Bihar*: Examination of household survey data of rural Bihar around Patna (1983) shows that although agriculture is pre-dominant occupation currently, its role is declining whereas role of tertiary sector is increasing. Non-manual services are dominated by literate male population. Upper caste Hindus are mainly owner cultivators and non-manual service holders. Scheduled caste Hindus are generally engaged as labourers.

6. *Life table for West Bengal 1980-81*: Age specific death rate data from the report on Ideal Registration and Model Health Unit, West Bengal have been

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utilised in the study. The life table, as constructed shows that expectations of life at birth are 58.4 and 60.7 for males and females respectively indicating lower mortality rates for females due to better health and lower risks at child birth.

7. *Attitude to family planning practice* : Two household surveys in Calcutta in 1970 and 1974 show decline in households' dis-approval to practice of family planning methods in respect of couples with more than 2 children alive. Rural surveys around Calcutta, 1978 and away from it, 1980 show considerable decline in unwilling attitude of Muslim couples to family planning practice due to religion.

C. Teaching and training

The Unit organised the following teaching/training programmes : (i) Vital Statistics and Demography for students of the Diploma in Health Statistics jointly with All India Institute of Hygiene and Public Health (April, 1985); (ii) Specialisation in Vital Statistics and Demography for participants of the Junior Certificate Course in Statistics (June, 1985); (iii) Dissertation for students of MA Economics, Kalyani University (Specialisation : Population, July, 1985); (iv) Specialisation in demography and vital statistics and sample surveys for ISEC trainees (January-March, 1986) and (v) Specialised training programme for UNDP fellows from Afghanistan (March, 1986).

ECONOMIC RESEARCH

This Unit continued to be engaged in teaching and training at various levels and in research work covering different fields of theoretical and applied economics. A brief account of these activities is given below.

1. *Teaching and training* : Members of the scientific staff shouldered the responsibilities of teaching economics, economic statistics and econometrics in the degree and other courses run at ISI, Calcutta. There were in addition a number of Junior/Senior Research Fellows working for the Ph.D. degree. Several members of the faculty participated in the teaching programmes of other universities and institutions, e.g. the M.A. Course in Economics of the Calcutta University.

2. *Research* : The research activities of the Unit during the period under review covered fields like economic theory, national and regional economic planning, sectorwise review of the performance of the Indian economy, level of living and poverty in India, besides methodological studies in theoretical and applied econometrics.

Economic theory : Research work had been going on over the past several years on the history of economic thought. This was widened out of its earlier pre-occupation with classical and post-classical economic theory. Attempt was also made to pass from the 'history' of the subject as such to a general 'historical view' of the subject drawing afresh the many internal and external boundaries that arise in this context. The two major themes pursued were social accounting and price formation.

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Investigations were also continued on the analytical foundations of Keynes' 'General Theory'; on social choice theory and game theory (covering topics like ethical indices of income mobility and migration and welfare); on aggregation problems in welfare economics, measurement of inequality, horizontal inequity, social mobility etc.; and on different models of international trade.

Economic planning: The short-term project on the 'Studies on Multisectoral Planning Model' sponsored by the Planning Commission was completed on 15 July 1985. Several reports emanating from the project have been submitted to the Planning Commission from time to time. The final report of the project is currently under preparation. The Planning Commission has entrusted the ISI with another two-year project on a 'Regional Model for Agriculture' and work on this was started on 16 July 1985.

Analytical studies in the area of regional planning were continued partly in connection with Ph.D. dissertations. Special mention may be made of two studies, one on optimal programming for spatial movements of foodgrains, and the other on VLS versus OLS regression techniques with applications to regional analysis.

Review of the Indian economy: Many scientific workers of the Unit revived a project for critically reviewing the performance of the Indian economy in its different sectors with particular emphasis on the year 1984-85. This led to a mimeographed report (released in August 1985) in which different members of the faculty contributed chapters reviewing different sectors or aspects, viz. agriculture, industry, power, foreign trade, prices, poverty and national income. Needless to say, individual members of the Unit continued to study particular sectors of the Indian economy quite apart from this collaborative study aiming at an overall view of the economy.

Poverty and level of living: The report on the ILO-sponsored project, 'Relative price of food and the rural poor—the case of India', was submitted to the ILO. This report, largely based on NSS data, makes a comprehensive analysis of trends in level of living and in the incidence of absolute poverty in rural India since the 50's. It is now being finalized in the light of comments received from the ILO and other economists. In another study partly based on NSS data, an attempt was made to compare the time trends in level of living in rural India revealed by large-scale sample surveys and the corresponding findings of the micro-studies conducted by anthropologists.

A survey project has been undertaken in rural areas of three districts of West Bengal with a view to assessing the changes in level of living, if any, since the early 70's. The main idea is to revisit sample villages and households covered in 27th/28th rounds of the NSS and to collect data on different aspects of level of living broadly following the NSS approach. Data are also being collected through daily visits from a sample of the poorest households with a view to studying their level of consumption and strategies for survival in different seasons. This study is expected to throw light on the potentials and weaknesses of the NSS methodology.

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Methodological studies in econometrics : Research work was carried out on various topics in the following areas : (a) formulation of new systems of demand equations and their performance vis-a-vis other wellknown systems in the analysis of Indian data ; (b) Estimation of single equation regression models with decomposed error terms ; use of Box-Cox transformations ; limited dependent variable models, etc.

Other studies : The report on the survey project, 'Consumption of iron and steel in the small-scale manufacturing enterprises : Calcutta Metropolitan District, 1963', undertaken in collaboration with CSU, was submitted to sponsors, the Joint Plant Committee/Planning Commission of the Government of India.

A project had been taken up during 1984-85 (in collaboration with the Demography Research Unit) to study the socio-economic and demographic trends since 1951 in three regions with special reference to disparities across various segments of the population based on religion, caste, mother tongue, ethnic group, etc. Collection of data for Tripura and Greater Calcutta was started in 1984-85. Professor J. B. Ganguly of the Calcutta University Postgraduate Studies Centre, Agartala, has been collaborating for the study on the Tripura region. The report on Tripura is expected to be completed during the year 1986-87. Work on Manipur was started during the period under review with the collaboration of Dr. L. Tombi Singh of the Department of Economics, Manipur University.

The Institute has undertaken a project in collaboration with the Oil and Natural Gas Commission (ONGC) on (i) estimation of discovery and production cost of hydrocarbon and (ii) development of an optimisation model for the allocation of resources between exploration and exploitation of hydrocarbon with a view to achieving some targets or goals. This is a two-year project and scientists from different Divisions of the Institute are participating in the Project.

PLANNING (DELHI)

1. *Economic theory* : Research was undertaken in the following topics :

(a) *Planning techniques* : Design of efficient resource allocation mechanisms in partially planned economies ; Optimality of various cost sharing rules in the provision of public goods ; the application of such rules in actual policy decisions by the Government ; Critical review of existing plan models.

(b) *Industrial organization* : Study of strategic firm behaviour in preventing potential entrants from entering an industry ; Exploration of how higher profitability of markets leads to greater control by a fewer number of firms.

(c) *Applied microeconomics* : Dual economy models and their welfare implications under growth ; effects of choice of production techniques on unemployment ; multinational firm behaviour, sectoral shifts and government policies ; optimal subsidy policies in dual economies.

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2. *Macromodelling and policy* : Work was carried out in constructing consistent macromodels to study the impacts of various policies in a general equilibrium context. Theoretical models of economics with more than one segmented market for the same good, were also constructed. These models were constructed with a view to their applicability to the Indian economy and a number of projects were carried out using these models. In particular, these dealt with administered price and credit rationing.

3. *Regional economic planning* : Studies have focused on the understanding and evaluation of the spatial dimensions in planning at the state and intrastate levels. Special topics included micro-level studies of environment and human settlements, patterns and processes of urbanization in Karnataka and energy resources in the Himalayan regions.

4. *Women's studies* : The study on the role of women in rice cultivation in three states continued during this period.

5. *Sociology* : Extensive field work was carried out in North Bengal, in connection with the project entitled "Conflict, Structure and Change".

ECONOMIC ANALYSIS (BANGALORE)

The Economic Analysis Unit made further progress in its research and training activities, leading to Ph.D. thesis on 'The problem of distribution in India's development'. Besides, the Unit contributed five research papers to refereed Indian Journals of Economics and Statistics. It maintained academic collaboration with Indian and foreign universities, and conducted an intensive international Workshop at Bangalore (August 5-8, 1985) which was attended by over 25 eminent social scientists from England, United States, Canada, The Netherlands, France and Switzerland. As part of the academic exchange two of its members visited the Development Economics Research Centre in the Department of Economics, University of Warwick (England).

A brief summary of research done during the period is given below :

1. *Appropriate criteria for the measurement of levels of living* : In developing countries, where food dominates household budgets and where incomes are low and unequally distributed, there will always be a large section of the population whose food needs are not being adequately met. In such cases, it is more appropriate to use quantity-based measures instead of value-based measures of consumption, where the equivalent scales for household consumption are exogenously determined. This approach is further refined by inclusion of household composition and occupation in the calculation of equivalent scales and compared with other conventional welfare indicators using the same data set.

2. *Pattern of asset holding in rural Andhra Pradesh* : Asset elasticities measure the propensity of households to accumulate specific forms of assets given an increase

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in their total assets. In this study an attempt was made to provide consistent estimates of such elasticities for land, livestock, machinery, etc. held by households in rural Andhra Pradesh.

3. *A general multicollinearity index for regression analysis* : In this study a new formula measuring multicollinearity is defined. This index takes the value of zero for an orthogonal model and a non-zero value for a non-orthogonal or multicollinear model. This new measure was applied to investigate the properties of the estimates in the Rotterdam model.

4. *A decomposition of consumption inequality* : Decomposition of inequality in the distribution of total consumption in terms of inequalities of its constituent items has attracted the attention of economic statisticians in recent years. In this study a simple approach, based on the use of specific concentration curves and ratios, was developed for the decomposition of inequality and illustrated with a concrete example based on NSS data for India.

5. *On the reliability of NSS data* : This paper is addressed to two specific questions : How far are the comparisons between NSS and CSO estimates of aggregate consumption valid ? Is there any other basis for the doubts generally expressed about the reliability of NSS estimates ? This study reveals possible sources of bias in NSS estimates, and goes into the conceptual and methodological differences underlying the estimates.

6. *The problem of distribution in India's development* : This major work is the outcome of a series of studies conducted at the Bangalore Centre during the last few years. It incorporates some of the studies on poverty and income distribution as part of its research project on regional demand patterns. The main focus of the study is on trends in growth and pattern of income distribution in India. The study, apart from answering some questions of current interest, also shows to what extent an inappropriate data analysis itself could give rise to illusory findings about relative inequality levels and trends in India. On the substantive side, the study shows that the precise impact of any redistributive change on poverty level varies from country to country depending upon the severity of poverty. This study has produced one dissertation for doctoral degree.

7. *Estimation of yield functions for major cereals in India* : This study uses simple fertilizer trials data to estimate agricultural response functions for selected crops under varying irrigation-crop variety combinations, and provides national-level yield functions under certain mild assumptions.

NATIONAL INCOME

The National Income Research Unit (NIRU) continued to be engaged in researches on different aspects of national income and related aggregates with special reference to the Indian economy at national and regional levels. The faculty members also participated in the teaching of economics and economic statistics in different courses conducted by ISI at Calcutta.

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The following is a brief account of the research activities of the Unit during the period under review.

One study made a preliminary assessment of the impact of urbanisation on various aspects of national income and allied aggregates. Another examined technological changes in manufacturing industries in India and their impact on the different factors of production.

The report on the sample survey of wage earnings of workers in small-scale manufacturing enterprises in Calcutta is nearing completion. The material collected in the household survey of unaccounted components of human capital formation conducted in the previous year is also being analysed for reporting.

A study has been undertaken with a view to evolving an overall index of development which takes account of different economic and non-economic indicators and then utilizing it to study the development of different countries over the past three decades.

LINGUISTICS

The Linguistic Research Unit continued its research endeavours in the areas of fundamental and applied linguistics during the year under review. Research projects in the Unit may be grouped under three main headings, namely, (1) Studies on the phonetic structure of major Indian languages and application of the results in the area of (a) speech pathology, (b) second language acquisition, and (c) cultivation of mother-tongue. (2) Studies on acquisition of language and bi-lingualism. (3) Application of statistics in linguistic problems.

A survey of the articulatory and acoustic structure of the Oriya language was initiated in 1979-80. Final analysis of quantitative data with the help of the sound spectrograph is in progress. Fundamental research on the supra-segmentals of Bengali, Hindi and Telugu is in progress. Prosodic elements of these languages are being analysed with the help of appropriate instruments.

Studies are in progress on (a) development of articulation of speech during the language acquisition period of the pre-school-age child and (b) the measurement of the threshold of bilingualism.

Based on linguistic data provided by Visiting Professor Djordje Kostic, Belgrade, Yugoslavia, a number of studies are in progress on the vocabularies of leading Yugoslav poets of the 19th and 20th Centuries. Linguistic data on the Bengali language has been collected for purposes of statistical processing for studies on author's vocabulary and linguistic usage.

In continuance of its pioneering efforts to study the acoustic structure and supra-segmental elements of major Indian languages a number of comparative studies are planned, based on spectrographic data on Indo-Aryan and Dravidian languages and also Serbo-Croat and English. Methods of Analysis and measurement of speech signals,

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supra-segmental differences, and the study of intra-cycle vocal chord motion, are also being worked out and planned with the Visi-Pitch, which the Unit is acquiring shortly.

The programme of speech Habilitation of hearing impaired children using the Kestic Methodology and Instrumentation continued according to the Unit's long-term plan of research in speech pathology during the year under review.

PRE-CENSUS POPULATION STUDIES

The Pre-Census Population Studies Unit conducts quantitative historical studies on India and works on the project on population of India prior to 1872 in collaboration with Office of the Registrar General, India. Two volumes have been published and another volume entitled Report on the Population Estimates of India, Vol. 3, 1811-1820, Part-B-India, is in the press.

The following are the plan projects :

(i) Editing the manuscripts of statistical survey of Bengal, 1807-14 by Francis Buchanan—the districts of Gorakhpur and Rungpore.

(ii) Economic changes in rural India : (a) A study of 200 villages in Bengal, Bihar and Orissa, 1850-1981, (b) Trends on socio-economic changes in 4 districts (Burdwan, Broach, Gorakhpur, Bellary) in India, 1801-1981.

(iii) Pre-census atlas.

Progress of the plan projects : Work on Gorakhpur was completed. The tract had been identified on a map of 1961 and statistical tables prepared. Trends of population and some other key variables at the district level were analysed upto 1971. Rungpore manuscripts were copied out. Relevant materials of the Rungpore survey including statistical tables are being presented in the Report on the population Estimates of India, Vol. II, 1801-1810.

Data were collected from Central Record Room of Directorate of Land Records and Survey of more than 3,000 villages of the districts of 24 Parganas, Nadia, Murshidabad, Malda and Birbhum for 1848-1850 on a ten per cent sample basis. There is a map for each village and statistical data are inserted on the map. Data are available on area, houses—kuchha and pucca, population by religion and by division into agricultural and non-agricultural sector, plough and other implements. Among these villages, 1080 have been identified on a current list contained in the respective District Census Handbook. Supplementary data at mouza level have already been collected from settlement Malka Office, Collectorate Record Room, Taxii Assessment Office and Settlement Circle Office of the respective district and some villages surveyed to obtain the long-term trend.

There was progress of work in all the 4 districts. (i) Broach—Data have been collected on area, area under cultivation by crops, soil type, population with age, sex, caste and religious breakdown, revenue, stock, wages and prices, typical family budget, urban population for several years between 1850 and 1876. A comparative

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wage table was presented for 1774, 1844, 1884 and 1875 for labourer, carpenter and bricklayer. A time series of prices of grain and cotton was available for 1810-20 and 1833-74. Materials on population and agriculture have been collected from the Maharashtra State Archives. (ii) Gorakhpur—Similar data were collected for this tract also, work on both the districts is continuing. Some materials have been incorporated in the pre-census volume relating to 1811-1820. (iii) Burdwan, Bellary—Data on various aspects have been collected and are being processed for analytical studies. New archival materials on Bellary have been located at Madras.

There has been good progress of pre-census atlas for Vol. III, Part-B—India, 1811-1820. The maps are being drawn under the general supervision of the Deputy Registrar General of the Map Division of the Registrar General, India. Maps have been planned for the volume 1801-1810.

PSYCHOMETRY

1. *Development of a forced-choice scale to measure certain managerial skills*: The scale was ready and the report writing was also completed.

2. *Development of a non-verbal intelligence test for hearing impaired children*: The test was ready; only data are being collected from different parts of India for development of norms.

3. *Consequences of socio-economic deprivation on academic achievements*: Survey of the relevant literature was over. A report on the pilot study is available. Data are being collected for the final study, and intermediate report is being written.

4. *Predictive validity of the forced-choice scale of managerial skill*: Although the project was scheduled for 1986-87, some preliminary work (e.g., literature review, etc.) had been carried out during the year.

5. *Popular views on mental health*: Part of data was computerised and analysis was in progress.

6. *Rorschach psychogram through computer programming*: The project was completed. One paper had been published and another was nearing completion.

7. *Statistical analysis of multiple-choice test scores*: A computer programme for estimation of the parameters of such test scores under the latent trait model was successfully developed. A very high correspondence between the expected results generated by the model and the actual data was found.

8. *Assessment of minimum learning in primary education*: Although the project was scheduled for 1986-87, some preliminary work relating to this project (e.g., consultation with experts and school authorities; collection of text books, syllabi, returns from schools and other relevant documents; preparation for a teachers' workshop, etc.) was carried out during the year.

Service projects :

1. Selection tests were conducted at three centres in August 1965 for recruitment of Officers (Technical and General) and Clerk-cum-Typists of the West Bengal Financial Corporation.
2. A selection test was undertaken in December 1965 for admission of students to the B.Lib.Sc. course of the Calcutta University.

SOCIOLOGY

1. *Social ecology of Sunderban* : The sampling design for the study was prepared in collaboration with a statistical colleague of Statistics-Mathematics Division of ISI. Relevant available materials from the existing sources were collated and the first phase of the field work was completed.
2. *Potentialities and constraints of development : A social-ecological approach* : The primary objective of this study was to explore the scopes and barriers to development of symbiotic relationship between societal groups and their natural resources in a specific ecological zone. The area under study is the Simlipal forest range in the district of Mayurbhanj, Orissa. The field survey is in progress.
3. *Problems of deforestation* : To identify and quantify the factors influencing the process of deforestation and its consequences on the geographic character of land and species of plants and socio-economic characteristics of the population depending on forest economy, was undertaken in two States, West Bengal and Bihar. A report of findings is being prepared.
4. *Ageing of population in India* : The study aims at to examine the nature of impact of ageing population on society, and that of society on ageing, and the conditions of life of older persons under varying social and economic circumstances covering both urban and rural areas.
5. *Village re-survey* : Re-survey (a) has scope to indicate changes in rural life over time, and also (b) helps to understand the processes of societal change. Data collected from a multi-ethnic village in West Bengal is being arranged in this context.
6. *Value systems and social change* : The study seeks to identify socio-cultural and political value patterns among various societal groups in two sample villages in Purulia to find out how and to what extent these affect the programmes of rural development. Data processing is under way.
7. *New pattern of leadership and social action : An exploratory enquiry* : The objective of the enquiry is to study the process and background of the new generation of leaders emerging in the villages along with the recent socio-political changes in the State. Field-work was completed. Data collection is in progress in collaboration with a scientist of Statistics-Mathematics Division.

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8. *The study of registry marriage and the impact of legislation and West Bengal* : The objective is to study the roles played by the marriage legislation in changing the character of marriage institution in West Bengal. Field work is continuing.

9. *The Hindu-Muslim relations in Bengal during the 18th Century with special reference to the Fakir and Sanjayani rebellion* : The Hindu-Muslim relations, which have played an important role in Indian Society, underwent significant change after introduction of the British rule. Objective of this project is to study these variations in the context of peasant risings which challenged the colonial rule from the middle of the 18th Century onwards. The project is nearing completion. This study has produced one dissertation for doctoral degree.

10. *A study of educational wastage (stagnation and drop-out) at primary and middle school levels (in collaboration with Demography Research Unit)* : The objective of the study is to (a) attempt an estimation of expected 'life' of a student—a problem of methodological interest; (b) find out educational wastage differential by various demographic, socio-economic and other related factors, and (c) try to identify and evaluate various factors as determinants of educational wastage. The study is confined to the 24-Parganas District of West Bengal. Field work is going on.

11. *The Peasant movements during the early phase of colonial rule in Bengal* : The object of the study is to trace the deep-rooted continuity of peasant resistance in Bengal throughout the colonial period. Source materials are being collected from the State Archives and different district collectorates of West Bengal.

12. *Post Congress Workshop to XI World Congress of Sociology—August 28-29, 1988* : The object of this post-session is to organise a small-group intensive discussion on the theme of : *Ideology, Social Formation and Transformation*, based upon invited papers written for this post-session. The Unit is organising this post-session in collaboration with other social scientists in Calcutta.

Statistical Quality Control and Operations Research

1. General

1.1 Statistical Quality Control and Operations Research Division (SQC & OR) was set up by the Government of India in 1952 under the technical guidance of the Indian Statistical Institute. The Division continued with its objectives of promoting applications of Statistical Quality Control (SQC) and Operations Research (OR) methods, training and education of executives, inspectors, trainees, operators, consultative services to industrial establishments and research in SQC and OR and allied methods. The activities of the Division are organised through comprehensive programme under the broad classification of (i) promotion, (ii) training, (iii) plant services, and (v) research.

1.2 Promotional activities were continued in public and private sectors. Inplant training of technologists, trainees, inspectors and operatives, etc. including the training programmes in local languages and services continued to have support

from a number of public and private sector organisations. The units of Bharat Heavy Electricals Ltd.,—Hyderabad, Hardwar, Bhopal and Jhansi etc. and Hyderabad and Calcutta Units of Hindustan Cables Ltd., continued as servicing plants of the Division besides a number of other plants both in public and private sectors. Several organisations were added to the list of servicing plants during the period.

1.3 The Division undertook new project assignments during the period apart from rendering consultative services to factories already on its roll. The Division has so far produced about 900 speciallata and over 750 research papers, technical literatures, manuals, etc.

1.4 The Division continued liaison with various academic and technical institutions, productivity councils, societies and several other national and international bodies by way of its academic, technical and promotional activities.

2. Service

2.1 During the period under review 15 plants joined the SQC service scheme. 180 technical reports were sent to factories and 15 factories discontinued. A total of 64 factories were taking consultative services as in March 1988.

2.2 Special studies involving applications of SQC and OR methods were taken up in the areas : Blending operation in refinery, optimal despatch model, optimisation of cutting material for connecting plate, control of heating elements, optimum design of air heater economiser, design optimisation of tubular air heaters, study on breakage of biscuit, moisture control in biscuit, valve stemgrinding, critical components for burner assembly, surface defects, of tubes, defective parts in weld joints, graphic of terminals etc. replacement of spinning and allied frames, welding of centrifugal compressor impeller, tool wear in machining of rotor slots, SFC of diesel engines, outgoing quality of diesel engine, leakage problem in DMA of FHP compressors, rejection in die casting, discharge gas temperature of compressors, amount of ash in paper, optimum design of ceiling fan, oscillation mechanism of table fan, stability of jelly filling process with regard to water penetration.

3. Education and training

3.1 Inplant training programme at various factories continued. A series of training programmes for senior executives of Bharat Heavy Electricals Ltd., continued on regular basis besides regular inplant programme for executives etc., at various level. One-year special programme for executives at fairly advanced level blended with practical applications continued for sixth and seventh batches of trainees at Madras. Several short term specially designed training programmes were also conducted at different units of the Division for select group of executives etc. from organisations in India and abroad.

3.2 During the period under review 4680 managers and technologists were trained in various inplants, general and other courses, 147 trainees underwent professional training in SQC and OR at a Post-graduate level and in part-time courses

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in Calcutta, Bombay, Delhi, Madras, Bangalore and Hyderabad. A general course and later, a specialisation course in SQC-OR was offered to the trainees of International Statistical Education Centre (ISEC) by the Division.

3.3 The Division organised a Summer Institute on Industrial Experimentation at IIT, Kharagpur from 20 May to 5 June 1985. Twentytwo participants including university teachers and SQC-OR specialists of the Division attended the programme. Besides SQC-OR specialists from the Division some external experts in the area served as faculty for the programme.

3.4 The division organised a staff development programme on "Development in Computer and Computer Programming" at Delhi from 24 March 1986 to 4 April 1986. The technical officers of the SQC-OR Division attended the programme. The programme was conducted by the internal and external faculty. Dr. T. S. Arthanari was the course Director.

4. Research

4.1 During the period under review 9 papers were published, 25 submitted for publication, and presented at conferences, seminars etc. 30 manuals and technical reports, etc. prepared by the specialists of the Division. Some of the areas in which applied research work was carried out included Scheduling and Hybrid Flowshop algorithm for testing a Z-matrix to be an M-Matrix, simple games and reliability coherent structure, operation of contraction for simple games based on analogy of matroids and some combinatorial results for matroidal games, optimum ordering internal for exponentially denying inventory, optimum design of control charts, inspection error and its effect on outgoing quality, continuous sampling plan, asymptotic solution to three-decision Bayesian sampling plan.

5. Promotional activities

5.1 The specialists from the Division delivered 179 lectures, talks etc. to various institutions and organisations. The Division also arranged 15 seminars and the specialists from various units attended 43 seminars.

5.2 Introductory visits were paid to 46 factories. Twelve surveys and pilot projects were carried out and 14 reports sent.

Library, Documentation and Information Sciences

Central Library : With the addition of 2,227 books and 1,000 bound volumes of journals to the stock, the total collection of the Library rose to 1,83,070 volumes. The total membership of the Library was 3,793. The total membership includes NSSO staff, ISI staff, research scholars and project assistants, B.Stat. & M. Stat. students, ISEC trainees etc., as well as outside students and institute members. 468 readers were given special permission to use the library for a short period.

Acquisition : Two thousand two hundred and twenty-seven books were accessioned during the period under report, out of which 1,600 were purchased and 623

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were received as gift. 4 titles were also acquired on exchange basis. It also acquired 397 titles for the Circulating Library.

Periodicals : The Library received 2,488 periodicals out of which 767 were received against subscription, 1,100 on complimentary basis and 619 on exchange arrangement with national and international organizations. The Library also acquired 47 back volumes of journals. It accessioned 1,160 bound volumes of journals and completed the technical processing of 1,000 journal titles.

Circulation : The Library issued 46,824 books and journals to the users on loan and on reference. 31 books and journals were borrowed from other libraries and 6 books and journals were loaned to other libraries under the inter-library loan arrangement.

Reports and records : The Library accessioned 672 titles and processed 812 titles. 1,305 titles were issued to borrowers during the period.

Translation service : The Library translated the following : *From Japanese* : (a) A research memoir on 'Multivariate Analysis—edited by Prof. T. Kitagawa, published by Tokyo University ; (b) Off-line quality control—a research memoir by Prof. G. Taguchi, published by Japan Science and Engineering Society. *From German* : (a) History of Medicine and Biology—Memoir no. 8 published by University of Basel.

Shri Sunit Bose, Translator, gave regular courses in Russian to the B. Stat. students.

Special Materials Collection : The Library accessioned 52 micro-documents and 105 Russian books.

Technical Processing : The Library classified 1,643 and catalogued 2,791 new books.

Documentation Services : The Library compiled (a) bibliography on different aspects of Indian Economy, (b) bibliography on two key-words (i) infinitely many parameters and (ii) nuisance parameter as also a bibliography of articles by Stuart Gemen.

Reprography and Photography Services : The Library provided 2,38,732 xerox prints for the users during the period under report.

648 frames of photographs of different occasions, 5,381 prints of bromide enlargements, 878 frames of microfilming from drawing books, charts, journals, etc. 2,028 copies of photoprints from big maps and documents, 451 slides for lectures were made during the period under report.

Circulating Library : The Workers' Circulating Library acquired 397 new titles bringing the total collection to 33,204. It issued 28,762 books to the members.

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Bangalore Centre Library : The Centre accessioned 559 books out of which 37 were received as gift. During the period 339 periodicals were received of which 30 were complimentary. It accessioned 475 bound volumes of journals. About 300 books were classified and catalogued. A total of about 4,350 books and 2,000 periodicals were circulated. About 350 inter-library loan transactions were handled.

With the addition of 559 books, the total book collection came to 9,021 and the stock of bound volumes rose to 2,521 with the addition of 475 bound volumes.

Delhi Centre Library : With the addition of 698 books and 615 bound periodicals the total collection rose to 25,382 volumes out of which 129 publications were received as gift.

260 periodicals were received out of which 256 were against subscription and the remaining 4 were on exchange/complimentary basis.

The Centre issued 9,894 books and journals to users on loan and on reference. 107 publications were lent out and 117 were borrowed on inter-library loan arrangement.

The Centre provided 3,632 xerox prints for the users.

The total membership of the Library was 80. 57 readers were given special permission to use the Library for a short period.

DOCUMENTATION RESEARCH AND TRAINING CENTRE (DRTC) BANGALORE

(i) *Objectives and programmes of DRTC* : The objectives of DRTC are as follows : (a) To contribute to the development of different branches of information sciences including documentation and library science by doing, guiding, and supporting research and development in the concerned fields. The aim is to develop expertise and excellence in different areas of information science. (b) To help development of information centres including libraries, documentation centres, data centres, and information analysis and consolidation centres by offering advisory services in designing specific development plans, tools, and techniques required for this purpose. (c) To disseminate results of research, information analysis and consolidation and of advisory services in different areas of information sciences including documentation and library science. (d) To develop man-power with appropriate professional skills and understanding that is capable of participating efficiently and effectively in the management (that is, design, development, organization, implementation, operation, control, and evaluation) of information service systems, centres, and programmes and in the advanced teaching and research programmes in information sciences ; and to help this manpower in finding appropriate job opportunities. (e) To ensure the development of the man-power engaged in professional activities. (f) To ensure the development of the members of the DRTC faculty.

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To achieve these objectives, the activities of DRTC have been organized into the following programmes :

(1) Research Programme (2) Advisory Service Programme (3) Extension Programme (4) Publication Programme (5) Training Programme (6) Employment Information Programme (7) Continuing Education Programme (8) Faculty Development Programme.

(ii) *Training in documentation and information science* : The 1985-86 session of the DRTC Course leading to the award 'Associatehip in Documentation and Information Science' commenced on 18th August 1985. On the basis of an admission test and interview, 7 candidates were selected for admission to the course. Two of the candidates ultimately could not join the course because of personal reasons. There were two deputed candidates, one from Bangladesh.

(iii) *Research activities* : The main topics of research in which the different members of the DRTC faculty were engaged during the period of report are furnished below :

(1) Application of the Postulate-based Permuted Subject Indexing (= POPSII) to text-indexing for information retrieval ; (2) Designing a classarrus based on the general theory of subject indexing language for indexing documents in the field of agricultural sciences and technology ; (3) Methodology of designing a code for cataloguing practice ; (4) Revision of the schedules of basic subjects and common isolates in the Colon Classification of Dr. S. R. Ranganathan ; (5) Analysis of the trends pertaining to the different varieties of sources of information and communication media ; (6) Impact of information technology on document delivery services in libraries ; (7) Planning and management of information systems and services ; (8) Information analysis and consolidation ; (9) Designing of depth classification version of colon classification in the field of biological and medical sciences ; (10) Computerization of library activities including development of software for library automation and information retrieval ; (11) Bibliometrics studies relating to the developments of measures for evaluating library and information services ; (12) Development of curriculum for library and information science programmes ; (13) Improvement of a system for on-line generation and maintenance of alphabetical classarrus ; (14) Computer generation of different kinds of index entries from a single input ; (15) Development of a micro-computer based operational and instructional systems for man-power planning for the library or an information centre.

Progress of the Project : The DRTC Project for designing a classarrus for agricultural sciences and technology was taken up by Dr. G. Bhattacharyya. The project has been planned to be completed in three years i.e. in November 1987. The work in all preliminary stages had been completed. A reference framework of classification scheme had been developed. This framework is to be augmented by examining many classification schemes and thesauri. The work of augmentation is in progress.

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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.*

A two-days Workshop on the Strategies for the Seventh Plan was held during 15-16 April 1985 at Delhi Centre of the Institute.

A four-day International Workshop on Measurement of Rural Economic Change, under the joint sponsorship of the Social Science Research Council (USA) and the Indian Statistical Institute, Bangalore Centre, was held at Bangalore during 5-8 August 1985. The Workshop was attended by 25 eminent Indian and foreign social scientists.

The 15th General Conference of the Indian Association for Research in National Income and Wealth, organised under the joint auspices of National Institute of Public Finance and Policy and the Indian Statistical Institute, was held at Delhi during 4-6 November, 1985.

A Data Analysis Workshop for the Medical Sciences was held at the Indian Statistical Institute, Calcutta, during the period 11-30 November, 1985. The object of the Workshop was to impart training in data analysis techniques to medical scientists. Apart from the medical scientists, two statisticians from the National Institute of Mental Health and Neurosciences, Bangalore, were invited to participate in the Workshop. Four data sets were taken-up for analysis during the Workshop. Apart from analysis of data, several lectures and practical sessions were held. Work on publication of the proceedings of the Workshop is in progress.

The third Annual Conference of the Indian Society for Medical Statistics was held at the Indian Statistical Institute, Calcutta, during the period 3-5 December, 1985. Prof. P. V. Sukhatme inaugurated the conference.

A Summer School was organised by the Indian Statistical Institute on the Applications of Statistics in Biology at the University of Mysore during 1-15 June 1985. The objective of the course was to acquaint the research workers and faculty members of universities and research institutions with modern statistical techniques used in quantitative biological research. Fourteen participants from various disciplines of biology joined the course. The morning technical classes were backed up by afternoon tutorial classes where the participants analysed various types of data and also presented their own problems.

The International Symposium on Advances in Multivariate Statistical Analysis was held at Indian Statistical Institute, Calcutta, from December 17 to 20, 1985. There were 28 invited speakers from India and foreign countries. Twenty-nine speakers participated in different contributed paper sessions. Papers relating to Advan-

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oes in classical multivariate analysis, Multidimensional probability theory, Multivariate non-parametric methods, Time series analysis, Discriminant analysis, Classification methods, Selection of variables, Computer-oriented methods and Projection pursuits were presented in the Symposium. Two workshop sessions dealing with applied problems in multivariate analysis were also held. The Symposium was organized by several faculty members of the Indian Statistical Institute along with Professor S. Chatterjee of Calcutta University and Professor S. Das Gupta as the Chairman.

A Summer Workshop on recent developments in Design of Experiments was held at ISI, Bangalore, during May 27--June 8, 1985.

A Seminar on 'Prospects and Problems of Green Vegetation Research' was organized jointly by the Indian Statistical Institute and the Society for Green Vegetation Research (SGVR) on 12 and 13 December 1985 at the Institute in Calcutta. Twentythree delegates participated. Proceedings of the Seminar, jointly edited by N. Singh and S. Matali, will be brought out shortly.

A specialized conference dealing with theoretical concepts, measurement and empirical findings of national income and wealth was co-hosted by the Planning Unit at the Delhi Centre in November, 1985. About 10 of the research papers presented are to be published in the *Journal of Income and Wealth*.

A workshop to study the economic effects of the Seventh Five Year Plan and recent changes in various economic policies organized by the Planning Unit at the Delhi Centre, in January 1986. Professionals from all over India participated and presented papers.

A nationwide conference on "Economic Theory and Related Mathematical Methods" was held at the Delhi Centre in March, 1986. It led to a number of publishable papers and a lot of collaborative analytical work with participants from other institutes.

A Seminar on Communication Disorder was held on 14 February, 1986 in collaboration with the Deputy Registrar General, Language Division, Ministry of Home Affairs and U.S.E.F.I. Dr. Teris Kim Schery, Professor Communication Disorders, California State University, U.S.A., conducted the seminar. There were 20 participants.

3.2 Lectures and seminars

The following seminars/lectures were arranged during the period :

Professor Martin Davis, Courant Institute of Mathematical Sciences, New York (26.7.85) : (i) Coding algorithm by exponential diophantine equations. (ii) A formal notion of program based test data adequacy.

Dr. Samar Mitra, Emory University, USA (14.7.85-18.7.85) : 'Stability in the presence of migration.'

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Professor B. N. Bhattacharya, Indiana University, USA (12.8.85-30.7.85) : 'Homogenization of elliptic operators with rapidly oscillating periodic or almost periodic coefficients—the Probabilistic method.'

Dr. Jens Ledet Jansen, Aarhus University, Denmark (1.4.85-9.6.85) : 'Exponential transformation models.'

Professor Malay Ghosh, Florida State University, USA (22.7.85) : 'Sequential shrinkage estimation.'

Dr. D. Ramachandran, University of California, USA (21.7.85-25.7.85) : 'On two notions of independence.'

Dr. G. Ramachandran, University of California, USA (21.7.85-25.7.85) : 'Audit sampling.'

Dr. S. Ramakrishnan, University of Miami, Florida, USA (14.7.85-14.8.85) : 'Good strategies for leavable gambling houses.'

Dr. Ravi T. Chari, Tufts University, USA (9.8.85) : 'Non-linear markov processes.'

Professor J. Stern, University of Caen, France (22.9.85-9.10.85) : 'Introduction to the forcing technique with applications to descriptive set theory and measure theory.'

Professor V. Mandrekar, Michigan State University, East Lansing, Michigan, USA (28.9.85) : 'Stochastic integration with respect to Gaussian process.'

Dr. Y. P. Chaubey, Concordia University, Canada (1.8.85) : 'Some investigations about the properties of the product estimator in finite population sampling.'

Dr. Prabir Burman, Rutgers University, Brunswick, USA (15.8.85-26.11.85) : 'Model selection in regression problem.'

Stat-Math (Bangalore)

Professor G. Kallianpur, University of North Carolina, Chapel Hill, USA (29.5.85) : "Stochastic differential equations and applications in biology."

Professor V. Sehadri, McGill University, Montreal, Canada (10.6.85) : "The inverse Gaussian distribution."

Dr. B. V. Ramamoorthi, Michigan State University, East Lansing, USA (16.7.85) : "Sufficiency for multivariate normal with unrestricted covariance matrix." He also gave a series of lectures entitled "Comparison of Experiments" during 20.11.85-30.11.85.

Professor John F. Price, University of New South Wales, Sydney, Australia (19.7.85, 24.7.85, 26.7.85) : (i) "Interference patterns and uncertainty principles." (ii) "An Introduction to well-concentrated functions, sampling and interpolation."

Dr. H. N. Nagaraja, Ohio State University, Columbus, Ohio, USA, (14.8.85) : "Discrete order statistics."

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Dr. S. Ramakrishnan, University of Miami, Coral Gables, USA (20.8.85-21.8.85) :
(i) "Finitely additive generalisation of the Birkhoff ergodic theorem..'' (ii) "Expected value of an everywhere stopped martingale."

Professor V. Mandrekar, Michigan State University, East Lansing, USA, (17.10.85-5.11.85) : A series of lectures on "The Central Limit problem and the geometry of Banach spaces." He also gave a lecture entitled "Halmos-Wold decomposition for commuting isometries" on 29.10.85.

Professor H. Kunita, Kyushu University, Japan (29.11.85) : "Tightness of measures in $D[0, T]; C$."

Professor J. Sethuraman, Florida State University, Tallahassee, USA, (20.12.85) : "Large deviations theory."

Professor K. B. Athreya, Iowa State University, USA (20.12.85) : "Bootstrapping the mean in the infinite variance case."

Dr. H. J. Vaman, Bangalore University (23.1.86) : "Sequential detection of disorder point."

Professor Bamesh Gangolli, University of Washington, Seattle, USA, (29.1.86) : "Harihar Chandra, his life and works."

Dr. V. V. Srivatas, ISI, Calcutta (18.2.86-25.4.86) : A series of lectures entitled "An introduction to descriptive set theory with applications to selection theorems."

Dr. Ravi T. Chary, Tufts University, Boston (5.3.86-16.4.86) : A series of lectures on "Nonlinear Markov processes."

Applied Statistics, Surveys and Computing

Dr. M. Pal, ISI, Calcutta (24.4.85) : "Estimation of threshold parameter in a three parameter lognormal distribution."

Dr. Diplik K. Saha, ISI, Calcutta (15.5.85) : "Ground water geology."

Mr. Chandra Nath Pal, ISI, Calcutta (29.5.85) : "Crop estimation procedure followed by West Bengal Bureau of Applied Economics and Statistics—An empirical study."

Dr. Bimal K. Roy, ISI, Calcutta (24.6.85) : "Construction of strongly balanced uniform repeated measurements design (Circular case)."

Dr. Sunanda Bagchi, ISI, Calcutta (14.8.85) : "On the optimality of MBGDDS of Type 1 under mixed effects models."

Mr. Anup K. De, ISI, Calcutta (11.9.85) : "Foreign tourists in India : Region-wise analysis."

Mr. Pulak Chakraborty, ISI, Calcutta (22.1.86) : "Review of some models of water management and presentation of some rainfall data from West Bengal."

Dr. B. M. Ghosh, Director, All India Institute of Hygiene and Public Health, Calcutta (24.4.85) : "Analysis of the inpatient system in a State hospital."

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Dr. S. Huda, Dacca University (26.4.85) : "Minimax design for the difference between estimated responses."

Professor Subrata Chakrabarty, National Institute for Training in Industrial Engineering, Bombay (17.5.85-22.5.85) : (i) "Manufacturing system reliability." (ii) "Transportation paradox."

Dr. N. Kirtoo, Director, Central Groundwater Board, Calcutta (26.4.85) : "Hydrogeology of river basins with special reference to West Bengal (a) Hard rock geology, (b) Geology of individual river basins."

Dr. S. P. Sinha Roy, Senior Hydrogeologist, Central Groundwater Board, Calcutta (26.4.85) : "Hydrogeology of river basins with special reference to West Bengal (a) Hard Rock Geology, (b) Geology of Individual River Basins."

Professor Biswa Nath Dutta, Northern Illinois University, Dekalb, Illinois, USA (17.7.85) : "Parallel matrix computations with a special attention to linear algebra problems arising in control theory."

Dr. D. G. Altman, Medical Research Council, England (9.12.85) : "Comparability of randomised groups."

Professor H. Yanai, Chiba University, Japan (18.12.85) : "Partial correspondence analysis."

Dr. Richard Brook, Massey University, New Zealand (5.2.85) : "Measuring agreement between observers."

Economic Research

Dr. Debdas Bandhyopadhyay, Kalyani University (10.4.85) : "On the structure of a plan model for growth and distribution."

Dr. Amitava Bose, Indian Institute of Management, Calcutta (17.4.85) : "On the short-run Macro-economics of Development."

Dr. Mallika Gopalkrishna, ISI, Bangalore Centre (22.4.85) : "Household needs and Measurement of welfare."

Dr. Anil Bera, University of Illinois, Urban Champaign, USA (12.6.85 and 19.6.85) : "Specification Analysis for market disequilibrium Models."

Dr. Kalyan Sanyal, University of Calcutta (26.6.85) : "Interaction between trading capital and productive capital in agriculture under uncertainty."

Dr. Sanjoy Bandhyopadhyay, SUNNY, Buffalo (7.8.85) : "Rational expectations and non-neutrality of money."

Dr. Abhirup Sarkar, ISI, Calcutta (14.8.85) : "A macro economic model for developing economies."

Dr. Ashim Dasgupta, Calcutta University (28.8.85) : "Decentralisation of planning in West Bengal."

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Dr. Satya Ranjan Chakrabarty, ISI, Calcutta (4.9.88) : "Characterisation of the entropy numbers equivalent."

Dr. Ranjan Roy, Delhi School of Economics, Delhi (24.12.85 and 1.1.86) :
(i) "Sensitivity of poverty estimates to poverty measures : A synthesis of alternative measure." (ii) "Optimal indirect taxes and expenditure system : An econometric study of India."

Dr. A. K. Sengupta, ISI, Calcutta (8.1.86) : "Efficiency in blast furnace process : An economic analysis."

Dr. Sugata Marjit, Jadavpur University (February 1986) : A short course of five lectures on "Rational Expectations Theory."

Linguistic Research

Dr. Abokananda Mitter, ISI Calcutta (18.3.86) : "The importance of Koetic methodology in the habilitation of hearing impaired children" for the National Institute of Hearing Handicapped Trainees.

Planning (Delhi)

Dr. Debraj Ray, Stanford University and ISI (3.10.85) : "Malnutrition and involuntary change in unemployment."

Dr. E. Malinvaud, INSEE, FRANCE (31.1.86) : "Theories of unemployment."

Dr. R. Guesnerie, Ecole des Hautes Etudes en Sciences Sociales, France (29.1.86) : "Rational expectations equilibrium."

Dr. W. Nordhaus, Yale University, USA (5.2.86) : "Recent development in fiscal and monetary policies."

Dr. Mukul Majumdar, Cornell University, USA (December 1985) : Four lectures on "Intertemporal economics."

Dr. Dilip Mukherjee, Stanford University (30.12.85) : "Principal-Agent models."

Sm. Shikha Jha, ISI (27.9.85) : "Dual pricing of edible oils."

Shri Dilip Bhat, ISI (20.9.85) : "The Vanaspoti industry."

Dr. Omkar Gorwami, JNU (15.11.85) : "The cotton textile industry."

Dr. Jean Dreze, LSE and DSE (25.2.86-28.2.86) : 3 lectures on "Cost benefit analysis."

Dr. John Whalley, University of Western Ontario (10.12.85) : "General equilibrium with foreign trade."

Dr. P. K. Upadhyay, ISI (6.3.86) : "An L. P. model of railway transport."

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Demography Research

Family Structure in Rural Bihar around Patna, on 22 April, 1985.

Laparoscopic Performance in Rural West Bengal, on 16 May, 1985.

Stability in the Presence of Migration, on 1 July, 1985.

Changing Net Maternity Rates Leading to Stability, on 12 July, 1985.

Health Development, Population Growth and Fertility, Change, on 2nd September, 1985.

DRTC (Bangalore)

A Seminar on "Development of INSDOC" was held on 16 April, 1985. The leading presentation was made by Shri T. S., Rajagopalan, Scientist-in-Charge, Indian National Scientific Documentation Centre, New Delhi.

A Seminar on "Ranganathan's contributions to modern library and information services" was held on 12 August, 1985. Presentations were made by Ms. R. Sugra Begum, Head of the Dept. of Library Science, Polytechnic for Women, Bangalore; Mr. B. S. Ramaswami, Deputy General Manager, Technical Information Centre, HMT Ltd., Bangalore; Dr. M. A. Gopinath and Dr. F. J. Devadasan, DBTC, Bangalore. Prof. Srinagabhuhana, Chairman, ISI Karnataka Branch was the president of the Seminar.

A panel discussion on "Research and training programmes in library and information science in Yugoslavia, Japan and India" was held on 13 August, 1985. The discussion was led by Mr. Edward W. Polman, Vice Rector, United Nations University, Japan; and by Dr. (Ma.) Ines Wesley Tanaskovic, Information Scientist, Information Centre for Medical Sciences, Belgrade.

A special lecture on "Lecture-demonstration method of teaching" was delivered on 20 August, 1985 by Prof. Charles Taylor, Topic Leader, Conference on Science and Technology Education, ICSU, Paris. This was followed by a discussion on "Education in the field of library and information science."

The Thirteenth Five Law Lecture series on "Manpower development for teaching library and information science" was held on 27 September, 1985. Dr. S. Seetharama delivered the lecture.

A Seminar on "Computer-based library management" was held on 1 October, 1985. The leading presentation was made by Prof. Christopher Turner, Brighton Polytechnic, Brighton, U.K.

The DRTC Refresher Seminar (16) on "Planning of libraries and information systems and services" was held in Bangalore. Dr. S. Seetharama prepared the working document and presented the same during the seminar. About 115 professionals and teachers of library and information science from different parts of India participated in the Seminar.

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A seminar on "Impact of information technology on library and information services" was held on 29 November, 1985. The leading presentations were made by Prof. D. J. Foskett, Former Goldsmith's Librarian and Director of Libraries, University of London, London, U.K.

A Seminar on "Fifth generation computers and its impact on library and information services" was held on 7 January, 1986. The presentations were made by Dr. Michael Shepherd, School of Computer Science, Technical University of Nova Scotia, Canada. The Seminar was attended by the teachers and students of the Department of Library and Information Science, Bangalore University and DBTC Faculty.

A Seminar on "Scientific Method" was held on 22 January, 1986. The leading presentation was made by Mrs. Tuula H. Laaksovirta, University of Tampere, Department of Library and Information Science, Tampere, Finland.

A special lecture on "Management of information analysis centres" was held on 6 February, 1986. The lecture was delivered by Shri N. K. Gopalkrishnan, Director, Energy Documentation Centre, Tata Energy Research Institute, Bombay.

4. PUBLICATIONS

The following publications were brought out during April 1985 to March 1986 :

(i) *Sankhyā* : The Indian Journal of Statistics, the official organ of the Indian Statistical Institute.

Series A : Vol. 47, Parts 2, 3

Series A : Vol. 48, Part 1

Series B : Vol. 47, Parts 1, 2, 3.

(ii) The following proceedings have been published during the period :

(1) Proceedings of the Indian Statistical Institute Golden Jubilee International Conference on Human Genetics and Adaptation.

Vol. 1 : Human Genetics

Edited by Kailash C. Malhotra and Amitabha Basu

(2) Proceedings of the Indian Statistical Institute Golden Jubilee Conference organised in collaboration with the Operational Research Society of India. Quality Control, Reliability and Operational Research Edited by S. C. Chakrabarty, S. R. Mohan and Y. R. Rau

(3) Proceedings of the Indian Statistical Institute Golden Jubilee International Conference on Women, Work and Society Edited by K. Saradamoni.

(iii) Thirty-four technical reports from the Statistics-Mathematics group have been issued during the period.

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6. SCIENTIFIC PAPERS AND PUBLICATIONS
SCIENTIFIC PAPERS PUBLISHED

Theoretical Statistics and Mathematics

1. Bagchi, B. (with Sastri, N.S.N.) (1986) : Minimum weight words of binary codes associated with finite projective geometries. *Discrete Math.*, 57, 307-310.
2. Bhatia, Rajendra (1986) : The distance between the eigenvalues of Hermitian matrices. *Proc. Am. math. Soc.*, 86, 41-42.
3. ——— (with Davis, Chandler) (1986) : Concavity of certain functions of matrices. *Linear and Multilinear Algebra*, 17, 155-164.
4. Bose, Arup (with Sinha, Bikas K.) (1986) : Unbiased sequential estimation of $1/p$: settlement of a conjecture. *Ann. Inst. statist. Math.*, 37, 465-460.
5. Das Gupta, Somesh (with Bhandari, S. K.) (1985) : The characterizations of doubly super-stochastic matrices. *Sankhyā*, Ser. A, 47, 357-365.
6. Ghosh, J. K. (1986) : Efficiency of Estimates—Part I. *Sankhyā*, Ser. A 47, 310-326.
7. ——— (with Mazumder, B.S., Saha, M., and Seungupta, S.) (1986) : Deposition of sand by suspension currents : experimental and theoretical studies. *J. sedim. Petrol.*, 56, 57-66.
8. Karandikar, R. (with Kallianpur, G.) (1985) : White noise calculus and non-linear filtering theory, Special invited paper. *Ann. Probability*, 13, 1033-1107.
9. ——— (with Kallianpur, G. and Kannan, D.) (1986) : Analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces and a cameron martin formula. *Ann. Inst. Henri Poincaré*, 21, 323-361.
10. ——— (with Kulkarni, V. G.) (1985) : Limiting distributions of functionals of Markov chains. *Stochastic Processes Applic.*, 19, 225-236.
11. Mazumder, B. S. (with Mukherjee, A.) (1985) : Buoyancy effect on dispersion of a solute in a flow through a horizontal channel. *Acta mech.*, 58, 137-163.
12. Mitra, S. K. (with Odell, P. L.) (1986) : On parallel summability of matrices. *Linear Algebra Applic.*, 74, 257-276.
13. Mukherjee, Rahul (1986) : Fraction selection problem in discrete multivariate analysis. *Sankhyā*, Ser. A 47, 350-356.
14. ——— (1985) : Some observations of Fuzzy relations over Fuzzy subsets. *Fuzzy Sets and Systems*, 15, 249-254.
15. ——— (1985) : Estimability and efficiency in proportional frequency plans. *J. Indian Soc. agri. Statist.* 37, 70-87.

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16. ——— (with Chandra, T. K.) (1985): Comparison of likelihood ratio, Wald's and Rao's tests. *Sankhyā, Ser. A* 47, 271-294.
17. ——— (with Chaudhuri, A.) (1985): Optionally randomised response techniques. *Calcutta statist. Ass. Bull.*, 34, 225-239.
18. ——— (with Chaudhuri, A.) (1985): Domain sampling in finite populations. *Aust. J. Statist.*, 27, 135-137.
19. ——— (with Huda, S.) (1985): D-optimal statistical designs with restricted string property. *Comm. Statist. Theory Meth.*, 14, 669-677.
20. ——— (with Huda, S.) (1985): A note on the construction of symmetric factorials retaining full information on main effects. *Algeria J. Statist.*, 5, 32-34.
21. ——— (with Saha Ray, R.) (1985): Asymptotically optimal weighing designs with string property, *J. Statist. Plan. Inf.*, 13, 87-91.
22. ——— (with Rao, T. J.) (1985): On a problem of allocation of sample size in stratified random sampling. *Biometrical J.*, 27, 327-331.
23. ——— (with Sen, M.) (1985): Universal optimality of a class of type 2 and allied sequences. *Sankhyā, Ser. A* 47, 216-223.
24. Nag, S. (1985): Schiffer variation of complex structure coordinates for Teichmüller spaces. *Proc. Indian Acad. Sci. (Math)*, 94, 111-122.
25. ——— (1985): On some involutions and retractions arising in Teichmüller spaces. *J. Indian math. Soc.*, 46, 1-29.
26. Natarsjan, S. (1985): Large Deviations, hypotheses testing and source coding for finite Markov Chains. *IEEE Trans. Inf. Theory*, 31, 360-366.
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30. ——— (with Mishra, M. N.) (1985): Asymptotic study of the maximum likelihood estimation for non-homogeneous diffusion processes. *Statist. Decisions*, 3, 193-203.
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3. ——— (1985) : Domain estimation infinite populations. *Am. J. Statist.*, 37, 125-127.
4. ——— (with Mukherjee, Rabul) (1985) : Optionally randomized response techniques. *Calcutta Statist. Ass. Bull.*, 34, 225-229.
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7. ——— (1985) : Universal testability of a MOS RMC networks for detecting physical failures. *Proc. First Int. Workshop on VLSI Design*.
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9. Maitra, T. (1985) : Consumption of Public Services in West Bengal. *Arthaniti*, XXII, 1-45.
10. Masumder, P. P. (with Das, S. K., Chakraborty, Ranajit and Majumder, T. K.) (1985) : Studies on Vitiligo, II. Familial Aggregation and Genetics. *Genet. Epidemiology (U.S.A.)*, 2, 255-262.

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14. Mukherjee, B. N. (1986) : The reliability and validity of the so-called 'soft' and 'hard' data. *J. soc. econ. Stud.*, 2, 135-191.
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a. Digital Systems

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2. Srimani, P. K. (with Sinha, B. P., Ghose, S. and Bhattacharya, B. B.) (1985) : An efficient distribution algorithm for directed circuits in a graph. *Proc. IEEE int. Symp. Circuits and Systems*, Kyoto, Japan.

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2. ——— (with Basu, Banarsi) (1985) : Random Fields, Ising Model and Boson-Fermion Phase Transition. *Lett. Nuovo Cimento*, 42, 391.
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4. ——— (with Roy, S.) (1985) : Geometrical aspects of magnetic monopoles. *Int. J. theor. Phys.*, 24, 967.
5. Bhattacharyya, S. (1985) : EMC effect—another outlook. *Lett. Nuovo Cimento*, 44, 116-128.
6. ——— (1985) : Some characteristic Comiso Ray orbits and an attempt at their explanation. Proc. 18th Int. Comiso Ray Conf. held in La Jolla, California, University of San Diego, USA, HE 3, 1-8.
7. Boychoudhury, R. K. (with Roy, Pinaki) (1985) : Question of degenerate states in supersymmetric quantum mechanics. *Phys. Rev.* D32, 1695.
8. ——— (with Roy, Pinaki) (1985) : Chiral Symmetry breaking in a non simply connected space-time. *Z. Naturf.*, A40, 957.
9. ——— (with Roy, Pinaki) (1986) : On derivation of a formula in finite temperature field theory. *Phys. Rev.*, D32, 498.
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12. ——— (with Roy, Barnana) (1986) : An algebraic approach to the exponential Comiso Screened Coulomb potential. *J. Math. Phys.*, 27, 229.

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2. Haider, K. (1985) : Effects of the shape of stenosis on the resistance to blood flow through an artery. *Bull. math. Biol.*, 47, 545-550.
3. Mazumdar, H. P. (with Chakraborty, A. K.) (1986) : A note on the stratified turbulent flow with no shear. *Z. Naturf.*, 40a, 649-650.
4. ——— (with Chakraborty, A. K.) (1986) : On the inertial energy spectrum of turbulence in a reacting gas. Proc. conf. Thermal Systems, Banaras, 299-305.
5. ——— (with Chakraborty, A. K. and Poreen, L. N.) (1986) : Some remarks on the weak interaction of mean and turbulent fields of temperature and wind velocity. *Arch. Mech. Engrg. Trans.*, 1-3, 206-212.

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1. Biswas, S. N. (with Choudhuri, B. B.) (1986) : On the generation of discrete circular objects with their properties. *CVGIP* 22, 158-170.

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2. ——— (with Choudhuri, B. B. and Dutta Majumder, D.) (1985) : Coric Sections in Digital Grid. *JITEB*, 22, 17-22.
3. Dutta Majumder, D. (1985) : Trends in Pattern Recognition and Machine Learning. *Def. Sci. J.*, 35, 337-351.
4. ——— (1985) : Application of fuzzy sets and systems approach in Planning and development. *SCIMA*, New Delhi, 14, 54-58.
5. ——— (1985) : Fuzzy sets in Pattern Recognition, Image Analysis and Automatic Speech Recognition. *Applikac Matematiky*, 30, 237-254.
6. Kundu, M. K. (with Choudhuri, B. B.) (1985) : The comparative study of a new pattern recognition based exact coding method with conventional coding methods for two tone graphics. *J. IETE*, 22, 48-55.
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Geology

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2. ——— (with Howard, J. D.) (1985) : A middle Paleozoic Shoal-bar sequence. *J. sedim. Petrol.* 55, 392-397.
3. Jain, S. L. (1985) : Some new observations on *Lepidotes maximus* (Holotsei : Semionotiformes) from the German Upper Jurassic. *J. palaeont. Soc. India*, 30, 18-25.
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6. Rudra, D. K. (with Bandyopadhyay, S.) (1985) : Upper Gondwana Stratigraphy north of the Pranrita-Godavari Confluence, Southern India. *J. geol. Soc. India*, 26, 261-266.
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Physics

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Biological Sciences

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