
Sree Chitra Tirunal Institute for
Medical Sciences & Technology
Trivandrum
SPICTRA CARDIOTOMY RESERVOIR
GAS VENT
PRIME THROUGH FILTER
PRIME THROUGH FILTER
spictra
SINGLE USE ONLY
SUCTION INLET
VENT INLET
SUCTION INLET
spictra
CARDIOTOMY RESERVOIR
WITH 37 MICROMETER FILTER
&
AUTOFILTER BYPASS
FOR SINGLE USE ONLY
OUTLET
ANNUAL REPORT
1988-1989

Rigid Shell Cardiotomy Reservoir
Developed at
SCTIMST

Device Fabrication
Sponsored by
Southern Petrochemical
Industries Corporation Ltd.,
Madras.

Annual Report
1988 - '89

Sree Chitra Tirunal Institute for
Medical Sciences and Technology, Trivandrum 695 011
Kerala, India.

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CONTENTS

OVERVIEW

If change is a measure of progress, the Institute could claim another year of satisfactory progress which included the addition of new buildings, commissioning of a major laboratory and transfer of technologies. At a different level, the dominant role of economic factors in health care as well as technology development received recognition in the establishment of a nucleus for the study of hospital economics during the year. Given the constraints on resources and the percentage allocation for various sectors of activities the performance record of the Institute during '88–89 was by no means unimpressive.

The economics of operating specialist services with emphasis on free service for poor patients continued to pose a challenge to the Institute. Whereas the gross expenditure of the Institute rose to 815 lakhs for capital and recurring items (Fig. 1), the percentage of hospital expenditure for patient care, salaries and utilities were 35%, 51% and 14% respectively which were substantially unchanged from the previous year (Fig. 2). The distribution of expenditure for the

hospital wing, biomedical technology wing, academic programmes and utilities also remained at the previous year's level (Fig. 3). As observed in Annual Reports over the years, the demonstration of the high standards of patient care as enjoined in the Act in the context of mounting demand of poor patients, liberal service conditions of employees and rising cost of patient care accessories will always remain the foremost challenge for the Institute.

DISTRIBUTION OF TOTAL EXPENDITURE

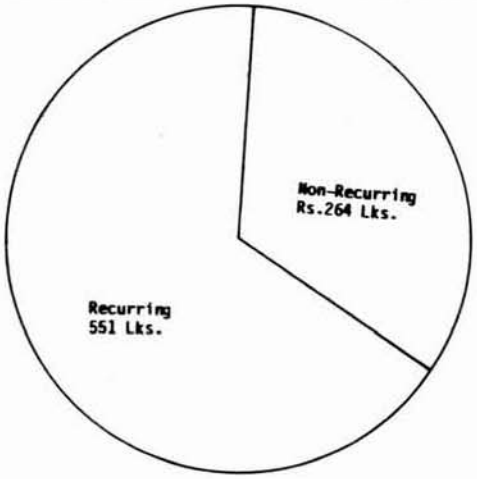

Fig. 1 Gross

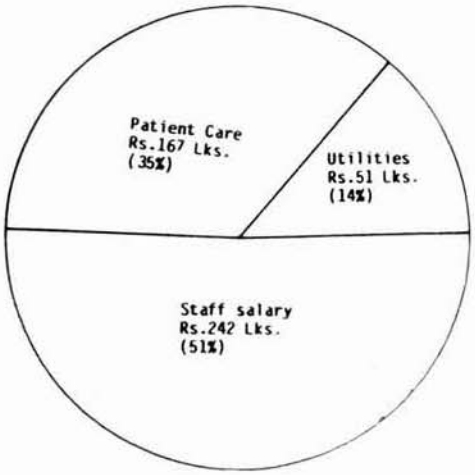

Fig. 2 Expenditure on Hospital

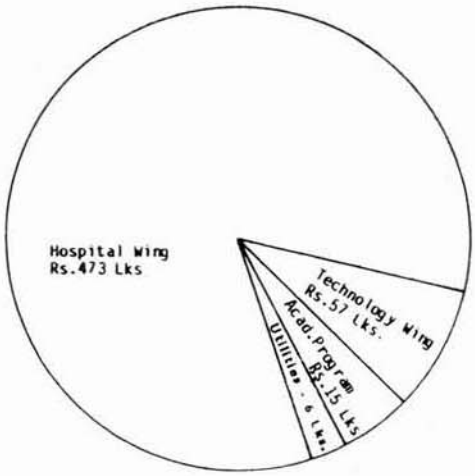

Fig. 3 Recurring

Fig. 4 Faculty hostel – Hospital complex.

Fig. 5 Faculty hostel – Technology wing.

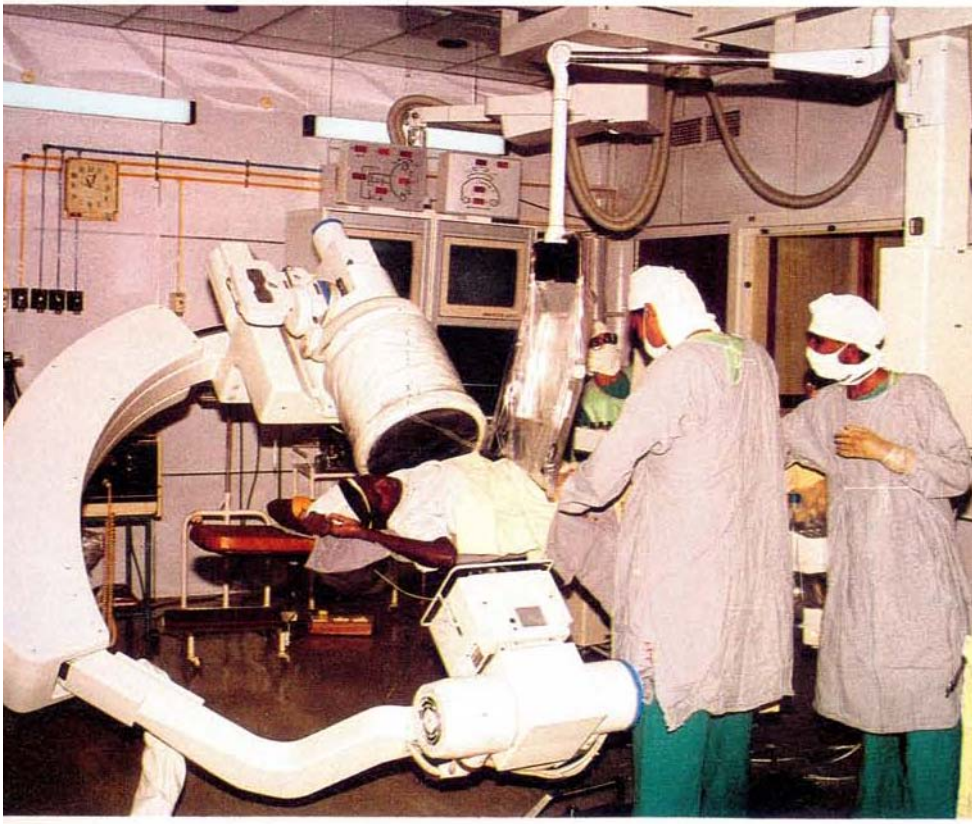

Fig. 6 The new cardiac catheterisation laboratory with DSA

The faculty hostels of the hospital and biomedical technology wings which had been under construction by the Central Public Works Department became ready for occupation and the allotment of quarters for the academic staff was expected to begin shortly (Figs. 4 & 5). The availability of comfortable accommodation on campus offered a much needed amenity for the staff who came to the Institute from many parts of India and often faced difficulties in hiring private housing.

As the obsolescence of equipment is a perennial problem in tertiary institutions, updating is necessary at periodic, if not frequent, intervals. The most costly exercise in the updating of equipment which the Institute undertook to-date related to the cardic catheterisation laboratory which was 13 years old and prone to breakdown. The new cardiac catheterisation laboratory with DSA and other complex attachments opened during the year and greatly increased the quality of diagnostic studies (Fig. 6). A similar exercise is in fact necessary for certain other critical items of equipment whose updating cannot be delayed much longer.

The commissioning of the 'Technoprove' facility and its regular use for the production of disposable devices on pilot scale opened a new chapter for the Institute in technology transfer. Currently being used under the sponsorship of SPIC for the production of devices, the facility has greatly strengthened capability for pilot production which had been the traditional weak-link between the laboratory and industry. The Technoprove was so designed as to be capable of reformulation at short notice for taking up the pilot production of diverse devices.

The academic status of the Institute was fully recognised by its membership in the Association of Indian and Commonwealth Universities and its representation in the Council of the Association of Commonwealth Universities.

The Institute operated two international cooperative programmes in relation to biomaterials and medical lasers respectively. Through an academic LINK programme supported by the British Council, the Institute entered into an arrangement with the Medical and Dental Bioengineering Department of the University of Liverpool (Prof. David Williams) and the Materials Science Department

of the Queen Mary College, London (Prof. William Bonfield) for the exchange of scientists in both directions and for undertaking specific experiments of mutual interest. A happy sequel to the Indo-UK symposium on biomaterials, the exchange of scientists made a beginning during the year with the visits of Mr. S. N. Pal and Mr. G. S. Bhuvaneshwar to the United Kingdom. Similarly the Indo-USSR programme on medical lasers had identified the Institute as one of the main participants for collaboration and the visit of the first batch of Soviet scientists took place during the year. This was to be followed shortly by the return visit of Dr. K. S. Neelakandhan and Dr. K. Ravimandalam to the Vishnevski Institute, Moscow for learning laser angioplasty and angiscopy procedures which had great scope in India.

SURVEY OF MAJOR PROGRAMMES

i. HOSPITAL SERVICES

Medical Superintendent: Dr. (Maj.) K. A. Hameed, MBBS

Administrative Medical Officer: Dr. D. Hariprasad, MBBS, MD

The patient care services remained substantially at the same level as in the previous year. Figures 7–11 represent graphically the growth in hospital services as reflected in new outpatient registration, follow-up visits, inpatient admissions, complex investigations and surgical proce-

HOSPITAL STATISTICS

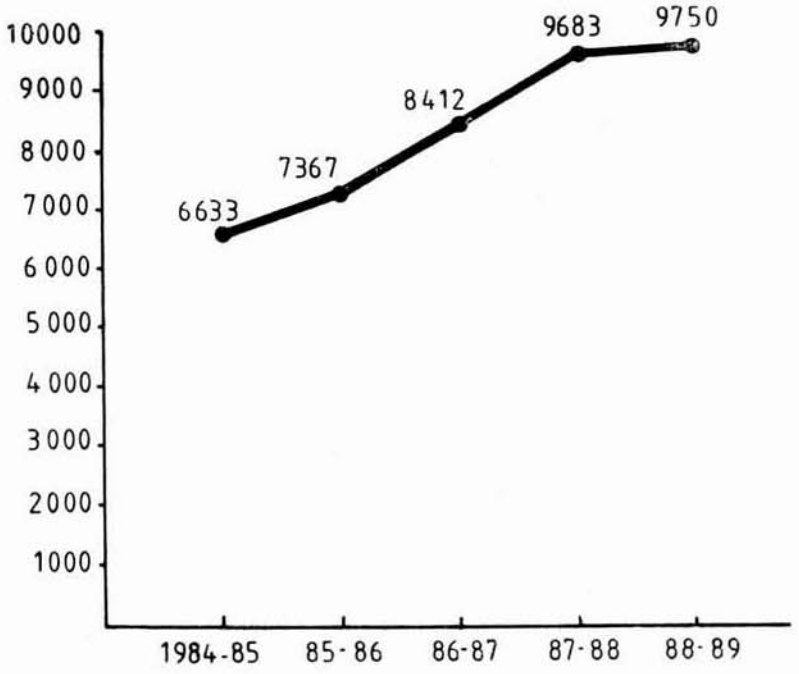

Fig. 7 New Registration

dures. The installation of the new laboratory for cardiac catheterisation and the upward trend in surgical procedures were suggestive of a continued increase in these services over the next few years.

Hospital Economics Study:

As mentioned earlier, the study of hospital economics made its debut at the Institute with the appointment of Dr. V. Ramankutty as a postdoctoral Fellow to initiate the new programme. A qualified pediatrician with formal training in economics and public health, his appointment reflected the concern of the Institute for the socio-economic determinants in the field of medicine and medical technology. The agenda for the hospital economics group would encompass a wide range of questions such as the criteria for the establishment of tertiary institutions, viable schemes for financing medical institutions, cost-benefit analysis of

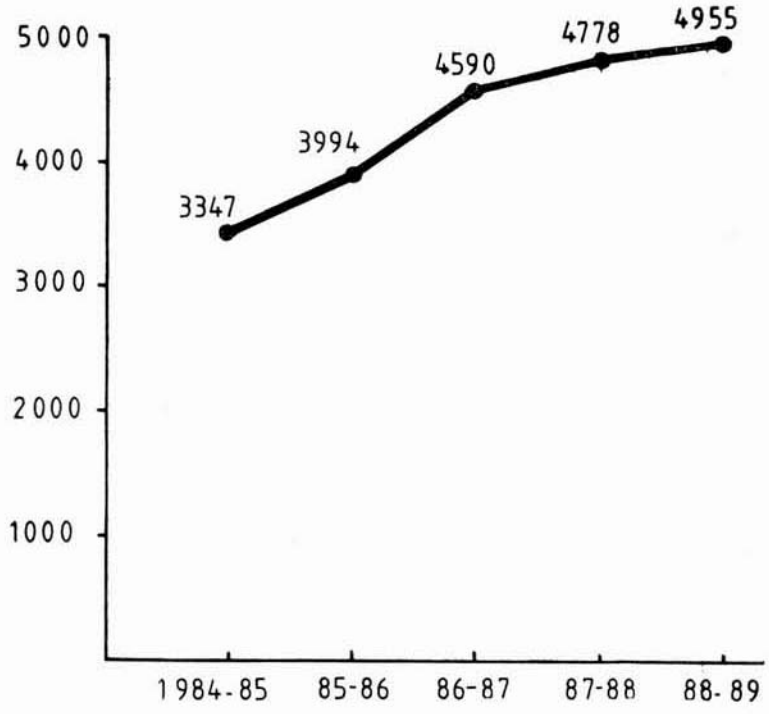

Fig. 8 Admissions

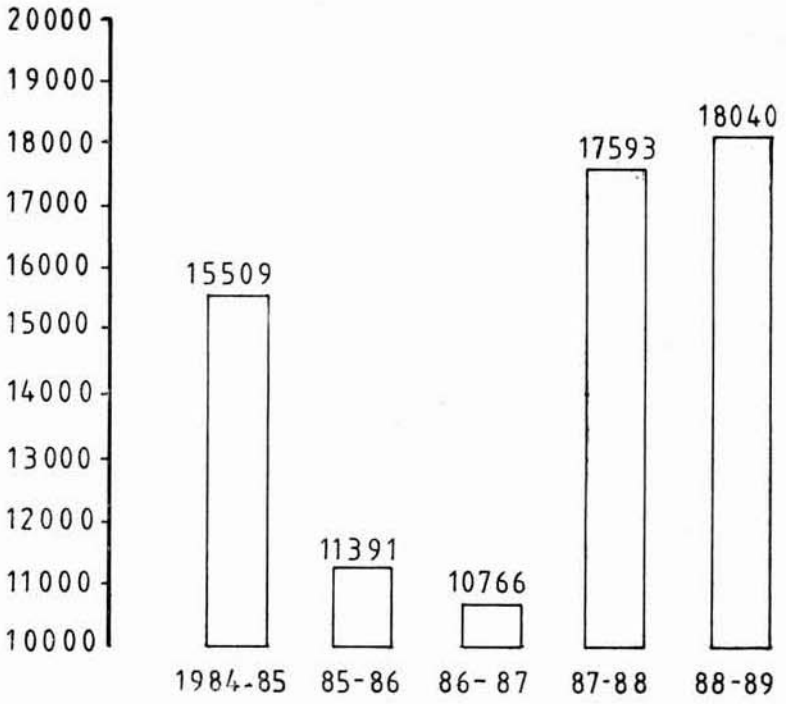

Fig. 9 Follow up cases during the last 5 years

hightech modalities in diagnosis and treatment and the assessment of emerging medical technologies. In the proposed studies, the hospital economics group was expected to work in collaboration with the Centre for Development Studies on problems of shared interest.

Medical Records

As the medical records services outgrew their old location in the hospital buildings, a new home was found for them in one of the Nurses Hostel Blocks which had become vacant and was modified for office use. If the procedures for the thinning of charts at the end of five years and transfer to microfilm at the end of ten years were adhered to, the new location was likely to be found adequate for at least ten years.

Nursing Services

Patient care supervision was ensured by the Nursing Superintendent

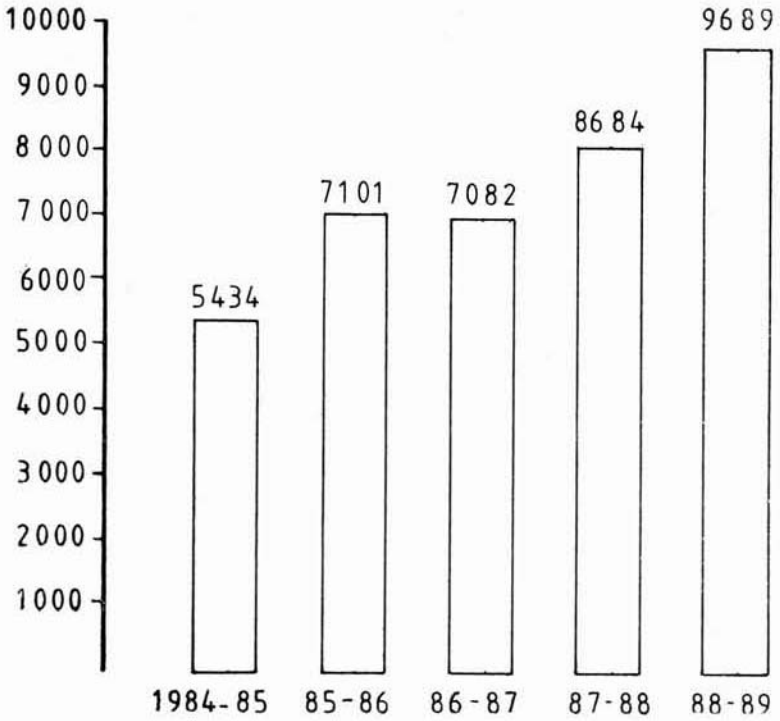

Fig. 10 Complex investigations

and other senior nursing supervisory staff by regularly following a printed check list. In-service training was promoted by staff education programmes in nursing procedures and by holding monthly staff conferences.

A two day conference was organised for the nurses with the themes focussed on "(1) Guillain Barre Syndrome (2) Sub Arachnoid Haemorrhage with special emphasis on I. C. aneurysm (3) Prosthetic valve thrombosis and aorto-iliac occlusive disease (4) Pacemaker implantation (5) Emergencies in the OPD of SCTIMST" during October 88 which attracted 65 nurses from various hospitals in Kerala.

Miss Hashmath Haque, Senior Lecturer RAK College of Nursing, New Delhi taught a course on 'Foundations and New Trends in Nursing' for the nursing students of the post-basic certificate course. The visitors

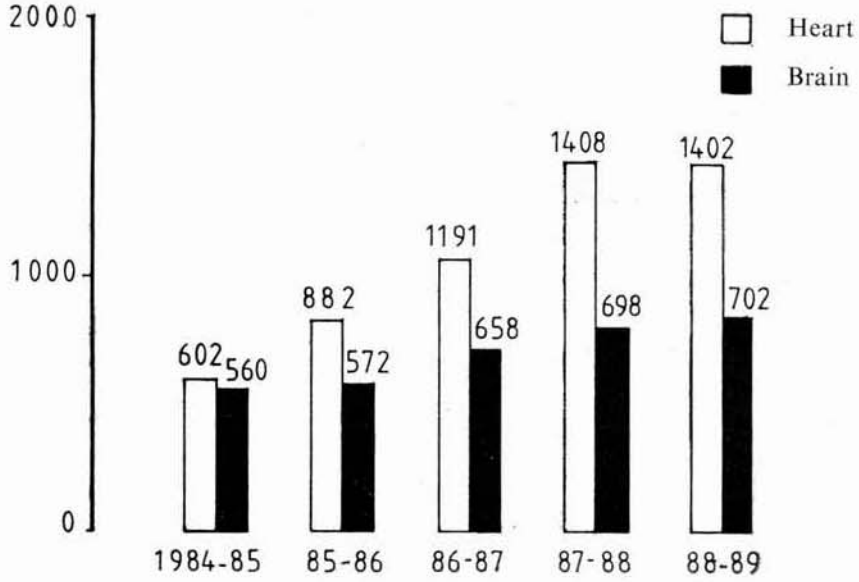

Fig. 11 Heart and Brain operations during the last 5 years

and trainees who attended the Nursing Department during the year are listed below.

Rev. Sr. Annie Vettukattil, IHM Hospital, Bharananganam

Sr. Little Flower, R.A.K. College of Nursing, New Delhi

Sr. Radha, Tata Tea Hospital, Munnar

Sri Mikayal Lal and Smt. Pratima Yogi, Rourkela Steel Plant Hospital. (for cardiothoracic surgery)
60 Public Health Nursing students from PHN School, Idukki

24 B. Sc. (Nursing) students from College of Nursing, Kottayam

Mrs. Deenamma Koshy took charge as Nursing Superintendent.

Clinical Engineering

Apart from maintenance operations, a major activity during the year was related to the installation of the new cardiac catheterisation laboratory which called for close interaction with the Indian and German Engineers of Siemens.

Two graduate engineering trainees and four diploma holders joined the

Division for training in medical instrumentation.

Mr. Koruthu P. Varughese and Mr. Mohandas played an important role in organising the IEEE Symposium on Superconductivity which was well attended.

Mr. Koruthu P. Varughese was elected as All-Kerala treasurer of IEEE–Kerala section and elected a member of the Computer Society of India.

Mr. R. Mohandas gave a lecture on Magnetic Resonance Imaging in TKM College of Engineering.

Rehabilitation Service

The Royal Family of Travancore offered a generous donation which was gratefully accepted for developing the existing physiotherapy section into a rehabilitation service. In consultation with Dr. Susheela Varma, Rtd. Prof. & Head, Rehabilitation Centre, Lucknow, the physiotherapy section was moved to a larger location and further development planned. Among the planned features of the new Rehabilitation Service is a Speech Therapy unit which would be of great benefit not only to the neurological patients of the Institute but also to patients with speech defects from other institutions.

ii. BIOMEDICAL TECHNOLOGY WING

Head: Shri A. V. Ramani, B.Sc. (Hons) Chem.Tech.

One of the major problems in India is the lack of a suitable interface between R&D and commercial production. As this is particularly true of development in biomedical devices technology, the Institute took a significant step by setting up a technology proving facility. The facility was conceived as a self-contained flexible manufacturing unit which could produce biomedical devices upto 20 to 25% of current market levels. The unit was meant to undertake pilot production of devices with industrial sponsorship, to generate production data and to supply clinically usable devices for market seeding.

The entire programme was configured to minimise entrepreneurial risk to the industry which could evaluate the commercial viability of the technologies developed at the Institute while generating useful production data. In addition, by the end of the programme, a core manufacturing team would have been fully trained in manufacture and quality assurance. As part of the general infrastructure an ethylene oxide sterilisation plant and a 160 KVA diesel generating set were also set up. The Southern Petrochemical Industries Corporation was the first major industrial group to avail of the technology proving facility by sponsoring a project on the production of the cardiotomy reservoir and the oxygenator developed at the Institute. The SPIC project made good progress and multicentric trials of both the devices were likely to start late in 1989 after single centre trials at the Institute.

The DST sponsored project on the hydrocephalus shunt also neared completion. This device was likely to be the next sponsored project for the technology proving facility.

As biotechnology can gain significantly from biomaterials development, R & D activities in polymer chemistry, biosurface technology, and polymer technology are being examined to include innovative programme on materials and devices which may be needed for biotechnology procedures.

iii. EDUCATIONAL PROGRAMMES

Registrar: Shri V. Narasimhan M.Sc., MIMS

As in previous years the postgraduate medical courses evoked enthusiastic response from different parts of the country (Table 1). The pattern of response to the courses in different specialities also remained unchanged (Table 2).

Table 1
Nation wide response

State/Union Territories	*Number applied*
Andhra Pradesh	25
Assam	1
Bihar	11
Delhi	28
Gujarat	16
Haryana	3
Himachal Pradesh	1
Jammu & Kashmir	9
Karnataka	26
Kerala	59
Madhya Pradesh	20
Maharashtra	30
Meghalaya	1
Orissa	8
Punjab	9
Rajasthan	22
Tamil Nadu	28
Uttar Pradesh	11
West Bengal	6

Postgraduate examinations

Barring one failure each in DM Cardiology and M.Ch. Neurosurgery all candidates were declared successful in the 1988 examination. The names of the successful candidates are listed in Table 3.

All the candidates registered for the Postdoctoral certificate courses completed their training satisfactorily in 1988. The details are listed in Table 4.

Ph. D. programme

Mr. Madhusoodana Nambiar and Miss Jyoti V. Nair, registered for Ph. D. in biochemistry under Prof. D. K. Basu submitted their thesis which were accepted after evaluation and defence in February 1989.

Mr. N. Shanmughakumar, a scholar appointed on a project registered for Ph. D. in biomaterials technology under Dr. M. Jayabalan on the 'Studies on the stability; prolyurethane materials and their interactions with tissues'.

M. Tech. Course

The introduction of the M. Tech Course received the approval of the Governing Body.

Table - 2

Course	*No. of applicants*	*No. selected and joined*
DM Cardiology	155	3
DM Neurology	30	3
M. Ch. Cardiovascular thoracic surgery	47	2
M. Ch. Neurosurgery	43	2
Postdoctoral certificate in Anaesthesiology	28	4
Postdoctoral certificate in Radiology	11	2

Training facilities for students and technical personnel

The demand for the training of perfusionists, blood transfusion technicians and clinical engineers continued to emerge from institutions in several parts of the country including distant States such as Assam and Uttar Pradesh. The Institute responded to the calls without exception and without charging fees for training.

Continuing medical education programme

Dr. P. K. Mohan, Head of the Department of Neurology organised six monthly programmes in continuing medical education with the support of the faculty of the Institute for medical practitioners in the region. The programmes were popular as they focussed on common problems such as hypertension, coronary artery disease and cerebrovascular disorders.

Nursing Education

The 10 month post-basic course in cardiovascular nursing entered the second year.

General

Sri Narasimhan was elected to the executive committee of the Trivandrum Management Association. He participated in the workshops held

Table - 3

List of successful candidates for DM/M.Ch.

Name of the candidates	*Degree*	*Speciality*
Dr. K. K. Haridas Dr. A. Nageswara Rao	DM	Cardiology
Dr. T. Rajendra Prasad Dr. SR. Krishna Manohar	M. Ch.	Cardiovascular and thoracic surgery
Dr. T. A. Subramanian Dr. Sanjeev Thomas Dr. Lekha Bhaskaran	DM	Neurology
Dr. MP. Haroon	M. Ch.	Neurosurgery

Table - 4

Name of the candidates	*Speciality*
Dr. Prakash	Cardiovascular and Neurosurgical Anaesthesiology
Dr. P. Bhattacharyya	,,
Dr. M. Srinivas	,,
Dr. A. M. Vaidya	,,
Dr. Sumit Roy	Cardiovascular and Neuroradiology

by the UGC and AIU and presented papers at the Annual Conference of the Association of University Administrators in 1989. He was elected to its Executive Committee.

SPECIAL SCHEMES OF RESEARCH

i. Centre for Advanced Research in Cardiomyopathy (Sponsored by the Indian Council of Medical Research)

Prof. M. S. Valiathan	Head of the Centre
Dr. C. C. Kartha, MD	Additional Prof. of Pathology
Dr. R. Renuka Nair Ph.D	Assistant Professor
Dr. K. Shivakumar Ph.D	Senior Research Officer
Dr. Prabha Nini Gupta MD	Research Officer
Dr. John T. Eapen Ph.D	Research Associate
Dr. Joseph Jacob MD	Research Associate

The research activities of the Centre which include animal experiments and tissue culture studies made considerable progress during the year. The experiments initiated in cultures of Coleus Parviflorus (a tuber plant) were completed. They revealed that when plants grown in magnesium deficient and normal media are exposed to cerium salts, the former accumulate significantly more cerium than the latter.

With regard to the hypothesis that magnesium deficiency and excess of one element of the actinide or lanthanide group (which forms the bulk of monazite sand) may synergistically act to produce cell injury, a question that needed to be answered is the interaction between biomolecules and these elements. Since the physicochemical properties of magnesium and elements of lanthanide and actinide group differ it seemed interesting to study their interactions with biomolecules. In invitro studies, it was demonstrated that both thorium and cerium can catalyse the non-enzymatic hydrolysis of ATP at physiological pH. It was also found that both thorium and cerium promote the binding of creatine kinase to Cibacron blue F3GA, the substrate analogue of the enzyme, even in the absence of magnesium ions, the physiological cofactor.

In long term experiments 20 non-human primates (Macaca radiata) aged 2.5 to 3 years were put on a low magnesium diet and administered cerium sulphate through weekly intraperitoneal injections. The animals were monitored by various haematologic and biochemical tests. The animals on low magnesium diet showed a significant decrease in the plasma magnesium levels. Measurement of levels of lipid peroxidation in red blood cells in these animals showed higher levels of lipid peroxidation. Further studies on biochemical and morphologic changes are in progress.

Analysis for trace elements, thorium and cerium in particular, was carried out throughout the studies at the Low Level Counting Agency, Health Physics Division, BARC whose support was valuable. The Centre collaborated with Prof. Rajamanickam in his studies on the molecular mechanisms of cardiac hypertrophy at the Madurai Kamaraj University and provided support in ultrastructural studies to the Dental College and Regional Cancer Centre on their investigations of oral submucous fibrosis and leucoplakia.

The equipment added during the year included Hitachi refrigerated high speed centrifuge, Hitachi table top centrifuge and a Hoshizaki ice maker.

A delegation of scientists from the USSR consisting of Drs. L. A. Matveetz, E. A. Ryabov, Dr. OA Tumanov visited the Centre and held a symposium on laser spectroscopy for biological applications. Dr. Dang from the Health Physics Division, BARC also visited the Centre for discussions on the ongoing collaboration in trace element studies.

Dr. Jose Jacob, MD (Biochem) Research Associate of CSIR, joined the Centre to initiate work on myocyte function in terms of the influence of actinide and lanthanide ions on calcium channels.

ii. Medical and Surgical applications of Lasers
(Sponsored by the Department of Science & Technology)

Principal Investigators:	Dr. M. S. Valiathan Sree Chitra Tirunal Institute	
	Dr. D. D. Bhawalkar Centre for Advanced Technology Dept. of Atomic Energy, Indore	
Co-Investigators:	Dr. K. Ravimandalam Dr. Arthur Vijayan Lal Dr. K. S. Neelakandhan Dr. Meera Mohanty Dr. V. R. K. Rao	SCTI
	Dr. V. K. Chatterji Dr. TPS Nathan Dr. L. M. Kukhreja	BARC
Project Scientist:	Dr. T. Ramachandran	
Duration:	3 years	

The activity was directed towards the three following objectives during the year.

(i) Development of delivery systems for intravascular use of lasers.

(ii) Creation of experimental animal models of vascular occlusion

(iii) Development of techniques to perform clinical laser angioplasty in peripheral vessels.

Modest progress was made in all three activities. A metallic hot tip of brass and stainless steel for contact vaporisation was developed which was found to deliver heat in a forward direction and perform satisfactorily in an experimental setting (Fig. 12). SMA type connectors suitable for 200 and 400 micron optical fibres were fabricated and evaluated. A modelling for preparing optical quality and surface for the fiber, was developed. Preliminary evaluations for the design of

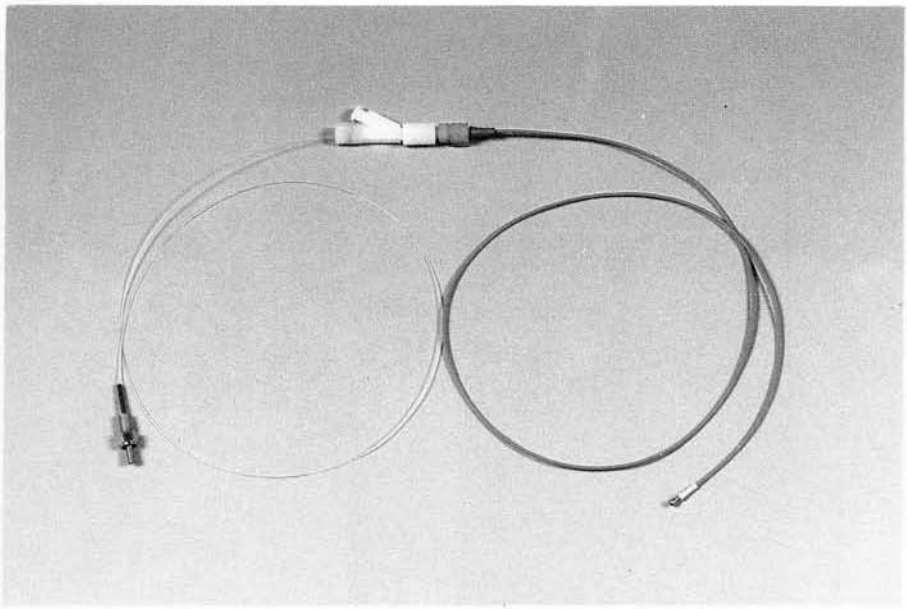

Fig. 12 Laser delivery system for angioplasty. One 200 micron fibre connected with indigenous metal tip and SMA type connector.

a cold sapphire tip were completed. A series of experiments were done to compare the efficacy of hot tips and cold tips on cadaveric tissue.

Models of arterial occlusion were created in canine iliac arteries, using human atherosclerotic plaque material (Fig. 13(a) and by inducing organised thrombosis by deliberate damage of the intima with oversized catheters (Fig. 13(b). Chronic vascular occlusions were also created by using embolic agents like IBCA. Following empirical experiments with cadeveric aortae, the first clinical laser angioplasty procedure was done on a 45 year old patient with a long segment femoro-popliteal arterial occlusion (Fig. 14(a). An Nd YAG laser system with a 600 μm fibre and a metal contact proble, was used for the procedure (Fig. 14(b).

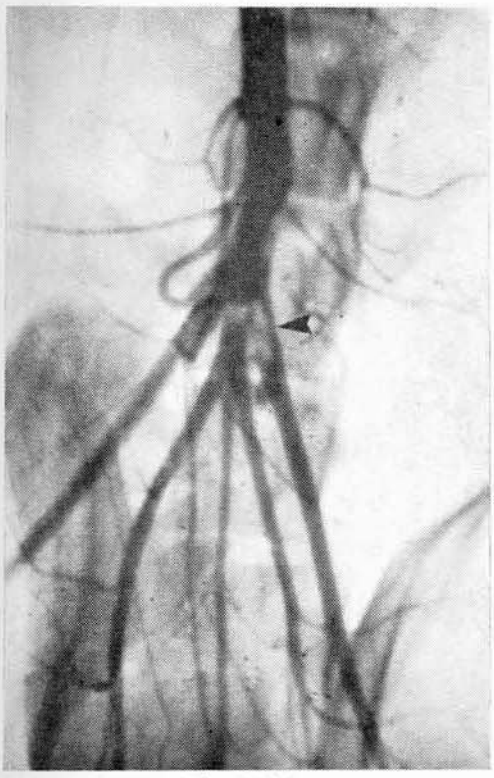

Fig. 13(a)
Human atheromatous embolous in canine iliac artery (arrow head)

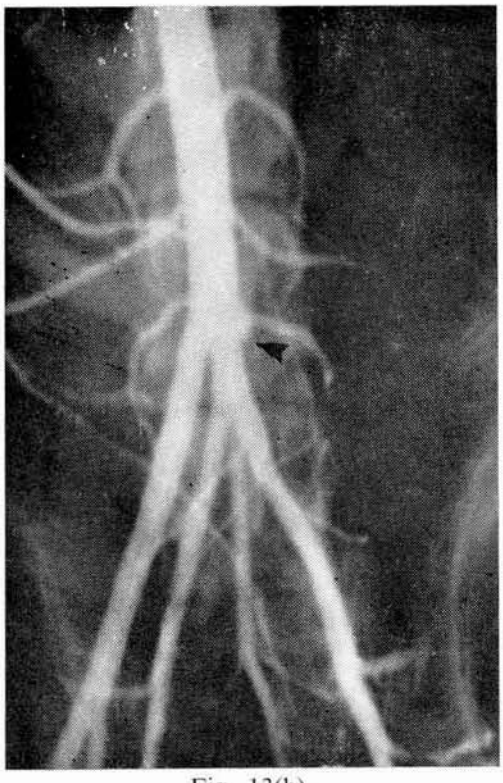

Fig. 13(b)
Proximal stump of occluded canine iliac artery. (arrow head occlusion induced by deliberate intimal damage.)

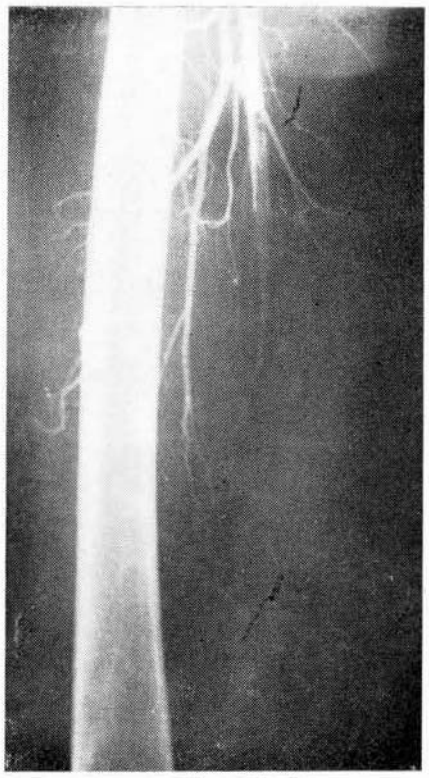

Fig. 14(a)
Long segment total occlusion of superficial femoral artery

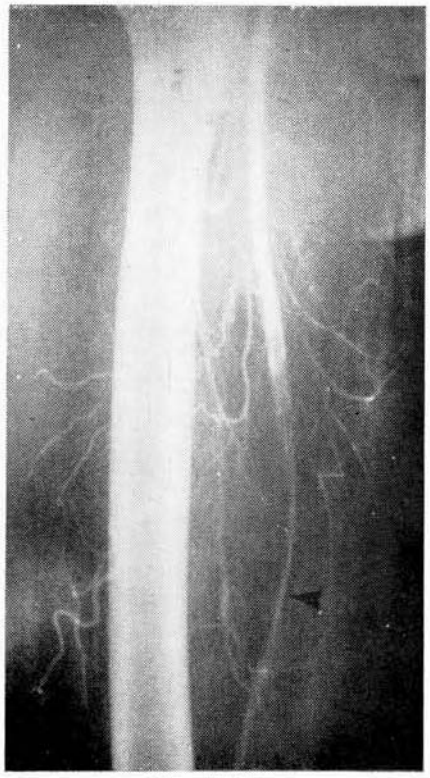

Fig. 14(b)
Recanalization with an Nd YAG laser contact probe (arrow head)

In accordance with the collaborative protocol, BARC was expected to deliver a CO_2 laser system during the current year. The feasibility of its use for transcatheter vascular applications were to be explored.

The delegation from the USSR consisting of the following surgeons and laser scientists visited the Institute.

Dr. Michail Sargin
Dr. AN. Nasodkin
Dr. V. S. Ivanov
Dr. SM. Nikiforov
Dr. YK. Danileikov

Dr. Sargin delivered lectures on excimer laser angioplasty and fibre-optic angioscopy as practised at the Vishnevski Institute, Moscow.

Dr. T. Ramachandran, Project scientist visited the Instrument Research Development Establishment, (IRDE) at Dehra Dun for two weeks.

DEPARTMENTAL REPORTS

HOSPITAL WING

Department of Anaesthesiology

Dr. K. Mohandas, MD	Professor and Head of the Dept.
Dr. V.Padmanabhan, MD	Professor
Dr. R. C. Rathod, MD	Additional Professor
Dr. Mrs. A. Rout, MD	Additional Professor
Dr. H. D. Waikar, MD	Assistant Professor
Dr. J. M. Shahani, MD	Assistant Professor
Dr. D. K. Saxena, MD	Assistant Professor
Dr. Madhavi Purohit, MD	do.
Dr. Roopa Sreedhar, MD	do.
Dr. Udaya Bhaskar, MD	do.
Dr. Raman Chadda, MD	do.
Dr. Nataraj Shyamala, MD	Candidate for Postdoctoral Certificate
Dr. Damien Joseph, MD	do.
Dr. Mruthyunjaya G, MD	do.
Dr. C. G. Raghuram, MD	do.

Anaesthesia was administered for 1400, 700 and 90 procedures in cardiothoracic surgery, neurosurgery and intervention radiology. The Department also provided overall supervision for the intensive care units and responded to the growing demands of patient care at the pre, intra and post-operative levels.

As an experiment in 'out-reach' programme, the Department provided anaesthesia and intensive care support for three months to the Department of Cardiothoracic Surgery of the Medical College, Calicut which had initiated open heart surgery on a regular basis. This was appreciated by the cardiothoracic team and the

Medical College authorities in Calicut.

Dr. Shahani was awarded the British Journal of Anaesthesia Travelling Fellowship for six weeks to visit Guy's and Cromption Hospitals in London. Dr. S. R. Verma, Anaesthesiologist, Pt. Jawaharlal Nehru Hospital, Bhilai and Dr. Mathew George, Anaesthesiologist, Lissie Hospital, Cochin visited the Institute as observers and postgraduate students in anaesthesia from the Medical College continued to attend for short term training. The Department hosted the scientific meeting of the Trivandrum city Branch of the Indian Society of Anaesthetists.

Division of Biochemistry

Dr. K. Subramonia Iyer, Ph.D.	Additional Professor
Dr. N. Jayakumari, Ph. D.	Assistant Professor
Mrs. Shantha A. George, M. Sc.	Scientist
Mr. B. Sasikumar, M.Sc.	Scientific Assistant

The Central clinical Laboratory provided round-the-clock service in clinical chemistry and clinical pathology with scrupulous regard for the quality of results. Additional investigations like the MB isoenzyme of creatine kinase in serum and vanillylmandelic acid in urine were introduced. The number of tests carried out by the clinical laboratory was 1.65 lakhs indicating a 10% increase over the previous year.

Installation of the Sodium potassium analyser (KNA2) from Radiometer and interfacing this equipment with the blood gas analyser in the satellite laboratory near the cardiac operating rooms greatly improved the management of surgical patients.

Three post-graduate students in cardiology received training in projects dealing with lipoprotein levels in atherosclerotic patients and CK–MB isoenzyme levels in patients following open heart surgery.

A batch of students doing B. Sc. Medical Laboratory technology in the Medical College, Trivandrum attended demonstration classes in blood gas analysis and automated analyses in clinical chemistry.

Dr. Iyer served as a member of the Board of Studies in Biochemistry, Kerala University. He was also nominated as a member of the Task Group in Biotechnology constituted by the State Committee on Science, Technology & Environment.

Project:	Membrane lipid peroxidation in human atherosclerosis. A study of risk associated byproducts and apolipoproteins
Principal Investigator:	N. Jayakumari
Funded by:	Department of Science & Technology Government of India
Status:	Ongoing

Division of Blood Transfusion Services

Dr. Jaisy Mathai, MBBS, DCP — Chief Blood Transfusion Officer
Dr. P. V. Sulochana, MBBS — Blood Transfusion Officer

The Division encouraged and provided guidance to enthusiastic organisers in forming new voluntary blood donor forums, thus involving a completely new section of the population in donation programmes. Members of the staff took part in several seminars and forums to promote better knowledge of blood transfusion and blood donation. During the year, routine screening of donors for irregular antibodies and HBs Ag detection by ELISA method were started. Component fractionation was done more often to meet the increased demand for components from the neighbouring institutions.

The service activities of the Blood Transfusion service are summarised in Table 5.

Table-5

Blood donation	5782
Whole blood transfusion	4352
Component transfusion	317
Compatibility tests:	
Saline	7701
Albumin	7701
AHG	2458
Papain	1806
Blood grouping:	
Patients	6190
Donors	8024
HBs Ag Screening RPHQ	5821
Syphilis RPR test	5782
Therapeutic plasmapheresis	72
Components issued to other institutions: YYP	25
PRP	32
Saline washed cells	15

In the field of research, collaborative support was provided to several Departments. A study of the prevalence of HBc Ag and anti HBc among healthy carriers of HBs Ag by micro ELISA method and a comparative study of HBs Ag in patients and blood donors by RPHA and ELISA methods were jointly undertaken with the Division of Microbiology. Similarly immune complex assay of patients with Guillain-Barre syndrome was carried out for the Department of Neurology.

In association with anaesthetic and cardiac surgical groups, a study was initiated for blood conservation. Assistance was also provided to the Biomedical Technology Wing for the standardisation of a blood filter which was under development.

Dr. Z.A. Bharucha of Tata Memorial Hospital, Bombay, visited Blood Bank in February 1989 and discussed quality control procedures with the staff.

Two nurses from the Directorate of Health Services receivd one month's training in Modern Blood Banking Technology in June 88. A medical officer was also deputed for 2 weeks in September 88 for training by the Directorate of Health Services.

Dr. Jaisy Mathai and Dr. P. V. Sulochana attended a Workshop on AIDS sponsored by WHO and Central Government at Trivandrum Medical College in February 1989.

Dr. Jaisy Mathai attended a demonstration of anti HIV screening at Apollo Hospital, Madras in December 88.

Department of Cardiology

Dr. K. G. Balakrishnan, MD DM, FACC, MNAMS	Professor & Head of the Dept.
Dr. C. G. Venkitachalam, MD, DM	Professor
Dr. R. Subramanyan, MD, DM	Additional Professor
Dr. Thomas Titus, MD, DM, MNAMS	Associate Professor
Dr. Jaganmohan Tharakan, MD DM	Associate Professor
Dr. M.V. Joseph Joy, MD, DM	Assistant Professor
Dr. P. K. Goel, MD, DM	Assistant Professor
Dr. Shyam Sunder, MD, DM	Assistant Professor
Dr. Tiny Nair, MD	Candidate for DM
Dr. Y.R. Yellury, MD	do.
Dr. K. Raghu, MD	do.
Dr. K. Sunitha Kumari, MD	do.
Dr. Maheshkumar Shah, MD	do.
Dr. Debanu Ghosh Ray, MD	do.

Despite the enforcement of prior appointment system for the registration of new patients and the restriction of new registration to 25 per day to enable better services to patients, approximately 6000 new patients were seen in the Cardiac clinic which exceeded the figure for previous years. The number of patients reviewed in the special follow up clinics increased by 14% as compared to previous year but prior appointment system could be enforced only for 87% of the patients. Following the installation of a new exercise laboratory with a computerised treadmill system, the quality and quantity of evaluation of patients for problems related to coronary artery disease showed great improvement. Following the installation of biplane cineangiography with digital substraction facility in February 1989, the number of patients undergoing coronary angiography also showed a steep increase. Given the number of patients being investigated and the training of Dr. K. G. Balakrishnan in PTCA procedures in the USA, the PTCA procedures for patients

with coronary artery disease was likely to begin during the current year as interventional catheterisation procedures like balloon atrial septostomy and balloon pulmonary valvotomy were already in routine use. Balloon valvotomy for mitral stenosis was also likely to be started during the current year.

In collaboration with Dr. P. N. Gupta of the ICMR Centre for Cardiomyopathies, a study of the natural history of endomyocardial fibrosis was completed and determinants of survival studied by statistical methods. The Department also carried out a retrospective analysis of cases with non-specific aortoarteritis in an effort to trace its natural history. Other clinical studies related to the non-invasive prediction of hemodynamics by echo Doppler method in patients with tetralogy of Fallot following intracardiac repair and the noninvassive quantification left-right shunts in patients with septal defects. Collaborative studies were undertaken with other Departments as in previous years. Investigation of lipoprotein and serum peroxidase levels in patients with coronary artery disease (Biochemistry), study of pulmonary vascular disease in rheumatic mitral stenosis and adults with congenital heart disease (Pathology, Cardiothoracic surgery), and assessment of pulmonary artery anatomy in patients with congenital cyanotic heart disease by CT Scan (Radiology) are examples of the many sided nature of the collaborative effort of the Department.

The following new equipment were added to the laboratory:

1. Computerised Treadmill system—Marquette case 12
2. Biplane cineangiography with DSA system for cardiac catheterisation laboratory—Siemens
3. 7 channel recorder–Mingograph Elema
4. Margen—Oxylog—for estimation of O_2 consumption.
5. Oximeter—Radiometer Copenhagen.

Dr. Balakrishnan received training in the operation of the biplane catheterisation laboratory system with DSA at the Presbyterian Hospital, Pittsburg, USA during the year and Dr. M. V. Joseph Joy, presented a paper in the 1st Asian Pacific Congress of Medical Virology at Singapore.

Important visitors to the Department included Professor Harris of Royal Post-graduate Medical School, London and Dr. I. S. Anand, Associate Professor of Cardiology PGI, Chandigraph who held a Symposium on Congestive heart failure. Dr. Shiela Haworth, Prof. of Cardiology, Hospital for Sick Children, Great Ormond Street, London visited the Institute on behalf of the British Council and held a series of discussions on Pulmonary vascular disease and Pulmonary hypertension in January 1989 which cleared the way for a systematic, inter-departmental study of these highly relevant problems.

MD (Pediatrics) postgraduates of SAT Hospital were posted to the Department for 2 weeks of rotation.

The Annual conference of the Kerala Chapter of the Cardiological Society of India was hosted by the Institute.

Department of Cardiovascularthoracic Surgery:

Dr. M. S. Valiathan, Ch. M. (L. Pool), FRCS (Edin), FRCS (Eng), FRCS (C), FACC FAMS, FASc, FNA	Professor & Head of the Department
Dr. M. P. Mohan Singh, FRCS (Eng), FRCS (Edin)	Professor
Dr. K.S. Neelakandhan, MS, M. Ch.	Associate Professor
Dr. R. Sankarkumar, MS, M.Ch	Associate Professor
Dr. K. G. Shyamkrishnan, MS, M. Ch.	Associate Professor
Dr. M. Unnikrishnan, MS, M. Ch.	Assistant Professor
Dr. Aruna Kashyap, MS, M. Ch.	Assistant Professor
Dr. A. B. Bhoyar, MS, M. Ch.	Assistant Professor
Dr. Y. Nazer, MS, M. Ch.	Assistant Professor
Dr. V. M. Kurian, MS	Candidate for M. Ch.
Dr. Sekhar Rao, MS	do.
Dr. R. N. Hyderabadi, MS	do.
Dr. Murtaza Ahmed Chesti, MS	do.
Dr. S. Mukhopadhyay, MS	do.
Dr. V. Rajagopalan, MS	do.
Dr. Zachariah Philip, MS	do.

The steady increase in the volume of patient services was reflected in the number of surgical admissions, operative procedures and attendance at the followup clinics. The rise in the number of cardiac, vascular and thoracic procedures was marked by an increasing degree of sub-specialisation in thoracic and vascular, pediatric and adult cardiac surgery. While the count of thoracic and vascular procedures reached 577, open heart operations for all types of patients numbered 650 and indicated the balanced development of subspecialities and diverse skills. The number of major vascular operations such as aneurysmectomies and the corrective procedures for complex cyanotic heart disease in babies

increased significantly during the year.

The cardiotomy reservoir which had been developed at the Biomedical Technology Wing in close collaboration with the department entered pilot production and clinical trial and established a milestone in the development of cardiac surgical technology at the Institute. No effort was spared to achieve a similar feat for the Chitra disposable oxygenator and valvular prosthesis during 1989 and 1990 respectively.

Dr. Y. Nazer rejoined the Department after spending three years of study leave in the Department of Cardiothoracic Surgery, Royal Prince Alfred Hospital, Australia where he received cardiac surgical training with special emphasis on coronary artery bypass and surgery for cardiac arrthymias. His accession was expected to boost the development of these procedures at the Institute.

The following technicians deputed by other institutions were given training in perfusion techniques during the year.

Mr. Manoj Kumar, King George Medical College Hospital, Lucknow;

Mr. Pradip Kumar Das, Gauhati Medical College, Assam;

Mr. K. B. Vincent and Smt. P. J. Alice Medical Trust Hospital, Cochin.

A team consisting of Dr. S.R. Verma, Mr. Mikayal Lal, Miss Pratima Yogi and Mr. Bharat Lal Dilliwar from the Jawaharlal Nehru Hospital and Research Centre, Bhilai spent four months in the Department for training.

On behalf of the Indian Council of Medical Research, Prof. Valiathan visited Mauritius for discussions on the development of the Sir Seeva Sagar Ramgoolam Institute of Medical Sciences. He was elected a Founder Member of the Materials Research Society, India.

Division of Microbiology

Dr. J. Shanmugham, Ph. D., FIMSA	Additional Professor
Dr. Aruna Shahani, MD	Assistant Professor
Miss Molly Thomas, M. Sc., D.M.V.	Assistant Professor
Mr. M. Ravindranath B. Sc.	Scientific Assistant
Mrs. K. Naseema, M. Sc.	do.

The Division of Microbiology continued to carry out primarily diagnostic services in Bacteriology, Virology and Immunology.

Besides the standard Ziel-Neelsen staining for the direct detection of acid-fast bacilli in clinical specimens, auramine staining which is more sensitive than the Z-N staining was introduced during the current year. The volume of diagnostic tests increased in proportion to the overall increase in patient services.

A two year project on the study of urinary tract infections among catheterised patients undergoing cardiac and neurosurgery neared completion in which nearly 750 specimens of voided and catheterised urine, catheter tips and meatus specimens were investigated. Eighteen to twenty per cent of the urethral meatus samples were found to harbour potential pathogens of UTI. The leading isolate was Klebsiella species (35%) followed by E. coli (30%). The isolates from neuro-surgery patients showed 15% more resistant strains than the isolates from cardiac surgery patients. Most of the coagulase negative Staphylococci from cardiac surgery patients belonged to S. hominis, while among neurosurgery patients S. epidermidis was the leading species. The determination of MIC values of various antibiotics against the urinary isolates is in progress.

In collaboration with the Department of Cardiology, the role of Coxsackie B viruses in the genesis of carditis was investigated. The preliminary data obtained in the study was presented at the First Asia-Pacific Congress of Medical Virology held in November 1988 at Singapore.

Dr. Aruna Shahani took the lead in setting up an 'Antibiotic Policy Mak-

ing Committee' with the participation of representatives from other Departments. The Committee was charged with the responsibility for formulating policies which would ensure the scientific use of antibiotics.

Dr. J. Shanmugam participated in the "First Asia-Pacific Congress of Medical Virology" held at Singapore in November 1988 and presented a paper on 'Study of Coxsackie B Viral Myocarditis in Kerala State, South India'.

Dr. Aruna Shahani participated as the sole delegate from India, in the "Western Pacific Congress on infectious Diseases and Chemotherapy", held at Kuala Lampur in February 1989 and presented a paper on 'Norfloxacin in the treatment of Urinary Tract Infections'. She attended the meeting of the panel for sterilisation of disposable medical devices and products organised by the Bureau of Indian Standards at Goa in December 1988.

Dr. J. Vandepitte, Director of the WHO International Quality Control Programme in Clinical Microbiology, Belgium visited the department in November 1988 and delivered a lecture on 'Application of Quinolone Antibiotics in Clinical Medicine'. He also held talks with the academic staff on current trends in diagnostic Microbiology.

Dr. P. Viswanatha Kurup, a mycologist from the Medical College of Wisconsin USA visited the department in November, 1989 and held discussions with the staff on opportunistic fungal infections in hospitals.

Dr. D. Panigrahi from PGIMER, Chandigarh delivered a guest lecture on 'Monoclonal antibodies in clinical medicine'.

The Final year M. Sc. students in Medical Microbiology from Mahatma Gandhi University, Kottayam underwent a short term training in Tissue culture and Virology in January 1989. The final year B. Sc. (MLT)students from the Trivandrum Medical College visited the laboratories to get acquainted with various diagnostic techniques in Bacteriology, Virology and Immunology in 1988.

Sister Little Flower, an M. Sc. student from Rajkumari Amritkaur College of Nursing, Delhi did a shot term study on Respiratory Infections following cardiac surgery under the supervision of Dr. Aruna Shahani during May 1988. Miss

Dolly Chacko, M.Sc. student in Bio-Technology from the Cochin University of Science and Technology, joined the Division to carry out her project work for a period of three months from March, 1989.

In collaboration with the Department of Microbiology, at Trivandrum Medical College, the Division organised the 12th National Congress of the Indian Association of Medical Microbiologists at Trivandrum in November 1988. The Microbiology Division also organised the 4th Bi-Annual Conference of the Kerala Indian Association of Medical Microbiologists Chapter at the Institute in June 1988.

Dr. J. Shanmugham was appointed the Sectional Editor in Medical Virology for the Indian Journal of Virology from the year 1989. He was also elected the Honorary Secretary of the Indian Association of Medical Microbiologists for the period 1989 to 1991.

With the assistance of Mr. Kurian, Computer Programmer and Mr. Vijayakumar, Computer Engineer, Dr. Aruna Shahani analysed the data on antibiotic susceptibility pattern for the isolates in the year 1988 which could prove to be useful in selecting appropriate antibiotic treatment.

Department of Neurology

Dr. P. K. Mohan, MD, DM	Additional Professor
Dr. John Tharakan, MD, DM	Associate Professor
Dr. C. Sarada, MD, DM	Assistant Professor
Dr. Muralidharan Nair, MD,DM	Assistant Professor
Dr. M. Veerendra Kumar, MBBS DM	Assistant Professor
Dr. Jacob Daniel, MD	Candidate for DM
Dr. Asha Vijayaraghavan, MD	do.
Dr. P. A. Suresh, MD	do.
Dr. Anoop Ranjan Verma, MD	do.
Dr. Gracykutty Mathew, MD	do.
Dr. Mathew Alexander, MD	do.

The department continued to register an upward trend in the number of new cases, ward admissions and specialised investigations like EEG, EMG and evoked potential studies. In view of the increasing number of patients in the special follow up clinics leading to overcrowding in the OPD and long waiting time, the department introduced postal follow up system whenever possible and this practice appeared to be working satisfactorily. The scope and activities of PAIN clinic was enlarged with the active participation of the faculty of Anaesthesiology. With the rejoining of Dr. John Tharakan after his Commonwealth Fellowship in neuro-immunology, efforts were made to expand and streamline the immunological investigations in neurological disorders.

The Department played an important role in the upgradation of the Physiotherapy Division which would soon have extra space, an additional speech therapy unit and improved facilities for the rehabilitation of neurologically disabled patients. It was hoped that the speech therapy service could also be made available to patients from other institutions in due course.

Prof. Kevin Barron, Chairman, Department of Neurology, Albany Medical College, New York visited the department in January 1989. One senior medical officer from Heavy Engineering Corporation, Ranchi, received training in clinical neuroelectrophysiological investigations. The Post-graduate students in pediatrics from the SAT Hospital, Trivandrum visited the department as observers.

Department of Neurosurgery

Dr. Damodar Rout, MS, M.Ch.	Professor & Head of the Dept.
Dr. R. N. Bhattacharya, MS, M.Ch.	Additional Professor
Dr. B.K. Misra, MS,M.Ch. MNAMS	Associate Professor
Dr. Rajeev Sharma, MS, M.Ch.	Associate Professor
Dr. N. Suresh Nair, M.Ch.	Assistant Professor
Dr. S. M. Rohatgi, MS, M.Ch.	do.
Dr. G. K. Prusty, M.Ch.	do.
Dr. Satish Krishnan, MBBS	Candidate for M. Ch.
Dr. Subodh Darbari, MS	do.
Dr. Dilip Paniker, MS	do.
Dr. R. S. Diwanji, MS	do.
Dr. A.K. Chand, MS	do.
Dr. S. Aadil Chagla, MS	do.
Dr. S.S. Praharaj, MS	do.

The department witnessed an impressive rate of growth in its volume and variety of clinical work and major intracranial operative procedures as compared to the previous years. It was a matter of satisfaction that there were increasing referrals for cerebral vascular problems from different parts of the country as the departmental emphasis continued to focus on the management of intracranial arteriovenous malformations and aneurysms. The other thrust areas were management of large acoustic schwannomas, posterior fossa and third ventricular tumours and other large tumours in inaccessible areas of the brain and base of the skull. The surgical effort was facilitated by the use of Cavitron Ultrasonic Surgical Aspirator (CUSA). There was a significant increase in the number of patients operated on for microvascular decompression in the management of trigeminal neuralgia. Intensive care monitoring was updated with the institution of intracranial (IC Pressure) monitoring in critically ill patients.

Dr. Rajeev Sharma was appointed to the post of Assistant Professor and Dr. G. K. Prusty was selected by the Europa-India Foundation, Neurosciences Wing, for a training visit of three months at the University of Tubingen, West Germany.

Project:	Development of an indigenous viable hydrocephalic shunt system
Principal Investigator:	D. Rout
Co-Principal Investigator:	G. S. Bhuvaneshwar
Co-Investigator	S. N. Pal
Funded by	Department of Science & Technology
Status	Ongoing

In collaboration with the divisions of microbiology, vivarium and pathophysiology, an experimental model for mycotic aneurysms/vasculopathy in rabbits was sought to be created. For a better understanding of the complex aetiopathogenesis attributed for syringohydromyelia, an experimental model of syringohydromyelia in dogs was successfully developed along with kaolin induced experimental hydrocephalus.

In collaboration with the divisions of Artificial Internal Organs and Polymer Technology the research project on the development of an indigenous viable hydrocephalic shunt system made excellent progress. Fully tested shunts were developed and subjected to animal implantation trials following experimental development of hydrocephalus in dogs. This life saving biomedical device became ready for technology transfer during the year.

Dr. V. P. Singh, Senior resident in Neurosurgery, AIIMS, New Delhi spent a week in the Department as an observer.

Dr. N. Muthukumar worked in the department as a Pool Officer of CSIR for a period of three months.

Dr. Rout was made the Organising Secretary by the Neurological Society of India and the Organising Committee of the 9th International Congress of Neurological Surgery to organise the International symposium on "Vascular lesions of the Brain" as a satellite conference of the Congress on October 15–16, 1989 at the Institute.

Dr. B. K Misra was elected as a member of the Congress of Neurological Surgeons, USA and Society of British Neurological Surgeons

Division of Neurochemistry

Dr. Debkumar Basu, Ph.D.	Professor
Dr. P. S. Appukuttan. Ph.D.	Assistant Professor
Mrs. K.I. Annamma, B.Sc.	Scientific Assistant
Miss Jyoti V. Nair, M.Sc.	Candidate for Ph.D.
Mr. Madhusoodana Nambiar M.Sc.	do.
Miss Yasmin Marikar, M.Sc.	do.
Mr. Bobby Zacharia, M.Sc.	do.

The service activities included specific neurochemical tests of serum and urine samples for rare congenital neurological diseases.

The main thrust of the Division continued to be on research on glycoprotein enzymes.

The glycoprotein enzymes, Mannosidase and β galactosidase from human placenta were purified to homogenity. The antibodies raised in rabbits against both the enzymes cross-reacted with similar enzymic activities from other foetal and adult human organs. The oligosachha-

Project :	:	Structure of Glycoprotein Enzymes. Role of their carbohydrate side chains and their interaction with lectins.
Principal Investigator	:	Debkumar Basu
Co-Investigator	:	P. S. Appukuttan
Funding	:	Department of Science & Technology
Duration	:	4 years
Status	:	Completed on June 30, 1988

ride side chain structural features were unravelled by different lectin affiinity chromatography. A beta-galactoside-binding lectin was isolated and purified to homogeneity from human placenta. The lectin had no enzymic activity but the antibody raised against it cross-reacted with β–galactosidase from human placenta. The lectin was found to be non-mitogenic to human lymphocytes. Other physicochemical and biological properties were studied in detail.

Jacalin, β–galactoside binding lectin from Jackfruit seed (Artocarpus integrafolia) was crystalized. The amino acids involved at the saccharide binding sites were identified by chemical modificaton of specific amino acid residues. The lectin was found to bind specifically mammalian lgA class immunoglobulin.

In continuation of the work on mammalian lectins a high molecular weight lectin from bovine heart muscle was isolated and characterised. The saccharide specificity was different from the earlier published work. This lectin was noted to have very high affinity for endogenous glycoprotein compared to low molecular weight lectins of bovine cardiac muscle. An inexpensive, quick method was developed to isolate anti-galactoside antibody present only in human and old world monkey serum and believed to be crucial in the defence of these mammals against infections.

The neurons and glial cells from developing human brains were isolated and characterised. The cell surface glycoproteins were isolated from the plasma membrane-rich fraction of the cells. This fraction was extracted with Western Blot buffer (25mM

Project	:	Cell Surface Glycoproteins of developing brain
Principal Investigator	:	Debkumar Basu
Funding	:	Council of Scientific & Industrial Research
Duration	:	3 years
Status	:	Ongoing

Tris–700 mM Glycine-0.1 PMSF–0.1% sodium oxide, pH 7.8) in Potter-Elevhjem homogeniser. The resultant supernatant was adjusted to pH 7.4 with acetic acid and mildly sonicated. The suspension was centrifuged for 2 min at 150 xg. The supernatant thus obtained was affinity chromatographed on ConA–Sepharose 4B column. The glycoproteins were eluted with 500 mM–methyl glucoside in 20Mm Tris–100 mM NaCl.pH 7.4 after washing the column with Western Blot buffer, pH 7.4. The brakethru' and washings were rechromatographed on ConA–sepharose 4B column. The ConA–Sephadex 4B affinity chromatography method was modified by pretreating the column with 8M Urea of 6M Guanidine. This treatment prevented the leaching of ConA, but resulted in diminition of binding capacity due to divalent nature of ConA. The glycoproteins from neurons and glial cells were accumulated for detailed characterisation studies.

Ms. Jyoti V. Nair and Sri P. Madhusoodana Nambiar, working as Junior Research Fellows under DST project (No. 1027GN) were awarded Ph. D. degrees of the Institute. The titles of their thesis are given below:

1. Structure and function of Lysosomal Alpha-Mannosidase from Human placenta. (Dr. Jyoti V Nair).
2. Structure and properties of β–Galactosidases and B–Galactoside-Binding Proteins of Human Placenta. (Dr. P. Madhusoodana Nambiar).

Division of Pathology

Dr. V. V. Radhakrishnan, MD	Additional Professor
Dr. C.C. Kartha, MD	Additional Professor
Dr. S. Sandhyamani, MD	Associate Professor
Dr. R. Renuka Nair, Ph.D.	Assistant Professor
Dr. C.R.L. Shastri, MD	Assistant Professor
Mrs. Annamma Mathai, M.Sc.	Scientific Assistant

During the year, the Division examined 825 surgical pathology specimens, 256 cytology specimens and carried out 1020 investigations in immunopathology. Frozen sections for rapid diagnosis at surgery was performed in 262 cases. There was an overall increase of 22 per cent in the number of diagnostic investigations over the previous year. The division performed 82 autospies in cardiac and neurological cases which formed an important source of teaching and research material.

The immunopathology laboratory contributed to the laboratory diagnosis of tubercular meningitis — a disease that poses a challenge to clinicians as well as laboratory personnel. Inhibition enzyme — linked immunosorbent assay was standardised which proved to be a more specific test than the previously established test — indirect ELISA. The assay contributed a specific diagnosis in 26 out of 40 clinically suspected cases of tubercular meningitis. The assay was also found useful in patients with chronic non-specific meningitis.

The division successfully purified and characterised Antigen 5 from culture — filtrates of H37 Re strain of m. tuberculosis. This antigen had not apparently been reported in Indian literature and has considerable diagnostic potentialities.

A primate facility was established as part of the project to reproduce the unusual generalised vascular mucopolysaccharidosis (Mucoid Vasculopathy) observed in human autopsies at this Institute. In order to examine a possible nutritional etiology for the lesions encountered, an experimental study was designed to induce the lesions in Bonnet monkeys. Preliminary observations in the experiments indicate the reproducibility of vascular lesions in the

Project	:	Cardiovascular changes in induced malnutrition
Principal Investigator	:	S. Sandhyamani
Funding	:	DST
Status	:	Ongoing

primate model. Detailed and extensive investigations are in progress to confirm, quantify and correlate vascular changes produced in the primate model with those observed in the human autopsies. Simultaneously, in depth histopathological studies employing histochemical, morphometric and electronmicroscopical techniques were conducted to study the pathology of the mucopolysaccharidiosis seen in human autospsy material at this Institute. To establish the nature of this disease entity, material from other parts of the country was compared in collaborative studies with Departments of foresnsic medicine and surgery, Medical College, Trivandrum and with Dr. S. G. Kinare, Emeritus Professor, Cardiovascular and Thoracic Centre, K.E.M. Hospital, Bombay.

During the visit of Dr. Sheila G. Haworth, Professor of Experimental Paediatric Cardiology, The Hospital for Sick Children, London, the following vascular changes with particular reference to possible visceral vascular involvement by mucoid vasculopathy, were identified and investigations initiated:

a) Cliniciopathological study on 'Stroke in Young Adults' with Department of Neurology

b) Pulmonary Vascular changes in Rheumatic Heart Disease with Department of Cardiology

c) Coronary Artery Disease — with Department of Cardiology.

Dr. Sheila Haworth's visit also helped in streamlining the diagnostic lung biopsies in patients with pulmonary hypertension secondary to congenital heart disease. During the discussions, it was felt that it would be worthwhile to study the natural history of adult patients with

left to right shunts, who undergo corrective operation. In these patiients if a lung biospsy is done at the time of operation, it would be possible at the end of the study to determine whether lung biospies would be helpful in the selection of the patients for corrective operation.

Over the years, the division of Pathology has accumulated a large number of autospsy specimens of congenital heart disease. This made it possible to initiate collaborative studies with the Department of Cardiology with a view to the correlation of morpology with angiocardiographic and echocardiographic data.

The division was provided with a Rotary microtome 820 II (Histocut – Roichert Jung) for the histopathology laboratory.

Six postgraduate students from Department of Pathology, Medical College Trivandrum received training in Frozen sections/histochemistry/electron microscopic techniques.

Department of Radiology

Dr. V. R. K. Rao, MD	Professor
Dr. Ravimandalam, MD	Associate Professor
Dr. Arunkumar Gupta, MD	Assistant Professor
Dr. Sunil Kumar, MD	Assistant Professor
Dr. Madhavan Unni, MD	do.
Dr. K. Santhosh Joseph, MD	do.
Dr. A. S. Rao, MD	do.
Dr. Varun Satija, MD	Candidate for Postdoctoral Certificate
Dr. Vijaykumar Gupta, MD	do.

The diagnostic and interventional procedues for 88-89 which continued to grow are given in Tables 6 and 7.

Table-6

Routine diagnostic procedures

O.P.X-rays	17518
Cardiac catheterisations	1076
Aortograms and peripheral Arteriograms	179
Bronchograms	46
C.T. — Institute patients C.T. — outside patients	5489
Four-vessel angiograms Carotid angiograms	240
Myelograms	224

Among research activities, evaluation of early and late patency rates as well as the biological effects of intravascular stainless steel stents in the arteries and veins of normal adult dogs was undertaken. These studies revealed neo'ntimal proliferation and veiled covering of the stents with preservation of the side-branches in aorta and vena cava after one year. (Fig. 16, 17, 18, 19). Scanning electron micrography confirmed the gross appearances. As a part of the DST project on lasers, the first clinical laser angioplasty procedure was done on 10–12–88 on a patient presenting with an occluded femoral artery.

Dr. Ravi Mandalam visited United States for an orientation programme in Digital Substration Angiography.

Fig. 15 Stainless steel stent in canine inferior cava with maintained patency of tributaries.

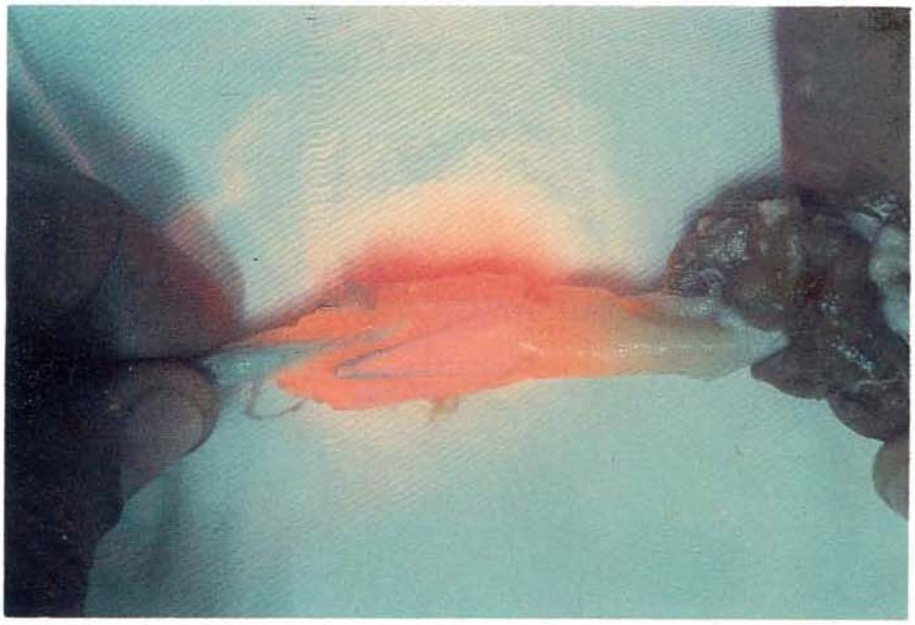

Fig. 16 Stent within canine inferior vena cava transilluminated with a Helium neon laser beam.

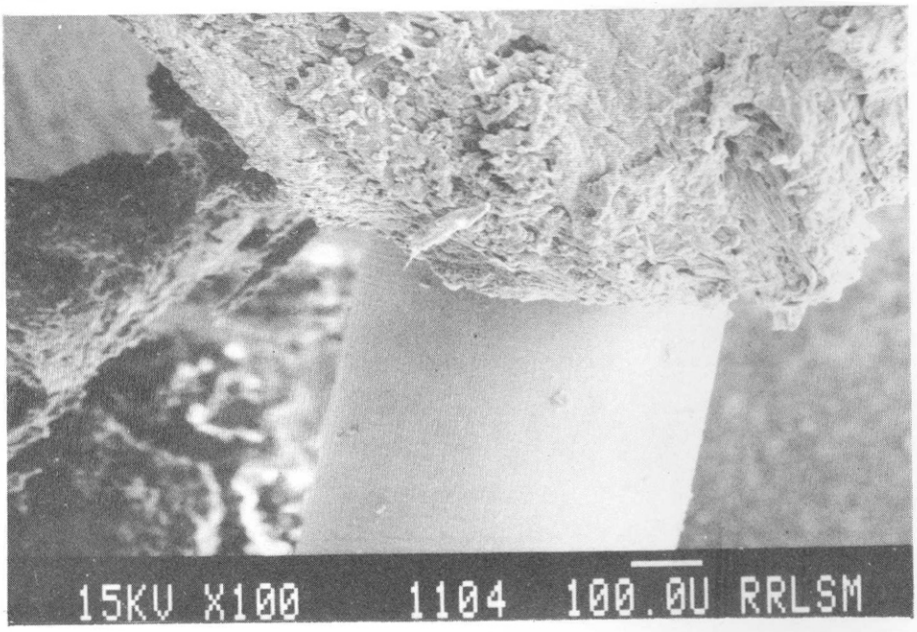

Fig. 17 SE Micrograph of canine aorta neointima covering a limb of the stent partly stripped to expose the stent.

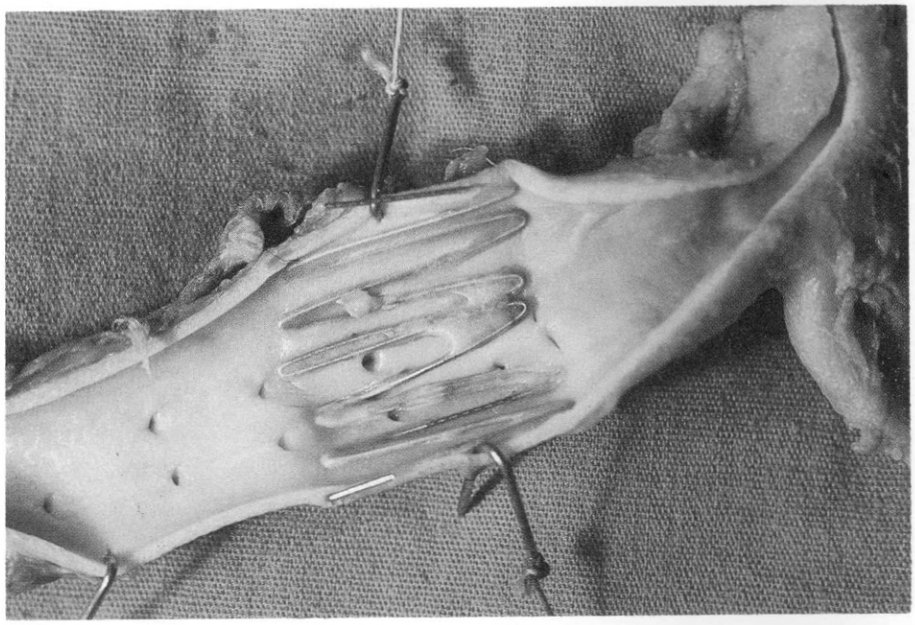

Fig. 18 Canine descending thoracic aorta with stent in situ. Intercostal artery ostia are patent.

Table - 7

Intervention procedures

Percutaneous Transluminal Angioplasties	55	procedues in 45 patients
Coil embolizations pre-aortic aneurysms	3	
Balloon embolizations — for carotid cavernous fistulae	3	
Laser angioplasty	1	

The following physicians visited the Department for observation and training.

Dr. Ramakrishnan Dr. Paul Korah Dr. Chandini Varma	Medical College, Trivandrum
Dr. Mathew Cherian Dr. Anand Tandon Dr. Giridhar Gopal Dr. Javed Rehman	JIPMER, Pondichery
Dr. Khandelwal	PGI, Chandigarh

Dr. V. R. K. Rao delivered the Achanta Lakshmipathi Oration 1988 at Madras in December 1988.

BIOMEDICAL TECHNOLOGY WING

Head: Mr. A. V. Ramani, B.Sc. (Hons.) Chem. Tech.

Department of Biomaterials Science

(i) Division of Technical evaluation of Biomaterials:

Dr. M. Jayabalan, Ph.D	Scientist
Mr. K. Sreenivasan, M.Sc	Scientific Officer
Mrs. Prabha D. Nair, M.Sc	Scientific Officer
Mr. N. Shunmugakumar, M.Sc	Candidate for Ph.D.

The service activities of a routine nature which the laboratory carried out during the year are given in Tables 8 and 9.

Table - 8
Routine Physicochemical characterization of Polymeric Materials (Intramural requests)

	Test	*No. of samples*
1.	IR Spectral analyses	325
2.	Thermal analyses	275
3.	Liquid chromatographic analyses	23
4.	Analyses for mechanical properties using INSTRON Universal testing machine	920
5.	Analyses for Rheological properties	25

The research activities of the Division laid emphasis on the development and evaluation of newer biomaterials along with setting new procedures for their technical evaluation.

Biomaterials developed for long term implantation exhibit degradation upon aging under invivo mechanical stress conditions. A major task therefore is to develop biomaterials with long term in vivo stability in motion sites without sacrificing biocompatibility. It has been observed that implant failures are mainly associated with tissue contact applications. In an effort to develop materials with good tissue linkage which would withstand mechanical stress, multiphase-crosslinked - segmented polyurethane (MCSPU) with

Table - 9

Physicochemical characterization of materials (external requests)

	Agency	*Tests*	*No. of samples*
1.	M/s. Peninsula Polymers Pvt. Ltd., Trivandrum	Tensile test	17
2.	Cochin University	Thermal analyses	6
3.	Kerala University	IR Spectral analyses	3
4.	Ayya Nadar Janaki Ammal College, Sivakasi, Tamilnadu	Thermal analyses	6
5.	Calicut University	Thermal analyses	19
6.	Regional Research Lab. Trivandrum	Thermal analyses	4
7.	Mahatma Gandhi University, Kottayam	Light Scattering Spectrophotometry for blood platelet aggregation studies	4

porous structure and linear segmented polyurethane (LSPU) were developed for subcutaneous implantation. When experimental prostheses (LSPU) were implanted in the dorsal aspect of rabbits subcutaneously, some samples migrated to motion sites during the post implantation period. These materials elicited surface corrosion and foreign body giant cell growth with particles of the material. The invivo experiments with MCSPU experimental prostheses are in progress with initial signs of tissue compatibility. In the evaluation of biocompatibility, emphasis was laid on parameters such as enzymatic attack, hydrolysis and oxidative degradation which affect the long term stability. Studies on long term ageing under minimal and maximal motion sites with MCSPU are also in progress.

In the progress of development of MCSPU, a new method of foam preparation was adopted. Sodium carbonate in polymer liquid was used for getting a porous structure sufficient to allow tissue growth into the polymeric structure.

Several interpenetrating polymer networks (IPN) based on polyurethanes and hydrophilic polymers were synthesised and characterised. Some of the IPNS exhibited enhanced mechanical and thermal properties. In vitro and biocompatibility studies indicated some of these materials to be suitble for biomedical applications. Further studies are in progress.

In addition to the histopathological technique which is conventionally used for tissue compatibility studies, a new technique, cage implant system, was introduced for the first time in the Institute to evaluate tissue compatibility. By this technique, tissue compatibility can be assessed under in vivo conditions within a short period of implantation by aspirating and analysing the exudate for protein, cells and enzymes. The newly developed polyurethane LSPU and MCSPU were evaluated by this technique which seemed to be promising and called for further evaluation.

Molecules like ATP have been shown to have an accelerated effect in destabilizing polyurethanes. Several polyurethanes of varied composition were synthesised and characterized and extensive studies carried out to

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Project	:	Studies on material-tissue interaction of experimental prostheses for reconstructive surgery.
Principal Investigator	:	M. Jayabalan
Co-Investigators	:	Mira Mohanty
		Arthur Vijayanlal
Funding	:	Department of Science & Technology
Duration	:	3 years
Status	:	Ongoing

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elucidate the diffusion of biological components in segmented polyurethanes. Novel methods were developed to alter the diffusion in segmented polyurethanes.

In the collaborative project 'Development of Indigenous composite dental restorative materials' under the Divison of Polymer Technology of BMT Wing, the division carried out the characterization of Bis-GMA resin which was prepared by different synthetic methods. Rheological properties of the resin were determined using Brook-field viscometer. The resin formation during the reaction was investigated by infrared spectral analysis apart from purity analyses. HPLC methods were also adopted for the analyses of unreacted monomers etc.

Dr. Jayabalan gave an invited talk on 'Application of polymers in health care services' in the symposium on 'Chemistry in the services of mankind' sponsored by C.B.M. College, Coimbatore and University Grants Commission in February 1989.

(ii) Division of Thrombosis:

Dr. M. Jamaluddin, Ph.D. — Scientist
Mrs. Lissy Kalliyanakrishnan M.Sc — Scientific Assistant

The year under review witnessed a significant achievement in so far as it put the thrombosis research division in a leading position in platelet research. The methodological and theoretical advances achieved earlier were put to use in a number of different ways to lend support to the hypothesis proposed by the group for platelet activation — that ligand–induced alterations of size and charge characteristics of a hemoprotein, in different platelet compartments' could form a uniform mechanism of chanelling the biochemical effects of diverse stimuli into response.

A Hewlett Packard V. V — Visible Spectrophotometer with diode array detecter was to be installed shortly in the laboratory.

Ms Prabha D Nair of division of Technical evaluation of Biomaterials and Mr. Kalliyanakrishnan of Polymer Technology Division studied platelet aggregation kinetics after storing platelets in contact with different biomaterials. The results demonstrated the applicability of the techniques and ideas developed by the group for biomaterials testing.

Dr. Lekha Bhaskaran working with Dr. P. K. Mohan did a project with the help of the division on platelet aggregation behaviour in certain cases of congenital heart disease.

Drs. Gafoorunissa and Mahtab S. Bamji of the National Institute of Nutrition visited the laboratory for discussions.

Mrs. Lissy Kalliyanakrishnan submitted her Ph. D. thesis.

Department of Biomedical Engineering

(i) Division of Artificial Internal Organs:

Mr. G. S. Bhuvaneshwar, B. Tech, MS	Biomedical Engineer
Mr. C. V. Mulalidharan, B.Tech.	Scientific Officer
Mr. R. Sreekumar, B.Sc.	Scientific Asst.

Chitra Heart Valve Prosthesis

After extensive studies in the Pin-on-wheel wear tester, Sand slurry test set up and simulated study in the Accelerated wear tester, the long term wear properties of Titanium/ UHMW-PE combination were found to be highly satisfactory. The prototypes of this combination already crossed 400 million cycles in the accelerated wear tester and the wear rates were found to be low and consistent.

Like other tough polymers, polishing of UHMW-PE to meet the prosthetic quality was extremely difficult especially when the processing starts from machined blanks. Thermal polishing technique was adopted as the conventional techniques of mechanical polishing were found to be inadequate. With proper choice of the processing parameters like temperature, time, heating and cooling rates, good surface finish was achieved. But the consistency in these results was found to be poor because of the variations in the machined blank. The development of a solid state processing technique to fabricate the discs directly from UMMW-PE resin using sintering/ compression moulding was under discussion with scientists at the National Chemical Laboratory, Pune.

Another problem encountered in the polishing lay in the removal of the flash generated during thermal polishing. Edge trimming by cryo-machining technique using liquid nitrogen was tried and showed promise. The initial set up for this procedure was made and the technique carried to the final stages of standardisation.

Failure analysis of sapphire discs:

The evaluation of TiN coated Haynes/Sapphire valves in animals showed that synthetic sapphire is an

excellent blood-compatible material for use in prosthetic heart valves. But to ensure fail-safe performance of this combination it is essential to understand the fracture mechanism of synthetic sapphire. In this regard Prof. W. Bonfield of Queen Mary College, London suggested the use of X-ray diffraction analysis and indentation fatigue fracture studies for fracture analysis. Accordingly Mr. G. S. Bhuvaneshwar proceeded to Queen Mary College, London on a scientific exchange programme to carry out detailed fracture analysis of sapphire discs.

Hydrocephalus shunt system:

The project on the development of hydrocephalus shunt system in collaboration with the Department of Neurosurgery and Division of Polymer Technology progressed smoothly during the last year. The assembly testing and evaluation of the flushing valves were standardised and the rejection rate for the flushing valves dropped to less than 40%, from the earlier rate of 90%. It is expected to go down further as further expertise is developed in the assembly of the valves. The fabrication and qualification of slit valves, catheters, and connectors were completed and a batch of 25 shunt systems fabricated. These were supplied for in-vivo evaluation in dogs which was in progress. Various studies, both theoretical simulations as well as experimental evaluations, were carried out to understand the behaviour of the device under operating conditions. The stage was thus set for undertaking the pilot production of 200 shunts for clinical evaluation.

Chitra humidifier

The fabrication of ten units of Mark II humidifier reached the final stages of completion. Two units were already assembled and detailed performance evaluation carried out before assembling the rest of the units. These units were expected to be available for clinical evaluation shortly.

Intra cranial pressure monitoring system

Preliminary studies on a non-invasive type ICP monitoring system was carried out by Mr. Cherian Schariah, student of Jadavpur University, as a part of his M.E. Programme. A prototype of ICP transducer was designed and vitro evaluation carried out.

New accelerated wear tester

The new accelerated wear test set up which had developed serious problems with its geared drive motor, was recommissioned after making necessary modifications to adapt single phase induction motor as its drive. The system resumed working smoothly and covered 120 million after recommissioning.

A data evaluation and analysis system (Aurelaec data processing systems) was installed as a part of the proposed pulse doppler based PULSE DUPLICATOR for the evaluation of the hydrodynamic performance of prosthetic heart valves.

(ii) Division of Bio-materials Technology

A. V. Ramani, B.Sc. (Hons.) Chem. Tech.	Scientist
Mr. B. Ajit Kumar, B. Tech	Scientific Officer
Mr. D. S. Nagesh, B.E.	Scientific Officer
S. Vijayan, M. Sc.	Scientific Assistant

The Division of extracorporeal devices was merged with this Division in the absence of Mr. Venkatesan and the congruence of research interests.

The major activity of the year was the development of a redesigned cardiotomy reservoir and oxygenator and their detailed evaluation. The development of production technology was also taken up with the active involvement of the Division of technology transfer. The full evaluation data on the cardiotomy reservoir was presented before the Ethics committee of the Institute and following an additional comparative evaluation, the device was cleared for human trials. The division transferred the technology of cardiotomy reservoir to the technology proving facility for pilot production of clinical models.

The oxygenator underwent extensive engineering trials for heat and mass transfer using blood analogues and fresh bovine blood and prototype fabrication got under way. A preliminary presentation on this device was made to the Ethics committee which was expected to consider it at a subsequent meeting for approval of clinical trial.

As Ethylene oxide sterilisation is one of the major approved methods of sterilisation with long shelf-life of biomedical devices, the Division took the responsibility for fully standardising a large 250 litre ETO facility. This involved not only commissioning the hardware but also the cycle parameters and a unique method for handling large dead-volume components like cardiotomy reservoirs and oxygenators under vacuum and positive pressures with no distortions or failures of integrity of packing. The entire technology was such as could be transferred for commercial use.

Because of world wide concern regarding blood conservation a joint

Project	:	Development of Carbon Fibre Reinforced Carbon as a Biomaterials
Principal Investigator	:	A. V. Ramani
Collaborating Institutes	:	National Physical Laboratory New Delhi and Vikram Sarabhai Space Centre, Trivandrum.
Funding	:	Department of Science & Technology
Duration	:	Three years
Status	:	Ongoing

activity with the anaesthesia and cardiovascular thoracic surgery departments was taken up to develop an autologous blood collection and transfusion systems. A special 20 cm H20 constant pressure generator was designed, fabricated, and installed in the ICU for trials. A complete commercialisable and disposable blood collection & transfusion system reached an advanced stage of design.

Under the CSIR scheme a research associate, Dr. S. N. Misra joined the division. A zinc orthophosphate dental cement conforming to international specifications is being developed with encouraging early results.

A simple technique for making solid carbon dioxide was standardised as this was much in demand by the pathology departments of the hospital and biomedical technology wing for tissue processing.

A joint programme between the CGCRI and this division is under consideration for developing bioglass ceramics.

A multiscribe 12 point Dataloger cum recorder was added to this laboratory during the year.

Two Final year students from the Trivandrum Engineering College and Medical College carried out project work on ethylene oxide diffusion through polyetheylene bags.

(iii) Division of Biosurface Technology

Dr. Chandra P. Sharma, M. Tech, M.S., Sc. D, MEBE	Scientist
Dr. Thomas Chandy Ph. D.	Scientist
Mr. P. R. Hari, B. Sc.,	Scientific Assistant

Studies with polyurethane were contituted to improve the permeability properties of the membranes. Efforts were made, in particular, to improve the permeability of polyether urethane urea membrane by various methods. Membranes were derived from blends of polyurethane/poly (methl methacrylate) in the ratio of 89:11, which showed high permeability properties compared to standard cellulose acetate membranes. These membranes were subjected to different sterilization processes and the changes in pore size and mechanical properties evaluated and compared with permeability functions. It appeared that the morphological changes occurring in these membranes due to different sterilization conditions could alter the permeability functions of the membrane.

Project	:	Studies on improving synthetic biomedical membranes for haemodialysis
Principal Investigator	:	C. P. Sharma
Co-Investigator	:	T. Chandy
Funding	:	Department of Science & Technology, New Delhi
Duration	:	Three years
Status	:	completed on 30 April, 1989

Further studies to improve the blood compatibility of paraformaldehyde cross-linked poly(vinyl alcohol) membranes were undertaken without affecting the permeability functions of the membrane. Polyethylene glycol demonstrated improved blood compatibility. Hence, blends of polyvinyl alcohol with polyethylene glycol were made and membranes prepared which showed improved permeability properties and reduced platelet-surface attachment.

Chitosan (a (1 — 4) 2-amino-2-deoxy-B-D-glucan), is a unique material derived from chitin, the most abundant polysaccharide produced by marine copepods. The efforts to improve the blood compatibility of chitosan membranes without altering the permeability functions continued during the year. Nonthrombogenic chitosan membranes were derived by immobilizing bioactive molecules like chondroitin sulphate, phosphoryl choline, heparin or a synthetic polyelectrolyte (having anticoagulant and antiplatelet activities) on albumin modified membranes via glow discharge techniques and the carbodiimide functional moiety. Such novel membranes demonstrated good permeability properties for small molecules and showed high degree of blood compatibility. The interfacial changes arising from surface modifications did not cause any significant interference in their permeability or mechanical properties.

As cell adhesion and deposition of calcium, lipoproteins, mucin etc. on the surface of hard and soft contact lenses of PMMA or PHEMA cause visual acuity, a method of surface modification of the lens with phosphoryl choline, a phospholipid, using glow discharge technique was attempted. Initial results suggested that phosphoryl chorine modified contact lenses have minimal cell adhesion and increased wettability which in turn may improve both patient vision and comfort and reduce the adherence of mucus on the lens.

Even though steroidal hormones have a profound role in thrombosis and hemostasis, adequate studies are not available to demonstrate their effect on the thromoembolic phenomena that occur at the blood-foreign material interface. Accordingly the interfacial phenomena of sustanon, menstrogen, mixogen, durabolin and ovral were studied. The results showed that the addition of steroid hormones to the polymer protein system can inhibit the level of surface bound albumin variably, whereas

Project	:	Surface modification-tissue compatibility towards the development of artificial skin
Principal Investigator	:	C. P. Sharma
Principal Co-Investigator	:	K. Rathinam
Funding	:	Indian Council of Medical Research
Duration	:	Three years
Status	:	Completed on 31 January, 1989

the fibrinogen binding to an artificial surface is enhanced or unaltered. These steroid drugs also increase the platelet-surface attachment to variable degrees. It would appear that the prolonged use of steroids or the estrogen containing oral contraceptive agents may not be advisable in patients having an artificial implant in contact with blood.

In the project on artificial skin, progress was made by modifying thin membranes of polyether urethane urea, with a dense layer of collagen and thin albumin layer and sterilising by autoclaving. The modified PEUU demonstrated improved wound healing properties compared to the control in guinea pigs and rabbits. Improved healing functions were observed with collagen modified polyvinyl alcohol membranes. Attempts were also made to find applications in substituting or regenerating the blood/tissue interfaces with the novel biomolecule, chitosan, which is biodegradable and biocompatible. The wound area was found to be without any infection and reduced considerably in size with collagen blended chitosan than without chitosan. This collaborative project was successfully completed on January 1989, with the division of Toxicological Screening of materials.

Dr. Thomas Chandy attended the short-term training course on the "Safety Aspects in the Research Applications of Ionising Radiation",

during December 1988 at the Bhabha Atomic Research Centre, Bombay. Dr. C. P. Sharma delivered the presidential address in the 2nd National conference of the Society for Biomaterials and Artificial Organs — India, during 13–14 April, 1988 at IIT, Delhi. Dr. Sharma continued to be the President of the Society for Biomaterials and Artificial Organs — India and Editor of Trends in Biomaterials and Artificial Organs. He also became an adviser to the Board of Directors of International Biomaterials Centre (USA) and shared the "Hall of Honour" at International Committee of Indian Society of Surface Science & Technology.

v) Division of Research Toxicology

Dr. P.V. Vedanarayanan, B.V.Sc., Ph. D.	Senior Materials Toxicologist
Dr. A. C. Fernandez, Ph.D.	Scientist

Studies on serum protein changes in rabbits as sequelae to the implantation of polymeric biomaterials continued through 1988-89. Experimental procedures in animals and subsequent studies of serum proteins using PAGE were completed and analysis of the results got underway.

Standardisation work done on primary cell cultures made progress. Latex particles necessary for testing the viability of cells was expected to be procured for the laboratory soon.

Dr. P. V. Vedanarayanan, at the invitation of the Bureau of Indian Standards, participated as an expert in the adhoc panel for the consideration of draft guidelines for the evaluation of Medical Devices for Biological Hazards and LAL test, in April, 1988. He chaired the opening session of the 9th Annual Symposium of the Academy of Environmental Biology held at Valvada, Gujarat during December and presented a paper on Indoor Air Pollution.

Sri K. Rathinam continued to do his doctoral work under Dr. P. V. Vedanarayanan.

(v) Division of Toxicological Screening of Materials

Mr. K. Rathinam, M.Sc. Scientist
Mr. Mohan P.V., B.Sc. Scientific Assistant

Biocompatibility studies, of various Chitra Intra and extracorporeal devices using international standard protocol of tests on biomaterials formed the main activity of the division. With the finished Chitra devices, mandatory tests such as pyrogen and sterility tests were also carried out in compliance with United States Pharmacopoeia. Besides these important activities, this division also maintained a small Animal Research Facility, comprising Rabbits, Guinea pigs, Rats and Mice required for biocompatibility tests and supplied them to other divisions of the BMT Wing and advanced centre for cardiomyopathies for investigations.

In a collaborative ICMR project with the Division of Biosurface Technology, sufficient research data was generated towards the development of artificial skin using polyether urethane urea material. Since the data obtained was found to fulfil the goal of the project, the project was terminated. In another collaborative study, biocompatibility data of newly developed polymethyl methacrylate (PMMA) bead materials were generated and supplied by this division. Subcutaneous biocompatibility studies were carried out for different formulations of polyurethane developed by the Division of Technical Evaluation of Biomaterials. Toxicological studies on the new plasticizer Tris (2–ethyl hexyl) trimellitae were carried out in view of its possible effect on immunological system and liver enzymes.

Sri K. Rathinam, underwent four months advanced training in biocompatibility evaluation of materials and implants at the Laboratories for Biocompatibility Research of Implant materials, Instituto Orthopedico Rizzole, Bologna, Italy under the guidance of Prof. Pizzoferrato. He also participated in the course on "Biomaterials for Orthopaedic Surgery" conducted by Prof. D. F. Williams, (University of Liverpool. UK), Prof. A. Bertoluzza, Prof. P.G. Marchett and Prof. A. Pizzoferrato (University of Bologna) at Bologna. At Instituto Orthopaedic Rizzole Bologna, Sri K. Rathinam delivered six lectures on topics related to biocompatibility. He became a life member, Laboratory Animal Science Association of India.

(vi) Division of Pathophysiology

Dr. Mira Mohanty, MD	Scientist
Dr. T. V. Kumari, Ph.D	Scientific Officer

Service activity increased further during the year in terms of the histopathological evaluation of tissue response to various implant materials in the intramuscular and subcutaneous locations. Polyurethane, polymethylmethacrylate, ultra high molecular weight polyethylene, metals and ceramics were examples of the materials which were studied. In addition, service was extended to the following ongoing projects:–

1. Implantation of hyrocephalus shunts in dogs.
2. Tissue response to lasers.
3. Processing of tissue for study on endomyocardial fibrosis in experimental animals.
4. Implantation of stainless steel stent in dogs.

Paraffinblocks prepared for histopathology

Laser project	16.5%
EMF Project	27.8%
Others	55.7%

The division continued to provide service for haematological and biochemical investigation of samples received from in vitro and in vivo experiments conducted by various scientific groups. Two of the major series of investigations carried out were:

1. Evaluation of the exudate around polyurethane implants in stainless steel cages for lysosomal enzymes — total alkaline phosphatase, total acid phosphatase, prostatic acid phosphatase, leucine aminopeptidase, total leucocyte and differential counts, total protein, albumin and globulin.

2. Evaluation of a haemofilter — pre and post filtered fresh and outdated blood.

(vii) Division of Polymer Chemistry

Dr. A. Jayakrishnan, Ph.D.	Scientist
Dr. Chithambara Thanoo, Ph.D.	Scientific Officer
Mr. M. C. Sunny, B.Sc.	Scientific Assistant

The activity of the Division during 1988-89 mainly centered around the development of radiopaque hydrogel microspheres for therapeutic embolization. Hydrolysed polymethyl methacrylate (PMMA) microspheres which had been evaluated for biocompatibility and occlusal effect in the renal arteries of dogs were found to be compatible and non-biodegradable for a period of a year. This material is presently ready for clinical trials.

A novel method for preparing highly porous microspheres (upto 1mm. dia.) of poly 2-hydroxyethyl methacrylate (PHEMA) was developed by suspension polymerization of 2-hydroxyethyl methacrylate in the presence of polymeric diluents such as PMMA in toluene or poly tetramethylene glycol. This material was prepared with the aim of using it as particulate emboli in therapeutic embolization. The porous nature of the beads would let the tissue grow into the pores, thus anchoring the emboli to the vascular lumen permanently.

A method for imparting radiopacity to the macroporous PHEMA beads was developed by chemical modification of the beads using clinically used heavy iodine compounds such as iothalamic acid and iopanoic acid. Microspheres with more than 30 wt% iodine could be prepared by the technique and they displayed sufficient radiopacity to be imaged by an X-ray camera. These microspheres would enable the post-surgical evaluation of embolization to be conducted using x-radiography without resorting to angiography. The radiopaque microspheres were evaluated for biocompatibility by subcutaneous implantation studies in Wistar rats.

A simple, but useful, technique for the encapsulation of barium sulphate in PHEMA microspheres was developed, again with the aim of using them as particulate emboli with

X-ray contrast properties. Both barium sulphate and PHEMA are compatible with the human tissue and barium sulphate is a highly radiopaque substance. PHEMA beads upto 1.5 mm in diameter could be prepared with upto 50% loading of barium sulphate. Porous microspheres with barium sulphate loading were prepared by the incorporation of sodium chloride during their preparation which was subsequently washed off with water to generate pores.

A new radiopaque vinyl monomer based on triiodo phenol was synthesized with the aim of co-polymerizing it with various other vinyl monomers such as methyl methacrylate and 2-hydroxyethyl methacrylate. To impart radiopacity to dental and bone cements, barium sulphate is currently incorporated as a very fine powder. This however, adversely affects the strength of the cement. Therefore efforts for preparing radiopaque copolymer of MMA with the radiopaque monomer based on triiodo phenol were undertaken and found successful. Efforts are on the way to study the effect of incorporation of this copolymer in the recipe for dental and bone cements and to evaluate the chemical and mechanical properties of the cements. If found successful this may have important applications in dentistry and orthopaedics.

(viii) Division of Polymer Technology

Mr. S. N. Pal, M.Sc. (Tech.)	Chemical Engineer
Mr. V. Kalliyanakrishnan, M.Sc.	Scientific Officer
Mr. M. Muraleedharan, MS	Scientific Officer

More than 8000 urine bags of 1 lit and 2 lit capacity and approx. 1000 chest drainage tubing systems were fabricated and supplied to the Hospital wing. About 400 metres of PVC tubing suitable for use as inhaler mouth pieces was also supplied to the Hospital wing. As in the past, the service provided by the division included moulding of more than 15000 components which were supplied to other divisions of the BMT wing.

Closely working with Technology Transfer Cell, imputs for preliminary documentation were made ready for the transfer of knowhow to interested entrepreneurs for the manufacture of urine bags.

A short appraisal of the research activity is given below:

(a) Hydrocephalus shunt

The main activities in this project were the design of moulds for mark II model of shunt system, studies in the change of properties due to the implantation of the materials used, fabrication of components for assembly and testing by Division of Artificial Internal Organs, and working closely with Neurosurgery and Technology Transfer cell for the preparation of preliminary documentation for the pilot production of the device.

(b) Blood filter

Tests for structural integrity, filter cleanliness, particle challenge, interface characteristics and materials toxicity for the components used were completed during the year. Evaluation of the device with outdated human and bovine blood and fresh bovine and packed cells were initiated according to the recommendations of 'American National Standard'.

Work was initiated on the development of BIS-GMA based dental restorative materials on a DST sponsored project from May 1988. One Research Scientist and a JRF were

Project	:	Development of Indigenous Composite Dental Restorative Materials
Principal Investigator	:	S. N. Pal
Principal co-investigator	:	V. Kalliyanakrishnan
Co-investigators	:	A. V. Ramani K. Rathinam Arthur Vijayan Lal M. Jayabalan Mira Mohanty
Funding	:	Dept. of Science & Technology
Duration	:	3 years
Status	:	Ongoing

recruited for the project. The synthesis and characterisation of the resins diglycidyl ether of BIS–GMA as well as BIS–GMA itself were successfully carried out during the first year.

Acrylic cements for cranioplasty

S.S. and Teflon moulds were fabricated for determining the various properties of cements like compressive strength, indentation resistance, exotherm temperature, water absorption etc. The above properties were studied for synthesised a crylic particles of size 100 microns or less.

Development of modified graft and blend PVC material

Modified migration resistant graft PVC was developed as a part of an ongoing doctoral research project. The platelet aggregation studies of the modified samples were carried out in addition to other properties such as migration in various media such as plasma, albumin solution, polar and non polar solvents etc.

Studies on theological and other physical properties and biocompatibility aspects of PVC blends were carried out during the year.

The following items of equipment were added to the Division.

1. Refractive Index Tester
2. Abrasion Tester
3. Tintometer
4. Elastosonic
5. Data processing facility as necessary for the above equipments

As part of Indo-UK exchange programme organised by the Institute, S. N. Pal visited the Institute for Dental and Medical Bio-engineering, University of Liverpool, U. K. during January–March 1989.

Miss M. S. Sheela of Department of Applied Chemistry, Cochin University joined the Division for carrying out project work for her M. Phil degree programme from February, 1989.

S. N. Pal was elected a Member of Indian Institute of Chemical Engineers (MIIChE) and his membership in Society of Plastics Engineers, Inc. (USA) was upgraded to 'Senior Member."

(ix) Division of Technology Transfer

Mr. H. Vijayakumar, BE — Biomedical Engineer
Mr. D. Ranjit, BE — Scientist

The know-how documentation of 'VARIFLO' Oxygenator was compiled with the development team's help and sent to M/s. NRDC. Procedures for handling industry — sponsored, production-oriented projects and technology transfer of small scale and tiny scale sector projects were streamlined. While co-ordination for structuring and framing technology related agreements and Memorandum of Understandings continued, technology transfer activities connected with CSF shunt and urine bag made progress. Technical consultancy was provided to M/s. Madhavi Mandiram Lok Seva Trust to implement their project for running a Hospital Supplies Unit. A feasibility report-cum-technical Document on the introduction of 'Disposable Needles' was prepared for the Hospital Wing.

Many divisions started using the centralised computer facility maintained by T. T. Cell. keeping in phase with various demands, more softwares to facilitate Engineering drawings, documentation etc. and hardware consisting of one PC/AT were added. The facility was shifted to a more spacious location in the Palace building.

Multifarious activities related to devices development continued to engage the centralised clean room facility being run by this division. Custom designed and fabricated drier for medical grade tubings and automation of water distillation were the new facilities added.

Intellectual Rights

The following table depicts the current status of applications for intellectual rights, being liaisoned by the division.

Table-10

Sealed Indian Patents	3
Registered design certificates	9
Indian patent applications in examination stage	2
International Patent applications in examination stage	3
New patent applications filed	2

Projects

Title	*Duration*	*Agency & Fund*	*Status*
1. Setting up of a Technology Proving Facility	Four months	Inhouse 2.45 lakhs	Completed
2. Production of Blood Oxygenator and Cardiotomy Reservoir	Two years	SPICF 17.5 lakhs	Ongoing
3. Production of CPB Custom Packs	Four months	Inhouse 45,000	Ongoing

This division undertook a major responsibility in planning and implementing a "Technology Proving Facility". The aim behind such an exercise was to take up Production Engineeing programmes of selected devices which had successfully crossed the developmental stage. The facility would be valuable for the translation of easily commercialisable, adoptable and absorbable technologies and would demand close interaction among the developing team, production group and sponsoring industries.

The first major project under this facility was the conception, planning and implementation of a novel, clean-room facility itself which would have all features and compatibility towards biomedical devices fabrication. This was completed successfully on schedule. Subsequently the productionisation exercises related to Blood Oxygenator and Cardiotomy Reservoir, an Industry sponsored project, and the production of CPB custom packs, an in-house project, were taken up and made progress. To provide a strong structured support for national programmes on biomedical research and technology, a proposal for setting up a state-of-the-art data analysis centre was prepared.

Medical device exhibits were sent for display in "POLYMERS—SUPER MOLECULAR AGE" museum of Srikrishnadevaraya University, Anantapur, A.P.

Mr. Ranjit co-ordinated the setting up and demonstration of Medical Devices from the BMT Wing in connection with the Nehru Centenary Year exhibition at the Institute.

(x) Division of Tool Room and Engineering Services

Mr. O. S. Neelakantan Nair, B.Sc. (Engg.) Tool Room Engineer

The Division of engineering services took an active supportive part in all hardware oriented projects.

A cryomachining technique based on liquid nitrogen as a coolant was developed to produce burr free heart valve components from ultra high molecular weight HDPE. A vendor development activity from CNC machined cages of artificial heart valves has been taken up with a firm in Bangalore. Tool room support was provided for various activities connected with the batch production of oxygenators and cardiotomy reservoirs. High precision miniature connectors for hydrocephalus shunt development and laser projects were fabricated. A 160 KVA diesel generator has been fully commissioned and is supplying electricity to all sections during power cuts.

In addition to these activities routine mould and fixture making, radiation sterilisation, and incineration have been carried out.

(xi) Division of Vivarium

Dr. Arthur Vijayan Lal, B. V. Sc. Veterinary Scientist
Dr. S. Bhaskara Rao, M. V. Sc. LL.B Veterinary Surgeon

The routine activities included the purchase, quarantine and preconditioning of animals prior to surgery perioperative management of animals like sheep, pigs, dogs etc., maintenance of a well equipped animal operation theatre for cardiovascular surgery; collection and supply of blood/tissue/organs to various divisions and departments, animal autopsy investigations as per experimental protocol and angiography in animals to monitor their post-surgical status.

The Division continued to take active part in the research and development projects of other Divisions as shown below:

Table - 11

Department	*Project*	*Procedure*
Cardiac Surgery/Artificial Internal Organs	Valvular prosthesis	Mitral valve Implantation in sheep
Radiology	Intravascular stents	Intravascular stainless steel stent insertion in dogs
Polymer Technology	Blood filter	Invitro test with slaughter house blood
Biomaterials Technology	Bubble oxygenator	In vitro tests
Radiology/Cardiac surgery	Medical laser	Experimental production of chronic arterial occlusion
Neurosurgery	Hydrocephalus Shunt	Experimental Production of hydrocephalus in dogs & shunt implantation

Dr. Bhaskara Rao took part in collaborative experimental studies on the role of chitosan in maintaining hemostasis, hemostatic potential of microfibrilar collagen and chitosan and the pre-neoplastic changes induced by n-nitrosomethyl urea. The vivarium also provided support to various investigative projects of the division of Microbiology relating to antibody response to bacterial and viral antigens. The facilities of the vivarium which had rabbits, guinea pigs, rats and mice in stock were fully used by investigators in Microbiology, Pathology and Neurochemistry Divisions.

An H. P. monitor, Manley Servovent anaesthesia ventilator and Siemens sircombile 4/L were added to the Division.

Dr. Bhaskar Rao delivered a lecture on Ethics in Animal Experimentation at a symposium on Environmental Risk Assessment and management conducted by the Academy of Environmental Biology, at Valvada, Gujarat during December 1988.

SCIENTIFIC PUBLICATIONS

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ADMINISTRATIVE BODIES (1986–91)

INSTITUTE BODY

President: G. Parthasarathi

1. Prof. M. M. S. Ahuja
   Head of the Department of Endocrinology & Metabolism
   All India Institute of Medical Sciences, New Delhi.
2. Dr. N. Balakrishnan Nair,
   Chairman, State Committee on Environment, Science & Technology,
   Govt. of Kerala, Trivandrum.
3. Dr. G. Balamohanan Thampi,
   Vice Chancellor,
   Kerala University, Trivandrum.
4. Dr. D. D. Bhawalkar,
   Director, Department of Atomic Energy, Government of India, Indore.
5. Shri A. Charles,
   Member of Parliament,
   T.C. I/1460, Burma Road,
   Kumarapuram, Trivandrum.
6. Shri B. K. Chaturvedi,
   Joint Secretary & FA,
   Ministry of Science & Technology, New Delhi.
7. Deputy Educational Adviser,
   (T) Shastri Bhavan,
   26, Haddows Road, Madras.
8. Dr. V. R. Gowarikar,
   Secretary to the Government of India, Ministry of Science & Technology, New Delhi.
9. Shri Palat Mohandas,
   Secretary to the Government of Kerala, Department of Health, Trivandrum.
10. Dr. R. A. Mashelkar,
    Director,
    National Chemical Laboratory
    Pune.
11. Dr. K. K. G. Menon,
    Principal Scientific Adviser,
    National Dairy Development Board, Bombay.
12. Prof. P. J. Kurien,
    Member of Parliament,
    Pallath House,
    P.O. Vellikulam, Alleppey.

13. Prof. B. Nag,
Director, Indian Institute of Technology, Powai, Bombay.

14. Prof. A. S. Paintal,
Director-General, Indian Council of Medical Research, New Delhi.

15. Shri A. V. Ramani,
Head, Biomedical Technology Wing, Sree Chitra Tirunal Institute, Trivandrum.

16. Shri R. Srinivasan,
Secretary to the Government of India, Ministry of Health and Family Welfare,
Government of India.

17. Shri Thomas Kuthiravattom,
Member of Parliament,
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Kerala.

18. Dr. G. K. Vishwakarma,
Director-General of Health Services, Nirman Bhavan,
New Delhi.

19. Prof. M. S. Valiathan,
Director of the Institute.

20. Dr. R. M. Varma,
Emeritus Professor,
NIMHANS, Bangalore.

21. Dr. N. H. Wadia,
Director of Neurology,
Jaslok Hospital and Consultant Neurologist, J. J. Group of Hospitals, Bombay.

GOVERNING BODY

Chairman : Shri G. Parthasarathi

1. Dr. N. Balakrishnan Nair,
   Chairman
   State Committee on Science & Technology,
   Government of Kerala.

2. Dr. V. R. Gowarikar,
   Secretary to the Government of India,
   Department of Science & Technology, New Delhi.

3. Dr. R. A. Mashelkar,
   Director,
   National Chemical Laboratory
   Pune.

4. Mr. A. V. Ramani,
   Head,
   Biomedical Technology Wing,
   Sree Chitra Tirunal Institute.

5. Dr. K. G. Balakrishnan,
   Professor of Cardiology,
   Sree Chitra Tirunal Institute.

6. Dr. M. S. Valiathan,
   Director,
   Sree Chitra Tirunal Institute.

7. Dr. G. K. Vishwakarma,
   Director General of Health Services,
   Government of India,
   New Delhi.

8. Dr. N. H. Wadia,
   Director of Neurology,
   Jaslok Hospital and Consultant Neurologist,
   J. J. Group of Hospitals,
   Bombay.

STANDING COMMITTEES

Academic Committee

Director (Chairman)

Prof. M. M. S. Ahuja,
Prof. of Medicine & Head of the Department of Endocrinology & Metabolism, AIIMS, New Delhi.

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Chairman, State Committee on Science & Technology, Kerala Trivandrum.

Shri G. Balamohanan Thampi,
Vice Chancellor, Kerala University, Trivandrum.

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Head of the Department of Cardiology, Sree Chitra Tirunal Institute.

Dr. J. S. Gujral,
Prof. & Head, Department of Cardiovascular & Thoracic Surgery, PGI, Chandigarh.

Dr. M. Jamaluddin,
Scientist, Thrombosis Research Unit, BMT Wing, Sree Chitra Tirunal Institute.

Dr. K. K. G. Menon,
Principal Scientific Adviser,
National Dairy Development Board, Bombay.

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Head of the Dept. of Neurology, Sree Chitra Tirunal Institute.

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Head, BMT Wing,
Sree Chitra Tirunal Institute.

Building Committee

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Construction Engineer,
Vikram Sarabhai Space Centre, Trivandrum.

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State Committee on Science & Technology, Government of Kerala, Trivandrum.

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Sree Chitra Tirunal Institute.

Financial Adviser & Chief Accounts Officer,
Sree Chitra Tirunal Institute.

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High Court of Kerala, Ernakulam.

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302, Sector 35A,
Chandigarh.

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Director-General of Health Services,
Government of India,
Nirman Bhavan,
New Delhi.

Dr. D. K. Basu,
Prof. of Neurochemistry,
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Director (Chairman)

Financial Adviser to the Department of Science & Technology, Government of India.

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Secretary to the Government of Kerala,
Department of Health,
Trivandrum.

Member of the Institute Body representing Department of Science & Technology.

Financial Adviser & Chief Accounts Officer of the Institute (Convener)

Junior Staff Selection Committee

Medical Superintendent of the Institute.

Head, Biomedical Technology Wing of the Institute.

Dr. Jaisy Mathai, BTO,
Sree Chitra Tirunal Institute.

Mr. O. S. Neelakantan Nair,
Tool Room Engineer,
Sree Chitra Tirunal Institute.

Mrs. Deenamma Koshy,
Nursing Superintendent of the Institute.

A representative of the Academic wing of the Institute nominated by the Director.

Senior Staff Selection Committee

Director (Chairman)

Dr. R. M. Varma,
Emeritus Professor,
NIMHANS, Bangalore.

A nominee of the Secretary, Department of Science & Technology of the Central Government.

Head, Biomedical Technology Wing of the Institute.

An expert from outside the Institute nominated by the President.

A Professor of the Institute

Research Advisory Committee

Dr. K. K. G. Menon,
Principal Scientific Adviser,
National Dairy Development Board, Bombay.

Director of the Institute.

Prof. M. M. S. Ahuja,
Prof. of Medicine & Head of the Department of Endocrinology & Metabolism,
All India Institute of Medical Sciences, New Delhi.

Prof. N. Balakrishnan Nair,
Chairman,
State Committee on Science & Technology,
Government of Kerala, Trivandrum.

Dr. D. D. Bhawalkar,
Director, CAT,
Department of Atomic Energy,
Government of India, Indore.

Dr. R. A. Mashelkar,
Director,
National Chemical Laboratory,
Pune.

Dr. B. Nag,
Director,
Indian Institute of Technology,
Powai, Bombay.

Dr. A. Jayakrishnan,
(Member-Secretary)
Sree Chitra Tirunal Institute.

Technology Development Committee

Director (Chairman)

Dr. D. D. Bhawalkar,
Director, CAT,
Department of Atomic Energy,
Govt. of India, Indore.

Dr. A. D. Damodaran,
Director,
Regional Research Laboratory,
Trivandrum.

Dr. R. A. Mashelkar,
Director,
National Chemical Laboratory,
Pune.

Dr. Mira Mohanty,
Scientist, BMT Wing,
Sree Chitra Tirunal Institute

Prof. B. Nag,
Director,
Indian Institute of Technology,
Bombay.

Dr. K. V. C. Rao,
Head, Chemical Engg. Group,
VSSC, Trivandrum.

Prof. S. Ramseshan,
Visiting Professor,
Raman Research Institute,
Bangalore.

Mr. A. V. Ramani,
Head, BMT Wing,
Sree Chitra Tirunal Institute.

Technology Transfer Committee

Prof. S. Ramaseshan,
Visiting Professor,
Raman Research Institute,
Bangalore.

A senior Officer of the DST nominated by Secretary, DST.

Manager,
Technology Transfer Division,
VSSC.

A nominee of Kerala State Industrial Development Corporation, Trivandrum.

Head of the Division of Technology Transfer, SCTIMST.

Director's nominee (in the case of devices) Expert.

Principal Investigator
(the corresponding person for each device to be called at appropriate time).

FA&CAO of Sree Chitra Tirunal Institute.

HOSPITALS REFERRING PATIENTS

Kerala State — District-wise

Alleppey

District Hospital, Alleppey
Government Hospital, Noornad
Medical College Hospital, Alleppey
SNMM Hospital, Shertallai
St. Thomas Hospital, Shertallai
St. Thomas Hospital, Kattanam
S. H. Hospital, Alleppey
Taluk Hospital, Mavelikara
Taluk Hospital, Chengannur
GEMS Hospital, Mavelikara
St. Thomas Mission Hospital, Malakkara
Govt. Hospital, Haripad
Govt. Hospital, Kayamkulam
General Hospital, Shertallai
Velayudhan Memorial Hospital, Shertallai
Priya's Hospital, Kandellore
St. George Hospital, Kayamkulam
Matha Medical Mission Hospital, Kayamkulam
Philip Memorial Hospital, Mavelikara
Vijaya Dispensary, Kayamkulam
Poopally Hospital, Chengannur

Calicut

Nirmala Hospital, Calicut
Medical College Hospital, Calicut

Cannanore

District Hospital, Cannanore
Archana Hospital, Cannanore
Govt. Hospital, Kanhangad

Ernakulam

City Hospital, Cochin
Janatha Clinic, North Parur
Kunhali's Nursing Home, Cochin
Lisie Hospital, Ernakulam
Medical Trust Hospital, Ernakulam
MOCM Hospital, Kolencherry
Little Flower Hospital, Angamally
Port Trust Hospital, Cochin
General Hospital, Ernakulam
Ananda Nursing Home, Kothamangalam
Samaritan Hospital, Alwaye
Santhinikatan Hospital, Moovattupuzha
St. Joseph's Hospital, Kothamangalam
Sree Krishna Nursing Home, Cochin
Sudheendra Medical Mission, Ernakulam
George Tharakan Hospital, Alwaye
P. H. C. Neriamangalam,
Sameksha Hospital, Cochin
Mar Basilus Hospital, Kothamangalam
AAJAM Hospital, Kottapuram

ANVM Hospital, Banerji Road, Ernakulam
Lourd Hospital, Ernakulam
Indian Navy Hospital, Naval Base. Cochin
FACT Hospital, Udyogamandal, Alwaye
Govt. Hospital, Perumbavoor
Vellukattil Hospital, Ernakulam
Jubilee Hospital, Edappally, Ernakuiam
Philomina Hospital, Manjapra, Ernakulam
India Gandhi Co-operative Hospital Cochin

Idukki

District Hospital, Idukki
St. John's Hospital, Kattappana
Karuna Hospital, Idukki
Tata Tea Hospital, Munnar

Kottayam

Carithas Hospital, Kottayam
Good Samaritan Hospital, Kottayam
Holy Family Hospital, Kottayam
KVMS Hindu Memorial Mission Hospital, Ponkunnam
Medical College Hospital, Kottayam
M. G. D. Hospital, Kottayam
Govt. Hospital, Vaikom
Mundakapadam Mandiram Hospital Kottayam
Kavakkattu Memorial Hospital, Anthinad
S. H. Medical Centre, Kottayam
Bhavana Hospital, Kottayam
E. S. I. Hospital, Vaikom

Malappuram

Govt. Hospital, Tirur
Dist. Hospital, Manjeri
Taluk Hospital, Tirur
Wandoor Nursing Home, Wandoor
C. S. I. Hospital, Codacal, Tirur

Palghat

Dist. Hospital Palghat
Palat Memorial Hospital, Palghat
7th Day Adventist Hospital, Ottapalam
Taluk Hospital, Ottapalam
Talik Hospital, Mannarghat
P. H. C., Palghat
Govt. Hospital, Alathoor, Palghat
Nainan's Clinic, Palghat.

Pathanamthitta

Dist. Hospital, Kozhencherry
G. K. Hospital, Tiruvalla
Govt. Hospital, Tiruvalla
Marthoma Medical Mission, Ranni
NSS Medical Mission, Pandalam
People's Clinic, Pathanamthitta
Pushpagiri Hospital, Tiruvalla
Tiruvalla Medical Mission, Tiruvalla
M. M. M. Hospital, Kozhencherry
Christian Medical Centre, Pathanamthitta

Govt. Hospital, Pathanamthitta
Medical Trust Hospital, Kulanada
Govt. Hospital, Adoor
Luke's Hospital, Pathanamthitta
K. T. C. M. Hospital, Thottambala, Pathanamthitta

Quilon

Benziger Hospital, Quilon
Dist. Hospital, Quilon
Deen Hospital, Quilon
ESI Hospital, Asramam
Holycross Hospital, Quilon
Janatha Clinic, Quilon
Taluk Hospital, Karunagapally
Upasana Hospital, Quilon
St. Joseph's Hospital, Anchal
Dr. Nair's Hospital, Quilon
Jayabharatham Nursing Home, Punalur
Taluk Head Quarter's Hospital, Kottarakara
Medical Trust Hospital, Kottarakara
H. M. M. Hospital, Ayur
Udayagiri Hospital, Paravoor
Govt. Hospital, Neendakara
Medical Trust Hospital, Puthoor
A. M. Hospital, Karunagapally
Vijayakumar Hospital, Kottarakara
Govt. Hospital Mayyanad
Assisi Atonement Hospital, Perumpuzha
ESI Dispensary, Perinad
Govt. Hospital, Sasthamkotta
PHC., Paripally
Victoria Hospital, Quilon
Parakkadu Hospital, Anchal
St. Vincent Hospital, Thoovayur
Brother's Hospital, Pathanapuram
V. V. M. S. Group Hospital, Isfield Estate Kaleuruthy
Raj Sree Hospital, Ayoor

Trivandrum

Saji Hospital, Kazhakuttam
P. H. C. Kanyakulangara
Khan's Hospital, Parassala
Sivagiri Medical Mission Hospital, Trivandrum
Gayathri Medical Centre, Poojapura
Govt. Hospital, Vamanapuram
G. G. Hospital, Trivandrum
Valsala Nursing Home Vazhuthacaud
Ophthalmic Hospital, Trivandrum
V. K. K. Mission Hospital, Venjaramoodu
Sree Uthradam Tirunal Hospital, Trivandrum
T. B. Hospital, Pulayanarkotta
S. R. Hospital, Beemapally
Edava Hospital, Edava
Prakash Memorial Hospital, Kilimanoor
Prakash Clinic, Trivandrum
Fort Hospital, Trivandrum
P. R. S. Hospital, Trivandrum
Stanley Hospital, Udiyankulangara Trivandrum
Cosmopolitan Hospital, Trivandrum

General Hospital, Trivandrum
Govt. Hospital, Peroorkada
Govt. Hospital, Parassala
Medical College Hospital, Trivandrum
Nirmala Hospital, Trivandrum
Sree Ramakrishna Mission Hospital, Sasthamangalam, Trivandrum
Taluk Head Quarters Hospital, Chirayinkil
Taluk Head Quarters Hospital, Neyyattinkara
Taluk Head Quarters Hospital, Nedumangad
VSSC Medical Division, Trivandrum
W&C Hospital, Trivandrum
Dr. Govindan's Hospital, Trivandrum
Military Hospital Pangode
Al-Arif Hospital, Ambalathara
Regional Cancer Centre, Trivandrum
Air Force Hospital, Trivandrum
Kalyan Hospital, Aryasala
ESI Hospital, Peroorkada
SAT Hospital, Trivandrum.

Trichur

Agrasala, Kodungalloor
Amala Cancer Centre, Trichur
Balya Children's Hospital, Veliyannur
E. S. I. Hospital, Olarikara
Jubilee Mission Hospital, Trichur
Dist. Co-operative Hospital, Trichur
Royal Hospital, Kunnamkulam
Dist. Hospital, Trichur
Govt. Hospital, Choondal
Taluk Head Quarters Hospital, Chavakkad
Elite Mission Hospital, Koorkancherry
Govt. Hospital, Irinjalakuda
Metropolitan Hospital, Kokkalal

Wynad

Assumption Mission Hospital, Sulthan Bettery
Govt. Hospital, Mannantody
Wynad Hospital, Sulthan Batteri

OTHERS — State-wise

Andhra Pradesh

N. S. General Hospital, Hyderabad
Medical College Hospital, Guntur
Vamsi Clinic, Visakhapatanam

West Bengal

Calcutta Clinical Lab. Calcutta
Postgraduate Institute, Calcutta

Jammu & Kashmir

Sher-I-Kashmir Institute of Medical Sciences, Srinagar.

Karnataka

Jayadeva Institute of Cardiology, Bangalore
Kasturba Medical College, Manipal

Medical College Hospital, Bangalore
St. John's Medical College Hospital, Bangalore
General Hospital, Bangalore
J. J. M. Medical College, Devengere
Gopal Nursing Home, Mysore
Rangaraya Medical College, Karnataka

Maharashtra

Bombay Hospital, Bombay
Christand Hospital, Bombay

Madhyapradesh

Indian Ordinance Factory Hospital, Jabalpur
MPEB Hospital, Chachal
Govt. Medical College, Jabalpur
Jabalpur Medical Centre, Jabalpur.

Meghalaya

State Health Services, Meghalaya Shilong

Orissa

SB Medical College, Cuttack

Pondicherry

JIPMER, Pondicherry

Rajasthan

State Health Services, Rajasthan

Tamil Nadu

Chandran Hospital, Marthandam
P. N. P. Hospital, Marthandam
Biswas Hospital, Marthandam
Catherine Booth Hospital, Nagercoil
Jayasekharan Hospital, Nagercoil
Jawahar Hospital, Nagercoil
Kunneth Hospital, Padanthalmoodu
Vin's Hospital, Kaliakkavila
Kanyakumari Medical Mission, Neyyore
Mathai's Hospital, Nagercoil
Merlin Hospital, Coimbatore
Govt. Rajaji Hospital, Madurai
Aravind eye Hospital, Madurai
Kuppuswamy Naidu Memorial Hospital, Coimbatore
General Hospital, Madras
Medical College Hospital, Tirunelveli
Taluk Hospital, Tiruchandoor
Dist. Head Quarters Hospital, Nagercoil
Gandhimathy Nursing Home, Tirunelveli
Dominic Hospital, Kulasekharam
Govt. Hospital, Tenkasi
Abdul Kadar's Nursing Home, Nagercoil
Annai Nursing Home, Tenkasi
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