

HISTORY¹ of the INSTITUTE of BIOMATERIALS and BIOMEDICAL ENGINEERING

The first 25 Years (1962 to 1988)

Early Biomedical Engineering in Canada

Biomedical engineering first emerged as a separate discipline during or shortly after the Second World War. In Canada, the beginning can be traced to the founding of the Defense Research Medical Laboratories in 1950² one of the purposes of which was to investigate certain aspects of the interaction between humans and machines, particularly under stress. The field soon broadened from instrumentation and measurement to active support in medical research and clinical practice, and the role of the biomedical engineer changed from that of designer to collaborator.

In 1950, Dr. W.G. Bigelow and Dr. J.C. Callaghan started investigating the use of hypothermia for heart surgery at Toronto General Hospital. They invited engineer Jack A. Hopps, of the National Research Council, to join their research team, and, as a result of their collaboration, the first practical external heart pacemaker was designed and tested, much groundwork was done towards a practical implanted pacemaker, and in addition a method was devised of using radio frequency heating for bringing the subject out of hypothermia.

In the same decade, a group interested in biomedical engineering was being established at the University of Saskatchewan. In October 1958, at a cocktail party given by Dr. Wendell McLeod (Dean of Medicine), Dr. Arthur Porter (Dean of Engineering) was introduced to Dr. William Feindel (Professor of Neurosurgery), and the talk soon turned to possible cooperation between the two Faculties. To make a long story short, Professor Norman Moody was called in to work on the problem of measuring blood flow in the carotid artery. Shortly after, in July 1959, Professor Moody was appointed Chairman of Electrical Engineering at the University of Saskatchewan, and he continued his interest and activity in the field of biomedical electronics.

Dr. Porter was then invited to form the Department of Industrial Engineering at the University of Toronto. He found, when he arrived in 1961, that here too was a strong interest in biomedical engineering; indeed, Professor Ian Dalton (Electrical Engineering) had already worked with surgeons at the Sick Children's Hospital on designing and developing a heart-lung machine. With the strong backing of the two Deans (Dean McLaughlin of Applied Science and Engineering, and Dean Hamilton of Medicine), a committee was set up to study the ways and means of establishing a formal group. One very active and enthusiastic member of this Committee was Dr. E. Llewellyn-Thomas, and strong supporters were Professor James M. Ham and Dr. John W. Scott.

The outcome of this Committee was the formation in July 1962 of the Institute of Biomedical Electronics at the University of Toronto, with Professor Norman F. Moody as Director, and, one year later, Dr. E. R. (Tommy) Llewellyn-Thomas as Associate Director.

Organization of the Institute

Originally, the Institute had a Council of 16 persons, and the Director reported to the President of the University through this Council. In fact, financial and other support came to the Institute through the Dean of Engineering and the Dean of Medicine. Also, as a Graduate Institute, the Director had responsibility to the Dean of Graduate Studies in graduate matters.

It was intended, right from the beginning, that the graduate students studying at the Institute should be drawn from a number of disciplines; from engineering, from the physical sciences, and from the life sciences. In order not to divorce these students from their base disciplines, they were (and most still are) enrolled in "home" departments, the Institute being a common ground where

they have their desks and meet to exchange ideas and experience. In order to make this possible, close cooperation between the Institute and the various departments is necessary, and to achieve this, we have always insisted that each student satisfies the requirements of the "home" department. It was only with the establishment of the Clinical Biomedical Engineering program in 1984 that we started enrolling students directly in the Institute.

The President's report for the year ending June 1962 had the following comments: "Professor Moody is recognized as an authority in the field of electronics and semi-conductor circuits. As director, of a "bio-medical engineering" group at the University of Saskatchewan, he has already made important contributions to medical electronics. Perhaps the most significant of these is a completely new type of recording system for the measurement of cerebral blood flow transit times, a system which has been installed in the Montreal Neurological Institute. A generous grant, "The Johnson Wax Fund", from S.C. Johnson and Son, Limited, Brantford, Ontario, will support this very significant development."

The Moody Years

The Moody Years: 1962-63

The Institute started in July 1962, with Professor Moody as the Founding Director. Its offices were situated more or less where they are today, on the fourth floor of what is now the Rosebrugh Building. At that time, it was called the (Old) Electrical Building; Electrical Engineering had recently moved into the Galbraith Building, which had just been opened. However, there were many reminders of the previous occupants; the present office area (rooms RS-415 to RS-418) formed one big laboratory where the students worked; see the photo on page xx. All of the floors were coated with an asphalt compound, which was supposed to have a high resistance, thereby reducing the possibility of electrical shock. There were a number of antennas on the roof, with feeders leading into various other laboratory rooms. There was only one outside telephone on the floor, but the offices were connected by an independent intercom phone system. At that time, there were two elevators; a freight elevator at the south end, and a small passenger elevator half way along the hallway. Both of these ran on 250V d-c, which was supplied from a bank of rectifiers in the basement of the Galbraith building.

Much of the secretarial work was done by Mrs. Moody. There was a small room at the top of the south staircase, formed by a wood and glass partition, where the secretary sat. The technical staff consisted of Mr. Bert de Kat, who came from Saskatoon having worked there under Prof. Moody.

In this first year, four students were admitted to MASc programmes through Electrical Engineering. They were Willy Riemer, Ted Saul, Barry Smith, and Dale Younge. The first to graduate from the Institute was Ted Saul, in April, 1964. David Lewis was appointed Senior Engineer. The Council of the Institute held its first meeting on 23 May 1963.

Support from outside the University was received from several research agencies; some directly to the Institute from S.C. Johnson and Son Limited and from Litton Systems (Canada) Limited, and some through grants awarded to individual members of the Council for work at the Institute.

The Moody Years: 1963-64

In its second year, the Institute continued to expand. Mrs. Ruth Goldstein was secretary for the first part of the year, and then Mrs. Anna-Marie Jamieson joined us. Many students of the

Institute will remember Mrs. Jamieson; she continued to be Secretary and Executive Assistant of the Institute for 20 years, until she retired in 1984. "Mother J", as she is affectionately known to the students, helped each and every of us through times both difficult and happy.

Another significant event was the appointment of Dr. E. (Tommy) Llewellyn Thomas as Associate Professor of Pharmacology and Special Lecturer in Electronic Engineering. Dr. Thomas had degrees and appointments in both medicine and engineering, and this appointment started the tradition which contributes to and emphasizes the interdisciplinary nature of the Institute.

Eight students started this year. Five of them were enrolled in MASc program; Cy Flacks, Jim Duffin, Gerry Gray, Jerry McElroy (Industrial), and Don Studney. The other three, Mike Joy (Physics), Dave Lewis, and Henry O'Beirne, were accepted as special students, who would enroll later in Master's programmes. Two of the eight, as shown, were not from Electrical Engineering; it has always been the As was mentioned before, the first Institute student to graduate was Ted Saul, who passed his MASc oral on April 6, 1964, and attended Convocation in June, 1964.

Professor Moody wrote in the Annual Report: "The interdisciplinary nature of the Institute is shown by the list of some sixteen projects which appear in the annual report to its Council, and the fact that twenty University departments, three research institutes and five hospitals are taking part.

"The investigations range from the creation of a camera-like instrument for the location of tumors by photographing radio-isotopes, to establishing the degree of lung development and function in premature infants (respiratory distress is a major cause of mortality). Three studies are devoted to the diagnosis or treatment of disease in very young children.

"In an attempt to gain deeper insight into the body's regulating mechanisms, the blood flow to the liver has been the subject of considerable research. Particularly valuable results have arisen from increased knowledge of the influence of various anesthetics and drugs upon its functions.

"Biochemical tests now play an important role in diagnosis. The procedures may be automated and, because of the large quantity of data arising within a hospital, digital machine techniques are best employed to collect and analyze the data. The Institute has drawn up the details of such a system for the Toronto General Hospital.

"Many of the problems outlined have been solved by the Institute's graduate students in the course of their studies for a higher degree. The number of student applications far exceeds its facilities; the 9 M.A.Sc. and 3 Ph.D. students at present enrolled are the limits of its present capacity.

"Special courses have been arranged for these interdisciplinary students. For those whose training is in the physical sciences there is a course in physiology. A course in human factors engineering, the important relationship between the human and the machine which he operates, will be introduced this fall. A course in biochemistry is also planned. For the life scientists there will be a special course in the fundamentals of scientific instrumentation.

"The operation of such an Institute is very expensive: apart from University support, its research programme must depend heavily on extra-mural funds. Aid is received from many sources, among which may be mentioned the National Research Council, the Medical Research Council, the University Alumni Fund, the Ford Foundation, and the Foster Bequest. Several commercial companies, particularly Johnson's Wax and Litton Systems of Canada, have been most generous."

The Moody Years: 1964-65

Seven students were accepted this year, two of these in PhD program. In addition, two of last year's special students continued into MASc program.

Theses projects this year included both theoretical projects such as the development of mathematical expressions to define the operation of the heart, and practical projects such as the development and construction (with Dr. D.L. Watt of the Toronto General Hospital) of an instrument to measure blood-clotting times. This instrument subsequently was manufactured by Litton Systems (Canada) Ltd., one of the original financial supporters of the Institute. Dr. Tommy Llewellyn Thomas continued his work on measuring eye movements.

The Moody Years: 1965-66

The number of students enrolled in the Institute was increasing, and therefore, the complement of staff also had to increase to take on the load. Henry O'Beirne was the first new academic staff member, appointed lecturer in September 1965.

The IBME section of the Graduate Calendar included six courses, designed especially for students in biomedical engineering. Members of the Institute were involved in no less than 20 research studies, embraced a surprisingly large area in Medicine. Research on the Gamma-ray Camera resulted in a clinical instrument used at the Sick Children's Hospital; there was a novel artificial lung, at first used for small animals, and subsequently on infants with respiratory trouble; we developed improved diagnostic methods for heart diseases; and our experimental ultrasonic studies suggested several novel applications in medicine. Departments collaborating in this work included Anatomy, Pathological Chemistry, Pediatrics, Pharmacology, Physiology, Psychiatry, Medicine, Surgery, Obstetrics and Gynaecology, Industrial Engineering, and Electrical Engineering. Support was received from the University, from the National Research Council, and from the Associates of the University of Toronto. Ten other donors also provided financial support to the Institute.

The Moody Years: 1966-67

Two academic staff and three technical staff members were appointed this year. Richard Cobbold, who had been a graduate student at the University of Saskatoon when Professor Moody was there, started as Associate Professor on 1 July 1966. Bob Simpson (electronic technologist) and Fred Greenwell (machinist) joined the technical staff in September 1966, and Don Morrison (technical officer) in November. Hans Kunov, having obtained his Ph.D. in Copenhagen, joined us in April 1967 as Assistant Professor. 1966 also saw the publication of Professor Moody's book *Semiconductors and Their Circuits*, English Universities Press: this was the Institute's first book.

Don Morrison, whose degree is in Physics, later enrolled in a MEng program, and graduated in 1976. He then enrolled in the medical program at Memorial University, and became a practicing anaesthesiology in Halifax. His duties at the Institute included designing and testing devices for measuring blood flow, and being an avid photographer, he was in charge of the photographic equipment. He designed and outfitted a darkroom in RS-220A.

This was a year of expansion, when the Provincial Government was providing funds to all universities and community colleges for new buildings and for the renovation of old space. The Institute benefited from this -- while the Old Electrical (now Rosebrugh) building was being refurbished to our specifications, we moved to temporary quarters in the Sandford Fleming Building (formerly the McLennan Physics Laboratories). We had the space around and above the rotunda, which housed a large lecture room, and in the middle of our laboratory was a huge d-c

motor that drove the ventilation fans. Luckily it was never used. We were quite active in forming the group that later became the Media Centre, and experimented with the effective use of video and audio aids in the classroom.

Other building was taking place around us; in this year, the "Little Red Schoolhouse", which had housed the Engineering Faculty since 1877, was torn down, to make space for the present Medical Sciences Building.

In September, the Canadian Medical and Biological Engineering Society (CMBES) recently formed largely at the instigation of Jack Hopps, held its first conference (CMBEC-I) in Ottawa. We, of course, were well represented -- Richard Cobbold was Chairman of the Papers Committee. We offered to host the second CMBEC in 1968 in Toronto.

A meeting of the Council of the Institute was held on 5 June 1967, at which the concept of Membership of the Institute of Bio-medical Electronics was introduced and approved. To quote Professor Moody:

"The Institute is not a Department and as such cannot offer cross-appointments. However, we wish to acknowledge our indebtedness to several senior colleagues in other Departments who take part in our researches, co-direct our students, and in some cases lecture to them. For this purpose we should like to introduce the class of Fellow (Senior Member).

"It is helpful to maintain close relationships with the heads of Engineering Departments of hospitals, and for this purpose to elect a class of Member. We should wish to appoint to this grade colleagues with whom we have interests in common, carry out occasional joint projects, undertake occasional joint student supervision, or share important facilities. The appointment of Members would be renewable on a two-year basis.

"Finally there should be a class of associate membership. The primary purpose of this one-year appointment is to afford the recipient the free use of our facilities so that he can carry out researches in the Institute."

The first appointments, for terms of varying length, were made shortly after the Council meeting, and took effect on 1 July 1967. Those appointed members were Dr. B. Leibel, Dr. K. Taylor, and Dr. L. Organ. Appointed associate members were Ted Saul, Barry Smith, Dr. D. Watt, Professor Piekarski, and Dr. Don Shepley.

By the end of the 1966-67 academic year, 20 of our students had met the requirements of the Master's Degree. Our total staff was now ten, of which five held academic appointments. Much part-time help was received from the Members of the Institute. Our floor space had increased to 10,000 square feet.

Professor Moody wrote in the Annual Report: "Our growth reflects the tremendous interest, both academic and commercial, in the whole field of bio-medical engineering throughout the world. In Canada, perhaps half of the universities have launched some venture in this area during these four years. The wisdom and foresight of the Faculties of Applied Science and Engineering and of Medicine in the early formation of the Institute have permitted the University of Toronto to attain a pre-eminent position in the Canadian scene.

"In this age of specialization, the Institute with its interdisciplinary and humanitarian aspects appeals strongly to a large class of students who seek a broader view of "natural philosophy". The increasing variety of employment opportunities in bioengineering promises to make this a very attractive new career for them. "The rapid expansion of the field, which is particularly marked in the United States, has led to a critical shortage of available staff with the unusual combination of qualifications and interests needed. This has hampered our expansion and has permitted us to accept only one out of every four qualified student applications. However, the

arrival of our three new staff members [H. O'Beirne, R.S.C. Cobbold, H. Kunov] during the last nine months, together with recruitment of another [J. Kryspin] planned for the coming year, will do a great deal to ease the situation. In the initial phases of our growth, we suffered year, which is being converted into modern laboratories and classrooms, should meet our space needs for some time to come. There will be physiological, biochemical and engineering laboratories. We have adequate equipment for the last, but shall need many new scientific instruments for our life science laboratories.

"The problems of establishing a complete program of research and teaching in a new area are many: our success owes much to the magnificent support given by our associated Faculties. Six graduate courses, designed especially for our students, have been very well received. We are involved in no fewer than twenty research studies which embrace a surprisingly large area in medicine. Thus, our early research on gamma ray cameras has resulted in a clinical instrument now in use at the Sick Children's Hospital, and our current research in this area will create cameras using new principles and which permit the taking of motion pictures showing radio-isotope movement in the living body. Such advanced cameras will provide a new tool for physiological research and routine diagnosis. The techniques of holography (the means whereby 3-dimensional photographs may be taken without the use of lenses) and of ultrasound have been embodied in another experimental "camera". The present results offer promise that a technique as important as X-ray photography may develop.

"The Institute is also undertaking studies in basic physiology. One may mention on the one hand, our work on the mechanisms of acetylcholine transport at neural synapses; and on the other, a three-year old research program on the control mechanism of the liver [Mike Albisser], and the development of a mathematical model of the respiratory control system [Jim Duffin] which has led to several intriguing ideas.

"Certain advanced clinical problems have also received attention. Major effort is being applied, for instance, to the rapid chemical analysis of blood in the condition of acute diabetic ketosis, and of subsequent digital computer computation to determine the treatment to be given the patient. Such methods may well find widespread application to many other medically critical situations.

"Departments collaborating in this work are Anatomy, Pathological Chemistry, Pediatrics, Pharmacology, Physiology, Psychiatry, Medicine, Surgery, Obstetrics and Gynaecology, Industrial Engineering, Physics, Electrical Engineering and others.

"We have found it very rewarding to follow the careers of our first students. Two have decided to enter medicine [Don Studney and Ken Ryan], and so have enrolled for the M.D. degree. Another [Jim Duffin] is studying for the Ph.D. degree in Pharmacology, with the object of qualifying himself to apply the techniques of engineering and physics to the assessment of drug action on living organisms. A fourth [Barry Smith] has joined one of the hospitals as an advisor on the engineering and instrumentation aspects of their medical research. A fifth [Art Quanbury] has joined N.R.C.'s medical research section. We are just about to supply our second recruit [Murray Morris] to I.B.M.'s division of data handling and computation in medicine. Other students have entered the commercial world to apply their specialized engineering knowledge: one is involved in the designing and planning of hospital operating room instrumentation, and another is engaged in the human factors engineering aspects of aircraft simulator design." [names in brackets inserted by the Editor]

The Moody Years: 1967-68

All of the professors in the Institute spent a part of their time in undergraduate teaching. In this year, a course in Biomedical Engineering was first offered as an elective to 4th year Electrical and Engineering Science students. The course (formerly 796; now ELE445) was organized by Richard Cobbold, helped by Henry O'Beirne, and was given in four or five segments, each by a different staff member. Basic physiology was taught by Dr. Llewellyn Thomas, and, to most of the students, was quite a departure from the usual engineering topic. However, Tommy was himself an engineer, and he had the unusual skill of being able to present the material with an engineering flavor. The course has usually been oversubscribed, and sometimes students have had to be turned away.

In November, the Institute held an Open House, to which many people were invited, and which was well attended. In addition, the Institute was host to scientists from a variety of countries, including Japan, France and the USSR, in order to promote better exchange of scientific information between widely separated research centres.

In March 1968, we returned to the refurbished space (our present location) on the fourth floor of the Rosebrugh building. We gained in particular our excellent workshop and darkroom facilities, most of which was laid out by Bert DeKat and Don Morrison. All the laboratories were furnished with sinks, with compressed air and gas (which have since been removed), and with a plentiful number of electrical outlets. At last, for a few years anyway, there were enough offices for the staff, and a carrel and desk was available for each student. The screened room was installed at this time. As yet, we had no computer; only a mechanical Munroe calculator and an advanced Hewlett-Packard electronic machine.

Only six new students started with us this year, but they were an unusual group. Every one of them, after finishing their Master's, continued into and completed a PhD program. These six are Russ Brown, Roland Drolet, Tom Ewart, Bill Gentles, Geoff Iles, and Al Lightstone.

We all celebrated Canada's centennial on July 1st, 1967.

Highlights of the year's researches include the development of a neural impedance probe which was soon put into clinical use, a new gamma-ray camera for cancer diagnosis and other radioactive tracer applications, and an "artificial pancreas".

The Moody Years: 1968-69

We hosted the annual conference of the Canadian Medical and Biological Engineering Society (CMBEC-II) at the King Edward Hotel on September 9 to 11, 1968. It was a successful and well-attended meeting, with a total of 192 paid registrants. The two invited lectures were given by Dr. Lawrence Stark³, with the University of Illinois at that time, and by A. Iwanovski and C.H. Dodge⁴ of the Library of Congress, U.S. Naval Observatory.

Members of the Conference Executive were Dr. Llewellyn Thomas (Chairman), Mrs. A.M. Jamieson (Executive Secretary), R.S.C. Cobbold (Treasurer), K.A. Ivey (Commercial Exhibits), H. Kunov (Registration), C. McLaurin (Member at Large), N.F. Moody (Papers Committee), H. O'Beirne (Aids).

Dr. Llewellyn Thomas was Acting Director while Professor Moody was on sabbatical. With his strong encouragement and support, a number of new graduate courses were mounted and offered to our students. Professor Richard Cobbold was appointed Graduate Secretary. The increased number of students from a variety of different departments made the coordination quite complex.

We had a visiting scientist this year: Dr. Y. Kurioka came from the National Physics Laboratory in Japan, and worked with Dr. Llewellyn Thomas and Professor O'Beirne on the investigation of eye movements. Dr. Paul Wang, a chemical engineer, joined the Institute's staff.

Our first computer, a DEC PDP-8/I (Lab-8) system, was delivered. This was a 12-bit machine with 8K words of core memory, analogue input and output, and a teletype and punched paper tape. Later we purchased a 32K word disk for this machine.

Dr. Llewellyn Thomas wrote in the Annual Report: "We now have a full-time academic staff of eight with appointments in electrical and chemical engineering, pharmacology, physiology and anaesthesia. There are also part-time teachers associated with the Institute from medicine, surgery, pathological chemistry, industrial engineering, and from the Departments of Medical Engineering and Computer Services in the teaching hospitals, as well as various clinical hospital departments.

"The core of our graduate student program remains the research project. However, teaching and research cannot logically be separated and, therefore, we offer eight graduate courses to cover those aspects of medical engineering not available within departmental teaching programs.

"Undergraduate teaching has increased through the introduction of six elective courses for medical students during their third and fourth years. We continue to offer a biomedical engineering option for fourth-year engineering students, and this course, limited by space and facilities, has always been over-subscribed.

"We have about thirty research projects in progress. All involve students as members of the research teams, and the great majority are joint studies with various departments in the Faculty of Medicine. They range from basic clinical problems, such as measuring the moment of ovulation, to the development of mathematical models in the circulatory system. Most graduate students have one supervisor from the Faculty of Applied Science and Engineering, and a second one from the Faculty of Medicine. They are therefore introduced to the techniques and methods of medical research as well as those of engineering science appropriate to their studies. One example of the fruitfulness of this co-operation is the award of first prize by the Canadian Urological Association to a student of the Institute and to a Research Fellow in the Department of Surgery [Roland Drolet and Dr. C.J. Robson] for their studies on electrical methods of stimulating in the neurogenic bladder.

"It is difficult to measure the effectiveness of teaching and research, but we can feel satisfaction in the caliber of the graduate students attracted, the research funds obtained, and the quality and number of papers published by members of the Institute in refereed journals, although they may only appear in the bibliography of the senior author's department. It is even more difficult to measure the "services" function of the Institute as a source of special knowledge and a place for introducing workers in difference fields to one another. But I know of several examples of fruitful research in the university host organization for the Second Canadian Medical and Biological Engineering Conference, and in June for the Annual Meeting of the Human Factors Association of Canada.

"Our renovated laboratories and workshops are very well equipped, and we have received financial support from the university, the federal and provincial governments, industry, and from private granting agencies.

"As Acting Director during Professor Moody's sabbatical leave, I must thank my colleagues and the technical and secretarial staff for their hard work and enthusiasm during the year. Our students have shown dedication and initiative not only in their scientific studies, but also through activities such as the student seminars, the presentation of scientific films, and in projects such as

the renovation of medical electronic equipment for dispatch to medical clinics in some of the less fortunate parts of the world. I am encouraged to think that a small organization such as ours, devoted to the application of knowledge from the engineering sciences to medicine, may not encounter all the problems facing many larger and older university departments. Perhaps this is because we need not doubt the relevance of our work; we can concentrate on its authenticity."

The Moody Years: 1969-70

One note that will be of interest to our present students: in December 1969, the IBME Student Organization was formed by Russ Brown, Abe Rolnick, and Bob Stasko. John Simpson joined the technical staff in March 1970.

From the President's Report for June 1970: "During the seven years of its existence the Institute has developed into the leading centre for research and education in medical engineering in Canada and is rapidly establishing a world-wide reputation. No less than 77 scientific papers have been published by its staff and students, of which 45 have appeared in refereed journals; and two books, together with several chapters in others, have been authored by our staff. We take particular pride in the acceptance of our students by leading research centres throughout the world: Thus, for example, one has joined the Karolinska Institute in Stockholm to continue his neurological studies, while another has completed two years postdoctoral fellowship at the Royal Postgraduate Medical School in London.

"Of the twenty areas of research in progress, space allows mention of only two whose significance is readily appreciated. A biological adhesive has been developed as an alternative to suturing procedures in surgery, and it has been successfully tested on animals. Extensive investigations of possible tissue effects must, of course, be undertaken before clinical trials with patients are permissible and this study is in progress.

"A new gamma-ray camera developed by the Institute allows isotope distribution to be photographed at cine-camera speed as they move through the living body. A model suitable for clinical trials is under construction.

"Formal student training has always been given equal weight to the informal training received in their researches. Accordingly the course offering of the Institute has been considerable enriched during the current year. Although 12 graduate courses are now given under direct Institute auspices, undergraduate training has not been neglected, and this phase of our activity is expected to increase in the future. There is a fourth year biomedical engineering option for engineering students, six elective courses for third and fourth year medical students and several electives in engineering for the life science students.

"With an academic staff of 9, a non-academic and professional staff of 10, and approximately 30 graduate students, the problems of space have become crucial. At present some of our staff and research laboratories must be sited in other buildings, with a resultant loss of efficiency and the close contact which spurs intellectual innovations. We hope that some way will be found to alleviate these problems in the coming year."

The Moody Years: 1970-71

From the President's Report, June 1971: "The Institute, founded in 1962, is now approaching the end of its first decade, and it has maintained the steady pace of accomplishments described in earlier President's Reports. It seems particularly significant to us that our function and aims are acknowledged by the many universities and groups in Canada now following our example: no fewer than 16 universities are now either undertaking some research in the field of bio-

engineering or have set up Departments or Institutes of their own. It has been said by the President of the Canadian Medical and Biological Engineering Society that: "The presence of a biomedical engineering nucleus at the university has proven helpful to graduate training in traditional medical or biological disciplines, e.g. physiology or pharmacology. Biomedical engineers, with or without the collaboration of their biomedical colleagues, are usually well qualified to organize such courses as bio-mathematics or use of mathematics in biology, control system theory as applied to biological systems, information theory, use of computers in biology, biomedical instrumentation, etc." (from a survey of biomedical engineering, published by CMBES)"

The Moody Years: 1971-72

This is the tenth year of the Institute of Biomedical Electronic's existence. It had been apparent for some time that the range of interest and activities of the Institute's staff far exceeded the area of electronics, and therefore it was decided to change its name by adding "and Engineering", making it IBMEE for this one year only (in the next year, "Electronics and" was dropped). In addition, Henry O'Beirne was appointed Assistant to the Director; the main duties of this position were keeping statistics for the Institute and preparing summaries and reports when required. David A. Croft joined us in January 1972 as mechanical design engineer in charge of the workshop.

From the President's report, June 1972: "The Institute presents a decade of progress with some pride. From an original staff of two, and a graduate student population of a single person, it now has ten academics, 2 research associates, a supporting staff of 7 and 40 graduates. Because of the interdisciplinary nature of our work, a graduate student invariably receives co-supervision from one or more additional university departments. To facilitate these linkages the Institute has elected some 20 members who belong to a life science, a physical science or a medical department, and whose researches interlock with the Institute.

"The Institute has gradually become recognized as the leader of the Medical Engineering field in Canada and has gained an international reputation in several areas.

"During the past year its area of interest has been extended into mechanical engineering by the cross-appointment of Dr. D.F. James to the Institute. Thus we now train students from the engineering areas of mechanical, civil, electrical, chemical, engineering science and also from physics, pharmacology and Ph.D. degrees, and all have found satisfactory employment. Indeed we expect that demand will outstrip supply within the next few years, for the important role of the biomedical engineer in hospitals is rapidly becoming recognized.

"Student applications for enrollment always exceed our capacity and for several years only outstanding students of scholarship caliber have been admitted.

"Although this report has featured the graduate aspects of the Institute's work, it should be mentioned that undergraduate teaching receives equal emphasis and absorbs some 50% of our staff time.

"Our expansion into chemical engineering occurred some years ago, but we have never been able to acquire the small extra space needed to incorporate this activity within our own building. There is no doubt that this isolates the chemical students, and they tell me that they do not feel "part of the Institute". In an interdisciplinary group where cross fertilization is vital the isolation is serious; but all efforts to solve the problem have proved unavailing."

The Moody Years: 1972-73

The Institute was again renamed: this time as the Institute of BioMedical Engineering.

1973 was celebrated by the Faculty of Applied Science and Engineering as its centennial year. In 1873, the Ontario School of Practical Science was founded, and in 1877, the first segment of "the Little Red Schoolhouse" was built.

As part of the celebrations, a series of eight lectures was presented throughout the year, under the general title of "The Next Hundred Years". Three of these were of particular interest to us.

The first, given by Dr. Dennis Gabor on January 17, 1973, called simply "The Next Hundred Years -- An Introduction", covered in general the problems that will face us. Many of these involve the relationship between Industry and Health.

The fifth, "Biomedical Engineering", was given by Dr. Llewellyn Thomas on September 26, 1973. His closing remarks are worth quoting: "At the bicentennial of this Faculty, in a hundred years, our descendants will find much to criticize about us. But, willy-nilly, they will have to accept that we were the first generation who broke free from our planet, who transcended the sun as a source of energy, who kept a fellow-man alive while his heart was stopped. These achievements are no mean memorial. They are the outcomes of our idealism, our skill and our creative genius expressed through our machines. Our major challenge in the next hundred years will be to bring these two aspects of our humanity, our idealism and our creativity, into yoked harmony. Our machines, by increasing our options, will force us to make trade-offs involving the Creation, the Preservation and the Destruction of Life. They will challenge us to show that political wisdom that Gabor defined as necessary for the survival of our Civilization."

The eighth and last lecture was given on December 5th, 1973, by Dr. Arthur Porter, on "The Education of an Engineer". In part of his talk, he emphasized that "The most incredible "machine" known to man is man himself and particularly his brain", and "...it is important to note that many engineering principles have been predicated on man's observation of the workings of his own human body."

From the Report of the Dean of Applied Science and Engineering, 1972-73: "Graduate enrollment has been well maintained at the approximate number of 40, which is the ceiling value permitted by our present staff and facilities. The wide-ranging research projects involved have called upon the aid of many of the 40 non-resident members of the Institute, and have been carried out in cooperation with many hospitals and other University Departments. I have been gratified that a majority of our graduates have been offered excellent employment positions of their choice, and note with interest that more and more hospitals in the Toronto area are forming Medical Engineering Departments, and that with rare exceptions they are staffed by our students. Our Institute remains by far the largest in Canada, and offers a much broader base of training than any of its sister institutions.

"There is a growing interest on the part of Government -- both Federal and Provincial -- in improving the efficiency and reducing the cost of Health Care Delivery, and not surprisingly these bodies are turning to engineering in medicine for assistance. Patient safety from the hazards introduced by instrumentation is also becoming a key issue. All of these trends emphasize the growing need for the people we train.

"Dr. E. Llewellyn-Thomas, my Associate Director, has recently been appointed Associate Dean of Medicine. Though we regret that in the future he will be able to spend only 25% of his time with the Institute, we look back with some nostalgia to the many contributions he has made to our progress in the previous decade."

The Moody Years: 1973-74

Dr. Llewellyn Thomas was now spending much of his time as the Associate Dean of Undergraduate Affairs in the Faculty of Medicine, an appointment which brought him into contact with each and every medical student, but which forced him to spend much less time in the Institute. However, for this year he was still our Associate Director and still actively supervised a number of Institute students.

Professor Cobbold was the Graduate Secretary, a particularly difficult position at this time. There was a peculiar state occurring in the numbers of students wishing to go to University; there was at the same time a large increase in undergraduate enrollment and a great decrease in graduate enrollment. This made it quite difficult to choose from those that might apply this year and to predict the numbers that might apply in near future years.

John Nicolaidis joined us as the machinist in the workshop.

As mentioned below in the President's report, Professor Moody resigned from the Directorship and Dr. Llewellyn Thomas from the Associate Directorship at the end of this academic year, though both of them remained at the University and part of the Institute for some time to come.

From the Report of the Dean of Applied Science and Engineering, 1973-74: "During the past year important and far reaching changes have occurred in the Institute. Both Professor N.F. Moody, the Institute's founding Director (since 1962), and Associate Director, Professor E. Llewellyn-Thomas, resigned their positions as of June 30, 1974. Professor Moody, after a sabbatical year, will return to the Institute to devote his energies to teaching and research. Dr. E. Llewellyn-Thomas has been appointed Associate Dean (Undergraduate Affairs) in the Faculty of Medicine; fortunately he will continue to teach and participate in the Institute's research activities on a part-time basis. These changes will inevitably affect the direction and thrust of the Institute and have already stimulated a broad re-assessment of our current program and its objectives.

"It should be noted that our program is certainly the largest in Canada and that it would rank as one of the largest in North America. Our graduates hold appointments in Canadian hospitals, industry, research institutes and a number of North American universities. Approximately 38 graduate students are supervised by the Institute's faculty in a broad range of activities that spans many disciplines at various levels of complexity. Many of the projects involve our graduate students directly in the University teaching hospitals as well as some specialized treatment centres, and thereby bring the student in direct contact with patient care. It is this direct involvement with the clinical aspects of bioengineering that has received increasing emphasis in recent years.

"The recent decision of the Canadian Medical and Biological Engineering Society to press for formal certification in Bioengineering for those graduates who will be working in direct contact with patients and their physicians, will inevitably have an important impact on our graduates. The Institute's faculty fully endorses the efforts of the CMBES in this area and has itself given much thought to its various ramifications. Important among these are the establishment of standards acceptable to both the engineer and the physician, an examination of the process of certification itself, and the re-appraisal of the Institute's current program to ensure an effective and natural progression from post-graduate training to actual employment in the clinical context.

"Faculty and students of the Institute have been directly involved with one particular bioengineering project that has attracted international interest. The development of an artificial pancreas by Dr. A.M. Albisser and co-workers at the Hospital for Sick Children, with clinical trials at Mount Sinai Hospital, has attracted wide attention. Two papers reporting this work were published in the May 1974 issue of "Diabetes". "In addition the staff and students have participated

in a large number of scientific meetings. One major event was the address of Professor Llewellyn-Thomas as invited speaker during the centenary year of the Faculty of Applied Science and Engineering. As one of the speakers in a series of addresses by international known scientists, he delivered an address entitled "Biomedical Engineering -- The Next Hundred Years".

The Cobbold Years

The Cobbold Years: 1974-75

Professor Richard Cobbold was appointed Acting Director when Norman Moody decided to step down from the Directorship and take a year's sabbatical leave. A Search Committee was struck, and after due process, Richard Cobbold agreed to be Director for a 5-year term retroactive to July 1, 1974. Subsequently, his appointment was extended for another 4 years; overall, he was Director from July 1974 to June 1983.

Hans Kunov took over the duties of Graduate Secretary. David James went on Leave of Absence for this year.

Early in 1975, encouraged by a report published by the Ontario Council of Health entitled 'Biomedical Engineering and Biophysics', we formed a Committee to examine the possibility of mounting a programme in the Institute for clinical biomedical engineers. The committee included eight academic staff members of the Institute and four graduate students. The concept was considered to be viable, and the committee published its findings in 'A Proposal for the Education and Training of Clinical Medical Engineers at the University of Toronto'.

This report had a considerable influence on the academic programme of the Institute over the subsequent decade. It was not possible for us to mount this programme until 1985, due to various fiscal constraints; but, even so, we worked towards its establishment by publicizing our proposal, investigating sources of funding, offering new Graduate courses and deleting old ones, all within the recommendations of the report. By the time the Clinical Biomedical Engineering Programme was finally launched, the stage was well set, and the transition was very smooth.

The Cobbold Years:1975-76

Dr. Walter Zingg agreed to become our Associate Director, and thus started his long association with the Institute.

As described in the extract from the Dean's Report, the Biomedical Instrumentation Development Unit (BIDU) was established in March 1976, and Professor Moody, who had returned from sabbatical leave, became its first Director.

An old friend and supporter of the Institute, Dr. Arthur Porter, who had founded and twice been Chairman of the Department of Industrial Engineering, retired from the University in June 1976. Henry O'Beirne took sabbatical leave this year, and spent much of the time at Leeds University in England.

From the Report of the Dean of Applied Science and Engineering: "In our last Annual Report we described proposals that would result in three educational research streams within the Institute; namely, scientific, industrial and clinical. The first of these already exists and is the traditional path for graduate students within the Institute.

"With regard to the Industrial stream, a proposal submitted in July 1975 to the Federal Department of Industry, Trade and Commerce to form a Biomedical Instrumentation Development Unit (BIDU) within the Institute was accepted for funding over a five-year period beginning March 1976. The overall objective of BIDU is to help translate ideas developed in Canadian laboratories

and by private inventors for the benefit of Canadian industry. Specifically, the objectives of BIDU are four-fold. First, to undertake the development of biomedical instrumentation and equipment for commercial manufacture under licence by Canadian industry. Second, to work with other research laboratories to help translate new instrumentation and equipment concepts from research and laboratory prototypes into commercially viable products. Third, to provide information and advice to Canadian industry on matters concerning the development and evaluation of biomedical instrumentation. And, finally, to provide facilities for graduate students to participate in the work of the Unit in order that they may gain experience in industrially oriented biomedical engineering and to contribute to the objectives of the Unit.

"Professor Norman F. Moody was formally appointed on March 1, 1976 as the Director of BIDU and steps were taken to set up a policy and advisory board, with representation from industry, hospitals, government and universities, to assist with important policy decisions concerning BIDU's activities. A suitable physical location to meet BIDU's fairly modest office and laboratory needs was found on the third floor of the Rosebrugh Building, immediately below the main Institute location, and plans were immediately drawn up to make the necessary modifications and to relocate the existing occupants.

"Events during the first four months of BIDU's existence support our view that over a five-year period BIDU can become self-supporting. Furthermore, the opportunity that BIDU provides for graduate student interaction will enable the Institute to provide for an educational and research stream in industrial biomedical engineering.

"In regard to the need to provide for education and training of clinical biomedical engineers to meet current and projected needs in the provincial health care system, a proposal was submitted in July 1975 to the faculties of Applied Science and Engineering and of Medicine for the creation of a two-year masters' level program in clinical biomedical engineering. Favourable support was received, and as a result our proposal was forwarded to the School of Graduate Studies and the Office of Planning and Resources. It is our hope that a clear indication concerning provincial support for this programme will be received from the Ministry of Health in the near future, so that the additional steps associated with program approval can proceed.

"Of major importance during the past year was the appointment of Professor Walter Zingg as Associate Director of the Institute. Dr. Zingg has, for many years been associated with a number of Institute research projects and has helped to co-supervise a number of our students. Dr. Zingg will maintain partial appointments with the Hospital for Sick Children (as Director of Surgical Research) and with the Department of Surgery, as well as undertaking his new duties in the Institute.

"Professor Henry O'Beirne spent a major portion of his sabbatical year in England studying the status of computers in hospitals, especially their use in intensive care monitoring. His return, with a wealth of new information and ideas, will have an important impact on the Institute's research program.

"Interest by high quality prospective graduate students in the program offered by the Institute has continued to be maintained and we have been again faced with the difficulty of turning down a large number of well qualified applicants due to limitations of space, facilities and supervisory capacity. An enrolment of approximately 40 graduate students, with some 10 graduating each year, appears to be well-matched to the bioengineering employment opportunities in Ontario and elsewhere in Canada."

The Cobbold Years:1976-77

The principal cause of excitement this year was the fire in the Sandford Fleming building, which occurred on February 11, 1977. For the next couple of years, while the building was being rebuilt, our lectures were scheduled at many different, some remote, places on Campus. The Faculty took over the old Metro Library at 214 College Street (now the Koffler Student Services Centre and Bookroom) and created seminar rooms and the Engineering Library within its labyrinthine interior.

This was our fifteenth year, though we did not mark it with any particular ceremony.

Professor Hans Kunov was on sabbatical leave this year, and the duties of graduate secretary were assumed by Professor Henry O'Beirne.

From the Report of the Dean of Applied Science and Engineering: "The past year has been one of consolidation and increased effort to attract more research funds in order to compensate partially for the decreased real value of the University's portion of the Institute's budget. It is perhaps fortunate for those Institute Faculty members concerned with applied research and development that external funding sources have generally increased their emphasis and support for clinically applicable research and development. However, it is of concern that this has been at the expense of longer range fundamental research, and, although we have achieved real growth in terms of funding from external sources, this has disturbed the delicate balance between the more fundamental and applied aspects of our activities.

"The Biomedical Instrumentation Development Unit (BIDU), which is an independent part of the Institute funded through the Federal Department of Industry, Trade and Commerce for a five-year period starting March 1976, has continued to grow and flourish. New space for this Unit on the third floor of the Rosebrugh Building was completed in March 1977, and is now fully utilised by the staff of BIDU. Based on the success of the first year's operations and experience, we are optimistic that by the end of the five-year support period by the Department of Industry, Trade and Commerce the Unit will be self-supporting.

"Professor Norman F. Moody, the founding Director of the Institute and more recently the first Director of BIDU, decided to take early retirement effective July 1, 1977. For much of the fifteen years that Professor Moody has been with the Institute he has had a major influence on its development and has been responsible for establishing the policy and structure of the Institute. More recently, his talents and experience were fully utilised for the 16 months that he was Director of BIDU. Professor Moody will maintain an association with the Institute through an appointment as Professor Emeritus, however, the faculty and staff of the Institute will certainly miss the daily contact with an old friend and colleague.

"The major contribution was made by the Institute faculty and students to the eleventh International Conference on Medical and Biological Engineering held in Ottawa, August 1976. Not only were 16 papers delivered by Institute staff and students at the conference, but also, the entire technical program was organized and administered through the Institute. Furthermore, Professor E. Llewellyn-Thomas was honoured by being invited to deliver the keynote conference address.

"While the writing and publication of scholarly papers is generally regarded as the normal occupation of academics, the writing and publication of books is particularly noteworthy. Not only does it represent a concerted effort over a long period of time, but it also represents a most important contribution to the education and teaching functions of academic Institutions.

"The recent publication of Professor K. H. Norwich's book, 'Molecular Dynamics in Biosystems' (Pergamon Press, 1977 pp 450), is a major contribution both in the understanding and

teaching of this particular area. Since the Institute's formation in 1962, it is the fourth book written and published by an Institute Faculty member, and some of these have been translated and published in several other countries.

"During the past year Professor Hans Kunov has been on sabbatical leave spending much of his time in Sweden at the Sahlgren's Hospital, University of Gothenburg, Sweden, and in Denmark at Rigshospitalet (University Hospital) Copenhagen, Denmark. During this time he has completed a short book on 'Acoustic Impedance and the Ear' which is expected to be published in the near future."

The Cobbold Years: 1977-78

Dr. Paul Wang was on sabbatical leave this year and Tony Jares joined us as mechanical design officer, in charge of the workshop facilities.

From the Report of the Dean of Applied Science and Engineering: "One of the major problems arising from the severe fiscal constraints of recent years has been the difficulty of replacing outdated and unreliable major equipment. For example, our PDP-8/I computer system purchased some 8 years ago, which has formed a basic tool for much of our research, can no longer meet our needs and has become very unreliable. Our efforts to obtain the necessary funds to replace it have been rewarded by a grant of \$71,900 from the National Research Council of Canada. The new system, which is currently being installed, consists of a PDP-11/34 with discs, magnetic tape, graphic facilities and a multi-terminal capability. It is expected that this system will meet our projected needs for both on and off-line computing for the next 6-8 years. A second example is an antiquated workshop lathe that we have, through University funds, been able to replace with a sturdy Canadian made instrument.

"In regard to graduate students we were concerned by a drop in enrolment in September 1977. One of the reasons for this may have been an increased desire by potential graduate students to take advantage immediately of job offers, rather than wait to complete graduate studies. Judging by the number of good applicants for the 1978-79 year we can expect to return to our prior position of a full complement. It is probably important to note that a strong demand for our graduates has been maintained and that all our current graduates have been able to secure challenging and remunerative employment.

"The Biomedical Instrumentation Development Unit (BIDU) which is currently supported through a grant from the Department of Industry, Trade and Commerce has continued to show excellent promise of achieving financial independence by the time the 5-year grant terminates (March 1981). When the previous BIDU director retired in June 1977 we encountered considerable difficulty in securing a replacement. Our efforts in this regard have now been rewarded and Mr. R. Kosmick will be taking up this position in September 1978. In the meantime I have had to carry the additional duty of Acting Director.

"Our efforts to secure approval and funding for a new Clinical Biomedical Engineering Program have been moving forward. Highly favourable external assessments of the Institute and its proposal by two international authorities were completed in April. We understand that approval by the Ontario Council of Universities can be expected very shortly. However, the problem of securing the necessary funding still remains, but hopefully this will be solved over the next few months through a direct approach to the Ontario Ministry of Health.

"One a more personal note we were pleased that Professor Paul Y. Wang was able to spend a sabbatical year at the Pasteur Institute in Paris and that Professor R. C. Frecker was promoted to Associate Professor, with tenure.

"There has been a considerable number of visitors to the Institute during the past year and some have been persuaded to present seminars. Lecturers include Professor Margot Roach, Department of Biophysics, University of Western Ontario, Ms. Monique Aubry-Frize of the Hopital Notre Dame, Montreal, Professor Marvin Sherebrin of the Health Sciences Centre, University of Western Ontario and Professor Robert M. Filler, Surgeon-in-Chief, Hospital for Sick Children."

The Cobbold Years:1978-79

As mentioned before, Dr. Richard Cobbold agreed to serve another 4-year term as Director of the Institute (to June 30,1983). Dr. Walter Zingg was still Associate Director, and Professor Henry O'Beirne was the graduate secretary, now called the Coordinator of Graduate Studies.

From the Report of the Dean of Applied Science and Engineering: "In completing my first five year term as Director, it is perhaps appropriate to briefly relect on the changes that have occurred during this period, both as a result of our planning and as a result of conditions beyond our direct control.

"In the first decade since its founding in 1962 the Institute emphasized in both its education and research program the application of electronics in medicine. Since 1970 this emphasis has gradually shifted and, although a large part of our work still involves the application of electronics, a considerable proportion now concerns the application of physics, chemical engineering and metallurgical engineering to biology and medicine. These changes have been reflected in changes in the background of graduate students entering the Institute and shifts in the interests of the faculty as well as in faculty appointments. In the past five years an increased number of graduate students have enrolled with backgrounds other than engineering, especially those with life sciences. The latter have been actively encouraged. In order to provide such students with some background in engineering a new course was planned and this will be operating in the 1979/80 session. Thus, just as our engineering graduate students are provided with background courses in physiology and biochemistry, so the life science students will be provided with a fundamental engineering course.

"Interest in biomedical engineering by undergraduate students has remained high, and as a result there has been little change in the number and quality of graduate students. No doubt this has also been helped by the steady demand for our graduates. However, there has been a significant decrease in the number of students wishing to continue from a master's to a doctorate program, and this can be partly attributed to the decline in availability of academic positions, as well as attractive job offers for our masters degree students. None-the-less we note that there still remains a steady demand for students with doctorates.

"The decrease in real funds provided by the University over the past five years has had a serious impact on our Institute. Not only has this resulted in a net decrease in our full-time equivalent faculty through the retirement of Professor Moody, but also it has resulted in a dependence on contract and grant money to a degree where the graduate education part of our program is now also totally dependent on these external sources. In order to ensure a continuation and increase in these funds it has been necessary for the faculty and staff to devote increasing time to seeking such sources and satisfying the obligations from contracts, even though they may not directly contribute to our primary goals. These additional demands on the faculty, together with increased undergraduate teaching, have had an adverse impact on our graduate student program.

"A major focus of the Institute has always been and continues to be experimental work, much of which is directed towards clinical applications. Such work requires expensive and up-to-date equipment. Increasing dependence on outdated equipment has caused more time to be devoted

to its repair and maintenance. None-the-less, through grant funds we have been able to replace two major items. Notably, our outdated PDP-8/I computer has been replaced by a sophisticated PDP-11/34 system, and a new lathe has replaced a worn-out model.

"Over the past year a number of important and significant appointments have been made. Following a prolonged search, Mr. Rod Kosmick was appointed Director of the Biomedical Instrumentation Development Unit. He joined the staff in September 1978 following two years as Director of Niagara Region Biomedical Engineering Shared Services. On the academic side, three very significant adjunct appointments have been made. Professor K.W. Johnston of the Department of Surgery was appointed assistant professor. Over the past five years he has made major contributions to our research program in ultrasound diagnostics. Professor M. Milner was appointed adjunct associate professor. Dr. Milner was formerly responsible for the biomedical engineering program at McMaster University before joining the Ontario Crippled Children's Centre as Director of Rehabilitation Engineering. His appointment is serving to greatly strengthen our biomechanics program as well as ensuring very close collaboration between the two organizations. Finally, Professor R. M. Pilliar, formerly of the Ontario Research Foundation, was appointed associate professor. His appointment followed the successful joint application of the Faculty of Dentistry, the Department of Metallurgy, and the Institute, for Provincial Lottery support for his appointment. Dr. Pilliar's expertise has provided increased strength to the Institute in the biomaterials area.

"Over the past year the Institute has had a number of visiting lecturers. Dr. Dennis White of Queen's University, Kingston, lectured on 'Echo Encephalography and its Historical Background'; Dr. David Johnston of the Bureau of the Medical Devices, Ottawa, spoke on "The Role of the Bureau on Medical Devices in Canadian Health Care Delivery System"; Dr. Pierre Morin from the Research Laboratory, Laval Hospital, Quebec City, presented "The Behaviour of Blood in Artificial Lungs", and Dr. Frank Johnston from the University of Nottingham, England, gave a seminar entitled "The Detection of Visual Search Patterns Associated with Radiographic Diagnosis."

"Finally I should like to express a note of thanks to the Institute faculty and staff for their continued support, constructive criticism and encouragement. My decision to accept a further four-year term as Director was made that much easier."

The Cobbold Years:1979-80

Dr. Gordon Slemon became the Dean of Applied Science and Engineering when Dean Ben Etkin finished his term. He was instrumental in establishing the Innovations Foundation in January 1980, an organization which was intended to foster the interaction between University and Industry.

From the Report of the Dean of Applied Science and Engineering: "The Institute's research program continues to span a broad range of activities; from aspects of biomechanics and biomaterials, through diagnostic systems using ultrasound and gamma emission, to fundamental aspects of neurophysiology and tracer kinetics. This breadth has been made possible by collaboration of the Institute's faculty with many individuals in related departments, hospitals and research organizations. For our incoming graduate students it has provided an excellent choice of research topics; on the other hand, such a broad spectrum of activities distributed amongst a relatively small number of faculty has made it difficult to forge internal collaborative links that could be considered as focal points of our activities. Over the past year we examined this dilemma and decided to institute a research program that would involve most of the faculty and utilize the special expertise in several areas. The topic chosen was the development of a computer diagnostic

system that would be small, self-contained and which would act as a physician's diagnostic aid. Work on this project began in May 1980 with the initial objective of developing a pilot program in dermatology.

"Over the past few years the number of high quality graduate students with undergraduate education in the life sciences, rather than in engineering or physics, has increased. Our faculty has welcomed and encouraged this development, which provides a better balance between the physical sciences and life sciences amongst the students, similar to that existing in our faculty. In order to teach the basics of engineering to this group of students a new compulsory graduate course was introduced in the fall of 1979: Bioengineering for Life Scientists. This course consists of formal lectures, laboratories plus tutorials to help overcome any background deficiencies. The results of this are most gratifying in that all four students taking this course were enthusiastic and performed exceptionally well.

"Since the Institute was founded in 1962, summer students have participated in various research programs and have been selected and supervised individually by the faculty. In recent years there has been a significant increase in the number of applicants, and as a result in 1979 it became necessary to institute a more formal application and selection procedure. Furthermore, in order to ensure that the students receive a broad overview of the Institute's research activities, a weekly seminary program was introduced in 1980, and all students were required to attend. The twelve students admitted to our summer program in 1980 all received substantial financial support. This was made possible by increased funding made available by the Health Sciences Committee and NSERC for this specific purpose. Overall, our new summer program has been very successful and this in no small measure is due to the efforts of Professor Zingg.

"While the writing and publication of scholarly papers is generally regarded as an essential duty of academics, the publication of books is particularly noteworthy. Professor K. H. Norwich's second book was published in 1980. Entitled "Classical Theoretical Physiology: The Conceptual Basis of Medical Physiology" (Intercept Press, Toronto) it is directed primarily to fourth year undergraduate students specializing in physiology.

"The Biomedical Instrumentation Development Unit under the direction of R. H. Kosmick has continued to increase the number and range of contracts with industry. One important spin-off of this activity has been the establishment of a graduate fellowship by Radionics Ltd., in the Institute, for a student conducting research in diagnostic ultrasound. I expect to report on the establishment of at least one additional fellowship in my next annual report. "There have been a number of visitors to the Institute over the past year and some of them have been prevailed upon to deliver lectures during our Thursday seminar period. Of particular note was the four month visit by Dr. Richard Wootton of the Medical Research Centre, London, England, to study and conduct research in our Institute, in collaboration with Professor K. H. Norwich. Finally, during the past year, Professor M.L.G. Joy was on sabbatical leave for the purpose of making a number of visits to other centres and for conducting his research on more-or-less a full-time basis."

The Cobbold Years:1980-81

From the Report of the Dean of Applied Science and Engineering: "The structure of the University of Toronto, as it relates to its teaching and research responsibilities, can be analyzed in terms of the Departmental and Institute/Centre organization. Those areas that are well defined and which over a period of years have established themselves as part of the teaching and research functions form the vertical components of a matrix organization. On the other hand, areas that are less well defined, or areas in which the fundamental basis is formed from the bases of one or more

disciplines, are part of the Institute/Centre organization. They form the horizontal components of the matrix, and interact at appropriate points with the vertical, departmental components. It is in relation to this overall structure that it is worthwhile to briefly examine the manner in which the Institute of Biomedical Engineering fits.

"The Institute was established jointly by the Faculty of Applied Science and Engineering and the Faculty of Medicine in 1962, through the Departments of Electrical Engineering and Pharmacology. Over the intervening years the Institute's interests and activities have expanded so as to encompass and interact with many departments and organizations both within and outside the University. Within the University particularly strong ties have been established with the Departments of Electrical Engineering, Pharmacology, Physiology, Mechanical Engineering, Surgery, Chemical Engineering, Physics and Zoology, as well as the Institute of Medical Sciences. In addition, strong working relations involving joint projects have been established with the Toronto General Hospital, Hospital for Sick Children's Centre, Mount Sinai Hospital and Women's College Hospital. Within these organizations major research projects are centered in particular laboratories. The Rehabilitation Engineering Department at O.C.C.C., the Silverman (Audiology) Laboratory at Mount Sinai and the Vascular Laboratory for the Toronto General Hospital are good examples of where our faculty and graduate students interact in a major way.

"From the above it can be seen that not only does the Institute interact directly with the University departments, but it also interacts with a substantial number of health care organizations that are either on the periphery or outside the University structure.

"One important project initiated during the past year concerns the development and use of computer assisted medical diagnosis. While the examination and interrogation of a patient remain within the exclusive province of a human physician, the manipulation of the clinical information so obtained in order to reach a diagnosis is a logical process whose rules can, to some extent, be formalized. We are developing a system, initially confined to diseases of the skin, whereby details of the patient's history and physical examination can be read into a computer by the attending physician. A computer program will then provide an ordered differential diagnosis -- that is, a list of the possible diagnoses in order of decreasing likelihood. The computer will often list in the differential diagnosis diseases which lay beyond the physician's sphere of familiarity or which because of their relative obscurity, he may have overlooked. The system may also be used by nurse practitioners. Computer assisted diagnosis may ultimately be of value to physicians and nurses working in relative isolation in more remote regions of the country.

"The system is being developed by the staff and students of the Institute (physicians together with engineers) under the direction of Prof. K. H. Norwich. It is currently being evaluated by the staff of the Family Practice Health Centre of the Women's College Hospital, who operate the PDP 11/34 computer at the Institute by means of a video display terminal situated in the Family Practice clinic.

"The summer student program on which I reported last year has been expanded further, in fact, to the stage where our physical resources were stretched to the limit. Seventeen students were accepted into the program and spent from three to four months, working on a wide variety of research projects. A condition for their acceptance and financial support was that they attend weekly seminars held during May, June and July specifically for their benefit. The experience they gain and the contribution they make to the research program have more than justified the financial commitment and consequently we intend to continue with the program in future years.

"As a result of a successful NSERC Capital Equipment Grant, spearheaded by Professor M. Joy, we received nearly \$75,000 to purchase an array processor and a new graphics system for our

PDP 11/34 system. Over the past year the system has been stretched to the limits of its capabilities in servicing the many simultaneous users at the terminals throughout our Institute. The array processor will greatly enhance our ability to cope with repetitive operations such as are encountered in image processing. Furthermore, our new graphics system will enable us to display in grey scale either black/white or colour images. Future expansion of the system will be required to increase our disc memory capacity.

"In the last report I pointed out the establishment of our first industry funded fellowship, the Radionics Graduate Fellowship in Ultrasound. Over the past year, as a result of a licensing agreement for our Doppler Ultrasound Analyzer, an additional graduate fellowship has been funded for a three year period by Bach-Simpson of London, Ont. We intend to continue our efforts to acquire further scholarship support from industry and, hopefully, I will be reporting positive results next year.

"Our seminar program was somewhat enlarged from previous years. Seventeen seminars were given during the Fall and Spring terms, with a mixture of speakers from Toronto and abroad.

"Finally, in relation to our efforts to obtain increased funding from sources outside the University, over the past seven years there has been a steady growth of real dollars. In the 1980/81 fiscal year, for the first time, our income from grants and contracts exceeded that received from the University. The long-term implications of this change in fiscal dependence, brought about by the continuing contraction of funds (in real dollars) from the University, are far reaching."

The Cobbold Years:1981-82

The reconstructed Sandford Fleming building was opened on 12 June 1982.

From the Report of the Dean of Applied Science and Engineering: "A vital part of the Institute's mandate is the collaboration with Departments and related health care institutions. Over the past decade there has been continued growth in such activities and this has resulted in the establishment of interdisciplinary research programs having a solid foundation and commitment from both Faculty and graduate students of our Institute. In some cases the research is focussed at laboratory away from the Institute's facilities, but generally use is made of the resources at both locations.

"Of particular significance has been the growth of a strong relationship with the Ontario Crippled Children's Centre. Professor M. Milner, as Director of Rehabilitation Engineering at O.C.C.C. and as a Professor in the Institute and Department of Mechanical Engineering, has been, and is, in a unique position to foster collaborative research and teaching. But this growth has also been assisted in a major way by the initiatives taken by our Associate Director, Professor Walter Zingg. The program now consists of research projects that our students participate in at the Centre under the supervision of Professor Milner and Professor O'Beirne, and a graduate course given at the Institute for the first time over the past academic year entitled 'Rehabilitation Engineering'.

"While I have dwelt on this particular aspect of our collaborative research, this should not give the impression that our other programs have been any less successful in this regard. However, it is an excellent example of what can be achieved given good will and a major effort to nurture such collaboration.

"Over the past year Professor Frecker took a well deserved year's leave to continue on a full-time basis his research program with the Addiction Research Foundation into the non-invasive assessment of the effects of drugs. While he continued to supervise his graduate students he did use the opportunity to visit a number of laboratories performing related work. Of particular significance to the Institute was the appointment of Dr. Igor Sherman as Lecturer in the Institute in

September 1982. He received an NSERC University Fellowship and is the first addition of a young faculty member to our Institute for many years. During the past year, amongst his other duties he has organized our seminar series.

"The increasing dependence of our research programs on our computer facilities has necessitated continued expansion to meet demands. Over the past year we installed an FPS array processor and a colour graphics system. We were also partially successful in a NSERC capital equipment grant request and received sufficient funds to purchase a large disc storage unit. The operation of our facility is under the general management of Professor H.O'Beirne, with Professor M. Joy making a major commitment of time and effort.

"Our Biomedical Instrumentation Development Unit underwent a major change with the resignation of Mr. Rod Kosmick in June 1981, and the subsequent resignation of Mr. Bruno Maruzo who has been with the Unit almost from the start some 6 years ago. A new Director, Dr. Hart Katz, was appointed in September 1981. Also in September, Dr. Harold Wodlinger joined the Unit as Senior Engineer from his prior position as Chief Engineer with Madsen Electronics. During the year difficulties continued and these arose in part from the revised direction that emphasized entrepreneurial activities and in part from continued conflicts with the University of Toronto Innovations Foundation.

"Our summer student program continued to flourish but the numbers were reduced to 13 from the previous high of 17. This reduction was necessitated by a decrease in Faculty requests. The graduate student intake was also lower than anticipated and this was partially attributed to a buoyant market for engineering graduates.

"Finally, as in previous years we had a number of visitors and some were persuaded to deliver seminars. Of the twelve seminars delivered from October to May 1982 the following are examples: Dr. F. Roberge, Institut de Genie Biomedical, Ecole Polytechnique, "Model Studies of Action Potential Generation and Conduction in Cardiac Tissues"; Dr. G. Iles, Rehabilitation Engineering Centre, Palmerston, New Zealand, "Rehabilitation Engineering in New Zealand"; Dr. H. H. Barrett, Optical Sciences Centre, The University of Arizona, "It is Plain to See the 3D Radon Transform"; Dr. O.L.R. Jacobs, University of Oxford, England, "Feedback Control of Post-Operative Pain."

The Cobbold Years:1982-83

From the Report of the Dean of Applied Science and Engineering: "In this my final annual report after nine years as Director, it is perhaps appropriate to summarize briefly the major changes that have occurred over these years, as well as to report the major activities of the past year.

"In spite of the financial constraints that began shortly before my assumption of duties, the Institute's research and teaching activities have expanded. The changes that have occurred in research are evidenced by two indicators: the annual operating and equipment grants and the total number of refereed publications. As of July 1 1974, the total research grants amounted to approximately \$50,000, while as of July 1 1983, the total was close to \$500,000. When the cost of living increase between these two dates is accounted for, the net change corresponds to an increase of more than a factor of four. Over the same period of time the increase in the total of grants and contracts received by the Institute has been such that over the past few years the total income from such sources constitutes more than 50% of the Institute's income. ...It should be noted that since 1976 with the establishment of the Biomedical Instrumentation Development Unit (BIDU) supported through the Department of Industry, Trade and Commerce, the total contract income to the Institute has exceeded \$200,000. However, owing to the changes that have occurred over the

past academic year in BIDU (and these will be described shortly), the total contract income will probably decrease substantially in the 1983-84 academic year.

"While the changes in peer adjudicated grants are a useful measure of research activities, it is also helpful to look at the changes in the number of refereed publications that have occurred over the same period of time. Naturally, such lists can be deceiving since they do not measure the quality of publications; nonetheless, they do provide an additional measure of research activities. ...The total number of refereed publications (and this includes full conference papers, books, and all journal articles) increased from 20 in 1974-75 to approximately 50 in 1982-83. This increase appears to match approximately the total grant increase when the latter is corrected for the cost of living index.

"Various changes have occurred in regard to the teaching and graduate student program over the past nine years. Some of the graduate courses have been changed substantially and new courses have been introduced. It should be noted that to match the current required program for students from the engineering and physical sciences a new core program was introduced for students with a life science background. While the number of graduate students has not changed substantially from the figure of approximately 40 in 1974, during the intervening years there have been fluctuations, and during one period of time it dropped to approximately 35. In addition it should be noted that there has been a decrease in the percentage of graduate students enrolled for the Ph.D. degree. One disappointment concerned the failure to obtain funding for a proposed clinical biomedical engineering program. In 1974-75 the Faculty of the Institute worked long and hard to establish a new program that would specifically meet the needs of hospitals. A program was proposed and outlined in detail in a report of the Institute issued in July 1975. Approval for the initiation of this program was received both from the University and from OCGD, however, a commitment of funds for implementing this program was not received from the Ontario Ministry of Health and as a result the program initiation was deferred indefinitely.

"Changes in the physical structure of the Institute over the past 9 years have not been very substantial. In 1976 additional space was acquired on the third floor of the Rosebrugh building: it was renovated and fully equipped for accommodating BIDU. In addition, a new office was constructed on the 4th floor to accommodate a new faculty member. Expansion of the research program was generally made possible through the increasing use made of laboratories in associated health care centres through which collaborative programs had been established. Perhaps the most important addition to the Institute's facilities was the awarding of grant funds in 1978 for the purchase and installation of a new computer facility, and the addition to this facility in subsequent years by further capital equipment grants. This facility has become a central tool for much of the Institute's current research and provides an indispensable tool for meeting our word processing needs.

"A number of personnel changes have also occurred. There has been a substantial increase in the number of research personnel supported from research grants. In addition, it should be noted that with two senior Faculty retirements and three new Faculty supported from grants, fellowships and the University budget, there has been a modest increase in the net full-time equivalent.

"The past year has not been without its problems. In August 1982, the Director of BIDU (Dr. Katz) and the Senior Engineer (Dr. Wodlinger) resigned to establish their own company. This left BIDU without any technical staff making it difficult to continue its functions. These changes together with the failure to achieve a self-sufficient operation resulted in the termination of the contract for support of BIDU from the Department of Industry, Trade and Commerce. However, the terms of the termination were favourable in the expectation that after careful review the aims

and functions would be continued in a revised manner. Following lengthy discussion with the Faculty of the Institute and various University officials, a committee was established to review the options available and arrive at recommendations for the future objectives, functions, and operations of BIDU. The committee was greatly aided in its deliberations by the advice and guidance of Dr. T.C. Clark.

"In August of 1982 it was decided by the Deans of Medicine and Applied Science and Engineering that the Institute should undergo a full review by outside reviewers of its structure, purpose, and operations. Extensive documentation for this review was prepared and submitted in August of 1982 to the two reviewers, Dr. L.A. Geddes (Showalter Professor of Bioengineering, Purdue University) and Dr. R.N. Scott (Director, Bioengineering Institute, University of New Brunswick). Their review of the Institute took place in September, 1982 with their final report being submitted in November, 1982. Following assessment of the report, which was generally favorable, a Search Committee was established to seek a new Director effective July 1, 1983.

"The appointment of Dr. B. Bardakjian as Lecturer effective July 1, 1982 has added important expertise to the Institute in the area of biological signal processing and the physiology and modeling of the GI tract. His appointment is continued during 1983/84 at the rank of Assistant Professor. In addition, effective July 1, 1982 Professor H. Kunov was promoted to the rank of Professor and Dr. I. Sherman to the rank of Assistant Professor. Professor E. Llewellyn Thomas who served as the first Associate Director 1963-1974, and who subsequently served as Associate Dean of Medicine, reached retirement as of July 1, 1983 and has been appointed Professor Emeritus. His influence and major contributions to the growth and direction of the Institute over more than 20 years is a legacy for which we are all grateful.

"Finally, in concluding this rather lengthy report, I should like to express my thanks to the Faculty and staff of the Institute for their support over the past 9 years, to the Deans of Medicine and Applied Science and Engineering for their interest and cooperation, and lastly to Professor Walter Zingg who as Associate Director from 1975-1983 has provided invaluable advice and loyalty over the years. Naturally, I am delighted that he has agreed to become Director, and I expect that under his guidance the Institute will increase in the quality of both its research and its graduate education."

The Zingg Years

The Zingg Years: 1983-84

Dr. Walter Zingg was appointed Director for a five-year term, to succeed Dr. Richard Cobbold. He asked Dr. Morris Milner to be Associate Director, and Professor Henry O'Beirne to continue as Graduate Coordinator. Dr. Cobbold took the customary sabbatical leave for one year.

One of the Director's concerns is to maintain contact with our former students and staff, and, with this in mind, he composed and published our first Alumni Newsletter. From the responses to this and subsequent mailings, we are compiling a list of addresses. About two-thirds of our previous students have been located.

Our policy about computers took an about-face; previously, we were striving to improve our big machine, a Digital Equipment of Canada PDP-11/34, running under RSX11-M, by adding peripherals such as a colour graphics system and an array processor. The cost of maintaining these devices had risen out of proportion to their usefulness. We decided to concentrate on small desktop computers, such as the IBM-XT and IBM-AT, and on workstations such as the Iris. If we had a

need for a more powerful machine, we would use the Engineering Computing Facility (8 micro vaxes running Unix) and the University's newly acquired Cray computer.

>From the Report of the Dean of Applied Science and Engineering: "The scope of Biomedical Engineering continues to expand, and the teaching program of the Institute is adjusting to meet changing requirements. Rehabilitation Engineering is now an integral part of the fabric of the Institute of Biomedical Engineering. The appointments of Professors G.R. Fernie and M. Milner, Dr. S. Naumann and Mr. F. Shein have contributed significantly to this. Five Master's students and a Ph.D. student are actively engaged in rehabilitation engineering projects at the Ontario Crippled Children's Centre. Their project areas include human locomotor engineering studies, functional electrostimulation of skeletal muscle in cerebral palsy, microprocessor control systems for powered wheelchairs and application of microprocessors for augmentative communication, education and leisure in cases of severe physical disability.

"The Gait laboratory resources based at the Ontario Crippled Children's Centre were enhanced significantly by an equipment grant from the Medical Research Council of Canada for an on-line tracking system to record 3-dimensional spatial movements.

"Several contributions by way of papers and presentations were made at the Second International Conference on Rehabilitation Engineering held in Ottawa in June, 1984.

"The course Rehabilitation Engineering 1442L in collaboration with the Department of Mechanical Engineering was given again in 1984.

"During the past year the West Park Rehabilitation Engineering Research Team increased modestly in size by the addition of a statistician and an industrial designer bringing the full time complement to nine. Research activities in the fields of prosthetics and geriatrics have continued.

"The major achievement in prosthetics was the completion of the development of a high speed non-contacting shape sensor that is capable of accurately sensing the three dimensional shape of an amputational residual limb in less than one second. This is part of an exciting collaborative project with a team in Vancouver and a team in London, England to develop a computer aided approach to prosthetic fitting and manufacture.

"The emphasis in geriatrics continued to be applied to the very significant problems of incontinence and of falls. A new approach to the urodynamic characterization of detrusor instability was published and a major drug trial of the common anticholinergic agent, propantheline bromide, was completed. Highlights of the research into the prevention of falling included the completion of a study of postural sway of subjects standing on an oscillating platform (providing further insight into methods of assessing the risk of individuals falling) and the completion of two studies under contract to the National Research Council to determine the optimum height of stair rails of three different stairway slopes. The findings of the stair rail study will be incorporated into building codes.

"Product design activities have included a new patient lifting aid that will shortly be available on the market and the commencement of research and design activities in collaboration with industry to develop specifications for a new range of seats suitable for the elderly and for production by the contract furniture industry.

"Other contracted work that was completed during the year included an evaluation for the Ministry of Transport of a British vehicle that kneels to the ground to ease wheelchair access and that can be driven whilst seated in a wheelchair. A study was done for the Ontario Ministry of Consumer and Corporate Affairs of the comparative risk of boxing and of full contact karate.

"This year also saw the opening of our orthopaedic laboratory at the Toronto General Hospital in temporary space until the new research wing is opened there. The emphasis in this

laboratory at present is on the study of techniques of fixation of spinal fracture. An apparatus was constructed for this purpose that cyclically loads bovine spines and monitors the three dimensional deflection of these spines at the fracture site. This was the first year that the West Park Team has been associated with the Biomedical Engineering Institute and we look forward with enthusiasm to the possibility of involving the staff and the students of the Institute in some of our research activities.

"The quality of our Graduate Students remains high. During the past years there has been a gradual decrease in the number of applicants for the Ph.D. degree. For the 1983/84 academic year we accepted eleven new students (1 - Ph.D., 8 - M.A.Sc., 1 - M.Sc., 1 - M.Eng.).

"The major problem - which of course is shared by many other Institutes and Departments - is that our tasks in Teaching, Research, and Development increase, while the resources provided by the University remain stationary or even decrease. The continuing success of the Institute of Biomedical Engineering is due to the dedication of our staff, particularly of the junior Academic Staff, who have accepted appointments with conditions which are far from ideal.

"How can we grow without additional resources? We have invited colleagues in other Departments of the University to join our Extended Faculty, to provide additional expertise with the supervision of Graduate Students and with research. In the past year the following cross-appointments have been made: D. R. Absolom (Mechanical Engineering), M. A. Herbert (Surgery), H. C. Kwan (Physiology), A. W. Neumann (Mechanical Engineering). The extended faculty will grow considerably in the near future.

"Professor B. L. Bardakjian received a Scholarship of the Medical Research Council of Canada. Dr. M. Eizenman was appointed to the Core Faculty (cross-appointed to the Department of Ophthalmology) with the rank of Lecturer. Professor M. Milner was appointed Associate Director of the Institute of Biomedical Engineering.

"The academic staff participated in various national and international activities. New appointments in the past year include the National Advisory Board for the Semiconductor Chemical Transducer Resource at Case Western Reserve University, the Associate Committee on Research and Development for Rehabilitation of the Disabled (National Research Council of Canada) and the National Advisory Board on Research and Development, Department of Civil Aviation Medicine (Health and Welfare Canada); the chairmanship of the International Commission on Technical Aids, Housing and Transportation of Rehabilitation International and of a Gordon Research Conference in New Hampshire; the Presidencies of the Rehabilitation Engineering Society of North America and of the Canadian Medical and Biological Engineering Society; site review teams visiting Stanford University and Universite de Montreal/Ecole Polytechnique.

"The Core Faculty is represented on the Editorial Boards of the following Scientific Publications: Annals of Biomedical Computing, Physiotherapy Canada, Journal of Clinical Engineering.

"Our research activities have been supported by grants and contracts. The Workshop was kept very busy with the Design, Construction and Testing of two environmental Chambers under the direction of Professor R. S. C. Cobbold. The Institute of Biomedical Engineering was a subcontractor to the Department of Ophthalmology on a project entitled: Biological Effects of Extremely Low Frequency Electric and Magnetic Fields on the Ocular Tissues: an In Vitro Study, Professor R. C. Frecker was successful in obtaining our first PRAI (Project Research Applicable in Industry) grant from NSERC for a project entitled: Development of a Helmet-Mounted Eye Tracker (with CAE Electronics Ltd. of Montreal).

"The Industrial Liason Program was further improved by a renovation of the Workshop, the appointment (part-time) of Mr. D. G. Harkness a Contract Manager, and the appointment of an Advisory Committee, chaired by Mr. G. Pay (of Madson Electronics Canada Limited). "In February Professor S. Rowlands, Head of the Department of Medical Biophysics, Faculty of Medicine, University of Calgary, spent a week with us as Visiting Professor, supported by the Medical Research Council of Canada. He gave a formal lecture, two seminars, and adjudicated student presentations. Staff and students found the visit stimulating; we hope to continue the Visiting Professorship on a yearly basis.

"In April the Institute of Biomedical Engineering organized an 'Artificial Endocrine Pancreas Day' at Hart House to which staff, students and alumni were invited. The occasion was the celebration of the tenth anniversary of the first clinical application of the artificial pancreas which was developed in the Institute for the improved treatment of diabetes mellitus. The original idea, suggested by Dr. B. S. Leibel and discussed with Professor N. S. Moody (Director of the Institute 1962-1974), was further developed in a Ph.D. thesis by A. M. Albisser, supervised by Professor E. Llewellyn-Thomas. Subsequently, C. K. Botz, T. G. Ewart, R. E. Gander and W. Zingg were involved in various stages of the project. The whole group was able to come and participate in the scientific session, followed by a private dinner. Professor Llewellyn-Thomas was the keynote speaker opening the scientific session. It is sad to report that this was Tommy's last contribution to the Institute of Biomedical Engineering: he died suddenly on July 5, 1984.

"After a valiant struggle with a chronic eye disease, the Administrative Assistant, Mrs. A. M. Jamieson, was forced to retire at the end of the year. She had guided the affairs of the Institute for 22 years."

The Zingg Years:1984-85

Dr. Zingg asked Professor Hans Kunov to be Associate Director for a two year term, to replace Dr. Morris Milner, who had been appointed Director of the Department of Rehabilitation Medicine.

Dr. Paul Wang became Graduate Coordinator, replacing Henry O'Beirne, who had been ill. Dr Wang started a much more aggressive program of recruiting new students, and increased the student complement by about 10.

The Clinical Engineering Program, a concept formulated in the Spring of 1975, at last became established under the guidance of Professor A.M. Dolan, and admitted 4 students. Now, for the first time, the Institute became a Graduate Department, and registered students directly. However, the majority of our students (those who are not in the Clinical Engineering Program) are still registered through other departments, as before.

Professor Kunov established an acoustics laboratory in room 422, including an acoustic chamber for testing subjects and equipment, 8 student carrels, and 2 work spaces.

>From the Report of the Dean of Applied Science and Engineering: "Over the past two decades the influx of technology into Canada's health care facilities has produced great benefits for patients. However, the technology is in a field somewhat unprepared to deal with it. The role of managing some problems have been generated as well, centering on the impact technological resources in the modern hospital which has come to be called clinical engineering, promises to become increasingly important.

"Accordingly a new Clinical Engineering Program has been initiated at the Institute of Biomedical Engineering and has accepted its second class of students. This new program will bring the sometimes diverse requirements of Clinical Engineering education into a coherent

program consisting of a minimum of eight graduate courses, a research project, and three periods of hospital internship.

"The primary objective of the new Clinical Engineering program is to educate engineers to meet the current and future specialized requirements of the hospitals, the medical profession and the patient problems they encounter. Through the inclusion of periods of hospital internship and the clinical flavours associated with a number of the courses, the students are exposed to the patients' problems, learn the limitation of technology and medical therapy and learn to integrate readily with the hospital environment. If the graduate should decide to pursue a higher degree, the academic standing of the degree permits entry into a subsequent Ph.D. program.

"The University of Toronto is particularly well suited to initiate such a program since the knowledge and expertise required already exists in the University of Toronto at the Institute of Biomedical Engineering. The Institute currently has the largest bioengineering graduate program in Canada with 42 students and an academic faculty who have appointments in either Engineering or Medicine. There are a number of teaching hospitals close to the Institute which have departments of biomedical engineering. These resources together with the economy that results from using courses for both the new program and the Institute's conventional program, make this program particularly cost effective. The program provides much needed support to Canada's health care system in managing the technology of today and tomorrow.

"Mr. A. M. Dolan was appointed Assistant Professor and Coordinator of the Clinical Engineering Program. Professor Hans Kunov was appointed Associate Director (replacing Professor Morris Milner) and Professor Paul Wang was appointed Graduate Coordinator (replacing Professor Henry O'Beirne).

"The 1985 Visiting Professor was Fernand A. Roberge, Directeur, Institut de Genie Biomedical, Universit, de Montreal."

The Zingg Years: 1985-86

From the Report of the Dean of Applied Science and Engineering: "In the last two Annual Reports we reported on our activities in Rehabilitation Engineering and in Clinical Engineering. These were new programs and deserved special emphasis. However, the more traditional activities continue and have been strengthened by the additional of expertise to the academic staff.

"Biomedical engineering has made important contributions to modern medicine, both to medical research and to clinical medicine. Technology is important in modern medicine. By and large its effort on the practice of medicine has been positive, but there have been some negative impacts.

"Biomedical engineering has the additional responsibility of developing further the inventions made in the laboratory through interaction with industry, in order to make the new processes and procedures available to the general public. University-industry liaison and technology transfer are under discussion at the present time. Indeed, the Institute of Biomedical Engineering has an Industry Liaison Program with an advisory committee consisting of representatives from the biomedical industry. The federal granting councils support this type of activity and, in fact, future increases in budget of the councils are dependent on cooperation with industry.

"Our Industry Liaison Program is small and progressing at a disappointingly slow rate. The reason is fairly obvious: the biomedical industry in Canada is very small, so the opportunities for technology transfer are limited. In our field we need programs to help establish new industry programs, rather than technology transfer programs.

"One of the traditional functions of the Institute of Biomedical Engineering is the design of medical instrumentation in cooperation with the medical profession. An example of this activity is the project directed by Professor R.S.C. Cobbold and Professor K. W. Johnston, Chief of the Division of Vascular Surgery at Toronto General Hospital.

"A Doppler Ultrasound flow imaging system is being developed for non-invasive assessment of the carotid artery. The system makes use of a linear array which rapidly scans an ultrasound beam across the artery. Doppler flow imaging enables visualization of the structure of the artery for identification of various sites such as the carotid bifurcation, and the detection of major vessel abnormalities. With the aid of the flow map, detailed analysis of the blood flow patterns of a specific site can be conducted.

"The prototype system has demonstrated the ability to image flow in the carotid artery of human subjects. Further development is under way to improve the image quality.

"The research in the Institute is funded primarily by the Natural Sciences and Engineering Research Council (including two grants under the University-Industry Program), the Medical Research Council, the Ontario Heart Foundation, and the Hospital for Sick Children Foundation.

"The 1986 Visiting Professor was L. A. Geddes, Showalter Distinguished Professor and Director of the William Hillenbrand Biomedical Engineering Center, Purdue University, West Lafayette, Indiana.

"On February 26, 1986, the Institute organized the first Llewellyn-Thomas Day and the Memorial Lecture given by Professor Laurence R. Young, Massachusetts Institute of Technology, entitled: 'Adapting to weightlessness: Eye movement on earth and in space'."

The Zingg Years:1986-87

This was our 25th Year. Professor M.L.G. Joy became Associate Director, replacing Dr. Kunov, and Dr. R.C. Frecker took over the duties of Graduate Coordinator from Dr. Wang.

To increase our computing capabilities, particularly in the area of image processing, we purchased an Iris work station, with a high-resolution graphics monitor. This machine has 4 serial ports, which can support up to 4 users simultaneously and runs under Unix.

From the Report of the Dean of Applied Science and Engineering: "The traditional university activities are teaching and research. Currently there are considerable pressures to add cooperative industrial projects, which should be incorporated into the academic program without interfering with the quality of the primary functions of teaching and research. This creates some tension and problems which have not yet been solved completely. For instance, industrial research does not produce as many publications in referred journals as the traditional type of research; at the same time, the granting councils demand such publications. This may create a dilemma for an individual scientist who is in the process of building up a research group with both basic science and industrial components.

"The academic staff of the Institute of Biomedical Engineering has been successful both in attracting grants from NSERC, MRC, and other granting agencies, and also in establishing several university-industry cooperative projects. We are actively involved with three of the five Centres of Excellence which have been established at the U of T. The scope of biomedical engineering is expanding at a rapid rate. "High technology" is an integral part of modern medicine. A large portion of the technology has been introduced recently, and it is not clear how these additional items should be built into the curriculum of the medical school. In the Faculty of Medicine we are exploring various possibilities of involving the Institute of Biomedical Engineering more in the teaching program.

"In the health care delivery system, the introduction of the new technologies has created new problems. Clearly, technically advanced care is not synonymous with optimal medical care, and important choices have to be made. High-technology medicine also is expensive, and various attempts of cost containment in the health care delivery system have been made. These problems are addressed in the Clinical Engineering programme, so that the graduates are aware of the problems and may contribute to solutions during their subsequent careers. "We have a social obligation to participate with industry to build up a biomedical industry in Canada. The cooperative programmes also give us an opportunity to acquire new equipment and to renovate facilities, which the University budget does not permit. During the last year another dedicated laboratory was established.

"The Biomedical Acoustics Laboratory was established within the Institute in late 1985, and became fully operational in 1986. It is headed by Prof. H. Kunov and has links to several hospitals and industries. The research in the laboratory relates primarily to the from acoustic impedance acoustics of hearing and hearing disorders, and the projects range transducer development to signal processing for implantable hearing aids (cochlear implants).

"An example of a project in the Laboratory is the development of an accurate acousto-mechanical model of the human head. The underlying research involved anthropometry, mechanics of soft tissue and acoustics of the ear canal. The resulting model head (Acoustic Test Fixture or ATF) has been used in objective studies of the attenuation of hearing protectors. This is particularly important in cases where impulsive noise must be attenuated, e.g. the noise from firearms, where subjective methods fail, or when accurate comparisons must be made between different designs for hearing protectors. Research for the ATF was funded by the Department of National Defense through D.C.I.E.M. Other projects in the Biomedical Acoustics Laboratory are funded by NSERC, MRC, and industrial contracts.

"The 1987 Visiting Professor was R. N. Scott, Director of Bioengineering Institute, University of New Brunswick, Fredericton, N. B.

The Zingg Years:1987-88

- We celebrated 25 full years!

APPENDIX A**Primary Faculty Members, 1962-1988**

Name	Appointed	Retired	Position	Deceased
Norman F. Moody	1962	1977	Prof & Director, 1962-1974	23 Oct 2004
E. Llewellyn-Thomas	1963	1984	Prof & Assoc-Dir, Assoc Dean Medicine	5 July 1984
Henry O'Beirne	1965	N/A	Professor	11 Nov 1995
Richard S.C. Cobbold	1966	1997	Prof & Director, 1974-1983	
Hans Kunov	1967	2003	Prof & Director, 1989-1999	
Jan Kryspin	1967	1972 (?)	Asst. Prof.	31 Jan 2010
Paul Y. Wang	1968	2003	Professor	
Kenneth H. Norwich	1970	2004	Professor	
Michael L.G. Joy	1970	2009	Professor, Assoc Chair ECE	
Rick C. Frecker	1973	2006	Professor, Assoc Dean Medicine	
David F. James	1971	2005	Professor	
Walter Zingg	1975	1989	Prof & Director, 1983-1989	23 Dec 1999
Berj Bardakjian	1982		Professor	
Moshe Eizenman	1983		Assoc. Professor	
Alfred M. Dolan	1984	2006	Prof & Dir of Clinical Eng.	

APPENDIX B**Staff Members, 1962-1988**

Name	Appointed	Retired	Position	Deceased
B.C. DeKat	1962	1973	Technologist	
A-M Jamieson	1963	1984	Admin. Asst.	????
Frederick Greenwell	1966	1973	Machinist(he was 65 when he joined)	
Bob Simpson	1966	1995	Technical Officer	
Don Morrison	1966	1976	Technical Officer	
John Simpson	1970	1997	Technologist	
David Croft	1972	1977	Engineer	
Bruno Maruzzo	1976	1980	Engineer (BIDU)	
Ivan Clark	1976	1980(?)	Engineer (BIDU)	
Tony Jares	1977	1991	Designer/Machinist	
John Nicolaidis	1973	1980	Designer/Machinist	2007
Franz Susch	1980	2003	Designer/Machinist	
Rod Kosmick	1978	1981	Director of BIDU	
Hart Katz	1981	1982	Director of BIDU	
Harold Wodlinger	1981	1982	Engineer (BIDU)	
Merle Lord	1968(?)	1999(?)	Financial Officer, Admin Asst.	
Rianna Wallace	1977	?	Secretary (BIDU)	
Linda Sarkar	?	?	Secretary (BIDU)	

REFERENCES & ENDNOTES

1. Bigelow, W.G., "Cold Hearts", McLelland & Stewart, 1984.
2. Callaghan, J.C., "30 Years of Open Heart Surgery at the University of Alberta Hospitals", 1986.
3. Hopps, J.A., "The Developing Role of Biomedical Engineering", Abstracts of the 86th Annual Congress of E.I.C, C.S.C.E., C.G.S. and C.S.M.E.: Saskatoon, October 2-7th, 1972.
4. Digest of the First Canadian Medical and Biological Conference: Ottawa, September 8-9th, 1966.
5. Digest of the Second Canadian Medical and Biological Engineering Conference: Toronto, September, 9-11th, 1968.

¹ This document was initially prepared by Professor Henry O'Beirne (1932-199?) and subsequently edited with additions by Professor Richard Cobbold

² Later to become The Defense and Civil Institute of Environmental Medicine (DCIEM), subsequently (2002) renamed as Defense R&D, Canada (DRDC) – Toronto.

³ The Pupillary Control System: its Nonlinear Adaptive and Stochastic Engineering Design Characteristics.

⁴ Engineering and Clinical Aspects of Electrosleep and Electroanesthesia.