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**BIOMEDICAL
TECHNOLOGY
IN HOSPITAL
DIAGNOSIS**

**A.T. ELDER
D.W. NEILL**

Biomedical Technology in Hospital Diagnosis

edited by

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Foreword

THE enormous advances that have occurred over recent years in the medical sciences and in medical practice have been due at least as much to techniques derived from the physical sciences as they have to developments in our understanding of biological processes as such. There cannot be any country in the world which does not reflect this fact in the development of its hospital services, which now depend as much upon the organization of scientific and technical departments as on the availability of general and specialized clinical staff. Equally there can be few areas of practice left in which the medically qualified man can operate without the support of people professionally trained in non-medical scientific disciplines. The variety of these disciplines, many of which only yesterday seemed remote from the medical field, is laid bare in the volume which Dr. Elder and Mr. Neill have organized and edited. As Chairman of an Official Committee which recently reported to the Ministers of Health on the Hospital Scientific and Technical Services in the United Kingdom, I can appreciate not only the inspiration by which they were guided, but also the immense importance and potential value of the volume for which they have asked me to provide this brief foreword. I have every confidence that the need which the book fills will be recognized by a very wide circulation.

S. ZUCKERMAN

Editorial Preface

THIS volume, issuing in the now well-known Westminster Series which is under the general direction of Dr. W. A. James Farndale of the Polytechnic of the South Bank, London, deals with the uses of instrumentation in medical diagnosis. The intent of the editors goes a little further afield as will become apparent from what follows.

That the practice of medicine is both an art and a science has been acknowledged from earliest times, and the very special relationship which exists between a patient and his personal medical attendant is one that is universally acknowledged, and one which must be preserved.

Nevertheless, a fast and accurate diagnosis is of the essence, and if machines can accomplish this then, in the interests of the patient, full use must be made of them. There are three major aspects of this study which merit a very full examination; the first is that complete collaboration between physicians and hospital scientists is essential, the second that instruments must be accurate and subject to regular overhaul, and the third that the economics of the use of machines must be fully assessed. It must never be forgotten that on many occasions an instrument may fail to register an abnormality yet the patient is not devoid of a pathological process. Herein lies the value of the good clinician, the instrument being there merely in a supporting role.

The economics of the health service is directly affected in terms of quick and accurate diagnosis helped by the computerization of data. As executive editors we have, in a few introductory chapters, sought the advice of experts on these major policy issues and first of all we are indebted to Mr. George Teeling-Smith, the Director of the Office of Health Economics, for a most useful evaluation of the economics of instrumentation and technological practices, which, he points out, "should never be introduced unless they can be justified in terms of bringing a worthwhile improvement in the length or quality of life to a proportion of the people to whom they are applied—whether they are patients or apparently healthy individuals".

Now, while the symposium is basically a study of the scientific aspects of the diagnosis and recording of disease patterns in human beings as opposed to the purely clinical practice of the physician, we invited two distinguished physicians to give us their considered opinions of the trend of events. Dr. Robert Marshall of the Queen's University of Belfast, an elder statesman of Medicine and a Senator of his University, has been honoured by the award of an Honorary LL.D. (1970), and is a Fellow of Royal Colleges of Physicians in England, Scotland and Ireland. He has, in his customary erudite fashion, traced the evolution of the uses of instrumentation from early times to its present complex form.

Professor John Anderson of King's College Medical School, London, a former Rockefeller Research Fellow at Harvard University, has given a very concise evaluation of these technological practices as seen through the eyes of the physician. His main

interests lie in medical education, endocrinology, neutron activation and the computerization of medical records, so there is no one more fitted for the task.

We go further, however, in our introduction in considering the status, qualifications and future technological requirements of the scientists allied to the practice of medicine.

In a government pamphlet of 1968 the Minister of Health pointed out that "the number of scientists and technicians in hospitals has greatly increased. Expansion of pathology in the fifties has been followed by new medical developments based on physics. This expansion seems likely to continue and the time has come to consider the effects which science and technology are going to have on the future of the hospital service and its staffing." Therefore the Secretary of State for Scotland and he had appointed a Committee under the chairmanship of Lord Zuckerman to consider the future organization and development of the hospital scientific service and the broad pattern of staffing required. The Staff Side of the Whitley Council could be consulted.

This Committee was, in point of fact, appointed in 1967, and we were fortunate in obtaining the help of one of the members of that Committee, Dr. Robert Gaddie, O.B.E., of the General Hospital, Birmingham, who can speak with first-hand knowledge of the many problems involved. He has looked at relevant questions of in-post training at all levels, and his chapter should be read and reread and carefully considered. He has had a wide experience of serving on scientific committees and is, amongst other things, a Past Chairman and President of the Association of Clinical Biochemists. He was awarded a Rockefeller Fellowship in 1939, before moving to the General Hospital, Birmingham, in 1942 as Head of his Biochemistry Department.

Without anticipating his chapter too much we can briefly study here some of the main recommendations of the Zuckerman Report:

A hospital scientific service should be set up within the existing National Health Service organization. It should include four main branches, i.e. pathology and the biological sciences; nuclear medicine; medical physics; biomedical engineering and applied physiology. Other specialties may be added. It should be organized in three parts at national, regional and district hospital levels.

On the institution of the National Health Service in 1948 about 9000 staff of those services were working in hospitals. The total, by 1969, had reached 27,000. This is a measure of the increasing load and importance of their support for medicine, and reflects also the acceleration of scientific developments.

The number of separate categories of staff is approximately forty, with new technical classes coming into being as new techniques are developed and new classes of technicians are recruited to work in them. Eight classes, of which the medical laboratory technicians, the radiographers and the physiotherapists are the most numerous, before being appointed to practice in the National Health Service, require statutory qualifications and registration under the Professions Supplementary to Medicine Act, 1960, but this still leaves a majority for whom no special qualifications are required. Amongst these are included those working in the fast developing fields of cardiology, nuclear medicine, haemodialysis and computer services.

It is essential to maintain a balanced viewpoint and a joint working party of the British Medical Association and the Joint Consultants Committee in a communication to the Council of the British Medical Association (quoted in *Medical News* No. 342 of 25 April 1969) is going on record as stating that the Zuckerman Report does not suffi-

ciently recognize the strength and value of links between graduates with medical qualifications and the clinical functions of hospitals.

"Maintenance intact of their membership of medical advisory committees, their present relationship with their clinical colleagues and their traditional channels of access to the hospital authorities are extremely important."

Still the working party welcomed the Zuckerman Report as an attempt to deal with a difficult problem in a radical way, and considered that the establishment of a hospital scientific and technical service would be of particular benefit to non-medical graduates and technicians.

Turning to the scientific chapters of the symposium, we would point out that it has been contributed to by medical scientists and non-medical scientists with a common interest in the uses of instrumentation in the diagnosis of disease. It deals with patterns of instrumentation, medical electronics, medical engineering and computerization of data.

It would appear to us as editors, one a non-medical scientist, one a public health physician, that in the ill-defined area of thought between the instrument room and the bedside there is much room for closer co-operation. We feel also that the field of training of scientific staff in hospital requires further definition.

Allied to this is a need for the medical undergraduate to obtain at some point in his training a true appreciation of the value and the limitations of uses of instrumentation in the diagnosis of disease.

In this context it is interesting to note from the *Medical News-Tribune* of 16 January 1970 that a new device which enables medical students to take charge of a patient from first introduction onwards is now installed in the University of Illinois medical centre. The heart of the apparatus is an I.B.M. 1130 computer holding a store of programmed "personalities", each suffering from a different disease. The potential in terms of student education would seem to be limitless.

We have divided the symposium into relevant sections as will be seen from the contents, and we begin the section dealing with the application of physical and biophysical technology, with a chapter at the hands of Dr. John V. G. A. Durnin of the Institute of Physiology at the University of Glasgow. Dr. Durnin is both a Doctor of Science and a Member of the Royal College of Physicians of Glasgow. The inter-relationship between health and physical activity is now well established. To use the crisp terminology of the World Health Organisation, "hypokinesia leads to a deterioration in musculoskeletal and cardiopulmonary function". It is equally true, however, that ill-directed activity can end the functions of an already badly damaged vital body organ. Dr. Durnin has examined carefully the field of physical anthropology and measurements of body functions and body physical tolerance.

He is at present engaged on a large multi-disciplinary project in New Guinea.

The two chapters which follow deal with electronic monitoring devices in cardiology and neuro-physiology. Dr. Michael Scott, after a most distinguished undergraduate and postgraduate academic career, has held research Fellowships in cardiology in Britain and in America. He is associated with Dr. Frank Pantridge, well known for his work in initiating the cardiac resuscitation ambulance service, and the monitoring of acutely ill cases in the initial phases of thrombosis. Dr. D. A. H. Yates, Physician in Charge of the Department of Physical Medicine and Rheumatology at St. Thomas' Hospital, London,

deals broadly with the subject of electro-diagnosis and the designing and equipping of an E.M.G. laboratory.

It should be mentioned at this stage that while there are special chapters on the medical uses of computers, any and all of our contributors may refer freely to computerization of data and Dr. Yates finds this an important part of his work also.

We turn again to Belfast for a description of the electron microscope in the capable hands of Dr. Evelyn Dermott, a scientist and lecturer in the Department of Microbiology, while the Consultant Virologist in the same Department, Dr. John H. Connolly, has dealt extensively with the whole field of microscopy. He also has had special experience in America, for in 1959 he spent a year as visiting Assistant Professor in Biochemistry at the Johns Hopkins University, Baltimore.

A new facet of instrumentation is the diagnostic laser beam and this with mirror techniques form the basis of Dr. Deryck Goodwin's chapter, from the University of York. He has dealt with the theory of laser action, the interaction of laser radiation and laser ophthalmology. He includes in his chapter reference to interaction of laser beams with neuro systems and dental applications.

Dr. Donald Forbes was in specialized practice as an obstetrician at the Springfield General Hospital, Massachusetts. He made a special study of the uses of ultrasonics and published several papers on the subject in America. We regret to announce the premature and very sudden death of Dr. Forbes on 7 November 1971 just after he had been elected a Fellow of the American College of Obstetricians and Gynaecologists.

Professor Ian Taylor of Manchester University, the author of many scientific and medical papers on hearing and speech defects in children, has, of course, such a wide field to cover that it is inevitably difficult to condense it into a brief chapter. Instruments for diagnosis have been used in audiometry for many years now and form an important aspect of the work of any such department.

To Mr. Charles Engel, Director of the Division of Audio-Visual Aids at British Medical Association House, London, we are much indebted for an intriguing chapter on the uses of photography in medical diagnosis. Mr. Engel has published several works in his own field and needs little introduction from us. It is difficult to condense in a chapter material which has formed the basis of an entire volume already.

Turning now to Section II of the Symposium, we enter another vast field which could have extended far beyond the boundaries we have set, yet it is hoped that the illustrations of the uses of chemical and biochemical techniques given will be of interest and use to our readers.

The four chapters which follow are in the nature of things highly specialized and written by experts in the various fields. They are followed by two chapters slightly different in their approaches and this will be explained below.

Dr. D. W. Hill, Reader in Medical Physics at the Institute of Basic Medical Science, University of London, obtained his Ph.D. for work on the application of gas chromatography in measurements during anaesthesia but he is currently working on the use of a digital computer system for physiological medicines.

We were fortunate in receiving the help and guidance of Professor L. G. Whitby, Dean of the Faculty of Medicine at Edinburgh University and one of Britain's foremost medical scientists, who has produced for us an excellent chapter on the principles underlying the uses of autoanalysers and computer data processing in clinical chemistry.

We had at first thought of using a title such as Cell Counting and Cytogenetics for the next chapter but eventually decided on two chapters on Cell Counting. The first is written by Dr. S. M. Lewis, who graduated in science and medicine at the University of Cape-town. He is Senior Lecturer in Haematology and a Consultant Haematologist at Hammer-smith Hospital. His main research activities lie in the field of the anaemias, the use of radioisotopes in haematology and electron microscopy studies of blood cells. The next chapter on Cellular Pathology, with special reference to cervical smears and automatic screening processes, is written by Dr. Oliver Anthony Husain, Consultant Pathologist at the Regional Cytology Centre, St. Stephen's Hospital, London.

Then we have a chapter on Enzyme Determination from Professor J. Henry Wilkinson, Professor of Chemical Pathology in the University of London, at Charing Cross Hospital Medical School. Professor Wilkinson has written extensively on this subject and has produced some major works (see Index of Authors).

The remaining chapter in this section deals with a broad survey and is slightly different in its approach. Dr. T. S. Eimerl, D.S.C., V.R.D., amongst many other appointments, was a member of the Annis Gillie Sub-Committee on the Field Work of the Family Doctor (H.M.S.O., 1963), and is well qualified to cover the potential uses of instrumentation in general practice.

A study of technological processes would be incomplete without reference to radiation techniques. The field is vast and occupies many textbooks, but we have attempted to define some of the main principles involved in two chapters, one from Dr. F. M. McIlrath of the Queen's University of Belfast, who incidentally spent some time studying at the Ulleval Hospital, Oslo, and the other from Dr. E. H. Belcher, a scientist graduate of the Universities of Cambridge and London, who after a distinguished career as a teacher, joined in 1963 the Section of Nuclear Medicine at the International Atomic Energy Agency, Vienna, where he is now Head of the Section of Medical Applications.

In Section IV we deal with a subject which has come very much to the fore of recent years. The emergence of the National Poisons Information Service, mandatory drug testing, and the Committee on Adverse Drug Reactions, have highlighted the importance of computerization of data in pharmacological applications. Dr. Roy Goulding, Principal Medical Officer of the Department of Health and Social Security, has been occupied with problems on pharmacology, chiefly on the standardization of drugs and subsequently on the wider toxicological aspects of drugs, agricultural pesticides and food additives. In 1963 he set up the National Poisons Information Service at Guy's Hospital, where he is now Director of Information Facilities and of the Chemical Toxicological Laboratory. His colleagues Jeffrey Grove and Brian Widdop have collaborated in the production of this chapter.

Dr. A. J. Howard has been director of the Department of Industrial and Forensic Science in Northern Ireland since 1947. He read Chemistry at Cambridge but has taken a Ph.D. at Queen's University of Belfast. In his chapter on Breath Analysis he has concentrated on methods currently in use in Northern Ireland, but this is a deliberate choice on his part after making a special study of techniques in use in some Scandinavian countries.

Lastly, we come to the chapter on Computer Analysis of Adverse Drug Reactions written by Dr. Natalie Hurwitz, a graduate in medicine of the University of St. Andrew's and who studied for a Ph.D. in Belfast in the subject on which she writes. In 1969 she

visited America and Canada as a temporary adviser to the World Health Organization on Intensive Hospital Monitoring Systems for Adverse Drug Reactions.

In Section V we are concerned with a new and developing field because along with the evolution of machines goes experimentation with these in animal laboratories. Modern laboratories require adequate space and a proper layout to accomplish work such as cardiac or kidney transplantation, or intra-cerebral monitoring and hence work of this nature requires a sophistication in the planning and uses of animal laboratories not even thought about a few years ago. These chapters are entrusted to Dr. R. S. Vine, Chief Inspector of the Home Office, London, whose experience of visiting and advising upon animal laboratories is unrivalled in Great Britain, and to Dr. William I. Gay, now Associate Director, Division of Allergy and Infectious Disease of the National Institutes of General Medical Science, U.S.A., who was previously Chief of the Animal Research Laboratories at the National Institutes of Health, Bethesda, Maryland. Dr. Gay was at one time Chairman of the American Animal Care Panel. His chapter concerns itself mainly with animal care for obviously reliable results can only be obtained if animal husbandry and laboratory hygiene are maintained at peak level. He received the Griffin Award in 1971.

Leaving the world of research and medical and scientific evaluation we finally consider the definitive aspects of data processing by way of mathematical approaches and the scope of engineering.

The first chapter on Computers is written by Dr. L. C. Payne who at the time he was writing was engaged on work for the International Training and Education Co. Ltd., London. He has since become a Medical Computer Consultant but at our request he compiled this chapter in fairly simple terms for the benefit of those who are more or less making a beginning of a study of computers, and it therefore acts as an excellent introduction to the chapters which follow.

Professor Eric Cheeseman, after spending several years lecturing on medical statistics in the Department of Social and Preventive Medicine at Queen's University of Belfast, became its first Professor of Medical Statistics. He is currently carrying out research into the possibilities of linked medical records with, of course, special emphasis on computer-based systems, but it follows that his chapter is orientated towards work that can be done by making use of computers rather than the technicalities of the computers themselves.

Thus we lead naturally on to the chapter on Data Processing by On-Line Laboratory Computer and AutoAnalyzer Linkage on which Professor Mario Werner of the Barnes Hospital, St. Louis, Missouri, and Professor George Brecher of the University of California have collaborated. It might seem that there is a degree of overlap between two very high-level chapters on Data Processing as between that written by Professor Whitby and that written by Professors Werner and Brecher, but we regard the two chapters as essential to the book because the one gives the present thoughts on the matter, particularly in relation to clinical chemistry, in Great Britain, whereas the other one, though couched in terms that are of world-wide significance, emanates from American universities. It is interesting therefore to see how far thoughts on this somewhat complicated subject coalesce on either side of the Atlantic. We are most grateful to these authors for the time and trouble they have taken over their chapters.

In the last section we are dealing with Engineering and Applied Physiology, the first chapter being from Professor Alistair Connell, now of Cincinnati, and formerly Lecturer

in Clinical Science in the Department of Surgery at the Queen's University of Belfast. He has for some years now been carrying out research based on the possibilities and scope of engineering devices in many aspects of medical research.

Professor Connell's chapter is followed by one from Mr. Sam Vincent, F.R.C.S., whose career is most interesting, in that he gave up his work as a successful consultant surgeon in order to concentrate on research into the control of incontinence. His pioneering work with the use of the electromyograph in the study of bladder control is now acknowledged and he is well known to the Biological Engineering Society as a lecturer and research worker in this field.

Before proceeding to Mr. Hendrie's concluding chapter on The Manufacturer's View-point, we thought fit to interpose a chapter on Profitable Medical Engineering Design to act as a kind of "bridging chapter" between the highly technical chapters and the ideas of the manufacturer.

In this we were most fortunate in obtaining the counsel of Dr. D. J. W. Taylor who incidentally is both a qualified engineer and a qualified medical man. His unique experience in both fields makes his ideas well worthy of study.

Then we thought that we could do no better than close with a chapter giving the point of view of the manufacturer because after all, though science may indicate the need, and the technologists advise on methods, we must eventually rely on the manufacturer to produce the instruments we use and as Mr. Hendrie rightly says the profit motive cannot altogether be discarded though in attempting to help medical science the manufacturer is often running a very grave risk of serious loss should a machine misfire or not be exactly what was originally intended.

Though it may seem that rather much of this study has emanated from the Belfast School, this was in a way only to be expected because of the fact that we were invited as executive co-editors to produce this volume. We have, however, sought the advice of the acknowledged experts further afield than Northern Ireland and we feel sure that no one will disagree when we say that we are delighted that so many well-known and distinguished teachers and research workers have agreed to collaborate with us.

We would like to close by thanking Dr. W. A. James Farndale and the publishers for inviting us to undertake this task for them, because we have gained a great deal of experience and enjoyment in so doing, our publishers especially for their great interest and help in many directions, particularly the Senior Editor, Mrs. Peggy Ducker. We also would like to thank our personal assistants Mrs. Reine Sheppard and Mrs. Dorothy Martin for much painstaking work in correspondence, filing, typing and the assembling of the volume.

ALEX. T. ELDER
DESMOND W. NEILL

Biographical Details

Robert Marshall, LL.D., M.D., D.P.H., F.R.C.P., F.R.C.P.I., Hon. F.R.C.P.S. (Glas.), qualified at the Queen's University of Belfast in 1912, took the D.P.H. in 1918, M.D. in 1920 and became a member of the Royal College of Physicians of Ireland the same year. He is a Fellow of the Royal Colleges of Physicians of Ireland and London, and was honoured with an honorary Fellowship by the Glasgow College in 1964, and with the award of an Hon. LL.D. in 1970 by the University of Belfast.

He was the first resident medical officer of the National Heart Hospital, London, in 1914, and thereafter saw active service with the Royal Army Medical Corps from 1914 to 1917.

He has given a lifetime of distinguished service to the cause of medicine, particularly the study of cardiology, as a consultant, university teacher, and examiner.

Now retired from active participation in the National Health Service, he is an Honorary Governor and Hon. Consultant Physician to the Royal Victoria Hospital and the Ulster Hospital, Belfast.

He was a Senator of the Queen's University of Belfast from 1950 to 1969, an External Examiner in Medicine to the University of Glasgow from 1947 to 1954, and also examined in medicine at Trinity College, Dublin from 1950 to 1954.

Apart from the many academic honours conferred on him he is the author of several books and articles of local medical interest and has contributed many scientific papers on cardiological and other medical subjects.

George Teeling-Smith, M.A., M.P.S., F.R.S.H. Read mathematics and natural sciences at Cambridge and then qualified as a pharmacist at Heriot-Watt College, Edinburgh.

He worked in the pharmaceutical and quality-control departments of T. & H. Smith Limited in Edinburgh, and for 3 years was a medical representative for their subsidiary, Duncan Flockhart and Company Limited.

Joining the marketing department of The Bayer Products Company, he was involved in the formation of their subsidiary companies throughout Europe, becoming commercial director and eventually deputy managing director.

He has been director of the Office of Health Economics since its formation in 1962.

Currently he is Vice-Chairman of the Editorial Board, *Journal of Social and Economic Administration*; Editorial Adviser, *Medical News Tribune of Great Britain*; Editor, *Science Industry and the State* (Pergamon Press) and several O.H.E. publications. Member of Council of the Royal Society of Health; Expert Adviser to O.E.C.D. on pharmaceutical "technological gaps" 1967.

Professor John Anderson graduated M.B. B.S. (Hons.) in 1950. He holds a B.Sc. (1st Class Hons. Physiology) (1952), the M.D. 1956 and F.R.C.P.(Lond.) 1962. He studied modern history at the University of Durham until the outbreak of World War II when he joined the armed forces.

After the war he came back to study medicine which has always been his first interest. He joined the Medical Unit at University College Hospital to study Metabolism.

He was a Rockefeller Research Fellow at the Massachusetts General Hospital, Harvard University, U.S.A. and travelled in the United States.

After returning to the University of Durham, he came to King's College Hospital where he has been since 1960. He was appointed to the Chair of Medicine at King's College Hospital in 1964.

His main interests are in medical education, endocrinology, neutron activation and the computerization of medical records.

Robert Gaddie, O.B.E., B.Sc., Ph.D., F.R.C.PATH., F.R.I.C. Qualified in Edinburgh, held teaching and research posts there, including a Beit Memorial Fellowship for Medical Research.

He spent 6 years as Senior Lecturer in Biochemistry at the University of Liverpool and was awarded a Rockefeller Fellowship in 1939. He moved to the General Hospital, Birmingham in 1942 as Head of Biochemistry Department and Clinical Lecturer in Biochemistry to the University.

Past Chairman and President of Association of Clinical Biochemists, and member of Council of Royal Institute of Chemistry. He is also a member of the Royal Society British National Committee for Biochemistry, of the Joint Examinations Board for the Mastership in Clinical Biochemistry and of the Joint Committee for Higher National Certificate and Higher National Diploma in Medical Laboratory Subjects.

He has been a member of various Departmental Committees including the Zuckerman Committee on Hospital Scientific and Technical Services.

John Valentine George Andrew Durnin, graduated M.A. (Aberdeen) in 1942; took the M.B., Ch.B. in 1946. He became a Doctor of Science (D.Sc.) of Glasgow University in 1961, M.R.C.P. (Glas.) in 1963, and F.R.C.P. (Glas.) in 1971.

He has always been interested in exercise physiology and in nutrition and has published many papers in American and in British journals on these topics.

He has held considerable research grants from the Medical Research Council, the U.S. Public Health Service, and the Royal Society. At present he is engaged on a large multi-disciplinary project in New Guinea.

He is a Member of various Government Committees, and was Director of N.I.H. and M.R.C. Research Units. Currently he is Reader at the Institute of Physiology, Glasgow University.

Michael E. Scott, graduated M.B., B.Ch., B.A.O. with Honours (at the Queen's University of Belfast) in 1963, having taken a B.Sc. in Anatomy (1st Class Honours) in 1960.

He has won many prizes including the Carnwath Medal in Social and Preventive Medicine, the Musgrave Prize in Pathology, a University Foundation Scholarship, the Dundonald Hospital Gold Medal in Paediatrics, and the Magrath Prize in Surgery.

He became M.R.C.P.(Ireland) in 1966, M.R.C.P.(London) in 1966, and then obtained the M.D. of Belfast. He was a Royal Victoria Hospital Research Fellow in Cardiology 1966/7, a Purce Fellow in Cardiology (1967/8), a Visiting Fellow (Cardiology Division) Johns Hopkins Hospital, Baltimore, Maryland, U.S.A., and is currently Consultant Physician (Cardiology), Craigavon Area Hospital, Craigavon.

D. A. H. Yates, M.D., M.R.C.P., D.PHYS.MED., is currently Physician at the Department of Physical Medicine and Rheumatology, St. Thomas' Hospital, London, S.E.1.

His published work includes a thesis on electrodiagnosis in sciatica and papers on endocrine myopathy, muscular changes in rheumatoid arthritis and the electrodiagnosis of myopathic disorders.

In 1966 he was appointed Director of the Department of Physical Medicine, St. Thomas' Hospital, where much of the pioneer work in clinical electrodiagnosis was performed by Dr. Philippe Bauwens, F.R.C.P., and the development of recording equipment carried out by Mr. Peter Styles of Medelec.

Evelyn Dermott, B.Sc., PH.D., is Assistant Lecturer in the Department of Microbiology, Queen's University of Belfast. After graduating from the Zoology Department, Queen's University, Belfast (2nd Class Honours) in 1963, she was awarded a 2-year studentship by the "Wellcome Foundation" during which time she carried out research using electron microscopy as her chief means of investigation.

Following that (1965-7) Dr. Dermott continued and extended this work as a Research Associate in the Zoology Department of Queen's University. The degree of Ph.D. was awarded for a thesis presented in 1967 entitled "Some Ultrastructural Studies on the Common Liver Fluke *Fasciola hepatica* (L)".

After a short spell as a Scientific Officer in the Virus Reference Laboratory at the Department of Microbiology, Dr. Dermott was appointed to a Lectureship in that department.

John H. Connolly, M.D., M.R.C.P.I., M.R.C.PATH. Consultant Virologist, Royal Victoria Hospital, Belfast, and Honorary Lecturer, Department of Microbiology, the Queen's University of Belfast.

Between 1955 and 1958 he was Assistant Lecturer, Tutor and Research Fellow for the National Fund for Poliomyelitis Research in the Department of Microbiology, Queen's University of Belfast.

During 1959 he spent the year as Visiting Assistant Professor in Biochemistry at Johns Hopkins University, Baltimore, U.S.A.

Since 1960 Dr. Connolly has been in charge of the Virus Reference Laboratory in the Department of Microbiology in Belfast. His published work includes papers on poliovirus vaccines, blood nucleases, epidemiology of Q fever in Northern Ireland, measles virus and subacute sclerosing panencephalitis as well as case reports of unusual clinical manifestations of viral infections.

Deryck W. Goodwin, B.Sc., PH.D.(Birmingham), A.INST.P. Took a Ph.D. for studies in research into nuclear physics and dielectrics.

He was for 14 years with the Scientific Civil Service—R.R.E. 1953–67.

His topics of research were:

1. Semiconducting Compounds.
2. Infrared Systems.
3. Microwave Solid State Detectors.
4. Solid State Lasers.

He was appointed in 1967 Senior Lecturer, University of York.

Arising out of infrared systems work, an interest in medical applications developed. He has produced several papers on infrared thermography as a diagnostic tool.

His present research is aimed at studying the interaction of laser beams with tissues and their use in endoscopic detection of carcinoma.

Donald A. Forbes, M.B., CH.B., B.A.O. (Q.U.B.), F.A.C.O.G., formerly obstetrician and gynaecologist on the staff of Wesson Women's Hospital, Springfield, Massachusetts, U.S.A.

Dr. Forbes was born in Northern Ireland, where he was educated at Campbell College and the Queen's University of Belfast. He received his primary medical degree in 1961.

After completing several years of training in General Surgery he emigrated to the United States of America in 1964. His training in Obstetrics and Gynaecology was carried out at the Springfield Hospital Medical Centre and the Wesson Women's Hospital, Springfield, Mass., and he was successful in passing the final examinations of the Massachusetts State Medical Board.

He was in private practice and on the active staff as Obstetrician and Gynaecologist at the following hospitals:

The Springfield Hospital Medical Centre, Massachusetts,
Wing Memorial Hospital, Springfield, Massachusetts,
Wesson Women's Hospital, Springfield, Massachusetts.

Shortly after his being awarded the Fellowship of the American College of Obstetricians and Gynaecologists in 1971, and while he was in the process of being appointed Associate Professor of Obstetrics and Gynaecology at Worcester Medical School, Massachusetts, a sudden fatal cerebral haemorrhage brought a promising medical career to an untimely end.

Professor Ian Galbraith Taylor graduated M.B., Ch.B. at Manchester in 1948. He gained a D.P.H. in 1954, and was awarded a Gold Medal for his M.D. thesis in 1962.

Presently Ellis Llwyd Jones Professor of Audiology and Education of the Deaf, University of Manchester, he is the author of many scientific and medical papers on Hearing and Speech Defects in Children.

Charles Edward Engel. Director, Department of Audio Visual Communication, British Medical Association, London.

Director, British Life Assurance Trust for Health Education.

Formerly, Director, Department of Audio Visual Aids, University of Melbourne.

Past Editor *Medical and Biological Illustration* (B.M.A. Quarterly Journal).

Editor *Photography for the Scientist* (1968), Academic Press.

Fellow Royal Photographic Society.

Fellow Biological Photographic Association.

Foreign Corresponding Member Deutsche Gesellschaft für Photographie.

Mr. Engel has recently been in Geneva as a consultant to W.H.O.

D. W. Hill is currently Reader in Medical Physics at the Institute of Basic Medical Sciences, University of London.

After graduating with the London, B.Sc. Special Physics degree he obtained his M.Sc. for research in gas discharge physics and his Ph.D. for work on the application of gas chromatography to measurements during anaesthesia.

Currently he is working on the use of a digital computer system for physiological measurements.

Professor Lionel Gordon Whitby trained first as a biochemist, gaining the Ph.D. (Cambridge) in 1951. He was elected a Fellow of King's College, Cambridge, and during the tenure of his Fellowship studied medicine, graduating M.B., B.Chir. in 1956. After two years in junior hospital appointments he began

his career in Chemical Pathology. He was appointed Professor of Clinical Chemistry in the University of Edinburgh in 1963 and has been Dean of the Faculty of Medicine since 1969. His research interests have included the development of a digital computer system dedicated to the work of a large clinical chemistry laboratory making considerable use of automatic analytical equipment. He is a Fellow of the Royal College of Physicians of Edinburgh and a Fellow of the Royal Society of Edinburgh, and is a member of the Scottish Health Services Scientific Council.

S. M. Lewis, M.D., B.Sc., D.C.P., M.R.C.PATH., is Reader in Haematology, Royal Postgraduate Medical School, London.

Dr. Lewis graduated in Science and Medicine at the University of Cape Town, and has been at the Royal Postgraduate Medical School since 1956, where he is now Reader in Haematology, and Consultant Haematologist at Hammersmith Hospital. His main research activities are in the field of anaemias, the use of radioisotopes in haematology, and electron microscopy of blood cells.

Dr. Lewis is the Secretary of the International Committee for Standardization in Hematology, and of the British Committee for Standards in Haematology, and he is Chairman of the British Standards Institution Committee on Haematological Equipment and Methods. He is a member of an Expert Panel on Cell Counting which has been established by the International Committee for Standardization in Hematology. He is co-author, with Professor J. V. Dacie, of *Practical Haematology*.

Oliver Anthony Nasseem Husain, M.D., F.R.C.PATH., graduated with honours in 1947.

He is Consultant Pathologist, Regional Cytology Centre, St. Stephen's Hospital, Chelsea, London, S.W.10.

Late Assistant Pathologist, Gp. Laboratory, Lambeth Hospital; he was a Senior Specialist Pathologist, R.A.M.C.

He is the author of several important scientific articles, particularly on the subject of Rheumatic Disorders and, more recently, on exfoliative cytology, including automation.

Professor J. H. Wilkinson, PH.D.(Lond), D.Sc., F.R.I.C., M.R.C.PATH., F.I.BIOL., F.P.S., is Professor of Chemical Pathology in the University of London at Charing Cross Hospital Medical School, and Honorary Consultant Chemical Pathologist to Charing Cross Hospital.

He was formerly Professor of Clinical Chemistry in the University of Pennsylvania (1965-9) and Reader in Chemical Pathology at Westminster Medical School (University of London) (1954-65).

He is the author of *An Introduction to Diagnostic Enzymology* (1962), and *Isoenzymes* (1965), and co-translator of R. Richterich's *Clinical Chemistry. Theory and Practice* (1969).

Teviot S. Eimerl, D.S.C., V.R.D., M.D. (Liverpool), F.R.C.G.P. Surgeon Captain R.N.R. (Retired). He saw over 6 years active war service.

He was Visiting Anaesthetist, Warrington Infirmary (1947-67), and in General Practice (1947-April 1968).

Lately, he was Chairman, Research Committee of Council, The Royal College of General Practitioners.

His present post, since May 1968, is in the Medical Service of the Department of Health and Social Security, London.

His other activities include chairman, Penketh Parish Council; Member of Annis Gillie Subcommittee, Field of Work of the Family Doctor (H.M.S.O., 1963); member of research committee United Liverpool Hospitals and Liverpool regional hospital board; quondam visiting lecturer Holland, Denmark, Australia, New Zealand, Israel, etc. Adviser in general practice to and member of Medical Care Research Unit, University of Manchester (1961-8).

E. M. McIlrath graduated at the Queen's University, Belfast, in 1956.

He took the D.M.R.D. in 1959, and became F.F.R.(London) in 1962.

He was a Medical Assistant, University College Hospital, London, in 1963, a Medical Assistant at Ulleval Hospital, Oslo, in 1966, and has been a Lecturer in Radiology at the Queen's University of Belfast since 1967.

E. H. Belcher graduated in 1941, B.A. (Hons.) Cantab., Natural Sciences Tripos and in 1946, M.A. (Hons.) Cantab. He saw service with the Royal Air Force, Signals (Radar) Branch (1942-7).

In 1951 he took his Ph.D. (Physics) London, and in 1957 B.Sc. Special (Physiology) London.

His later career was in the Department of Physical Chemistry, University of Cambridge; Research Assistant (1947-8); Department of Physics, Institute of Cancer Research, Royal Cancer Hospital, London (1948-58); Lecturer in Biophysics (1952), Recognized Teacher, University of London (1955); Senior Lecturer in Biophysics (1957), the Section of Medical Physics, Royal Postgraduate Medical School

of London (1958–63); Lecturer in Medical Physics and Head of Section of Medical Physics (1958); Senior Lecturer in Medical Physics and Head of Section of Medical Physics (1960) and the Medical Applications Section, International Atomic Energy Agency, Vienna (1963–); First Officer (1963); Senior Officer (1964); and Senior Officer of Medical Applications Section (1967).

He is the author of numerous scientific papers, review papers, review articles and books dealing with medical applications of radioisotopes.

Roy Goulding, B.Sc., M.D., F.R.C.P. Director, Poisons Unit, Guy's Hospital, London.

Qualified in medicine at Guy's Hospital Medical School, University of London, and occupied a series of house appointments, including specialization in neurology. He then joined the Department of Pharmacology, Guy's Hospital Medical School, and there engaged on teaching and research, chiefly into the experimental chemotherapy and immunology of tuberculosis, actions of corticosteroids, local anaesthetics and purgatives.

He spent a short time in general practice and became a medical officer in the (then) Ministry of Health, being occupied with problems of pharmacology, chiefly of the standardization of drugs and subsequently the wider toxicological aspects of drugs, agricultural pesticides and food additives.

In 1963 he set up the National Poisons Information Service at Guy's Hospital which, in 1967, was incorporated with the Poisons Unit there. He is now director of both the information facilities and the chemical toxicological laboratory, besides being consultant in clinical toxicology. Meanwhile he retains his position as toxicologist to the (now) Department of Health and Social Security, London.

He is the author of numerous papers and articles and joint editor of *Modern Trends in Toxicology*, Butterworth, 1968. The chapter in this present book was written in collaboration with **Jeffrey Grove** and **Brian Widdop** of the Poisons Unit, Guy's Hospital.

A. J. Howard, M.A., Ph.D., F.R.I.C., has been Director of the Department of Industrial and Forensic Science in Northern Ireland since 1947, when the Department was first formed as the Directorate of Scientific Development, Ministry of Commerce.

He is responsible for the direction of the activities of the Department, which are carried out by two main divisions.

The Industrial Division provides scientific and technical advice and information for local industries and government departments in Northern Ireland. It also undertakes laboratory examinations and field work on a fee-paying basis.

The Forensic Science Division provides a laboratory service to assist the Courts in the investigation of crime.

He read chemistry at Cambridge and has a Ph.D. from Queen's University of Belfast.

Prior to becoming Director of his present Department he was Director of Canning, Ministry of Food, after having spent some time in industry with Metal Box Company Limited.

Natalie Hurwitz graduated M.B., Ch.B. University of St. Andrews in 1958 and became a Ph.D. of the Queen's University, Belfast, in 1968.

She has had an interest in adverse drug reactions since 1965.

From 1965 to 1968 she was a Research Assistant, Department of Therapeutics and Pharmacology, Queen's University of Belfast, for the study of adverse drug reactions, supported by the Nuffield Provincial Hospitals Trust.

In 1969 she visited the U.S.A. and Canada as temporary adviser to the World Health Organization on intensive hospital monitoring systems for adverse drug reactions.

Her present appointment is that of World Health Organization Research Fellow, Department of Therapeutics and Pharmacology, Queen's University of Belfast, for a study of the problems of amalgamating data on adverse drug reactions from various centres.

Publications include:

HURWITZ, N. and WADE, O. L. (1969) Intensive hospital monitoring of adverse reactions to drugs.

Brit. Med. J. **1**, 531–6.

HURWITZ, N. (1969) Predisposing factors in adverse reactions to drugs. *Brit. Med. J.* **1**, 536–9.

HURWITZ, N. (1969) Admissions to hospital due to drugs. *Brit. Med. J.* **1**, 539–40.

Colonel R. S. Vine, B.Sc., M.R.C.S., L.R.C.P., F.R.C.PATH., qualified at Guy's Hospital, London.

He was with the Royal Army Medical Corps from 1934 to 1960, and served in India until 1939; then War Service in Egypt and Europe until 1945. Post-war service in Greece, Canal Zone, Malta and the United Kingdom.

He retired in 1960 from the Army having been appointed senior specialist in Pathology in 1949.

He joined the Cruelty to Animals Inspectorate of the Home Office in 1960, and is presently its Chief Inspector.

William I. Gay is Associate Director, Extramural Programs, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda, Maryland. For 9 years he was Chief of the Animal Hospital Section of the N.I.H.

Dr. Gay is a member of the American Association for Laboratory Animal Science and a founding member of its Washington branch. He has served as president of both the local and national organizations. He is a diplomate of the American College of Laboratory Animal Medicine and served as program chairman of the International Symposium on Laboratory Animals held in Washington, D.C. in April of 1969. He received the 1971 Griffin award of the American Association for Laboratory Animal Science.

Author of many articles in experimental surgery, veterinary medicine and laboratory animal medicine.

L. C. Payne graduated originally with a first-class honours mathematics degree, and subsequently obtained a Cambridge Ph.D. in genetics.

He has been active in the application of computers to the biological sciences since 1953, and in the medical field since 1961, when he first lectured on the subject at the Royal College of Surgeons, London.

He was founder-director of the Medical Automation Experimental Unit at University College Hospital, London—the first unit of its kind in the United Kingdom—and since that time has broadcast, published and lectured a great deal on medical computing, both here as well as in Europe, the United States and Australia. In particular he is the author of *Introduction to Medical Automation* first published in 1966; a revised edition is in the press.

Dr. Payne is now engaged full-time in the medical computer consultancy/lecturing field, for which he runs his own company.

Professor E. A. Cheeseman, B.Sc.(Econ.), Ph.D.(Med.)Lond. Professor of Medical Statistics of The Queen's University of Belfast, Honorary Director of the Northern Ireland Medical Record Linkage Research Unit, Chairman of the Northern Ireland Medical Records Linkage Steering Committee, and statistical adviser to the Northern Ireland Hospitals Authority.

Formerly a member of the Medical Research Council's Statistical Committee and currently a member of that Council's Committee on General Epidemiology, Chairman of the Computer Committee of The Queen's University of Belfast, and a member of the Computer Consultative Council of the Computer Board for Universities and Research Councils. Fellow of the Royal Statistical Society and member of the Biometrics Society, the Statistical and Social Inquiry Society of Ireland, and the Society for Social Medicine.

Present interests include general applications of statistical methods in clinical and human-genetic research and the development of systems of linked medical records and medical computing.

Professor Mario Werner, a native of Switzerland, received his medical degree from the University of Zurich, Switzerland, in 1956. After specializing in internal medicine at the University of Basle, Switzerland, he came to the United States—as a fellow of the Swiss Academy of Medical Sciences—to work at the National Institutes of Health, Bethesda, Maryland, and at the Rockefeller University, New York. From 1964 to 1966 he served as chief of the Central Laboratory at the Klinikum Essen, Ruhr University, Germany. From 1967 to 1970 he joined the Department of Clinical Pathology and Laboratory Medicine at the University of California, San Francisco, as Assistant Professor. Since 1970 he is Associate Professor of Medicine and of Pathology at Washington University Medical School, and Director of Clinical Chemistry, Barnes Hospital, St. Louis.

Dr. Werner is best known as a Clinical Chemist. His research has dealt mainly with protein and lipo-protein metabolism. To improve the definition and use of normal values for diagnostic discrimination he has written both theoretical papers and practical papers defining the effects of physiological factors such as sex and age. He is the co-editor of a book on *Automation and Data Processing in the Clinical Laboratory*.

Professor George Brecher, a native of Czechoslovakia, studied Mathematics and Physics in Goettingen, Medicine in Zurich and Prague, graduating M.D. in 1938. He received a D.T.M.&H. from the London School of Hygiene and Tropical Medicine in 1940, served in the British Emergency Medical Service and was a fellow in pathology at the Mayo Clinic, a U.S. Government physician in Haiti, a Captain in the