# DAIRY RESEARCH FOUNDATION

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## Introduction

The inaugural meeting of the Dairy Husbandry Research Foundation (now known as the Dairy Research Foundation (DRF)) was held on the 16th April 1959, following several years of planning and development initiated and vigorously pursued by Professor T.J. Robinson, the Foundation Professor of Animal Husbandry at the University of Sydney. Since that time the DRF has enjoyed the continuous support of the dairy industry and is now recognised nationally as a major centre for dairy research and development.

In 2006 the Council of the DRF accepted a proposal by Mr D. Crosby (Governor) that it would be timely to record the history of the Foundation. A former Director of the DRF, Emeritus Professor E.F. Annison agreed to undertake this task.

This project has been made possible by the diligence of generations of DRF staff who have preserved the records of all major activities. The archives of the DRF include the Minutes of Council Meetings, Annual Reports and Proceedings of Annual Symposia, which make up the source material on which this record of the formation of the Foundation and its subsequent activities is based.

The Poultry Husbandry Research Foundation was established at much the same time as the DRF, and for similar reasons. The poultry industry, in the fifties in Australia, like the dairy industry had failed to take advantage of scientific developments, particularly in genetics on which the industry in USA and Europe was based. Professor Robinson was again the driving force in convincing the poultry industry to support the new Foundation. The inaugural meetings of both Foundations were held in April/May 1959, and Mr Bridges-Maxwell was appointed secretary of both Foundations.

This joint secretary-ship of the two Foundations functioned efficiently, and facilitated co-operation between them, which continues to this day. This includes

the sharing of laboratory skills and joint access to scientific equipment acquired by both Foundations.

Professor Robinson held the view that at some stage the Dairy and Poultry Foundations should merge to form an Animal Research Foundation, which would embrace other disciplines at Sydney University relevant to the agricultural industries. This proposed initiative proved unacceptable to the Councils of both Foundations, although on one occasion (1977) the Foundations held a joint Annual Dinner.

The management structure of the DRF established at the inaugural meeting in 1959 comprises a Council of representatives of those companies providing annual financial subscriptions to the Foundation. Council members elect the President, who acts as Chairman of Council, and the Vice-President. The Head of the Department of Animal Husbandry (from 1986 termed Animal Science) was automatically Director of the Foundation, but when Departments in the Faculty of Veterinary Science were abolished in 1990 the senior academic staff member involved with the Foundation functioned as Director. When Professor W.J Fulkerson was appointed in 2000 to the Chair of Dairy Science at Camden, he became Director of the Foundation.

The DRF was established to support the Dairy Industry by undertaking relevant research and development, providing technical advice and assisting in the training of industry personnel (p 5). The first Research Director of the Dairy Unit, Dr Walter Whittlestone, succeeded brilliantly in realising these objectives and the Foundation has continued this tradition whilst over the years developing new initiatives to support the dairy industry.

The Directors and Research Directors of the DRF since its inception are shown in Table 1 (p 66).

The first major Symposium of the DRF, "The Dairy Industry 1977: The Way Ahead) was staged in 1977. This Symposium was considered by industry personnel to be a most useful contribution by the DRF and the then Chairman of the Foundation, Mr H. W. Marchant, noted in the Annual report of the Foundation that "*The outstanding Foundation event was the successful Symposium held in November. Excellent papers were presented and lively discussions marked the interest shown by the participants".*

In 1978, the UK authority on dairy cow nutrition, Dr W.H Broster, was invited to speak at the second of what became a series of Symposia on dairy research and development which have been held annually from that time. Invited overseas speakers, without exception, agreed to undertake a series of visits to address dairy producers at rural centres either before or after Annual Symposia. These visits became known as Country Tours, and were usually arranged with the administrative support of the NSW Department of Agriculture or the Queensland Department of Primary Industries, or local dairy factory field officers. The printed Symposia Proceedings have become a valuable means of advising dairy producers of relevant advances in dairy production. The responsibility for organising the Annual Symposia, producing the Symposium Proceedings and arranging Country Tours was initially undertaken by Dr Graham McDowell until he took up his appointment as Professor of Animal Science at La Trobe University in 1989. Associate Professor Jim Gooden took over these complex and time consuming responsibilities until he retired in 2001. In addition, he usually accompanied the visiting speakers undertaking the Country Tour, which was greatly appreciated by our guest speakers. The successful development of the Annual Symposium into a national conference, with increasing participation of dairy farmers and processors from rural areas led to the decision in 2001 to discontinue the Country Tours.

## Establishment of the Foundation

The formation and successful development of the DRF followed the establishment of the Department of Animal Husbandry in 1955, an academic initiative made possible by the provision of land at Camden by the agricultural industries. The Corstorphine Farm and May Farm, totaling some 300 hectares, were purchased by the University in 1954 with funds (£150,000) provided, in equal measures, by the Australian Dairy Produce Board, Wool Board and Meat Board. These two farms were part of the original land grant to John Macarthur in 1812, but were sold out of Camden Park Estate in 1880. Associate Professor Hector Geddes, the first Director of University Farms, was responsible for the development of farm facilities, and in particular, the Corstorphine Dairy. A crucial initiative of Associate Professor Geddes, an authority on all aspects of dairy farm management, was the construction of several large water storage dams on the University farms. This harvested water has proved invaluable in times of drought, particularly to the Mayfarm Dairy. Associate Professor Geddes was a member of the Dairy Industry Advisory Council set up by the NSW Government in 1968 to investigate the dairy industry in NSW. The recommendation of the Council that the NSW Milk Board should be replaced by the NSW Dairy Industry Marketing Authority, with overall control of the marketing of liquid milk and other dairy products, was accepted by the NSW Government. In hindsight, the limited formal involvement of Hector Geddes with the DRF is most puzzling, given his standing in the dairy industry. In his role as University Farms Director, however, he was always ready to assist the Director and staff at the Dairy Unit.

Professor T.J Robinson, an internationally recognised authority in the field of applied reproduction in livestock was appointed Head of the Department of Animal Husbandry in 1955. A unique feature of the Department was that although placed in the Faculty of Veterinary Science for administrative purposes, members of academic staff enjoyed full membership of the Faculties of both Veterinary Science and Agriculture. This commitment of the Department to teaching and research in both Faculties allowed the Department to grow rapidly, and by the early 1970s the

Department comprised 15 members of academic staff, of whom 9 were based at Camden. The Department, by that time, had established internationally recognised research units in Dairy Science, Poultry Science, Animal Genetics and Applied Animal Reproduction.

The dairy industry in Australia in 1955 was relatively inefficient, and lagged far behind its counterparts in the USA and Europe in the application of advances in knowledge in the biological sciences. Professor Robinson recognised the need to establish a specialised Dairy Husbandry teaching and research unit similar to those he had encountered during his visits to the University of California at Davis, and at other State Universities in the USA. This view was shared by Mr Jack Ferguson, the then Chairman of the NSW Milk Board. Mr Ferguson's encouragement and influence was crucial in persuading a good proportion of the dairy companies in NSW to provide financial support for the proposed Foundation. These included the United Dairies Milk Company, the Fresh Food and Ice Company (which later became Peters Ice Cream) and the Dairy Farmers Co-operative. The Chairman of United Dairies, Mr Doug Lindsay, aided by Mr Les Juskovic, Company Secretary and Mr Doug Crosby, Director, were particularly active in convincing the dairy industry of the need for the new Foundation. Similar active encouragement and financial support was generously given by Mr Murray Mead, on behalf of the Dairy Farmers Co-operative, and Mr Frank Bowe, the Chairman of the Fresh Food and Ice Company. In 1957, a Provisional Committee was appointed to draw up plans to establish the Dairy Husbandry Research Foundation. The Committee comprised leaders of each section of the dairy industry, together with senior members of the University academic and administrative staff.

The major objectives of the Foundation agreed by the Provisional Committee are shown below:

- Finance and undertake research relevant to the problems of the Australian Dairy Industry.
- Promote the application of research findings to the industry.

- Provide advice to the Dairy Industry on problems encountered in the field.
- Assist in the scientific training of experts to service the industry.
- Raise funds for these purposes.

These objectives remain valid today.

The new Foundation, before formal inauguration, was extremely fortunate to be able to appoint Dr Whittlestone in 1958 as the first Research Director of the Dairy Unit at Camden. The appointment was made possible by the endowment of a Readership in Dairy Husbandry by C.S.I.R.O. This critical support arose from a meeting between Professor Robinson, Sir Ian Clunies Ross (C.S.I.R.O) and Professor (later 'Sir') Stephen Roberts (Vice-Chancellor). The endowment was for five years, with the University accepting financial responsibility for the position after that period.

The inaugural meeting of the DRF was held on the 16th April, 1959. Mr Rupert Rudder was elected Chairman (termed President from 1978) of the new Foundation Council and Mr Jack Ferguson, Deputy Chairman. The membership of the Council is shown in Table 2 (p 67). The Council elected Mr Fred Sedgwick as a Governor and Mr W Bridges-Maxwell was appointed Secretary of the Foundation. Mr Rudder was succeeded by a distinguished group of senior representatives of companies that invariably provided generous financial support for the Foundation (Table 3, p 68).

Foundation Council meetings usually have been held twice-yearly, the mid-year meeting serving as the Annual General Meeting (AGM).

The early success of the Foundation would not have been possible without the constant support of Foundation Council members, who were able to convince the companies and institutions that they represented that financial support for the Foundation was in the best long-term interests of the dairy industry.

An account of the research undertaken at the Dairy Unit from its inception was presented by Professor Robinson at the DRF Annual Symposium in 1988.[1] In addition, a list of all the post graduate students trained at the Dairy unit from its inception until 1980 was included in the paper. An updated list is shown in Table 4 (p 4).

## Dairy Husbandry Unit at Camden, 1958-63

The unit, designed by the first Director, Dr Whittlestone, was built on 12 hectares of Corstorphine Farm, which provided enough pasture to support a small dairy herd for teaching and research purposes. The first building erected was termed a milking laboratory and contained milking bails within the laboratory equipped to permit the study of both the physiology of milk secretion, and milking machine design. The ready access to dairy cows in the milking bails greatly assisted undergraduate teaching. Within a further 1-2 years a well equipped research laboratory and ancillary facilities, which included a workshop, feeding stalls and a seminar room, were built.

The Dairy Unit was built as part of a 5 year capital works program, starting in 1959, which was mainly funded by the generous support of the dairy industry (Table 5, p72). The funding raised by the Foundation at that time was equivalent to more than $1 million at current currency values.

Dr Whittlestone's approach to research and development activities at the Dairy Unit was to blend basic research on milk secretion with applied studies on milking machine design and usage. The basic studies on the physiology of milk ejection provided topics for postgraduate research students, and enhanced the academic standing of the Foundation and the University. By far his heaviest commitments however centred on efforts to improve all aspects of milking machine design and

[1] * see: Current Topics in Dairy Production, Volume 4

milk collection. Dr Whittlestone's work in this area is exemplified by his studies on the effectiveness of detergents and sanitisers used in milking parlours. A number of new products were tested in collaboration with the NSW Department of Agriculture, and with the cooperation of a considerable number of NSW milk producers.

Dr Whittlestone's major contribution to the dairy industry was almost certainly his recognition that poorly designed or operated milking machines contributed significantly to the incidence of mastitis in dairy cows. In addition to his work on sanitisers and the most effective procedures for their use, Dr Whittlestone initiated careful studies on the performance of milking machine components, in collaboration with the NSW Department of Agriculture and Hawkesbury College (now incorporated into University of Western Sydney). The importance to the industry of this work led the Foundation to form a Standards Committee in May 1959 to establish performance standards for milking machines. This initiative was widely supported by the dairy industry and the committee included representatives of manufactures and distributors of milking machine components, the NSW Department of Agriculture, the NSW Milk Board, the Australian Society of Dairy Technology and farming organisations. This committee remained active for some years after Dr Whittlestone returned to New Zealand in 1963.

Dr Whittlestone attracted a number of students to the Dairy Unit to undertake postgraduate studies. Mr G.R Olney (1961) and Mr K Rathey (1962) were awarded Diploma's in Dairy Husbandry. Miss Elizabeth Kernohan joined Dr Whittlestone in 1960 as Research Assistant and Demonstrator. Her field of study was milk ejection and milk composition, and she completed her Masters Degree in 1963. Miss Kernohan accepted a teaching post with the NSW Department of Technical Education in 1963 but returned to the Dairy Unit as Professional Officer in 1965. She subsequently completed her PhD at the Dairy Unit and went on to become a much loved and respected University Lecturer/Senior Lecturer and Assistant Director/Director of University Farms before entering State Parliament in 1991.

Mr D.A Clark (1962) obtained a Masters Degree for his studies on machine milking and mastitis. Part of this work was carried out with the cooperation of Mr (later Dr) L Fell at Hawkesbury Agricultural College and with the NSW Department of Agriculture. Mr Clarke also collaborated with Miss J Nield, who was also working for her MSc.Agr. and with Miss J Toomey at Hawkesbury College on milking machine hygiene.

In 1962 the research thrust at the Dairy Unit was greatly strengthened by the appointment of Dr A.K Lascelles as Senior Research Fellow. Dr Lascelles had been a member of the distinguished research group headed by Professor Bede Morris at the Australian National University (ANU). Professor Morris, a renowned authority on immunity in animals, had devised surgical procedures for the quantative collection of lymph which Dr Lascelles introduced at Camden. An early study of Dr Lascelles on the role of lymph in mammary gland function in dairy cows was undertaken with a distinguished visitor, Dr A.T Cowie from the National Institute for Research in Dairying, UK. Dr Lascelles' first PhD student, Mr P Hartmann (1962-1964), who took part in these studies, went on to become an authority on human lactation and is now Professor of Biochemistry at the University of Western Australia.

Professor Lascelles and his students were at the forefront of studies on the contribution of dietary fat to milk fat synthesis in the mammary glands of ruminants. At much the same time, the highly regarded and distinguished authority on the physiology of the ruminant mammary gland, Dr James Linzell at Cambridge, UK, was developing techniques for the quantative study of the role of circulating metabolites in milk synthesis. Professor Lascelles, during overseas study leave, joined forces with Dr Linzell's group in studies which provided quantative data on the role of chylomicrons in the transport and uptake of dietary fat by the lactating ruminant mammary gland.

Other major research programs initiated and supervised by Professor Lascelles included the role of colostrum in the newborn ruminant, with special reference to the source and transfer into colostrum of the immunoglobulins which confer passive

immunity on the newborn. The involvement of the lymphatic system in the absorption from the alimentary tract of the large amounts of these immumoglobulins was closely studied. The findings from this research had a considerable influence on calving practices, and highlighted the importance of colostrum to the survival of young ruminants. Professor Lascelles also initiated research on the importance of the local immune system for protection of the mammary gland (and later other organs) from infectious disease, in particular mastitis

The Dairy Unit was formally opened on the 10th May 1963 by the Honorable C.F Alderman, the Minster for Primary Industries. Other speakers were Sir Charles Bickerton Blackburn (Chancellor, University of Sydney), Mr R Rudder (Chairman of the DRF) and Professor T.J Robinson (Director). The Opening Ceremony was followed by an inspection of the laboratories.

A few months after the Dairy Unit was formally opened, Dr Whittlestone tendered his resignation effective from the end of December 1963. Dr Whittlestone's decision to return to the Ruakura Research Centre in New Zealand was a considerable blow to the standing of the Foundation in the dairy industry. In addition to his research and development work with milking machines, and the physiology of milk ejection, Dr Whittlestone proved to be an excellent communicator at dairy industry meetings, and as a broadcaster with the ABC.

The success of the Dairy Unit as a centre for research and development was revealed at the AGM of the Foundation, held on 9th August 1963. In spite of the difficulties involved in establishing new laboratories and recruiting and training students and support staff, by that time 19 research publications had appeared (12 by Dr Whittlestone, 7 by Dr Lascelles). In the years immediately following Dr Whittlestone's departure, basic research on the physiology of the lactating dairy cow flourished under the direction of Dr Lascelles, as outlined in the following account.

Financial support for the Dairy Foundation from inception until 1963 was largely met by grants from the NSW Milk Board and the University. Annual subscription fees from member companies totalled about $20,000 and remained at this level for the next decade or so.

## The Foundation, 1963-1974

Dr A.K Lascelles succeeded Dr Whittlestone in the academic position of Reader and as Director of the Dairy Unit. In 1964, the Foundation persuaded the University to convert the Readership into the First Chair in Dairying at Sydney University with the help of dairy industry funds. The increase in salary involved was met by the Australian Dairy Produce Board. Dr Lascelles was appointed to the Chair in 1965, and his research programs expanded with the appointment of more postgraduate students and his success in competing successfully for industry research funding. At that time, the Dairy Unit was the only major Dairy Husbandry Unit in any Australian University and was well equipped with laboratories and ancillary facilities.

The Dairy Unit was honored on 7th April 1965 by the visit of their Royal Highnesses, the Duke and Duchess of Gloucester, who inspected the laboratories whilst accompanied by Mr Rudder and Professors A.K Lascelles and T.J Robinson. Although the main thrust of Professor Lascelles research was in the area of the physiology of lactation, applied research on the prevention and treatment of mastitis was continued often in collaboration with other institutions. Basic studies on the local synthesis of antibody in the mammary gland in response to bacterial mastitis carried out initially with Mr Peter Outteridge and Mr Duncan Mackenzie (PhD student 1964-67), and then with Mr Graham McDowell, a PhD student (1967-1970), directly supported the mastitis prevention programs. This approach to mastitis research exemplified the prevailing culture at the Dairy Unit, namely that improved productivity and profitability would inevitably stem from a greater understanding of the physiology of the dairy cow. The leaders of the dairy industry at that time, with wisdom and foresight, generously funded research initiated by

Professor Lascelles. Funds totaling almost $90,000 were received during 1967, which included $19,000 from the Australian Dairy Produce Board, $10,000 from the NSW Milk Board and $13,400 in member's subscriptions ($3,200 unpaid at that time).

The research projects at the Dairy Unit provided excellent opportunities for postgraduate studies. Successful PhD programs yielding data acceptable for publication in refereed scientific journals were undertaken by a succession of postgraduate students all of whom pursued successful careers after leaving Camden. One of the group, Dr Graham McDowell returned to the Dairy Unit as a Senior Research Fellow. Dr McDowell was subsequently promoted to Lecturer/Senior lecturer/Associate Professor before accepting the Chair in Agricultural Science at La Trobe University in 1988. Professor McDowell was appointed Deputy Vice-Chancellor at La Trobe in 1996. Dr McDowell devoted considerable time and effort to Foundation affairs, and played a key role in the revival of the Foundation in 1975 following its decline after the loss of the secretary, Mr Begaud, and Professor Lascelles in 1973.

The success of Professor Lascelles in implementing research projects and training postgraduate students ensured continuous research funding for the Dairy Unit by the Australian Dairy Produce Board and NSW Milk Board. The Secretary of the Australian Dairy Produce Board, Mr Oliver Cassar, recognised the research excellence of the Dairy Unit, and Professor Lascelles and his colleagues benefited greatly from his objectivity and experience when advising the Unit on research priorities.

In 1968, in addition to continuing support from the Dairy Produce Board, Professor Lascelles was awarded a Rural Credits Development Fund Grant of $16,175 for his studies on mastitis control, renewable for two further years. Professor Lascelles and Dr Peter Hartmann, newly appointed as Research Fellow at the Dairy Unit, were invited speakers at a Symposium on lactogenetics held at the University of Pennsylvania in August 1968.

The success of both the Dairy Unit and Poultry Foundation Unit at Camden in competing for industry research funds was in sharp contrast to the failure of both Foundations to increase annual income by recruiting more company members. This financial stringency made it necessary to dispense with the services of the Secretary to both Foundations, Mr Kevin Begaud, in 1972. This decision resulted in administrative chaos for both Foundations since the research units at Camden were virtually autonomous and played no part in the financial management of the Foundations. In fact, at the Dairy Foundation AGM held in July 1972, Council appointed an Executive Committee (Chairman, Deputy-Chairman, Director and Secretary) which excluded Professor Lascelles. This inexplicable decision contributed significantly to the decline in dairy industry involvement with the Foundation from 1970 until the appointment of a second Professor of Animal Husbandry at Camden in 1974 (Professor E.F Annison) and a new Secretary to both Foundations (Mr Charles Morbey) in early 1975.

Research at the Dairy Unit continued to expand in the early 1970's. Studies undertaken by postgraduate students supervised by Professor Lascelles included the development of immunity in young ruminants (with Mr A. Husband); local immunity in the mammary gland initially with Dr D. Mackenzie and Dr P. Outtteridge and subsequently with Dr G. McDowell and Dr C.S. Lee, and then Dr D. Watson; the diagnosis of Bovine Brucellosis (with Dr K.J Beh) and studies on local immunity in the intestine (with Dr K.J Beh). Research in the area of endocrinology focused on factors affecting milk production (with Dr W.J Fulkerson) and included investigation of the effects of oestrogen on established lactation, and its role in the artificial induction of lactation by treatment with the hormones that initiate normal lactation. Nutritional research included the effects of dietary lipid, including 'protected' lipid (sunflower oil particles coated with formaldehyde-treated protein) on the composition of milk, (with Dr J.C. Wadsworth and later, Dr J.M Gooden) and studies supervised by Dr R.C Kellaway on protein requirements of the lactating ruminant (with Dr S.S.E Ranawana), and on the nutrition of early weaned calves. In

later studies, Dr Kellaway collaborated with Dr Jane Leibholz to develop diets for early weaned calves (p 23).

The industry problem of interpreting yellow stain on the sediment discs in milking machines was investigated by Dr E.A Kernohan as part of her successful PhD studies.

Professor Lascelles resigned from Sydney University in 1973 to become Chief, C.S.I.R.O Division of Animal Health. Dr R.C Kellaway, who had moved from the Franklin Laboratory, Camden, to the Dairy Unit in 1971, became Acting-Director of the Unit when Professor Lascelles departed. Dr Kellaway supervised the PhD studies of Miss Kernohan, who was awarded the degree in 1976. Dr Kellaway returned to the Franklin Laboratory in 1975 to replace Associates Professor H.L Davies, who was appointed to a Chair at the University of NSW. Dr Kellaway continued to support the Dairy Foundation and became well known to the dairy industry when he developed and marketed "CAMDAIRY", a computer based model of production responses of dairy cows to defined intakes of feed (p 25).

## The Foundation 1974 – 1991

The administrative problems stemming from the loss of the Foundation secretary, Mr K. Begaud, and the departure of Professor Lascelles were alluded to earlier (p 13). The Vice-Chancellor, Professor Bruce Williams, responded to the difficulties being experienced by both the Dairy and Poultry Foundations by agreeing to the appointment, on University establishment, of an Administrative Assistant to the Department of Animal Husbandry whose duties would include those of Secretary to both Foundations. Further, the Chair of Dairying vacated by Professor Lascelles was replaced by a second Chair of Animal Husbandry at Camden. Professor E.F. Annison, whose research background included ruminant metabolism, physiology of lactation and poultry science, was appointed to the second Chair of Animal Husbandry, and arrived at Camden in late 1974.

In early 1975, the Department was extremely fortunate to acquire the services of Mr Charles Morbey, a retired Naval Officer, as Administrative Assistant, and Secretary to the Foundations. At that time the most pressing requirement of the DRF was the recruitment of more Company members, since income from member's annual subscriptions and sundry grants had fallen to somewhat less than $10,000 in 1975. The recruitment of new members could only be achieved by publicising the value to the dairy industry of the Foundation's research and development activities.

Charles Morbey proved to be a most effective spokesman for the Foundation, and made every effort to visit dairy companies who were potential members. Other approaches to the problem of more effective involvement with dairy producers were the holding of Field Days at Wyong and Jamberoo in 1975, and of several seminars at Camden, with the co operation of the Extension Services of the Department of Agriculture. University academic staff at Camden and invited speakers from the dairy industry gave presentations at these efforts to liaise more effectively with the dairy industry. Dr Graham McDowell, a Senior Research Fellow at the Dairy Unit, played in a key role in these Foundation activities.

Research activities at the Dairy unit in 1975-76 included studies on the role of hormones in lactation, the control of staphylococcal mastitis by vaccination and the protein requirements of the lactating ruminant. The current Director of the Foundation, Professor W.J. Fulkerson, was then a PhD student supervised initially by Professor Lascelles, and subsequently advised by Dr McDowell and supervised by Dr Kellaway, spearheaded the research on the hormonal control of lactation. The data generated in these studies were reported in 5 refereed publications, (see Annual Report, 1976) a notable achievement.

The continuing interest of the dairy industry in reducing the incidence of mastitis prompted Dr Mc Dowell to initiate protection by the formulation of staphylococcal vaccines as possible measures of mastitis control. These studies were undertaken with Mr P.Darton, a PhD student.

Dr R Kellaway and his PhD student, Mr Ranawana, continued their studies on the effects of supplements of abdominally infused casein on milk production in lactating goats. The increases in milk yield confirmed the importance of ensuring that a high proportion of feed protein, both naturally or in response to processing, should escape from the rumen and undergo digestion and absorption from the small intestine.

Dr Kernohan completed her studies on yellow strain under the supervision of Dr Kellaway in 1977. Dr Kernohan, who had been appointed to a lectureship in the Department of Animal Husbandry in 1975, became Assistant Director of University Farms in 1978, and succeeded Professor Frank Crofts as Director in 1982, before entering State Parliament as a member of the Legislative Assembly in 1991.

Dr Kernohan was an ex-officio member of the DRF Council from 1975, and was appointed a Governor of the Foundation when she entered State Parliament. Dr Kernohan, who was raised on her family's dairy farm in the Hunter Valley Region, was a dedicated supporter of both the dairy industry, and the Foundation. Her sudden death in 2004 deeply shocked and saddened her numerous friends and admirers at Sydney University and in local and State Government circles.

The Dairy Unit, under the leadership of the Research Director Dr McDowell competed successfully for Dairy Research and Development Council, Dairy Research Council and Reserve Bank Rural Credits Grants. This research funding made it possible for the Dairy Unit to accept a steady flow of postgraduate students, many from overseas (Table 4, p 69). This access to research funds for basic research provided suitable research programs for postgraduate students. The effectiveness of these programs was demonstrated by the continued high output of research publications based on successful postgraduate degree theses.

The vacant teaching position resulting from appointment of Dr Kernohan as Assistant Director of University Farms in 1978 was filled by Dr James Gooden, a

former PhD Student at the Dairy Unit who had moved to a position with D.S.I.R. New Zealand after completing his PhD. Dr Gooden's previous association with the Dairy Unit ensured that he quickly established his teaching and research activities, and in addition became an enthusiastic and effective player in Dairy Foundation affairs. Dr Gooden was appointed Research Director of the Dairy Unit when Professor Mc Dowell moved to La Trobe University in 1989. Dr Gooden was promoted to Associate Professor in 1994.

Mr Rupert Rudder, the first Chairman of the DRF, represented the Nestle Company (Australia) and was succeeded in 1974 by Mr Harold Marchant, who at that time was C.E.O. at Nestle. Mr Marchant remained Chairman until he retired from Nestle in 1982. The Council elected Mr Don Ferguson of the Dairy Industry Marketing Authority, Chairman of Council in 1983, but ill health compelled Mr Ferguson to resign from the DRF Council in 1984. Mr Ferguson was the son of Mr Jack Ferguson, who as Chairman of the NSW Milk Board played a vital role in the formation of the Foundation (p 6). Mr Murray Mead, of Dairy Farmers Cooperative Ltd replaced Mr Ferguson as Chairman of the Foundation in 1985 but sadly died suddenly in 1986. Mr Robert Whan (NSW Dairy Corporation) who was Deputy-Chairman at that time, was elected Chairman and retained that position until other commitments compelled him to resign in 1989. When Mr Whan became Chairman in 1986 he felt strongly that the Foundation should increase efforts to raise company membership. In spite of the persistent efforts of Mr Charles Morbey to increase company membership aided by the success of the Annual Symposia and Country Tours, the number of company members had shrunk to 6. The loss of the support of the Nestle Company (Australia) in 1985 was particularly regrettable, in view of their generous support since the formation of the Foundation. With the help and encouragement of Mr Whan, however, renewed efforts to recruit new members had some success with the Commonwealth Bank, NSW Dairy Farmers Association and the Bega Cooperative Society Ltd joining the Foundation. Membership subscriptions rose to about $20,000 per annum in 1988, an increase of about $4,000 over the annual subscription income of the previous decade. The

number of company members was maintained and by 1991 the membership had grown to 10 and the annual subscription income had risen to nearly $24,000.

The impact of the relatively small contribution of member's annual subscription income on the activities of the Dairy Unit at Camden had always been overcome by the success of Research Directors and their colleagues in competing for dairy industry research grants. This funding pattern began with Dr Whittlestone, the first Director and is largely unchanged to this day. The University through the Faculty of Veterinary Science provides academic staff salaries, major equipment and infra-structure costs. In return, the contribution of the Dairy Unit to undergraduate and postgraduate teaching, and in particular, the continuing impressive output of research publications has contributed significantly to the academic standing of both the Veterinary Faculty and the University.

Mr Charles Morbey retired from the University in 1984 after a decade of unstinting service to the Dairy and Poultry Foundation, and to the Department of Animal Science. Mr Peter Hewson succeeded Charles Morbey, transferring from the University Accounts Branch to the Department. Mr Hewson was a most welcome appointment as Secretary to both Foundations, and his decision to leave the University in 1987 to enter the hotel industry was a considerable blow to the Department and Foundations. The loss of Mr Hewson coincided with increasing financial stringencies imposed on the University by inadequate Federal Government funding. At that time more than 90% of the funding for the Veterinary Faculty provided by the University was committed to staff salaries.

In order to increase the funds for general use by the Department of Animal Science, the position occupied by Mr Hewson was sacrificed in the interests of salary savings. This decision would have severely disadvantaged both the Dairy and Poultry Foundations if, a year earlier, the foundations had not been fortunate enough to employ a part-time Administrative Assistant, Mrs Deirdre Pudney. Mrs Pudney, with both administrative and superb interpersonal skills, coped splendidly with a work load that included monitoring Foundation income and expenditure,

organising two annual council meetings, assisting with the arrangements for the Annual Symposia and Country tours and acting as a friendly and efficient interface between members and the University. Mrs Pudney's resignation in 1998 was much regretted by both Foundations.

In 1977 the Foundation presented the first formal symposium featuring an invited overseas speaker, Dr A. Robertson from Edinburgh, UK (p 4). Seminars and meetings on a range of topics had been part of normal Foundation activities since the appointment of the first Research Director at Camden, Dr Whittlestone. The overseas speaker at the second Symposium was Dr W.H. Broster, from the National institute for Research in Dairying, Reading UK. Dr Broster was well known for his comprehensive studies on the inter-relationships between feed intake, live weight and milk production in high yielding cows throughout lactation. At that time average milk yields on Australian pasture fed dairy herds were low by U.S.A., UK and Israeli standards, where supplementary feeding of dairy cows was standard practice.

The main speaker at third Symposium, held in 1981, was Professor David Armstrong from the University of Newcastle, UK, a well known authority on ruminant metabolism, who in his address highlighted the new UK system of feed protein classification for ruminant livestock. Professor Armstrong, a great speaker with a warm personality was popular with dairy producers when he undertook the first of the Country Tours which were an important feature of succeeding Symposia. Symposium 4, 1982, welcomed back Dr Walter Whittlestone from Ruakura, as the featured speaker on advances in milking technology. Dr Whittlestone addressed dairy producers at a succession of meetings from Bega to Brisbane. In response to advice from the dairy industry, Dr Broster was invited back to address Symposium 5 in 1983, and spoke on the feeding and breeding of dairy cows. In 1984 Dr R.H. Phipps, from N.I.R.D., UK, in his featured address discussed the production, conservation and utilization of maize silage for milk production. The Foundation had by this time firmly established the Annual Symposium as a forum for dairy producers in the Eastern States. A full list of

overseas invited speakers and the topics that they addressed at Annual Symposia from 1977 to 2007 are shown in Table 6 (p 73).

Associate Professor Graham McDowell and Dr James Gooden cheerfully accepted the major burden of organising the country Tours, and accompanying the speakers, who usually travelled with their wife or partner, to widely scattered rural centres and cities.

The resignation of Mr Whan in 1989 and the election of Mr Tony Perich as Chairman (now termed President) and Mr Rowan Moore as Vice President represented a significant change in Foundation management. Both President and Vice-President were, and indeed still are successful and innovative local dairy farmers. Mr Tony Perich, the owner and "hands on manager" of a very large dairy farm was also the major player in a range of similarly successful business activities. The new President, like his predecessor Mr Whan quickly appreciated that Foundation income was too small, but that mergers resulting in the reduction in the numbers of dairy companies made it unlikely that a significant increase in company membership could be achieved. Mr Perich convinced the Council that income could be generated from the established Annual Symposia, which were well supported by dairy producers. This could be accomplished not by raising Symposium fees, but through increased sponsorship from dairy companies and relevant associated industries. This approach to fundraising proved effective largely because of Mr Perich's personal intervention, and his extensive business contacts.

Mr Perich pointed out to the Council that the Foundation, in focusing on overseas speakers for the Symposia from UK, had neglected to engage dairy extension experts from U.S.A. This led to the decision to invite Dr Don Bath, a well known U.S. authority and communicator in the field of dairy extension. The Foundation featured Mr Bath as the main speaker at a major Symposium held at Jupiters Casino on the Gold Coast in 1991. The symposium was an outstanding success, and in subsequent years a number of speakers held in high regard in U.S.A. accepted invitations to speak at Foundation Symposia (Table 6, p 73).

The new approaches to sponsorship initiated by Mr Perich proved to be timely because the Commonwealth Bank, which had generously supported the Annual Symposia and Country Tours from 1985, discontinued their support in 1990. The normal sequence of a Symposium and Country Tour resumed after the 1991 major dairy industry Symposium on the Gold Coast, and Allowrie Foods, Australian Cooperative Foods, Continental Airlines and the Dairy Research and Development Corporation (DRDC) were all major sponsors of the 1992 Symposium and Country Tour. The support of Continental Airlines, which continued until 1994 when the airline discontinued services to Australia, was due to the successful lobbying of a long serving member of Council, Mr Douglas Crosby. At succeeding Annual Symposia and Country Tours, major sponsors included National Dairies, Dairy Farmers and National Foods Milk Ltd. From 1999, the major sponsorship was shared by National Foods and Dairy Farmers.

The successful approaches to Foundation sponsorship introduced by the President, Mr Perich, overcame the financial constraints that had limited further development of both the Annual Symposia, and Country Tours. The extra funding made it possible to invite more speakers to the Symposia, improve the venues for the Symposia, enlarge the Country tours and substantially improve the quality of the published Symposia Proceedings. These developments would not have been possible without the enthusiasm and dedication of Dr Gooden, who with limited administrative assistance not only ensured that all aspects of the Symposia operated smoothly, but always accompanied the overseas speakers and their partners on the Country Tours.

The minutes of the 1970 AGM included a generous and well deserved tribute to Mr John Alexander Ferguson (Jack Ferguson), the long-serving Chairman of the NSW Milk Board who died August 2nd, 1969. As outlined earlier, Mr Ferguson's support for the proposal to establish a DRF ensured invaluable dairy industry support.

## Research Activities 1977-1990

Dr McDowell's studies on the control of staphylococcal mastitis with Mr P Darton, a PhD student, continued until 1981. This research was funded by the Dairy Research Committee (DRC) and the Australian Research Grants Committee (ARC). Early studies based on the local immunisation of heifers in the University herds at Camden, and at Bega Demonstration Farm yielded promising results. The incidence of mastitis in immunised quarters of the udder was substantially lower than in non-immunised quarters. These findings encouraged detailed studies on basic aspects of immune responses to staphylococcal antigens. An important research finding was that staphylococcal mucopeptide is an important antigen of the staphylococcal cell wall. The mucopeptide proved to be at least as effective as whole killed staphylococci in vaccination trials. Although this research yielded valuable data on immunological responses to staphylococcal infections in the mammary gland, field trials showed that mastitis could not be controlled by a single vaccine. The range of bacteria involved in mastitis contributes greatly to the difficulty of immunological approaches to mastitis control.

In the late 1970's, Dr Kellaway collaborated with Dr Jane Leibholz, and Mr Tom Grant, a farmer at Cowra, to develop diets for early waned calves. The studies demonstrated the beneficial effects on the growth of calves of the inclusion in the diets of roughage and buffers. The roughage had an important role in promoting rumen development by stimulating the production of saliva, a natural buffer, which together with buffers in the diet contributed to a rumen environment (pH $>5.5$) able to support the proliferation of the cellulolytic microorganisms which digest roughage. The research led to the development of the commercially successful 'Venavite' calf rearing system marketed by Mr Grant.

The success of the Dairy Unit in attracting postgraduate students was evident by 1980, when 6 PhD students and 3 M.Sc.Ag students were undertaking research projects (Annual Report, 1980). One of the PhD students was Mr P.C Wynn, who after completing his degree, supervised by Dr McDowell and Professor Annison,

joined C.S.I.R.O at the Prospect Laboratory before returning to Camden as Senior Lecturer in 1990. Dr (now Associate Professor) Wynn remains active in both dairy research and Foundation affairs.

The main thrust of research at the Dairy Unit in the period 1980-90 involved the many factors that influence lactation in the dairy cow. In some instances lactating ewes were used as models for the dairy cow both to minimise the costs of experimental animals and their housing and maintenance, and for ease of handling and surgical preparation for physiological studies. In addition, in metabolic studies, greatly reduced amounts of expensive and potentially hazardous radioisotopes were required.

An exciting development in the 1970's was the application of knowledge acquired many years earlier that milk yields in well-fed dairy cows could be increased by about 10% by the injection of growth hormone. This finding became of great interest when growth hormone was produced in large amounts by genetically engineered bacteria and became available for commercial use. The possible use of this product in Australia led Professor (then Dr) McDowell to spend his study leave in 1982 with Dr Ian Hart at N.I.R.D, in the UK. Dr Hart was a recognised authority on growth hormone, and Professor McDowell quickly acquired the necessary skills to work in this new field. When Professor McDowell returned to Camden in 1983, he initiated a series of studies both on the efficacy of somatotrophin (the commercial term for growth hormone) in stimulating milk production under Australian conditions, and on the biological mechanisms involved.

The Dairy Unit in the 1980's was ideally suited to investigate the metabolic effects of somatotrophin. Professor McDowell had built an effective team of trained technical staff and postgraduate students, and had established good relationships with overseas research groups working on somatotrophin. In addition Dr Gooden, his colleague and collaborator was a gifted surgeon with considerable experience in the preparation of surgically modified animals for metabolic studies.

Professor McDowell recognised that most dairy herds in Australia were pasture-fed, with limited use of feed supplements. The increased milk production in somatotrophin treated cows, which averaged about 10%, resulted in an equivalent increase in feed intake. Failure to provide adequate supplementary feeding resulted in excessive liveweight loss, which in turn could adversely affect fertility if not corrected in late lactation. Another difficulty was the need for daily injections of somatotrophin, a problem partially overcome some years later by the use of slow release hormone injections. These difficulties in the use of somatotrophin in the Australian dairy industry provided the stimulus for the detailed metabolic studies on lactating ewes and cows undertaken by Professor McDowell and Dr Gooden, together with a number of postgraduate students.

Experimental animals with surgically fitted catheters in external and internal blood vessels and in some cases lymphatic vessels were used to measure and compare the uptake or release of circulating metabolites by the mammary gland and skeletal muscle. Most interest focused on the circulating metabolites used by muscle tissue for energy requirements, and by the mammary gland for milk biosynthesis. Measurement of the concentrations of glucose, free and bound fatty acids and amino acids in arterial blood, and in the venous blood draining the defined tissue combined with blood flow measurements provided quantitative data on body tissue and mammary gland metabolism. These measurements were made in animals treated with somatotrophin and compared with values obtained in untreated control animals. Data were obtained in ewes and cows in different physiological and nutritional situations. A major finding was that somatotrophin increased the availability of glucose for milk synthesis in somatotrophin treated animals by sparing glucose utilisation in skeletal muscle, the energy deficit being met by circulating fatty acids. The results of these metabolic studies were published in a series of papers (Table 7, p 77).

The capacity of computers to store and process vast amounts of disparate data began to be exploited in the early 1980's to formulate computer simulation models to assist in the management of domestic animals. Dr Kellaway, during his sabbatical

leave in the USA in 1982 developed a nutritional management program for dairy cows based on a University of California model. The new system, termed 'CAMDAIRY', was quickly adopted by the dairy advisers of the NSW Department of Agriculture. This initial success encouraged Dr Kellaway to embark on the continuous modification and improvement of the CAMDAIRY program based on the acquisition of data from the increasing numbers of users of the system. The latter are largely dairy advisers in both the Government and private sectors, although an increasing number of computer literate dairy producers are adopting the CAMDAIRY system. The program has been taken up by advisory staff in the UK and Spain, and Dr Mark Stephenson, a former student of Dr Ian Lean, introduced CAMDAIRY to New Zealand. In 2000, computer programmers at Massey University worked with Dr Kellaway to improve the user interface and help screens of the program, to facilitate use of the program as a teaching aid. The new version, released in 2002, was sold to Ridley Agriproducts Pty Ltd, a major supplier of animal feeds in Australia.

In 1989 the Dairy Unit purchased new equipment for the continuous measurement of blood flow. The ultrasonic device proved to be reliable and accurate over a range of different applications and was used in a series of studies on nutrient absorption from the alimentary tract, and subsequent utilisation in tissues. A few years later the equipment was used for the indirect measurement of energy expenditure in animals by measuring oxygen uptake from the blood supply to the lungs.

The staff at the Dairy Unit was always willing to collaborate with other scientist and institutions, and a typical example was the joint research with Dr Graeme Rogers at the Ellinbank Dairy Research Institute, Victoria.

Dr Rogers and his colleagues had been examining the increases in milk yields in dairy cows fed ryegrass pastures containing high levels of white clover. The long held explanation for the higher milk yields on clover dominant pastures was increased feed intake stemming from the faster clearance of clover from the rumen. Another possible explanation was that absorbed nutrients in clover fed dairy cows

are used more efficiently for milk production. This hypothesis was tested using the procedures for the measurement of nutrient supply and utilisation in dairy cows developed at the Dairy Unit. The arterio-venous difference studies were applied to sets of surgically prepared identical twin dairy cows. One of each set of twins was fed clover, and the other ryegrass. No clear differences in the pattern of utilisation of nutrients emerged from these studies. Quantitative differences in nutrient supply could be accounted for by differences in feed intake, in accordance with conventional wisdom.

## Research 1990-2000

The departure of Dr McDowell in 1989, and increased teaching commitments in the Department of Animal Science made it possible to appoint two new Senior Lecturers in 1990. These were Dr P.C Wynn and Dr I.J Lean, both of whom had studied at Camden earlier in their careers. Dr Wynn, a University of New England graduate, completed his PhD at the Dairy Unit under the supervision of Dr McDowell and Professor Annison in 1982. Dr Lean graduated in Veterinary Science at Sydney University in 1974.

At the completion of his PhD, Dr Wynn competed successfully for a prestigious C.S.I.R.O post-doctoral Fellowship at the National Institutes of Health (N.I.H), USA. At N.I.H, Dr Wynn worked with Professor Catt, a distinguished cell biologist, for two years before joining C.S.I.R.O at the Prospect Laboratory as a Research Scientist. Dr Wynn's research program included detailed studies on the effects at the cellular level of epidermal growth factor, in support of the efforts by C.S.I.R.O to develop systems of wool harvesting by chemical treatment. Dr Wynn's studies on growth hormone during his PhD program and subsequent experience in cell biology at CSIRO were invaluable in his research at Camden on the control of lactogenesis in dairy cows.

After graduation, Dr Lean entered veterinary practice in the Hunter Valley region, specializing in dairy herd health and production. Some 5-6 years later, he decided to pursue research in this field by undertaking postgraduate studies for his PhD at the University of California. His major research topic was an in-depth study of the effects of somatotropin on the health, productivity and nutritional requirements of high yielding dairy cows. Effective studies in this field of research require large numbers of animals, which the University of California was able to supply. The interpretation of the results of studies with large numbers of dairy cows relies heavily on the use of epidemiological statistics, and Dr Lean acquired the necessary mathematical skills. A major weakness in much dairy cow trialling in Australia has been the failure to take advantage of advances in population statistics in the design and interpretation of experiments. Dr Lean is also an authority on meta-analysis, which makes possible the retrospective evaluation of earlier published data.

Until the arrival of Dr Lean, almost all of the animal research at the Dairy Unit had involved intensive studies on relatively small numbers of animals. Indeed, for detailed metabolic studies which require frequent sampling of tissues and body fluids no other approach is feasible. The large scale trialling of dairy herds with daily or weekly sampling of blood and/or rumen contents is an effective approach in the identification of metabolic diseases or disorders which impact on milk production, or in the evaluation of the effects of new treatments or management systems. If rigorous statistical examination of the experimental data reveals effects on metabolism, these can be studied intensively in small numbers of animals. This approach was pursued effectively by Dr Lean and his colleagues, as discussed below.

Dr Lean, fresh from his postgraduate studies on dairy health and production in California, was anxious to resume research in this area at Camden. At first sight, the presence of the University dairy herd at Corstorphine would have seemed a potential resource for Dr Lean's research, but the herd had never been used for major research projects. The herd had been established by Mr Geddes some years before the formation of the Department of Animal Husbandry in 1955, and had

always operated independently of the Faculties of Veterinary Science and Agriculture. A small number of animals were made available to the Faculties each year for undergraduate teaching purposes, but Faculty members played no part in the management of the University dairy herd until Dr Kernohan became the Director of University Farms in 1979. Dr Kernohan sought help from Professor Nicholas, Head of the Genetics Unit in the Department of Animal Science, and a recognised authority on dairy herd improvement. Within a few years, the performance of the University herd rose considerably. Dr Kernohan supported the concept of research within the herds, but was constrained by the strict commercial focus of the administration brief given to her. The herd access, consequently, was limited for research studies. This problem was overcome initially by enlisting the help of dairy producers sympathetic to research, and who were generous enough to allow their animals to be used in studies of immediate relevance to the dairy industry.

The ideal solution to Dr Lean's research needs, however, was the acquisition of sufficient research funds to develop and maintain a dairy herd for research purposes. This objective was met in 1998 when the University joined forces with New South Wales Agriculture and several major dairy companies to compete successfully for an Australian Research Council (ARC) Collaborative Research Grant in Dairying (CRG). The complex and time consuming task of organizing meetings and interviews with potential partners, and producing the formal application fell to Dr Lean, whose enthusiasm and commitment was critical to the success of the combined venture. The initial grant from ARC of $240,000 per annum was conditional on the partners raising $120,000 from the dairy industry. These additional funds were generously provided by the industry and during the 3 year life of the project; approximately $2.4 million was raised in support from all sources.

The key objective of the ARC research funding was improved efficiency of milk production, which required quantitative studies on the complex interactions of nutrient supply and milk production in individual animals. The University dairy herd at Corstorphine was not equipped for these measurements, and in any event, was unlikely to become available for long-term studies. Similarly, the limited facilities at

the Dairy Unit were inadequate for measuring production responses to nutrient supply. After prolonged consideration of possible sites for the construction of an appropriate concrete feed pad equipped with Callan gates for the accurate measurement of feed intakes, May Farm was selected as the best available site for the new dairy unit. Dr Lean and Mr Jim Della Vedova were responsible for building and maintaining the Callan gates.

This decision was reached with the agreement of the University Farms Manager, Mr Allingham, and with the approval of Mr Fulton, the University Properties Manager. All parties agreed that rationalization of dairy production and research and development in dairy science at Camden was long overdue, and that a major dairy facility housing several hundred cows, and equipped to meet the needs of teaching and research, was a worthy long term objective. The May Farm facility, however, was an invaluable stop gap measure which made it possible to implement the CRG research program. Dr Gooden, Research Director of the Dairy Unit, accepted much of the responsibility for the construction of the May Farm dairy cow feed pad and also organised office facilities for staff by the installation of portable housing. The small dairy herd at the Dairy Unit moved to May Farm, but the number of animals was too small to allow effective research. This was overcome by the provision of animals from two sources. Mr Fulton, the University Properties Manager generously permitted the loan of a number of cows from the University dairy herd. These animals were supplemented with the help of a number of local dairy producers, namely Messrs. Tony Perich, Rowan Moore and Bill Inglis who kindly loaned enough animals to allow the May Farm herd to be used for quantative research and development. Synopses of this research appear below.

Research at May Farm, which, thanks to the unstinting efforts of Dr Lean and Dr Gooden and their postgraduate students and support staff, began with so much promise, was severely handicapped by two developments, which were probably linked. These were the decision of ARC not to renew the CRG funding in 1996 and the departure of Dr Lean to set up his own consultancy, Strategic Bovine Services. Inevitably, research at May Farm diminished until the arrival of Professor Bill

Fulkerson to the position of endowed Chair of Dairy Science funded by the dairy industry. Within a few years Professor Fulkerson was able to integrate May Farm into the new Corstorphine Dairy.

In the decade 1990-2000, research productivity rose sharply, in response to the arrival of Drs Lean and Wynn, and the continued research activities of Drs Gooden and Kellaway. The research group was outstandingly successful in competing for industry and national research funds, as exemplified by their financial support for 1991-95 (Table 8, p 114). This increased funding made it possible to accept considerably more postgraduate students, and the numbers enrolled rose from 10 in 1990 to 21 in 1995. The number of publications in refereed scientific journals increased proportionately with the high success rate of postgraduate students.

Synopses of the major research areas studied during the decade are shown below. The need to use sheep, and in some instances pigs, as animal models for subsequent studies with dairy cows was discussed earlier (p 24).

1.Arterio-venous difference studies

The availability of the ultrasonics system for the accurate and continuous measurement of blood flow made it possible to measure nutrient flows across tissues, and by measuring oxygen removed from arterial blood by the lungs to calculate the total energy expenditure of the animal.

a) Nutrient flows

Amino acids absorbed from the small intestine reach the liver via the portal vein. The high portal blood flow and relatively small portal-arterial differences make quantification of amino acid uptake from the gut difficult, but the capacity to measure blood flow accurately and continuously largely overcame this problem. These studies were undertaken by Dr Gooden and his postgraduate student, Stephen Neutze, and in some instances, with Dr Hutton Oddy of the Elizabeth Macarthur Agricultural Institute (EMAI).

b) Tissue metabolism

Drs Lean, Gooden and Miller devised a new method for evaluating ovarian function in sheep by combining AV difference studies with the continuous measurement of ovarian blood flow. The uptake of a range of metabolites, and of oxygen was measured, with particular emphasis on the role of cholesterol in progesterone synthesis. This model was extended to dairy cattle and resulted in the first in vivo estimates of energy use by the ovary and the first in vivo description of substrate use by the ovary in any species. The luteal ovary was found to be a very metabolically active organ, which utilises glucose as the major source of energy. The uptake of cholesterol by the ovary was strongly linked to the uptake of glucose.

2. Indirect measurement of energy expenditure

A procedure for the indirect measurement of energy expenditure from total oxygen consumption was developed based on the measurement of cardiac output and the uptake of oxygen by the lungs. The continuous recording of oxygen consumption was made possible by combining transit-time, ultrasound measurements of blood flow with blood oxygen levels measured by fibre-optic oximetry. The procedure was applied successfully to calculate energy expenditure in pigs and sheep from whole-body oxygen consumption and was extended to study energy metabolism in the mammary glands of dairy cows. These studies were undertaken by Dr Gooden, Professor Annison and their students, Zuu Rajcyk, David Ward, Heather Bray, Roger Giles and Mark Lorschy, in collaboration with Dr J.L. Black of CSIRO, Prospect.

A major weakness of the system for the measurement of energy expenditure based on oxygen consumption was the need to restrain the animal, because the recording of blood flow and blood oxygen levels required leads to conduct electrical signals to relatively bulky equipment adjacent to the animal. At the time these studies were undertaken, the research staff involved were confident that developments in electronics would make it possible to apply the procedure to the grazing animal, and

obtain data on normally managed dairy cows. Two possible approaches would be either to construct a small, lightweight recording apparatus that could be carried by the grazing animal without interfering with normal behaviour, or the development of micro-transmitters incorporated into the blood flow and oxygen measuring equipment and able to transmit data to recording equipment housed nearby. At this time these advances in electronics have not occurred, largely because of lack of funding for this area of research. The successful miniaturisation of recording equipment used in human medicine, however, may well prove adaptable to animal research.

3) Role of vitamin D in milk fever

The then Director of the Foundation, Professor David Fraser, an internationally recognised authority on the role of vitamin D in calcium metabolism, began a series of studies in 1990 on the role of vitamin D in milk fever with his post graduate student, Michelle Hyde. This research continued until 1997, and contributed significantly to knowledge of the impact of milk fever on overall calcium metabolism. The major finding was that milk fever impairs calcium homeostasis, and prevents cows from responding rapidly to the sudden increased demand for calcium at the onset of lactation. A subsidiary finding was that a high roughage diet enhances calcium absorption from the rumen, and that the ruminal absorption of calcium becomes crucial during milk fever, when uptake from the normal major absorptive site, the small intestine, is adversely affected.

4) Effect of nutrition on the quality of milk

This study by Drs Lean and Gooden, and their postgraduate student, Jennianne Garvin, was based on 82 multi-parous lactating cows of differing genetic merit, and examined the influence of the rumen degradability of dietary protein on the yield and composition of milk and its suitability for cheese manufacture. Blood profiles for the major energy yielding metabolites were measured, and factors which influenced yield of milk protein, total casein and individual caseins and were identified using

stepwise multiple regression. Similar statistical treatments were used to examine metabolic contributors to total milk, fat and lactose yields. The studies fleshed out earlier findings by its emphasis on sound experimental design and statistical treatment of comprehensive quantitative data. The efforts of Professor Frank Nicholas and Dr Liz Kernohan in producing a herd of high genetic merit were validated in the study, as cows fed in the study produced at levels consistent with more than 12000 litres per lactation. This was an important finding for farmers and gave them confidence that Australian dairy cows could produce at levels consistent with those in the Northern Hemisphere.

5) Effects of dietary protein and cow genetic merit on dairy cattle reproduction

This large scale study was undertaken by Dr Lean and his PhD student, Charlotte Westwood. The impetus for this work was generated by conflicting observations on the effects of high levels of dietary rumen degradable protein (DRDP) on the fertility of dairy herds. The negative association of high concentrations of DSRDP in herds in the Northern hemisphere was not found in Australian and New Zealand dairy herds maintained on pastures with high levels of DRDP. The intensive observations on energy balance and fertility intrinsic to this study were made in well designed experiments, and the data analysed by appropriate statistical analysis. Important interactions between protein degradability, body weight, dry matter intake and fertility were demonstrated. Diets of higher degradability did reduce fertility; however, these effects were not independent of body weight loss. There was little or no evidence that genetic merit had a substantial effect on fertility, but higher milk production, however, did have a very substantial effect on fertility. This effect was directly moderated by higher feed intake. These findings have been widely cited. Again, blood cholesterol and glucose levels were important metabolic indicators associated with fertility.

6) Hormonal factors that regulate the expression of milk protein genes

This and subsequent studies in this research field were undertaken by Dr Wynn and his PhD student, Mr Paul Sheehy, in collaboration with Dr K Nicholas, then from the Victorian Institute of Animal Science, Attwood, Victoria. The studies were based on the availability of mammary explants and prepared from tissue obtained by biopsy by Mr Della Vedova. The explants were derived from mammary tissue collected at intervals before and after calving, and the synthesis of casein in the explants occurred by inducing expression of the casein genes in the tissue by exposure to a combination of the hormones insulin, cortisol and prolactin.

7) Meta-analysis of reproductive manipulations using hormones:

A series of studies based on meta-analysis were conducted by Dr Lean with veterinary students Mr W Morgan, Ms Natalie Burton, PhD student Margaret Curtis, and Masters Student Mr Sam Beckett. These studies were among the very first in animal and veterinary science and data from many small and some large field studies were used. The study led to the identification, with much greater confidence than hitherto, of ways in which the reproductive hormones prostaglandin and gonadotropic releasing hormone (GnRH) influence fertility and other aspects of reproduction in dairy cattle. Importantly, the use of GnRH in repeat breeder cattle was found to be effective at increasing rates of conception by nearly 25%. This remains the only effective treatment for improving fertility in this group of cattle.

8) Farm Factors Affecting Fertility

In her Master's study with Dr Lean, Ms Fleur Webster investigated the farm level factors influencing fertility in herd-recorded farms in NSW with the best and lowest reproductive performance. Managers of herds with poorer reproductive performance did not mate cattle as soon after calving as managers with better reproductive

performance, were not as active in seeking veterinary advice on reproduction, and attempted to treat reproductive diseases and disorders themselves. Examination of 83 management practices affecting fertility indicated that managers of herds with good reproductive performance employed better management and breeding practices than managers of herds with poor reproductive performance

9) Culling in Dairy Cattle in NSW

Culling in dairy cattle in NSW was investigated by Dr Lean in conjunction with Mr Mark Stevenson.

In two studies, one retrospective and one prospective, it was found that overall herd wastage rates were 27% of the herd per year, a level similar to surveys conducted recently in Australia and overseas. Several approaches which minimise involuntary culling and maximise herd profitability were identified including:

(i) Culling decisions need to be flexible, taking into account an individual's milk production, age, reproductive status, and genetic value;

(ii) Since a high level of involuntary loss was associated with the peri-parturient period, improved husbandry, housing, and nutrition of stock during the period before, during, and immediately after calving should assist in minimising involuntary losses;

(iii) Reduction of the mean age at first calving and maintaining the mean length of productive herd life will enable a reduction in exposure to the high level of risk associated with increasing length of herd life, with the *proviso* that heifer rearing needs to be optimised in order for the benefits of this strategy to be realised, and;

(iv) In herds where there are progressive reductions in intercalving interval (usually associated with improved reproductive performance), there is a need to improve mastitis control and nutritional management in order to reduce involuntary losses stemming from udder disorders and low milk production.

10) Studies on rumen modifiers (monensin, virginiamycin, tylosin)

Associate Professor Roy Kellaway, Dr Geoffrey Annison and Dr Ian Lean studied the effects of acidosis in dairy cattle with PhD student Yanin Opatpatanakit. It was clear from these studies that there was a great deal of variability in grains in their potential to induce acidosis. In studies of cows at pasture on tightly controlled diets it was not possible to demonstrate acidosis readily despite diets that should have disrupted rumen function. These studies provided the impetus to further examine the role of rumen function using the rumen modifiers virginiamycin, monensin and tylosin. Comparative studies using sodium bicarbonate were also conducted. Dr Lean in conjunction with Professor Jim Rowe of the University of New England found that virginamycin was an effective agent for reducing the risk of acidosis and that monensin and tylosin in conjunction markedly increased ruminal production of propionate and increased milk production, while maintaining what appeared to be a more stable rumen environment.

A series of studies were conducted using monensin sodium by Dr Lean, Dr Nori Abe (visiting Japanese scholar), Mr Sam Beckett, and Ms Kellie Stephenson, a BVSc student. In these studies the effects of monensin on milk production and reproduction were examined in several thousand cows, by the monitoring of the levels of ketone bodies and glucose in a significant number of animals. The population studies looking at milk production and reproduction involved several thousand animals. It was found that monensin was very effective in reducing ketone levels in dairy cattle and indeed ketosis. Despite this action and improving glucose concentrations in blood, there was no significant effect on reproductive performance of cattle. Milk production was significantly increased, while milk

protein concentrations held constant or increased and milk fat concentrations slightly decreased. These Australian studies led to accurate prediction of the results of studies later conducted in other research centres and have been extensitively cited.

11) Studies on metritis in dairy cattle

In these studies metabolic and epidemiologic relationships among anti-oxidants, blood metabolites, health and reproduction were examined in approximately 300 dairy cows by Dr Lean and PhD student Margaret Curtis. There were very significant associations among anti-oxidant concentrations over calving that were consistent with the hypothesised role of these in metabolism. Critically, concentrations of these anti-oxidants were related to health and reproductive outcomes. Approximately 82% of variation in calving to conception interval could be predicted in the statistical models developed. However, very little variation in conception at insemination was predicted. This finding was consistent with those in studies conducted with Ms Westwood and later with Mr Neil Moss. At best, approximately 7% of variation in conception was predicted in any of these studies. This finding raises considerable potential for future research in this area.

12) Protein requirements of dairy cows

The CAMDAIRY nutritional management system for dairy cows (p 25) includes estimates of protein requirements. The variable degradation of dietary protein in the rumen, however, and the passage of significant amounts of microbial protein from the rumen make it extremely difficult to estimate the amounts of protein which become available for digestion in the small intestine. Dr's Kellaway and Lean encouraged their PhD student, Mr B.B Jones, who had earlier demonstrated his skills in computer modeling, to tackle this highly challenging and complex biological problem.

The success of the resulting research efforts led to a modified CAMDAIRY system able to provide more accurate estimates of available protein in dairy cow rations. The new system was published in a monograph* which attracted favourable comments from overseas research groups committed to the modeling of the nutrient requirements of domestic animals.

* Jones, B.B., Kellaway, R.C. and Lean, I.J. (1996). Protein requirements of dairy cows. Dairy Research and Development Corporation.

## Research 2000 - 2007

The retirement of Associate Professor James Gooden, the Acting Director of the DRF and the departure of Dr Ian Lean severely restricted the research activities of the DRF and left a serious gap in the teaching resources of the Veterinary and Agriculture Faculties. Also, at that time the University Farms facilities, particularly the Corstorphine Dairy, were badly in need of refurbishment, and the whole of the Farms operations required rationalization.

The University, and the dairy industry through the DRF, recognised that the most effective solution to this problem would be to recruit a senior research scientist widely experienced in dairying and farm management. This led to the decision to create an endowed Chair of Dairy Science, as outlined below.

## Establishment of Chair of Dairy Science

The improvement in the profitability of the University Farms following the appointment of Dr Kernohan was achieved in spite of difficulties which included the limitations of the aging Corstorphine dairy, residual problems of overstaffing and the need to rationalise the management of the Corstorphine, May Farm, Westwood and Wolverton farms. The loss of Dr Kernohan to State politics in 1991 occurred at a

time when the continued location of the Veterinary Faculty at Camden was in question. If the Faculty had decided to move to an alternative rural centre, the continued operations of the University Farms would have been difficult to justify. These uncertainties led the University to defer appointing a new Farms Director to replace Dr Kernohan, and Mr Allingham, the Assistant Manager of the Farms assumed day-to-day responsibility for their management.

By the late 1990's, doubts concerning the long-term commitment of the University to the Camden campus had largely abated, but the difficulties concerning the management of University Farms alluded to earlier had worsened. The major problem was the increasing inadequacy of the Corstorphine dairy both in terms of its relatively small size, which limited profitability, and inadequate facilities to support teaching and research. The latter issue was highlighted by the complex arrangements which had to be implemented at May Farm in order to undertake the research funded the ARC Collaborative Research in Dairying (p 29). At about this time the DRF, representing the dairy industry, realised that the loss of Dr Lean and Associate Professor Gooden would severely restrict future dairy research at Camden unless new leadership emerged. Similarly, the Faculties of Veterinary Science and Agriculture recognised the need for the appointment of a senior academic able to accept responsibility for teaching and research in dairy science. A further significant issue was that University senior management appreciated that a suitable appointee would be able to accept the role of Director of University Farms, and contribute to the much needed rationalisation of the Farms. This three-fold recognition of the urgent need for the appointment of a senior academic experienced in dairy science led to much discussion between the relevant interests. These included the University, NSW Agriculture, the then Dairy Research and Development Corporation (now Dairy Australia) and the DRF.

The senior management of the University was represented by Mr Paul Slater, Pro-Vice Chancellor (Research), and academic interests were vigorously and ably managed by Dr Wayne Bryden, the Deputy Dean of the Veterinary Faculty. The successful outcome of these meetings was the decision to create a new, endowed

Chair of Dairy Science at Sydney University. NSW Agriculture, Dairy Australia and the DRF (from individual contracts with agribusiness sponsors) each agreed to provide $40,000 per annum, with the University supplying appropriate infrastructure and other support. The industry groups contributing to the annual DRF support for the new Chair of Dairy Science are listed in Table 9 (p 116).

The new Chair was advertised in 1999, and Dr W.J. Fulkerson competed successfully for the Chair in 2001. Professor (Bill) Fulkerson, who completed his Ph.D. studies at Camden in 1975, has had a distinguished career in dairy science, and is widely recognised for his research on the management of pastures for grazing dairy cows to maximise milk yields within a framework of increased overall profitability. He is very much a "hands on" research manager, and is involved in all aspects of dairy management and research. Professor Fulkerson had held senior research positions in the Departments of Agriculture in Western Australia, Tasmania and NSW.

In addition to his undergraduate and postgraduate teaching commitments at Camden, Professor Fulkerson was appointed Director of the DRF, and assumed responsibility for the overall management of the University Farms. The magnitude of these combined responsibilities for teaching, research and management is incredibly onerous, and made more difficult by the paucity of administrative and technical support staff. In these circumstances, the success of Professor Fulkerson in the rationalisation of University Farms, including the installation of a new Corstorphine dairy, and at the same time leading productive research and development projects was quite remarkable, as indicated in later sections.

Doubts concerning the long term commitment of the University to the Camden campus alluded to earlier, and the loss of Dr Kernohan as Farms Director undoubtedly contributed to the absence of significant investment in the University Farms during the period 1991-98. This led to the steady decline in the profitability of University Farms. In an effort to reduce operating costs, and in particular the losses accrued by the Corstorphine Dairy, the University had appointed Associate

Professor Kellaway as a consultant over the period 1997-2000. Associate Professor Kellaway, a member of the Department of Animal Science from 1968 until his retirement in 1997, was widely experienced in dairy cow management, and his skills in computer based modeling which culminated in the development of CAMDAIRY allowed him to provide a quantitative analysis and projection of each of the possible strategies to improve the profitability of all University Farms activities. For the first time, the resources of all eight University Farms were quantified in terms of stock carrying capacity under both dryland and irrigated systems. Not surprisingly, given Associate Professor Kellaway's experience in dairy cow nutrition, milk production at the Corstorphine Dairy rose 28% by 2000 in response to his recommendations. These increased milk yields (herd average 9000L/cow) were achieved by feeding high levels of feed concentrates. Professor Fulkerson, when appointed in 2001, reduced the inputs of feed concentrates in favour of increased levels of forages in order to mirror the feeding practices adopted by the majority of commercial dairy farms in NSW at that time. Milk yields fell to a herd average of 7700L/cow without economic penalty. In spite of these responses to improved management, the small capacity of the Dairy precluded profitable milk production.

Associate Professor Kellaway's two comprehensive reports to University management, however, highlighted the urgent need for the rationalization of University farms operations, and for the replacement of the Corstorphine dairy with a larger modern dairy equipped to support teaching and research.

In spite of the improvements to the management of University Farms achieved by Associate Professor Kellaway's consultancy, when Professor Fulkerson took up his appointment at Camden, the only operating funds came from a few thousand dollars profit from the DRF Annual Symposium. The Mayfarm operating budget was some $250,000 in debt and the other Camden farms were operating at a combined annual loss of about $200,000. The highly creditable turnaround in funding achieved by Professor Fulkerson since assuming responsibility for University Farms and initiating research programs is shown in Table 10 (p 117). The effective use of these industry funds is shown by the excellent publication rate of Professor

Fulkerson and his colleagues. Some 16 research papers in refereed journals and the publication of 5 invited reviews confirm the success of the research programmes.

**Construction of the new Corstorphine Dairy**

When Professor Fulkerson arrived at Camden to take up his Chair of Dairy Science, he was understandably dismayed at the obsolescent and poorly maintained state of the main dairy at Corstorphine, and of the two other dairies at Mayfarm and Wolverton. The inadequate maintenance of the dairies and other facilities on the University Farms began after the loss of Dr E. Kernohan, the Farms Director, to State politics in 1991. Factors contributing to the lack of investment in the University Farms were alluded to earlier. Dr Kernohan, during her stewardship as Director of University Farms regarded the construction of a new, large dairy to replace the aging Corstorphine Dairy as an issue of the highest priority. Indeed, she established a building fund for the new dairy by persuading the University to set aside a proportion of the Farms operating profit each year. At the time of Dr Kernohan's departure, several hundred thousand dollars had accumulated in this building fund. In the years after her departure, however, financial stringencies in the University Farms operations led to the loss of the funds sequestered by Dr Kernohan for the new dairy.

Professor Fulkerson, acutely conscious of the urgent need of a new dairy in Camden in order to undertake research relevant to the dairy industry, immediately campaigned for the necessary funding. The University Pro-Vice Chancellor (Research), Mr Paul Slater, who had been so supportive in achieving University financial backing for the Chair of Dairy Science, was again sympathetic, and coincidently, a windfall of $1 million dollars became available to the University following the deregulation of the dairy industry. Dairy producers were provided with Federal Government funds administered by the dairy industry to compensate for the loss of capital value of their farms, possible lower milk prices and to provide capital for new technologies to ensure the future viability of their enterprises.

Professor Fulkerson, in his discussions with Mr Paul Slater, was supported by Associate Professor Wayne Bryden, representing the Veterinary Faculty, and Vice President of the DRF, Mr Bill Inglis. The outcome of the meetings was that the university agreed not only to commit the $1,000,000 compensation package to the construction of a new dairy, but also to provide another $500,000 to complete the new development. The only conditions associated with the funding were that the new dairy would provide the best possible facilities for teaching and research, and would be financially self-sufficient.

Professor Fulkerson visited a number of dairies in Australia and overseas which were known to embrace new technologies in dairy production. His findings, and consultation with DeLaval Milking Machine Manufacturing Company led him to design a 20 cow per side doubled up herringbone milking parlour equipped with individual milking stations and automatic milking cup removers. The identification of individual cows by the permanent placement of transponders in their rumen also allowed the use of these signals to open electronically fitted drafting gates. When the cows exited the dairy after milking the selection of cows for teaching and research on a daily basis was greatly simplified. The system permits the feed supply of each cow to be adjusted to both milk yield and stage of the animals' lactation cycle. Each milking station is equipped with a mini computer connected to the main computer system, which records milk yield and milking speed and also makes it possible for milking shed staff to access relevant data for individual cows at each milking station.

The herringbone 'pit' is large enough to allow up to 30 students to be taught how to milk cows using modern milking technology and provide space for studies on the cows during milking. The new dairy was large enough to milk 350-400 cows, which is about double the capacity of the original Corstorphine dairy. The funding available also allowed the installation of other important supporting facilities which included two silage pits, new cattle handling facilities for teaching purposes, new laneways and two new pivot irrigators each able to irrigate 50Ha of pasture.

The new dairy, which is now recognised as one of the most efficient in NSW, has restored the credibility of the DRF as a centre for industry funded research. An important contribution to the successful operation of the new dairy was the appointment of Mr Kim McKean as the Farms Supervisor. Not only did Kim bring a wealth of practical farm management experience to the position, but he also continues to work cooperatively with the Faculty to ensure full use of the resources by the Faculty for research and teaching.

The milk produced by the new dairy is supplied, on alternate years, to National Foods and Dairy Farmers companies as both companies are generous supporters of the DRF, particularly with respect to their sponsorship of the DRF Annual Symposium.

## Major areas of Research

### *The FutureDairy Project*

The success of the new Corstorphine Dairy owed much to the application of new technologies to dairy production, exemplified by the identification of individual cows by the implantation of transponders, and the use of these signals to open electronically equipped drafting gates (p 46). Professor Fulkerson decided to explore the feasibility of exploiting the rapid developments in technology to develop a fully automated or robotic dairy. To this end, he convinced a meeting in Camden in 2002 of interested scientists, dairy farmers and industry representatives to explore the feasibility of the concept.

A number of potential innovations were identified which if adopted by the industry would significantly improve both profitability, and no less importantly, the lifestyle of dairy farmers. These included fully automatic or robotic milking, the continuous monitoring of rumen function and the sensing of pasture mass to ensure accurate feed allocation.

The evaluation and development of these and future innovations would require considerable research funding. Coincidentally, the dairy industry at that time was somewhat disenchanted with current industry funded research and development. A survey commissioned by Dairy Australia in 2004 revealed that dairy farm productivity had improved by only 1.6% per annum over several decades in spite of relatively large investments in the areas of research, development and extension. Dairy Australia agreed to support the proposal to take advantage of available technical innovations, and the project, termed FutureDairy, was framed in terms of three modules which address the major challenges to dairy producers. These are:

1. The rising cost of land and water, which can be best offset by increasing forage production/ha of land – the Forages Module.
2. The need to employ appropriate technical innovations to increase the efficiency of feed utilisation – the Feeding Module.
3. The falling availability and skills levels of labour available to the industry, and the associated lifestyle issues for dairy producers highlights the need for technical innovations, particularly those which lead to increased automation of all aspects of dairy farm operations – the Innovations Module.

The generous support of Dairy Australia for the FutureDairy project has been supplemented by substantial funding from the University of Sydney, NSW Department of Primary Industries (DPI) and DeLaval. The direct funding and 'in kind' support (provision of infra-structure costs and research facilities) has exceeded $10 million over the first 4 years of the project.

Professor Fulkerson, the Project Leader, is supported by two senior colleagues. These are Dr Yani Garcia, the Senior Scientist who directs the studies on both the Forages and Feeding Modules and Dr Kendra Davis at EMAI is responsible for the Automatic Milking Systems which are the major component of the Innovations Module. The studies at EMAI are supported by cooperative activities with a number of collaborating farmers located in NSW, South Australia and Victoria.

The research on forages is complementary to Professor Fulkerson's long term efforts to improve the quality and yield of pasture to support milk production. The initial objective embraced by the Forages Module, namely to develop a forage management system able to produce some 40 tonnes DM/ha per annum of acceptable quality within an economically and environmentally sustainable system, has been achieved. The complementary forage rotation system incorporates maize as a bulk crop, forage rape as a break crop and Persian clover to fix atmospheric nitrogen. This system represents a major achievement, given that the average pasture utilised on dairy farms in Australia is 8-9t DM/ha, and the general belief that the maximum achievable yield is about 20t DM/ha.

In the feeding module, a number of feeding systems have been studied to identify the most profitable combinations of stocking rate and levels of supplementary feeding, using dairy cows of varying genetic merit. The impact of significant increases in milk production on management practices which include pasture utilisation and animal reproduction has been studied in relation to profitability.

Technical innovations which reduce labour inputs and reduce stress on dairy cows have obvious advantages in dairy management. Automatic Milking Systems (AMS), in which a robot arm attaches milking cups to the cows when it voluntarily enters the milking station after making its way from the paddock and returning there after milking, represents a new approach to dairy farming in Australia. The cows present themselves for milking when they desire to eat, not because of milk pressure in the udder. Typically, the cows enter the milking station 2.3-2.5 times per day but the advantage is that higher producing cows can be encouraged to return to be milked more often (2.5-3.5 times/day) than cows in later lactation (1.2-1.8 times/day) – something not possible with conventional milking. The cows are less stressed than in the usual milking systems, and this is reflected in a lower incidence of diseases, such as mastitis and, importantly, a much improved lifestyle for the dairy farmer.

There are about 3000 AMS's worldwide, but almost all are in feedlot type systems, or in situations where access to pasture is minimal and the retention of high rates of pasture utilisation is not important. In contrast, a high rate of pasture utilisation on Australian dairy farms is an economic necessity. Professor Fulkerson and his colleagues recognised that to become a viable option in Australia, two issues associated with AMS's would need to be addressed. These are appropriate frequency of visitation to the milking stations by the cows, and the maintenance of a high level of pasture utilisation. Increased visits to the milking stations have been achieved by the strategic use of feeds, namely access to liberal supplies of high quality pasture, feed supplements on a feedpad and concentrate feeds at the AMS.

The FutureDairy team has worked closely with DeLaval to develop an AMS with a far greater throughput than the present machines in order to be economically viable in Australia. It is interesting that Dr Whittlestone, the first Director of the Foundation, worked closely with the Alfa Laval Company (now DeLaval) in the early 1960's on many aspects of milking machine design.

The trialling of management systems and innovations at Camden and on commercial dairy farms, achieved through FutureDairy's collaboration with commercial dairy farms termed Partner Farms, has led to more robust guidelines for the adoption of these technologies. There are Partner Farms in NSW, Victoria and South Australia which adopt and adapt innovations/systems being trialled at Camden and provide feedback on gaps in knowledge or raise new research questions. The Partner Farms include Warren's AMS farm, the only other AMS farm in Australia.

FutureDairy has a designated Extension Development Leader, Sean Kenny who is responsible for the development of extension programs and tools to facilitate both the awareness and adoption of these innovations. Effective transfer of technology to dairy farmers is crucial to the acceptance of new management systems. In NSW, FutureDairy's program complements the Department of Primary Industries extension program.

The social aspects of the adoption of the innovations to milking systems emerging from FutureDairy's activities are being studied by Dr Carolyn Kaboré under the supervision of Dr Mark Paine (Melbourne University). Dr Paine's group will seek to assess the impact of new systems of dairying on the lifestyle of dairy farmers and their families.

Students involved:

*Pancha Shrestha* (Masters). Assessing various crop options for a Complementary Forage Rotation for the dairy industry. (Supervisor is Dr Yani Garcia) (Awarded 2007)

*Bertin Kaboré* (Masters). Environmental sustainability of a very high yielding Complementary Forage Rotation system. (Supervisor is Professor Bill Fulkerson)

*Mariana Pedernera* (PhD). The health, production and reproductive performance of dairy cows fed to contrasting levels of production. (Supervisor is Dr Yani Garcia) (Awarded 2008)

*Ravneet Jhajj* (PhD). The rumen efficiency of rations fed to dairy cows. (Supervisor is Dr Yani Garcia)

***Development of a more suitable forage base for the Australian Dairy Industry***

The heavy reliance of the Australian dairy industry on pasture generated this project in which attempts are being made to identify forage species which may be alternatives to perennial ryegrass, which has been found to lack an acceptable level of persistence in most dairy areas. The field work for this project was completed in December 2006.

The project is a national one funded by Dairy Australia and is jointly managed by the University of Sydney and NSW DPI. Two commercial companies – Wrightsons Seeds and PGG Seeds – have also funded the project.

In the project 35 different forage species are being studied for criteria which are important in dairy pastures, namely:

i. water use efficiency:
ii. nutrient contentions; and
iii. palatability

All species have been analysed for nutrient content (acid detergent fibre, neutral detergent fibre, crude protein, nitrates, and water soluble carbohydrates) and degradability rates in the rumen of organic matter and protein have also been measured.

The data on yield in relation to moisture availability have been expressed as kg DM/ML water or MJ metabolisable energy/ML water. The data from the nutrients module and the water use efficiency module will be used to determine the best combination of forages on a whole farm basis with several variables (milk price, climate etc.) being tested.

The palatability module has correlated the palatability of pasture species to their chemical composition.

Students involved:

*James Neal* (PhD). Comparative water use efficiency of 35 forage species suitable for feeding Dairy cows. (Supervisor is Professor Bill Fulkerson)

*Richard Morris* (Masters). Determination of the water use efficiency of various pasture species in WA. (Supervisor is Professor Bill Fulkerson)

***The problem of excess mobilisation of body reserves in the modern dairy cow***

The continued selection of dairy cows for high milk production has, inevitably, selected animals with an increased ability to mobilise body tissues to support milk biosynthesis in the udder. In high yielding cows the vastly increased demand for nutrients cannot be met by the increased feed intakes that accompany lactation, and the deficit is met by the mobilisation of tissues to support milk production. This reliance on the drainage of nutrients from body tissues is more critical in pasture fed cows, where milk yields rarely exceed 21L/day, and there is a limit to the amount of supplementary feeds, that can be consumed at milking times by cows milked twice daily (<6kg Cow/day). This amount of supplementary feed, even if of the highest quality, is unlikely to raise milk yields by more than 9L/day. This inadequacy in the supply of dietary nutrients to meet the demands of the udder for milk synthesis in high yielding cows results in a dramatic loss of condition, or liveweight, which if not corrected in late lactation may adversely reduce fertility.

In this study attempts have been made to identify indicators of excess mobilisation of body tissues during the lactation cycle in high yielding cows. Possible metabolic indicators to supplement obvious changes in liveweight and condition score include non-esterified fatty acids (NEFA) which are mobilised from adipose tissues during dietary energy deficits, and ketone bodies (acetoacetate, 3-hydroxybutyrate, acetone) which are produced during the metabolism of NEFA. The best metabolic indicator and the easiest to measure proved to be the level of acetone in milk.

Daily monitoring of milk revealed that acetone levels exhibit a 21-23 day cycle with peaks at or near ovulation. Research is ongoing to understand the role of acetone in reproduction, and how this marker can be used to intervene in cows exhibiting excessive body tissue mobilisation.

Students involved:

*Cameron Clarke* (PhD). Identifying indicators of energy balance for pasture-based dairy cows in early lactation. (Supervisor is Professor Bill Fulkerson) (Awarded 2005)

*Helen Smith* (PhD). The relationship between acetone in circulation and the reproductive cycle in dairy cows. (Supervisor is Professor Bill Fulkerson)

***Acidosis and lameness in dairy cows***

A survey was conducted by Ms. Liz Bramley, a post graduate student, of over 100 dairy farms throughout Australia to determine the extent and cause of rumen acidosis and lameness. In each herd the feed fed on the day of visit was collected and 8 cows in early lactation (<100 days : 3 primiparous and 5 multiparous) were sampled to collect data on rumen fluid pH and levels of VFA, ammonia and D-lactate.

Using cluster analysis, 3 groups were formed with the most important factors being propionate and valerate concentration, not pH or D-lactate. The effectiveness of valerate as an indicator of acidosis presumably reflects that it is a product of lactate metabolism.

A total of 10% of cows were in group 1 – acidotic (low milk fat), the rest of the cows in group 1 had lower neutral detergent fibre (NDF: 30.4 vs. 36.1%) and significantly higher non fibrous carbohydrate (NFC: 40.3 vs. 33.5%) in the diet.

Cows in group 1 had a greater risk of lameness and lower rumen score.

The amount of wheat fed and grazing on legume pastures (low fibre) and lush pastures were major predisposing factors to the incidence of lameness.

A useful indicator to formulate rations was the NDF: NFC ratio.

Student involved:

*Elizabeth Bramley* (PhD) The effect of acidosis on cattle health and production. (Supervisor is Professor Bill Fulkerson) (Awarded in 2005)

***Modeling the relationship between intake and grazing management***

In this study feed intake in relation to the DM of pasture on offer and the duration of grazing was measured. The practical objectives were to optimise:

i) pasture utilisation in relation to feed on offer and grazing duration; and

ii) intake in relation to damage of pasture under conditions of water logging.

Student involved:

*Robin Dobos* (PhD) Development of an intake model for dairy cows. (Professor Bill Fulkerson was Associate Supervisor) (submitted in 2007)

***Nutrition pre calving in relation to reducing the incidence of hypocalcaemia post calving***

In this study, undertaken by Marie Bhanugopan as part of her PhD degree, comparisons were made between cows fed either a high potassium (K) ration (i.e. green pasture) or with a low K ration (i.e. cereal hay) in the knowledge that K has been implicated in the incidence of hypocalcaemia and milk fever at calving in dairy cows.

Minerals levels in blood pre- and post-calving and the storage and release of minerals from bones were measured. It was found that high K diets had little effect on calcium availability but dramatically reduced the amount of magnesium (Mg) in

circulation and this was presumably due to the impaired absorption of Mg. This effect on Mg lasted for over 2½ weeks after the high K diet (i.e. pasture) was removed and replaced with a low K diet (i.e. cereal hay).

From these results it is possible to explain why supplementing cows pre calving with Mg, even if cows are fed a low K diet is beneficial. It is recommended that cows fed a low K diet for more than 3 weeks before calving should be fed 100 to 150g Magnesium oxide/cow/day until calving.

This important work not only explains the reason why the feeding of low K diets and supplementary Mg pre calving is effective in reducing the incidence of hypocalcaemia post calving, but also allows the daily intakes of K and Mg to be adjusted for maximum efficacy.

Student involved:

*Marie Bhanogopan* (PhD) 'Optimising calcium metabolism in the dairy cow to maximise bone health and minimise risk of milk fever' (Supervisor is Professor Bill Fulkerson) (Awarded in 2006)

***Synchronising nitrogen and carbohydrates in the rumen***

Comparisons were made of the efficiency of the rumen and milk production of cows fed to generate different ratios of nitrogen to fermentable carbohydrate (energy) in the rumen over time. The value of synchronising the availability of nitrogen and energy to maximise microbial efficiency, as exemplified by the benefits of grazing pasture in the afternoon in order to be able to source the water soluble carbohydrates accumulated in plant species during the day before they are lost by respiration overnight was clearly demonstrated. There was a net increase of 1 to 2L milk/cow/day in response to grazing cows in the afternoon instead of in the morning.

Student involved:

*Leigh Trevaskis* (PhD) 'Improving the efficiency of nitrogen utilisation in ruminants grazing pasture' (Supervisor is Professor Bill Fulkerson)

***Studies of the vitamin D and calcium status of adolescent girls in China***

In 1994 a Chinese medical graduate who was also trained in public health, Dr Xueqin Du, contacted Professor Heather Greenfield in the Department of Food Science at the University of New South Wales about the possibility of undertaking a PhD under Heather's supervision on some topic of nutrition related to public health in China. Heather Greenfield consulted Professor David Fraser and it was agreed that a project be established in Beijing and surrounding districts to investigate the nutritional and vitamin D status of adolescent girls in China. The project was jointly supervised by Heather Greenfield and David Fraser and was financed by the Dairy Research and Development Corporation (DRDC). With the assistance of colleagues from the Institute for Nutrition and Food Safety of the Chinese Centre for Disease Control and Prevention a large scale cross sectional study was undertaken of 1,248 Beijing girls aged 12-14 years. The results of this research demonstrated that this population of adolescent girls had a high prevalence of deficiencies of vitamin D and calcium which were affecting bone development during adolescence.

In 1997 Heather Greenfield retired from the University of NSW and moved to the Department of Animal Science in the University of Sydney, first as an Adjunct Associate Professor and subsequently as an Adjunct Professor. Dr Du, having completed her PhD in 1998, was then appointed as a postdoctoral fellow in the Department with the financial support of DRDC. A second large scale population study in China was planned with Dr Du as the leader of a large team of field investigators and technicians. This second project, again financed by DRDC and jointly supervised by Heather Greenfield and David Fraser, was an intervention

study in which 757 girls, starting at the age of 10 years in 1999 were given milk supplements provided by Murray Goulburn Co-operative Co. Ltd. on school days for two years. Many conclusions were drawn from this intervention study but the main ones were that the milk supplement had not only improved bone mineralisation of the young girls but it had also induced a faster growth rate. After two years of milk supplementation the girls were significantly taller than un-supplemented controls. Although the improvement in bone mineralisation was a response to the increased supply of calcium from milk, the effect on growth was independent of calcium and was related to some other component of the milk supplement.

A subsequent follow-up survey, financed by the Nestlé Foundation, investigated the longer term effects of the two-year milk supplement, three years after the supplementation had ceased. This survey revealed that all of the benefits attributed to the increased consumption of milk had been lost. Several postgraduate PhD students in the Department of Animal Science were involved in this research including Drs Kathy Zhu, Leng Huat Foo and Qian Zhang. Many field workers in China worked tirelessly to ensure that these large scale projects were completed successfully. The Chinese authorities were impressed by the findings and a general policy of increased milk production in China was instituted. Heather Greenfield and David Fraser fostered collaborative links between the Australian and Chinese dairy industries through the formation of a Sino-Australian Dairy Research and Training programme (SADRAT). This was most effectively followed up by Professor Peter Wynn and his colleagues.

In a related project, Professor Fraser was asked by the World Health Organisation to help investigate the high prevalence of rickets in young children in Mongolia. Another large scale survey in that country in 2000-2002 demonstrated that the cause of the disease was vitamin D deficiency which was associated with protein and energy malnutrition. The disease appeared to be related to the decline in the Mongolian economy and widespread poverty after the collapse of the Soviet Union in 1990 and the transfer of sovereignty to an inexperienced Mongolian government.

## Dairy Science Award

In 1992, the Foundation established an Annual Dairy Science Award to recognise those individuals who have contributed significantly to the advancement and success of the dairy industry. Tetrapak Marketing Pty Ltd agreed to sponsor the Award, which included a framed citation and a cheque for $500. The award, which was presented at the Annual Symposium Dinner, was quickly accepted by the dairy industry as fitting recognition of outstanding service to the industry.

The Tetrapak Marketing Company funded the award until 1995, when the NSW Dairy Corporation replaced them as sponsor until 1999. From 2000 the Annual Dairy Science Award has been sponsored by Safe Foods NSW (now NSW Food Authority).

**Mr Oliver Cassar**, the first recipient of the Award, served for many years as Secretary to the Dairy Research and Development Corporation and its predecessor organisations. The Corporation, which was funded by a levy on milk producers matched by equivalent Federal Government finance, funded research and development in all areas relevant to the profitability of the dairy industry. Mr Cassar was responsible for the effective deployment of research funds for several decades, and his dedication and integrity in the complex tasks of awarding grants and monitoring their progress, was much admired by all concerned.

The recipient of the Annual Award in 1993 was **Mr Rowan Moore**, a well known and highly respected dairy producer at Camden. Mr Moore joined the Foundation in 1984 as a Producer Member, a category of membership introduced by the Foundation in the same year. Mr Moore's active participation in the Foundation was recognised in 1989, when he was elected Deputy-Chairman to Mr Tony Perich, who succeeded Mr Bob Whan as Chairman. The new team of Mr Perich and Mr Moore, both successful local dairy farmers, was instrumental in the development of the

Annual Symposia and Country Tours as major extension services to the dairy industry.

In 1994, the Annual Award was presented to the sisters **Annette and Elizabeth Thomson**, long established dairy producers at Bringelly, in recognition of the life-long contributions to the dairy industry. These included their active involvement with local issues affecting the dairy industry, and their encouragement of young people entering the industry.

**Mr Jim Forsyth**, who received the Award in 1995, was widely experienced in all aspects of the dairy industry. For more than three decades he served as Chairman of United Dairies Milk Company, a founding member of the Foundation, and of the Market Milk Federation of Australia.

**Mr David Heptonstall**, who was recognised for his longstanding commitment to the dairy industry by the Annual Award in 1996, represented the NSW Department of Agriculture on the Foundation Council for almost 2 decades. Mr Heptonstall provided invaluable guidance to Council on the transfer of research findings to dairy producers and on the choice of invited speakers to Annual Symposia. In addition, Mr Heptonstall and his colleagues assisted the Foundation in the management of the Country Tours which became a recognised accompaniment to the Annual Symposia.

The Annual Award in 1997 was presented to **Mr Jack Green** of the Victorian Department of Agriculture. Mr Green, during his long service with the Department, became a well known, much liked and highly respected advisor to at least two generations of dairy producers. Indeed, in many areas of Victoria his fame as a skilful and helpful advisor was unique.

The recipient of the Dairy Science Award in 1998 was **Mr Philip Armstrong**, the Manager of the Bega Co-operative. Mr Armstrong, a long standing supporter of the Foundation and active member of Council, encouraged the Foundation to include

Bega in the itineraries of the Country Tours. Mr Armstrong and his colleagues would assume responsibility for the local arrangements and ensure that meetings addressed by the visiting speaker would be well attended by local dairy farmers.

**Dr John Craven**, recognised for his contributions to the dairy industry for more than 35 years, received the Award in 1999. He was Director of the Veterinary Research Laboratory, Attwood, before his appointment in 1986 as Inner Melbourne Regional Manager of the Victorian Department of Agriculture and Rural Affairs. Subsequently in his role as a manager with the DRDC, Dr Craven worked closely with the dairy industry to establish priorities for research and development.

**Dr Bill Fulkerson**, who received the Annual Award in 2000, completed his PhD at the Dairy Unit, Camden, in 1975 and returned to the Unit as Professor of Dairy Science in 2001. In the intervening years, Professor Fulkerson made significant contributions to Dairy Science during his research activities with the Departments of Agriculture in Western Australia, Tasmania and NSW. Professor Fulkerson is a recognised authority on the management of pastures to maximise milk production.

**Winston Watts** was warded the Annual DRF/ NWS Food Authority Dairy Science Ward in 2001. The award recognises the major contributions to the dairy industry made by Mr Watts since his appointment as Executive Director of the NSW Dairy Farmers Association in 1980. At that time the NSW dairy industry was factionalised and operating in difficult conditions. Mr Watts has also had a major impact on the national dairy industry. He contributed to two Industry Commission Reviews, and three Federal Market Plans, and was heavily involved in the National Competition Policy Review Debate and in its subsequent negotiations that led to the deregulation of the dairy industry, and the adoption of the Dairy Structural Adjustment Program.

In 2002, **Dr Liz Kernohan** was presented with the Dairy Science Award in recognition of her long association with the dairy industry, particularly with education and training at Camden. After obtaining PhD from the University of Sydney in 1978, she was appointed Director of the University Farms in 1983 and

proved to be an excellent overseer both in terms of providing resources for research and teaching and using the farms in a profitable way at Camden. In addition to this she became Mayor of Camden in 1980 and 1985 – 1991 after which she was elected to the Legislative Assembly as the Member for Camden. Her knowledge and experience of agriculture was greatly respected in parliament. Dr Kernohan's support of the DRF was long and outstanding and this was recognised in 1992 when she was appointed and Honorary Governor.

**Associate Professor Jim Gooden** was the recipient of the Dairy Science Award in 2003. Associate Professor Gooden played a major role in the activities of the DRF since he returned in 1977 to the Dairy Unit at Camden, where he had completed his PhD a decade or so earlier. His duties as Lecturer included a full teaching load, and he quickly competed successfully for dairy industry research funds. Much of his research was undertaken in collaboration with Professor Graham McDowell, and more recently with Dr Ian Lean. He worked with Professor McDowell to develop the DRF Annual Symposia and the Country Tours, at which invited speakers to the Symposia kindly agreed to address groups of dairy producers at rural centres. When Professor McDowell moved to La Trobe University in 1988, Associate Professor Gooden was appointed Research Director, and assumed responsibility for the DRF research and extension programs, which have continued to increase in relevance to the dairy industry.

**Alex Ashwood** was presented with the award in 2004 for his untiring contribution to the Dairy Industry in NSW and also nationally as the technical specialist in the NSW Department of Primary Industries. Alex was primarily responsible for changing the *modus operandi* of the Dairy Section from a 1 to 1 advisory service to a program-based section with priorities more in tune with industry needs. Alex was a tireless worker always striving for perfection.

**Dr Peter Doyle,** who was awarded the Dairy Science Prize in 2005, completed his undergraduate and postgraduate training in agricultural science at the University of Western Australia. His PhD studies were supervised by Dr Reg Moir, an

internationally recognised authority in the field of ruminant nutrition. Dr Peter Doyle joined Melbourne University in 1978 as a Lecturer, then Senior Research Fellow before returning to Western Australia as a Senior Nutritionist with the Department of Agriculture, where he studied feed intake regulation and the efficiency of utilisation of feed supplements in sheep. In 1994, Dr Doyle was appointed Principal Scientist (Dairy) in the Victorian Department of Primary Industry, where he has continued to implement research programmes designed to increase the efficiency of dairy production.

The presentation of the award in 2006 to **Mr Pat Rowley** recognized his outstanding contributions to the dairy industry during the past 3-4 decades. He has negotiated national agreements on stable marketing arrangements for milk in Australia in his role as Chairman of the Dairy Industry Council, a monumental task at a time when the industry was split between states operating on quota systems (NSW, WA, QLD) and those exporting milk (VIC, TAS). Pat Rowley who was Chairman of Dairy Australia at that time initiated many changes to the organization, including recognition of the need to increase accountability by introducing a 5 yearly vote on the level of the levy paid by producers to support Dairy Australia.

**Mrs Janet Moxey** was presented with the Dairy Science Award in 2007 for her contribution to the Dairy Industry. Janet's family has shown how a very large dairy enterprise can be run successfully with a family structure. The Moxey family operates a dairy farm with over 2000 cows. They were one of the innovative coastal farmers who sought to transfer inland to Coolagong and run a feedlot dairy, close to grain sources and irrigation water. Janet's contribution to the dairy industry is also in Agripolitics, holding the Chair of NSW Farmer's Association Dairy Committee from 2004. She has also been a member on the NSW Dairy Industry Conference representing NSW farmers in many situations nationally. In 2006, Janet Moxey became the first female Vice-President of the NSW Farmers Association.

## Technical and Support Staff

The Dairy Unit at Camden and the other sections that made up the Department of Animal Husbandry relied heavily in its day to day activities on the services of support staff able to manage farm animal and laboratory animals, undertake laboratory services and provide a range of workshop, administrative and secretarial skills. The first Director, Dr Whittlestone in his efforts to improve milking machine design, and to assist in the construction of his laboratory, recruited Mr Harold Cannon. Mr Cannon, a skilled engineer and instrument maker, established a well equipped workshop and until his retirement in 1985 built and serviced equipment for the Department at Camden.

Professor Lascelles in 1965 appointed Miss Alwyn Morgan as Dairy Unit Secretary, and she coped extremely well with the typing, filing and accountancy services of the unit. Miss Morgan resigned in 1976, and was succeeded by Mrs Pat Grundy, an exceptionally competent administrative assistant who provided secretarial services to the whole department at Camden. Mrs Grundy resigned in 1990, and her successor Ms Elizabeth Thomas aided by her computer skills continued the tradition of excellent secretarial support for Camden staff until the Department of Animal Science was incorporated into the Faculty of Veterinary Science in 2000.

Professor Lascelles, shortly after joining the Dairy Unit appointed a young teenager, Mr Kim McKean, to assist with the management of animals. Mr McKean quickly acquired the necessary range of skills including the milking and feeding of dairy cows, and is still at the Dairy Unit as an invaluable assistant to Professor Fulkerson. Mr McKean was promoted to Technical Officer in 1991, and appointed Supervisor of the University farms at Camden in 2004.

Since its inception, the Dairy Unit has enjoyed the services of a succession of laboratory assistants, several of whom have been promoted to Technical Officer. Few of these staff were funded by the University or the Foundation; instead their

salaries were paid from research grants. The individuals who have played such an important role in the success of the Dairy Unit and DRF Unit are listed in Table 11 (p 118).

In 2001, when Professor Fulkerson took over the directorship of the DRF, the administrative support provided was reduced from 2.5 days/week to nil in order to save money. This position became untenable and the Faculty agreed to provide 1 day administrative support if the DRF did likewise. Thus, from 2001 Mrs Lynden Webber became Personal Assistant. In 2003 the position was increased by the Faculty to 2 days/week. From 2004 to the present day the position has been ably filled by Mrs Michelle Heward.

The accounts and personnel requirements of the DRF have been handled by Mrs Sherry Catt. This included all accounts relating to the Chair of Dairy Science and the major research projects, totalling over $1.2m/year.

## Concluding Comments

As the 50th Anniversary of the establishment of the DRF approaches, the confidence of the Inaugural Council in the likely success of the proposed Foundation structure has been vindicated, as indicated in this report.

That structure committed the University to provide staff, buildings and infra-structure for the DRF, with the dairy industry providing funds to support relevant research programmes. Until the mid 1990's, this arrangement worked well. The Foundation was based within the Department of Animal Husbandry (now Animal Science) and academic staff responsible for teaching and research in dairy science also represented the DRF. The Department and the DRF were mutually supportive, and the considerable intellectual and material resources of the Department underpinned the research and development undertaken on behalf of the DRF. For most of this time, there were at least two members of the Department supervising

postgraduate students undertaking research in dairy science. These highly productive periods began with Dr's Whittlestone and Lascelles, followed by Dr's McDowell and Gooden and Dr's Gooden and Lean, and ended with the departure of Dr Ian Lean in 1996. Dr Lean was not replaced, and about this time the abolition of Departments by the Veterinary Faculty ended the synergies between the Department of Animal Science and the DRF that had proved so effective since the inception of the Foundation. The loss of Dr Lean's position was due to lack of University funding, and highlights the straitened financial situation of the Faculty which faced Professor Fulkerson when he arrived in Camden in 2000. Potential financial difficulties, however, were avoided by the generous provision of funds by the University for the construction of the new Corstorphine dairy, and the outstanding success of Professor Fulkerson in competing for dairy industry research funds.

At this time, however, the responsibility for undergraduate and postgraduate teaching in dairy science, the acquisition of industry research funds, the supervision of research activities, the organization of the Annual Symposia and the overall administration of the DRF rests entirely with Professor Fulkerson whose only administrative assistance is provided by a part-time (1 days/week) secretary. Increased academic/technical/administrative support for Professor Fulkerson and more importantly, his successor, should be considered by the University and the DRF.

The further improvement in both the profitability and lifestyle of dairy producers will remain dependent on the ready acceptance of advances in technology. This process will continue to be facilitated by the training of students in dairy science able to service the increasingly science-based dairy industry. The DRF has played an important role in these developments through post graduate teaching and research, and by the success of the Annual Symposia in alerting dairy producers to advances in management practices leading to increased profitability.

The author would like to thank the many colleagues who have assisted in the preparation of this account of the formation and activities of the DRF. Michelle Heward, Professor Fulkerson's part-time administrative assistant, kindly and patiently typed and amended many versions of this document. Professor Graham McDowell and Dr Jim Gooden provided invaluable material, and crucial encouragement. The role of Doug Crosby in launching this project should be noted. The author is indebted to Professor McDowell for proof-reading the final draft of this document.

**Table 1.**

***Directors and Research Directors of the Foundation***

| *Term of Office* | *Name* |
|---|---|
| **Directors** | |
| 1959-1977 | T J Robinson |
| 1978-1982 | E F Annison |
| 1983-1985 | T J Robinson |
| 1986-1991 | E F Annison |
| 1991-1998 | D R Fraser |
| 1998-2000 | W M C Maxwell |
| 2000 - 2007 | W J Fulkerson |
| **Research Directors** | |
| 1958 – 1963 | W G Whittlestone |
| 1963 – 1973 | A K Lascelles |
| 1973 – 1974 | R C Kellaway |
| 1974 – 1978 | E F Annison |
| 1978 – 1989 | G H McDowell |
| 1989 – 1999 | J M Gooden |

**Table 2.**

***Membership of the Council of the Dairy Husbandry Research Foundation appointed at the inaugural meeting on 16th April 1959***

| | |
|---|---|
| Mr R.R Rudder (Nestle) | Chairman |
| Mr J.A Ferguson (NSW Milk Board) | Deputy Chairman |
| Professor T.J Robinson | Director |
| Mr C.M Barker (Dairy Farmers Cooperative) | |
| Mr H.J Bate (P.D.S) | |
| Mr F.H Daniel (Mauri Bros.) | |
| Mr R.C Gibson (Dairy Produce Board) | |
| Mr J.S Haddin (Horlicks Pty Ltd) | |
| Mr A.E McCartney (Peters Creameries) | |
| Mr P.D Scarr (Hunter Valley Cooperative) | |

**Table 3.**

***Presidents and Vice Presidents of the Dairy Husbandry Research Foundation***

| *Term of Office* | *President* | *Company* |
|---|---|---|
| 1959-1974 | Mr Rupert R Rudder | Nestlé Company Ltd |
| 1975-1972 | Mr Harold W Marchant | Nestlé Company Ltd |
| 1983-1984 | Mr Donald A Ferguson | Dairy Industry Marketing Authority |
| 1985-1986 | Mr Murray Mead | Dairy Farmers Cooperative Ltd |
| 1987-1988 | Mr Robert B Whan | NSW Dairy Corporation |
| 1989-2000 | Mr Anthony Perich | Leppington Pastoral Co. Pty Ltd |
| 2001- 2007 | Mr Greg Lindsay-Owen | Dairy Corp Ltd |
| | ***Vice President*** | |
| 1959-1968 | Mr Jack A Ferguson | NSW Dairy Corporation |
| 1969-1976 | Mr Darryl W Crowfoot | Dairy Industry Authority of NSW |
| 1977-1980 | Dr Fred Butler | Dairy Industry Authority on NSW |
| 1981-1982 | Mr Donald A Ferguson | Dairy Industry Marketing Authority |
| 1983-1983 | Mr Murray Mead | Dairy Farmers Cooperative |
| 1985-1986 | Mr Robert Whan | NSW Dairy Corporation |
| 1987-1988 | Mr Donald Kinnersley | Dairy Farmers Cooperative Ltd |
| 1989-2000 | Mr Rowan R Moore | Producer Member |
| 2001- 2007 | Mr William Inglis | Producer Member |

**Table 4.**

***Postgraduate students who completed degrees at Camden on research topics relevant to the dairy industry***

| Name | Degree (date) |
|---|---|
| G Olney | Dip Dairy Husb (1962) |
| K Rathet | Dip Dairy Husb (1963) |
| J Nield | M Sc Agr (19??) |
| D Clarke | M Sc Ag (1966) |
| P Hartmann | PhD (1966) |
| D Mackenzie | PhD (1967) |
| P Outteridge | PhD (1967) |
| A Shannon | PhD (1967 |
| E Kernohan | M Sc Ag (1963); PhD (1977) |
| G McDowell | PhD (1970) |
| C.S Lee | PhD (1970) |
| J Wadsworth | PhD (1971) |
| A Kaiser | M Sc Ag (1972) |
| P Colditz | M Sc Ag (1972) |
| M Brandon | PhD (1972) |
| D Watson | PhD (1972) |
| J Gooden | PhD (1972) |
| K Beh | PhD (1973) |
| A Husband | PhD (1974) |
| W Fulkerson | PhD (1975) |
| J Quinn | PhD (1976) |
| S Ranawana | PhD (1976) |
| M Sharif | Dip. Dairy Husbandry (1976) |
| A Rizwi | Dip. Dairy Husbandry (1976) |
| R Salanuddin | Dip. Dairy Husbandry (1976) |
| M Paul | Dip. Dairy Husbandry (1978) |

| | |
|---|---|
| D Field | M Sc Ag (1979) |
| S Aryjasse | M Sc Ag (1980) |
| C Gow | PhD (1980) |
| P Darton | M Sc Ag (1982) |
| E Teleni | PhD (1983) |
| K King | M Sc Ag (1983) |
| B Ronda | Dip Dairy Husb (1983) |
| I Sukarini | M Sc Agr (1983) |
| N Nusada | M Sc Agr (1983) |
| P Wynn | PhD (1984) |
| G Hough | M Sc Ag (1882); PhD (1987) |
| M Jois | PhD (1986) |
| I Jang | M Sc Ag (1987) |
| D Leenanuruksa | M.Sc. Ag (1982); PhD (1988) |
| P Niumsup | PhD (1988) |
| D Taylor | M Sc Ag (1989) |
| B Rustamadji | PhD (1990) |
| G Drane | PhD (1990) |
| R Faroogi | M Sc Ag (1990) |
| S Sinclair | M Sc Ag (1990) |
| J Maas | M Sc Ag (1991) |
| G D'Cruz | PhD (1991) |
| Ming Der Hang | M Sc Ag (1991) |
| P Greenwood | M Sc Ag (1991) |
| J Lush | PhD (1992) |
| L Giles | PhD (1992) |
| M Lorschy | PhD (1993) |
| J Bond | PhD (1993) |
| D Ward | M Sc Ag (1993) |
| Y Opatpatanakit | PhD (1994) |
| V Rooney | PhD (1994) |
| S Pattison | PhD (1994) |

| | |
|---|---|
| H Bray | PhD (1995) |
| M Hyde | PhD (1995) |
| S Neutze | PhD (1996) |
| A Rabiee | PhD (1996) |
| A Shahneh | PhD (1996) |
| S Beckett | M Vet Sci (1996) |
| M Stevenson | M Vet Sci (1996) |
| K Bofouri | PhD (1996) |
| C Westwood | PhD (1996) |
| F Webster | M Vet Sci (1996) |
| G House | PhD (1997) |
| R Dobos | M Vet Sci (1997) |
| M Curtis | PhD (1997) |
| R Behrendt | PhD (1997) |
| J Garvin | PhD (1999) |
| P Sheehy | PhD (1999) |
| Z Rajcyk | PhD (1999) |
| B Jones | PhD (2004) |
| L Trevaskis | PhD (2003) |
| M Bhanugopan | PhD (2005) |
| C Clark | PhD (2005) |
| E Bramley | PhD (2007) |

**Table 5.**

***Financial support by the Dairy Industry for the construction and establishment of the DHRF Dairy Unit at Camden, 1959-62***

| **Integrated Milking Parlour and Laboratory** | **Pounds (A£)** |
|---|---|
| Members Subscriptions | 14,000 |
| Australian Dairy Produce Board | 14,000 |
| **Dairy Research Laboratory** | |
| Members Subscriptions | 45,000 |
| Australian Dairy Produce Board | 10,000 |
| NSW Milk Board | 10,000 |
| **Total** | **£93,000** |

**Table 6.**

***Dairy Research Foundation Annual Symposia***

| *Year* | *Invited Overseas Speaker* | *Topic* |
|---|---|---|
| 1977 | Dr A Robertson<br>Institute of Animal Genetics<br>Edinburgh, UK | Recent developments in dairy cattle breeding programmes |
| 1978 | Dr W H Broster<br>N.I.R.D, UK | Interrelationships of nutrient supply, liveweight and milk production during the lactation cycle |
| 1981 | Professor D.G Armstrong<br>Newcastle University, UK | Protein requirements for dairy cows |
| 1982 | Dr W.G Whittlestone<br>Puakura, NZ | Recent developments in milking machine technology |
| 1983 | Dr W.H Broster | Control of milk production by nutrition |
| 1984 | Dr R.H Phipps<br>N.I.R.D, UK | Production, conservation and utilisation of maize for milk production |
| 1985 | Dr J.D Oldham<br>Edinburgh School of Agriculture, Edinburgh | Effects of nutrition on milk yield and composition |
| 1986 | Dr R.T Cowan<br>Queensland DPI<br>Mutdapilly Research Station, Ipswich, QLD | Factors which influence the protein and solids-not-fat in milk |

| | | |
|---|---|---|
| 1987 | Professor D.G Armstrong<br>Newcastle University, UK | Biotechnology – its potential contribution to dairy farming in the future |
| 1989 | Professor J.D Leaver<br>Wye College<br>University of London, UK | Feeding and management systems for the dairy herd |
| 1990 | Dr J.D Sutton AFRC Institute of Grassland and Environmental Research, Hurley, UK | Dietary control of milk composition |
| 1991 | Dr D Bath<br>University of California, USA | Feeding strategies for maximum profit or maximum production |
| 1992 | Dr L Satter<br>US Department of Agriculture, Madison, USA | Supplementation of forage and pasture for cows |
| 1993 | Mr D Armstrong<br>Department of Animal Sciences, University of Arizona, USA | Heat stress in dairy cattle<br>Increasing herd size – problems and benefits |
| 1994 | Professor J.D Leaver<br>Wye College,<br>University of London, UK | Least cost feeding systems for dairy cows |
| | Mr B Schouter<br>Warkworth Veterinary Services LTD, Warkworth, NZ | Intensive calf rearing |

| | | |
|---|---|---|
| 1995 | Dr P Johnson<br>PO BOX 1758, Enterprise, Alabama, 36331, USA | Production factors that influence profit |
| | Professor W Parker<br>Agricultural and Horticultural Systems, Massey University, NZ | Managing pastures for profit – a New Zealand perspective |
| 1997 | Professor W Chalupa<br>University of Pennsylvania, USA | Adoption of technology: the way to the future |
| 1998 | Dr S Mayne<br>Agricultural Institute of Northern Ireland | Recent advances in improving animal production from conserved products |
| 1999 | Dr R. H Bennett<br>Applied Life Sciences<br>Windsor, California, USA | Perception, Markets and Science: Milk quality in the new millennium |
| | Dr W Parker<br>Massey University, NZ | Change management; How to get the results you want |
| | Mr R Smith<br>Express Milk Partnership<br>North Yorkshire, UK | Marketing milk in a deregulated economy |
| 2000 | Mr D Bennink<br>University of Florida, USA | Managing and developing large dairy herds |

| | | |
|---|---|---|
| | Mr K Hammond<br>FAO, Rome, Italy | Sustainable intensification and the conservation of farm animal genetic resources |
| | Mr Y Izaike<br>National Institute of Animal technology, Tsukuba,Japan | Recent advances in bovine biotechnology |
| 2005 | Professor L Hansen<br>University of Minnesota, USA | The California Experience – breeding Holstein cows with imported semen from red breeds in Scandinavia and France |

**Table 7. Publications of Personnel at the Dairy Research Unit, 1962-2008**

1. Papers in Journals, Book Chapters and Reviews


Abe, N., Lean, I.J., Rabiee, A., Porter, J. and Graham, C. (1994) Effects of sodium monensin on the reproductive performance of dairy cattle. II. Effects on metabolites in plasma and resumption of cyclicity and oestrus in lactating cows. Aust. Vet. J. 71: 277-283

Ali, S., Bassett, J.R., Jones, M.R. and Wynn, P.C. (1992) The development of corticosteroid bindong globulin-like activity in foetal sheep blood. Physiology. 18: 13-18.

Anderson, M.L., Lean, I.J. and Blanchard, P.C. (1990). Corynebacterium pseudotuberculosis associated skin disease of Holstein cattle in the San Joaquin Valley, California. Bov. Practitioner. 25: 73-75

Annison, E.F. (1976) The usefulness to the animal producer of research on nutritional factors which influence the yield and composition of milk. Proc.Aust.Soc.Anim.Prod. 11: 465-471.

Annison, E.F. (1976). Energy utilization in the body. In 'Principles of Cattle Production.' Chapter 6, pp. 169-199. Ed. H.W. Swan, Butterworths: London.

Annison, E.F. (1983) Lipid metabolism .In ' Physiology and Biochemistry of the Domestic Fowl. Vol. 4:' pp.165-175. Ed. B. M. Freedman. Academic Press: London.

Annison, E.F. (1983). Metabolite utilization by the ruminant mammary gland. In 'Biochemistry of Lactation.' pp. 399-436. Ed. T.B. Mepham. Elsevier, Amsterdam and New York.

Annison, E.F. (1984). Interrelationships of mammary and overall metabolism. In 'Ruminant Physiology – concepts and consequences – a tribute to R.J. Moir'. University of Western Australia. Pp.299-310.

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Annison, E.F. (1988). Lactation. In 'The Scientific Basis of Modern Agriculture.' Chapter 18, pp. 296-305. Eds. K.O. Campbell and J.W. Bowyer. Sydney University Press, Sydney.

Annison, E.F. (1990). Aspects of quantative animal nutrition. Tagungsbericht, ETF – Zurich, Institut fir Nutztierwissenschaften.

Annison, E.F. (1991). Measurement of metabolism in whole animals and their tissues: an overview. Proc. Nutr. Soc. Aust.16: 146-153.

Annison, E.F., Gooden, J.M., Hough, G.M., McDowell, G.H. and Williams, A.J. (1984). Physiological cost of pregnancy and lactation in the ewe. In 'Reproduction in Sheep', pp. 174-181. Eds. D.R. Lindsay and D.T. Pearce. Australian Academy of Science/Australian Wool Corporation: Canberra.

Annison, E.F., Gooden, J.M. and Oddy, V.H. (1982). Hormonal: nutrition interactions in metabolic regulation in ruminants. Proc. Nutr. Soc. Aust. 7:81-88

Annison, E.F. and Leng, R.A. (1991) A history of the use of isotope tracer technology in ruminant nutrition: Lessons for present research. In 'Proceedings of an International Symposium on Nuclear and Related Techniques in Animal Production and Health.' Volume 318. pp. 3-23. Internation Atomic Energy Agency, Vienna. .

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Annison, E.F. and McDowell, G.H (1981). Nutrient responses in the dairy cow. Review prepared for the Australian Dairying Research Committee

Annison, E.F. and Mollah, Y. (1977) Prediction of nutritive value of feedstuffs from chemical composition. Proc. Symp. Poultry Husb. Res. Fdn. 13-21

Batterham, R.L., MacAuley, T.G., Drynan, R.G., Whelan, S.P., Barnes, S.A. and Gooden, J.M. (1993) Are dairy farms big enough? In 'Research Report commissioned for Australian Cooperative Foods Ltd.' Vol. 1, pp. 1-24 Department of Agricultural Economics: University of Sydney.

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Beh, K.J., Watson, D.L. and Lascelles, A.K. (1974). Concentrations of immunoglobulins and albumin in lymph collected from various regions of the body of the sheep. Aust. J. Exp. Biol. Med. Sci. 52: 81-86.

Bond, J.J., Wynn, P.C. and Moore, G.P.M (1996) Effects of epidermal growth factor and transforming growth factor alpha on the function of wool follicles in culture. Arch. Dermatol. Res. 288: 373-382

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Brandon, M.R. and Lascelles, A.K. (1975) The effect of pre-partum milking on the transfer of immunoglobulin into mammary secretion of cows. Aust. J. Exp. Biol. Med. Sci. 53: 197-204

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Callow, M.N., Fulkerson, W.J., Donaghy, D.J. Morris, R.J., Sweeney, G., Upjohn, B. (2005). Response of perennial ryegrass (*lolium perenne)* to renovation in Australian dairy pastures. Aust. J. Exp. Agric 46: 1041-1055.

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Clarke, D.J. and Lascelles, A.K. (1965). Factors affecting rate of flow in pipeline milking machines. Aust. J. Exp. Agric. Anim. Husb. 5: 115-119.

Cowie, A.T., Lascelles, A.K. and Wallace, J.G. (1964), Flow and protein content of testicular lymph in conscious rams. J. Physiol 171: 176-187.

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Darton, P.J. and McDowell, G.H. (1979). The effect of oestrogen on selective transfer of $IgG_1$ into mammary secretion of ewes. Aust. J. Exp. Biol. Med Sci. 57:617-623.

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Dobos, R.C and Fulkerson, WJ. (2004). A database program to assist in the allocation of pasture and supplements to grazing dairy cows. Exp Modelling and Software.19: 581 – 589.

Dorner,J.W., Cole, R.J., Elrington, D.J.., Suksupath, S., McDowell, G.H. and Bryden, W.L. (1994). Cyclopiazonic acid residues in milk and eggs. J. Agric.Fd. Chem 42,1516-1518.

Esler, W.J. and Kernohan, E.A. ((1971). Factors affecting the yellow stain on milk sediment discs. Aust. J. Dairy. Tech. 26:106-108.

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***3. Theses of Post-graduate Scholars from The Dairy Research Unit***

Aryajasse, S. (1980) Nutritional factors affecting milk yield and composition with special reference to energy supply of lactating ewes.
*Master of Agriculture.*

Beh, K.J.
*Doctor of Philopophy.*

Brandon, M.R. (1973) Transport of proteins across epithelial membranes.
*Doctor of Philosophy.*

Cappelini, O.R. (1984) Studies on the incidence of subclinical mastitis in dairy herds.
*Master of Agriculture*.

Clarke, D.J. (1966) A study of milking efficiency and vacuum characteristics of pipeline milking machines.
*Master of Science in Agriculture.*

Colditz, P.J.

Darton, P.J. (1981). Factors affecting transfer of immunoglobulin into ruminant milk.
*Master of Science in Agriculture*

Elrington, D.J. (1991). Mycotoxin and organochlorine residues in milk.
*Master of Science in Agriculture.*

Farooqi. R. (1989). The responses to exogenous bovine growth hormone in lactating ewes.
*Master of Agriculture.*

Field, D.E. (1979). Studies on the artificial induction of lactation in ruminants.
*Master of Science in Agriculture.*

Gooden, J.M.
*Doctor of Philosophy.*

G. Gow, C.B (1980). Studies on the initiation and maintenance of lactation in ruminants.
*Doctor of Philosophy*.

Greenwood, P
*Master of Science in Agriculture.*

Hargreaves, G.

Hartmann, P.E. (1966). Studies on lactational physiology in the cow with special reference to synthesis of milk fat.
*Doctor of Philosophy*.

Hough, G.M. (1982). Some aspects of glucose and acetate metabolism in the lactating ewe.
*Master of Science in Agriculture*

Hough, G.M. (1988). Partitioning of nutrients in the pregnant and lactating ewe.
*Doctor of Philosophy.*

Husband, A. J.
*Doctor of Philosophy.*

Jang, I.H. (1988). Effects of ergot derivatives on productivity and some physiological parameters in lactating ruminants.
*Master of Science in Agriculture*.

Jois. M. (1987). Amino acid metabolism in ruminants.
*Doctor of Philosophy.*

Kaiser, A.G..
*Master of Science in Agriculture*

Kernohan, E. (1977) Yellow stain on milk sediment test discs.
*Doctor of Philosophy*.

King, K.R. (1984). Lipid metabolism in the lactating ewe.
*Master of Science in Agriculture*

Lee, C.S. (1970). Histology of the Mammary gland.
*Doctor of Philosophy.*

Leenanuruksa, D. (1982). Some aspects of glucose metabolism in lactating ewes.
*Master of Science in Agriculture*.

Leenanuruksa, D. (1989). Roles of insulin and growth hormone in controlling glucose homeostasis in ruminants.
*Doctor of Philosophy*.

McDowell, G.H. (1970). Antibody in milk and immunity to staphylococcal mastitis.
*Doctor of Philosophy*.

Mackenzie, D.D.S..(1968). Studies on the transfer of blood serum constituents across the glandular epithelium of the mammary gland.
*Doctor of Philosophy*.

Mohammad Sharif, C.H. (1976). Effect of thyrotropin-releasing hormone (TRH) on lactating ewes.
*Diploma of Dairy Husbandry*.

Neutze, S.

Niumsup, P. (1990) Lipid metabolism in ruminants:Roles of growth hormone and insulin.
*Doctor of Philosophy.*

*Nusada, N. (1983) Studies on lactation in sheep.*
*Master of Agriculture*

Oddy, V.H.

Outteridge, P.M. (1967). Studies on local immunity in the mammary gland with particular reference to staphylococcal mastitis.
*Doctor of Philosophy.*

Paul, M.L. (1978). Studies on improving milk production in ruminants.
*Diploma of Dairy Husbandry.*

Perry, R.J. (1988) The effect of growth hormone upon some aspects of hepatic substrate metabolism in the ewe.
*Diploma of Dairy Husbandry*.

Ranawana, S.S.E. (1976) Aspects of protein and amino acid nutrition in the lactating ruminant.
*Doctor of Philosophy.*

Rizvi, A.W. 91976). Administration of TRH to ewes during the pre-parturient period and effect on milk production.
*Diploma of Dairy Husbandry.*

Ronda, B.R. (1981). Some effects of energy utilisation on milk yield and composition in ewes.
*Diploma of Dairy Husbandry*

Salahuddin, R.919760. The effect of the administration of the synthetic thyroprotein releasing hormone (TRH) on milk yield and composition.
*Diploma of Dairy Husbandry.*

Shannon, A.D..
*Doctor of Philosophy*

Sheldrake, R.F. (1981). Indirect tests for predicting the presence of intramammary infection in lactating cows.
*Master of Science in Agriculture.*

Sinclair, S.E.
*Master of Science in Agriculture.*

Sukarini, I.A.M. (1983) Studies on immunity to staphylococcal mastitis.
*Master of Agriculture.*

Sun, Y.X. (1989). Effects of manipulating growth hormone on nutrient utilization and productivity in ruminants.
*Doctor of Philosophy.*

Teleni, E. (1985). Muscle metabolism in ruminants.
*Doctor of Philosophy*.

Wadsworth J.C..
*Doctor of Philosophy*.

Watson, D.L.
*Doctor of Philosophy*.

Westwood, C.T. (1998.) Effects of Dietary protein degradability and genetic merit on the reproductive performance of lactating dairy cows.
*Doctor of Philosophy*.

Wynn P.C
*Doctor of Philosophy.*

**Table 8**

***Research Funding for Dairy Unit (1991-95)***

| *Year* | *Funded by* | *Amount ($)* |
|---|---|---|
| 1991 | Dairy Research Foundation (DRF) | 23,870 |
| | Dairy Research and Development Corporation (DRDC) | 29,142 |
| | Australian Research Grants (ARC) | 10,298 |
| | Pig Research and Development Corporation (PRDC) | 67,590 |
| | Australian Wool Corporation (AWC) | 3,000 |
| | Australian Meat and Livestock Research and Development Corporation (AMLRDC) | 119,000 |
| | ***Total*** | ***252900*** |
| 1992 | DRF | 22,845 |
| | DRDC | 71,588 |
| | PRDC | 80,406 |
| | AWC | 7,500 |
| | AMLRDC | 110,000 |
| | ARC | 9000 |
| | CSIRO/University Collaborative Research Grant Scheme (CSIRO/UCRGS) | 8150 |
| | ***Total*** | ***309,489*** |
| 1993 | DRF | 20,815 |
| | DRDC | 131,667 |
| | ARC | 40,500 |
| | PRDC | 84,255 |
| | AWC | 57,982 |

| | | |
|---|---|---|
| | AMLRDC | 113,000 |
| | CSIRO/UCRGS | 13,000 |
| | ***Total*** | ***461,219*** |
| 1994 | DRF | 21,650 |
| | DRDC | 142,550 |
| | ARC | 42,600 |
| | CSIRO/UCRGS | 13,000 |
| | Collaborative Research Grant in Dairying | 480,000 |
| | ***Total*** | ***699,800*** |
| 1995 | DRF | 21,500 |
| | CSIRO/UCRGS | 13,500 |
| | Collaborative Research Grant in Dairying | 480,000 |
| | ARC | 49,500 |
| | ***Total*** | ***564,500*** |

**Table 9**

***DRF sponsors contracted to provide in total $40,000 in support of the endowed Chair of Dairy Science***

National Foods

NSW Food Authority

DHC Enterprises (Doug Crosby)

PGG Wrightsons Seeds

Dairy Farmers

DidCo

Dairy Industry Conference

NSW Farmers Association

**Table 10.**

***Industry funded research grants to DRF following the appointment of Professor Fulkerson***

| | $ ,000 |
|---|---|
| 2000/01 | 24 |
| 2001/02 | 223 |
| 2002/03 | 423 |
| 2003/04 | 370 |
| 2004/05 | 1,108 |
| 2005/06 | 973 |
| 2006/07 | 783 |

**Table 11.**

***Technical and other support staff based at Dairy Unit 1957-2007***

| | | | |
|---|---|---|---|
| Ms J | Armstrong | 1964 – 1967 | Laboratory Assistant |
| Mr S | Barnes | 1992 – 1993 | Research Assistant |
| Mr S | Bennetts | 2000 – 2007 | Dairy Apprentice/Technical Assistant |
| Miss K | Blackshaw | 1988 | Lab Assistant |
| Miss D | Bornow | 1984 | Lab Assistant |
| Miss S | Brookes | 2004 – 2007 | Technical Officer |
| Mrs C | Browne | 1997 | Admin Assistant |
| Miss K | Bye | 1978 – 1980 | Lab Assistant |
| Mrs E | Cannon | 1978 – 1987 | Lab Attendant |
| Mr H | Cannon | 1978 – 1985 | Technical Officer |
| Miss J | Carr | 1978 – 1984 | Lab Assistant |
| Mr N | Catt | 1978 – 1987 | Animal Attendant |
| Mrs S | Catt | 1980 - 2007 | Lab Attendant/ Tech Officer/ Admin Assistant |
| Miss J | Clark | 1982 | Lab Attendant |
| Ms L | Davis | 1970 - 1973 | Lab Assistant |
| Mr D | Dickeson | 2007 | Research Assistant |
| Miss K | Eardley | 1990 – 1993 | Technical Officer |
| Miss J | Emmerton | 1987 – 1990 | Animal Attendant |
| Mr G | Gray | 1965 - 1970 | Senior Animal Attendant |
| Mr P | Hahn | 1984 - 1986 | Lab Assistant |
| Mrs E | Hall | 1995 | Lab Assistant |
| Miss M | Hall | 2002 – 2004 | Lab Assistant |
| Miss D | Harrison (Horsley) | 1981 – 1991 | Dairy Hand |
| Mrs S | Harrop | 1980 – 1982 | Cleaner |
| Mrs M | Heward | 2004 – 2007 | Admin Assistant |
| Mr P | Hewson | 1985 – 1987 | Secretariat |

| | | | |
|---|---|---|---|
| Mrs C | Horne | 1973 - 1981 | Dairy Hand |
| Mr D | Lam | 2006 | Technical Assistant |
| Mr P | Looby | 2005 | Technical Officer |
| Mr J | Marsh | 1992 – 2007 | Dairy Hand |
| Mr K | McKean | 1978 – 2007 | Farm Hand/ Animal Attendant/ Farm Supervisor |
| Mrs H | Miller | 1982 – 1984 | Lab Technician |
| Mr P | Moules | 1968 - 1970 | Animal Attendant |
| Mrs B | Mulley | 1975 -1978 | Cleaner |
| Miss K | Officer (Van der Jagt) | 1980 – 1990 | Lab Attendant/Technical Officer |
| Mr S | Pattison | 1992 – 1994 | Research Assistant |
| Ms R | Pell | 1965 – 1970 | Lab Attendant/Technical Officer |
| Mrs D | Pudney | 1985 – 1997 | Stenographer/Admin Assistant |
| Ms J | Rock | 1964 – 1969 | Lab Assistant/Technical Officer |
| Mrs A | Rogers | 2004 – 2006 | Technical Officer |
| Ms C | Salt | 1967 - 1970 | Lab Attendant |
| Mrs M | Saunders | 1967 -1972;1978 – 1982 | Lab Attendant/ Technical Officer |
| Mrs J | Sclater | 1995 - 2000 | Technical Officer |
| Mrs K | Scrimgeour | 1987 – 1998 | Lab Assistant/Technical Officer |
| Mrs R | Small (Smith) | 1969 -1975;1995 – 1998 | Technical Officer |
| Ms C | Smith | 1969 -1972 | Lab Assistant |
| Mr C | Stimson | 1997 – 2001 | Senior Technical Officer |
| Ms E | Stubenrauch | 1968 – 1970 | Laboratory Assistant |
| Mr S | Suarez-Sandoval | 2005 – 2007 | Technical Assistant |
| Mrs E | Sylvester | 1978 | Cleaner |
| Mr J | Trenear | 1991 – 1992 | Technical Officer |
| Mrs K | Van der Jagt | 1985 – 1990 | Technical Officer |
| Mr W | Van Kouterik | 2006 | Technical Assistant |
| Mr C | Wadsworth | 1978 -1985 | Gardener |

| | | | |
|---|---|---|---|
| Mr D | Ward | 1992 – 1993 | Research Assistant |
| Miss M | Webb | 1986 | Research Assistant |
| Mrs L | Webber | 2002 – 2003 | Admin Assistant |
| Mrs N | West | 1987 – 1997 | Admin Assistant |
| Mrs N | West | 2006 – 2007 | Admin Assistant |
| Mrs A | Whittington | 1978 | Lab Assistant |
| Mrs M | Widridge | 1998 – 2001 | Admin Assistant |