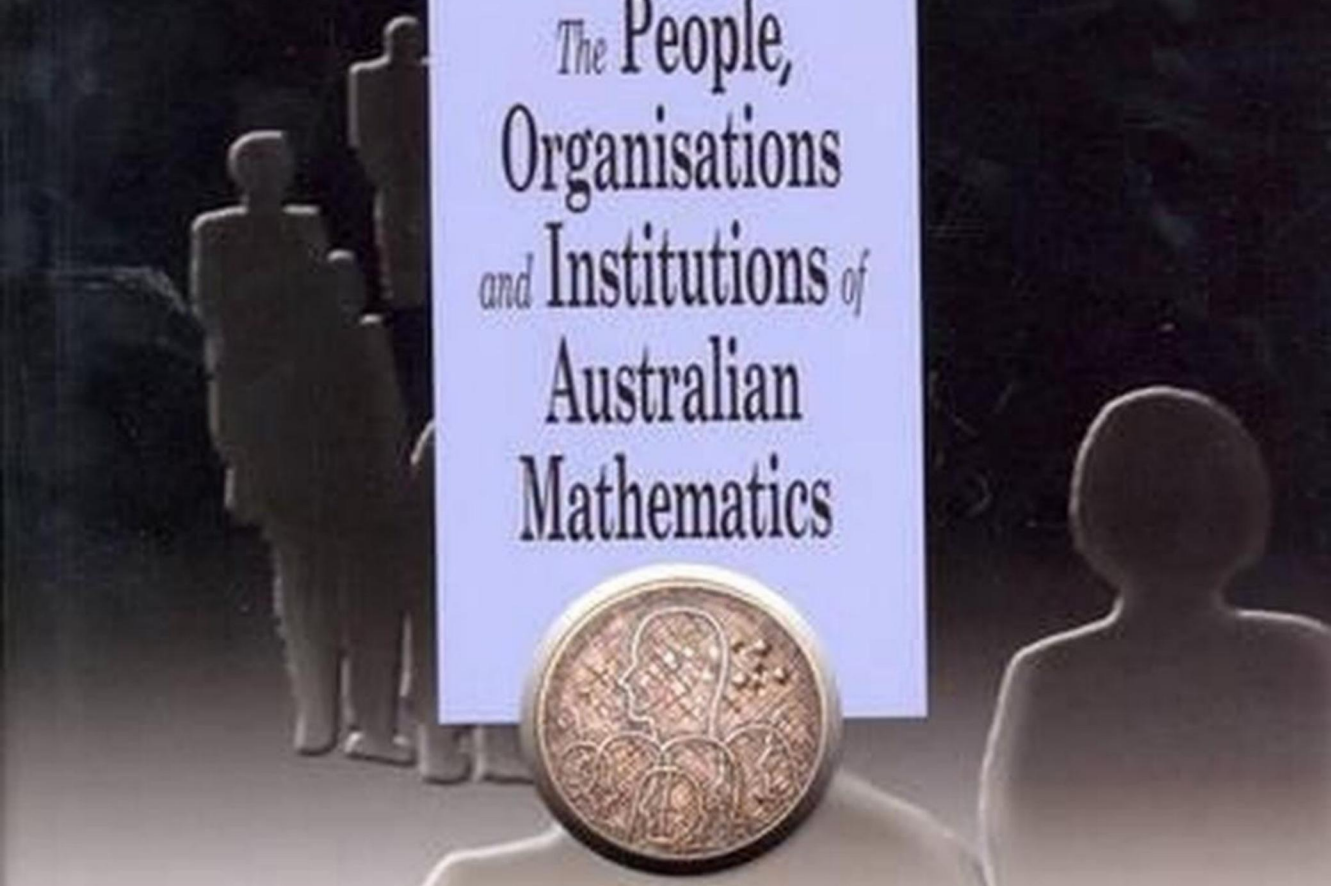
COUNTING AUSTRALIA IN

The People, Organisations and Institutions of Australian Mathematics



Graeme Cohen

With a foreword by Lord Robert May of Oxford

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GRAEME COHEN

Halstead Press in association with
The Australian Mathematical Society

SYDNEY MMVI
Published by Halstead Press
300/3 Smail Street,
Broadway, N.S.W., 2007

in association with
The Australian Mathematical Society
c/-Department of Mathematics
Australian National University, Canberra, A.C.T., 0200

 Typeset by Network Printing, Kensington, N.S.W.
Designer: Kylie Prats. Printed in Sydney by Ligare.

National Library cataloguing in publication entry

Cohen, Graeme L. (Graeme Laurence).
Counting Australia in : the people, organisations and institutions of Australian mathematics.

Bibliography.
Includes index.
ISBN 1 920831 39 8.

1. Mathematics – Australia – Societies, etc. 2. Mathematics – Australia – History. 3. Mathematicians - Australia – History. I. Title.

506.094

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Foreword

It is a great pleasure to write a Foreword to this book.

For one thing, the book gives an excellent and informative account of the history of mathematics in Australia, from the earliest times—beginning, appropriately, even before the advent of James Cook—to the present. It brings home the exceptionally high quality of mathematics teaching and research in Australia, even in earlier days when the "tyranny of distance" was much more real than it is today.

For another thing, the book interprets "mathematics" in the widest sense, embracing pure and applied mathematics along with statistics (covering both "mathematical statistics" and some important areas of application). I think this ecumenical definition of mathematics in Australian universities is one of the country's strengths. Although comparisons with the definition of mathematics departments in universities elsewhere lies largely, and understandably, outside the scope of this volume, I think it notable that "Mathematics Department" in most US universities means pure mathematics. Many of the distinguished faculty in Princeton's superb Mathematics Department, for example, lamented John Tukey dissipating his talents on mere research on statistics (taught in his time in the small and separate Statistics Department).

Although there were and are departments of applied mathematics alongside pure mathematics in some US universities—Brown and Minnesota are notable examples—they were, for most of the twentieth century, exceptions. Thus at Harvard in the 1960s, I taught Applied Math 105a in the Division of Engineering and Applied Physics, which paralleled the alternative Mathematics 105a in the Mathematics Department. Both dealt essentially with vector calculus, matrix algebra and suchlike. The difference was basically that in Applied Math 105a Green's Theorem was "proved" by cancelling an integral sign against dx, whereas Mathematics 105a focussed rigorously on the exquisite epsilonology of the proof. Elsewhere, in the "real Cambridge" in the UK, the distinguished Applied Mathematics Department was and is brigaded with Theoretical Physics in the Department of Applied Mathematics and Theoretical Physics. I think things are changing everywhere to a more uniform approach, but in many ways Australia was ahead of the game.

This may explain why Australian applied mathematicians and statisticians are notably abundant on the international stage, some based in their home country, others exported. In saying this, I am taking a broad view of "applied mathematics" and of "mathematical statistics", to embrace the practice of such mathematical activities outside departments labelled as mathematics departments. Thus in biology, Australian population geneticists seem over-represented (Ewens, Feldman, Donnelly, to name a few), arguably reflecting the familiar phenomenon of the influence of a dominant person (in this case Moran) in a relatively small country.

It is entirely justifiable that the present volume focuses mainly—although with many exceptions—on Australian mathematics as taught and practised in mathematics departments. This occasionally means skipping over interesting people and interesting mathematical developments. At Sydney University, after the arrival of Butler, Blatt and Schafroth in the Theoretical Physics Department in the late 1950s, the mathematical research there in my opinion overshadowed

that in the Applied Mathematics Department, which is discussed in much greater detail. Other applied mathematicians who worked outside applied mathematics departments receive due attention. One example is the colourful John Philip FRS, FAA—director of the notable CSIRO soil science unit—with whom I had the privilege of sharing an office at Harvard in the early 1960s. Brian Anderson, President of the Australian Academy of Science (1998–2002), gets relatively little mention, essentially because he practised mathematics in an electrical engineering department.

These are minor quibbles about a volume that is thoroughly researched, and which presents a vast amount of material in a lucid and engaging way. I hugely enjoyed conjuring up my youth as I read of the quarrels between the Pure Professor Room ("all these points and lines are, of course, purely imaginary") and the Applied Professor Bullen ("now turn to page 126 of My Book"), and the comments on departmental affairs made by people such as Bruce Bolt and Les Woods whose lectures and general mentoring I recall with pleasure and affection. Just as poetry is "emotion recollected in tranquillity", this book offers to many mathematics graduates of Australian universities an opportunity to revisit early learning experiences and challenges, and see them afresh with the perspective afforded by distance.

Robert M May OM AC
President, The Royal Society
28 November 2005

To Susan
who was very helpful and very forebearing,
even though she thought I had retired.

Preface

In October 1999, in a note in the *Australian Mathematical Society Gazette*, the secretary at the time, David Elliott, drew attention to the 50th anniversary of the Society to occur in 2006 and asked for someone to write its history. My offer more than a year later to David and Alan Carey, then the president, was much more ambitious—the history of mathematics in Australia.

This book is the culmination of what became the Australian Mathematical Society History Project. Other aspects of the project have been the taping of interviews with foundation members of the Society and other prominent mathematicians, and the gathering of photographs and other images relevant to the history. Twenty-four interviews were conducted and all have been fully logged; more than 200 images were collected, of which more than 80 are included in the book. All notes connected with the book, including emailed messages and letters referenced in the book as "private communications", all tapes and all images will be catalogued and stored with the Society's archives, held by the Basser Library in the Australian Academy of Science, Canberra.

Counting Australia In is a comprehensive account, in ten chapters and three appendices, of mathematics in Australia up to the present day. In particular, Chapter 10 is the requested history of the Society itself. Quite purposely, despite my original offer, the title of the book does not refer to a history. That would suggest the development of mathematics as an academic study in Australia, with all its sub-disciplines, and that is a task beyond any individual. The subtitle of the book says it all: it is about the people, organisations and institutions of Australian mathematics.

Nothing of this scope has been undertaken previously. There have been obituaries of the more notable mathematicians and published accounts of the early history of mathematics and statistics departments at the University of Sydney, the University of Melbourne, the University of Adelaide, the Australian National University and CSIRO. As well, background notes in various forms have been collated in the past concerning the departments in five or so other universities. Research for this book, sponsored by the Australian Mathematical Society, has taken me to all states in the country and to Canberra, incorporating visits to many university libraries and archives and State Libraries.

Mathematics as an academic pursuit began in Australia with the first lecture given in the University of Sydney in October 1852. Chapter 2 starts out with those details but before that there were many instances of the use of mathematics, and of quantitative thinking by Aboriginals and Islanders, and these are the content of Chapter 1. In particular, there is a survey of mathematics in the schools prior to the 1850s, given partly as background to the establishment of the first universities. Besides university mathematics and statistics departments, the coverage includes relevant aspects of the country's Royal Societies, the Australasian Association for the Advancement of Science and ANZAAS, CSIRO and its forerunners, the Australian Bureau of Statistics and the Australian Academy of Science.

Archival and library research has uncovered the following.

- The first mathematics book produced in the country, a small book of multiplication tables published in Sydney in 1831.
- The mathematical work of the surveyor Martin Gardiner in the 1850s to 1870s. Although none of his work has modern ramifications, Gardiner was prolific and well acquainted with international study in the relevant areas.
- An application from Thomas Gerald Room for the chair of mathematics in the University of Western Australia in 1928. This was six years before he gained the chair in Sydney. The earlier interest in coming to Australia was not known to his biographers.
- The circumstances concerning the appointment of Thomas Cherry as professor of mathematics in the University of Melbourne ahead of the highly regarded American, Norbert Wiener. Little, if anything, was previously known of this.
- The complete background to the antipathy between Room and Keith Bullen at the University of Sydney. The existence of the antipathy was certainly well known, to the detriment of mathematics there, but more information has now been made available on Bullen's quest for equal recognition.

There are also the various firsts that have been confirmed. For example:

- Elphinstone Moors, born in Melbourne in 1859, was the first Australian mathematician of note to be born in this country. He joined the University of Sydney in 1887. Furthermore his course on Actuarial Mathematics and Statistics, introduced in 1913, was the first such in the country.
- John Michell, of the University of Melbourne, was the first Australian-born professor of mathematics and the first Australian fellow of the Royal Society in the mathematical sciences.
- Margaret Moir (University of Western Australia) and Edith Lowenstern (University of Tasmania) were the first full-time women lecturers in mathematics in Australia, both appointed in 1929.

There have been other delights resulting from this work, such as the discovery of Basil Rennie's diary and its account of the inaugural meeting of the Australian Mathematical Society, and the gaining of permission from CSIRO to publish, for the first time, a photo of Helen Newton Turner and Sir Ronald Fisher sailing on Sydney Harbour.

Best of all has been the opportunity to meet and correspond with hundreds of people from all over Australia and a few dozen more from around the world.

There are 25 mathematicians around the country whom I interviewed on tape for the Australian Mathematical Society History Project. Five of those, Oliver Lancaster, Bernhard Neumann, Ren Potts, George Szekeres and Fenton Pillow, did not live to see the publication of *Counting Australia In*. Sadly, Lancaster's interview was too late in his life to be of use to my project, but the other 24 are quoted with grateful acknowledgment through the book.

Some of those and a great many others were exceptional in the assistance they provided and I am happy to acknowledge that help. I apologise to all those who feel they too should be mentioned. They are probably right. But I would particularly like to include here: Paul Ashton, Rodney Baxter, Elizabeth Billington, Walter Bloom, Ern Bowen, Maurie Brearley, John Burns, John Clark, Susan Cohen, Michael Cowling, Neville de Mestre, David Elliott, Jim Franklin, Walter Freiberger, Joe Gani, John Giles, Tony Guttmann, Vince Hart, Malcolm Hood, Algy

Howe, Hans Lausch, John Louis, John Mack, Daniel Mathieu, Rob McDougall, Mike Newman, Graham Pollard, Cheryl Praeger, Barbara Rennie, Mark Richmond, Eugene Seneta, Terry Speed, Jan Thomas, Ernie Tuck, Jo Watson, Kevin Wilkins and Beth Wright.

I also very much enjoyed two conversations with Fenton Pillow in Brisbane and detailed emails from Dick Dalitz at Oxford. Both are now deceased.

Matthew Richardson at Halstead Press and Kylie Prats at Network Printing must be mentioned for the care that they and their colleagues have put into the presentation of this book. I am very grateful. This work has been undertaken under three presidents of the Australian Mathematical Society. To them and the Councils with which they worked I can only say that I am truly humbled in my recognition of the encouragement and support that they have given me throughout the project.

Graeme Cohen
August 2006

Main abbreviations

AAAS – Australasian Association for the Advancement of Science
AAMT – Australian Association of Mathematics Teachers
ABC – Australian Broadcasting Corporation
ADB – Australian Dictionary of Biography, Melbourne University Press
ADFA – Australian Defence Force Academy
AIF – Australian Imperial Force
AMC – Australian Mathematics Competition
AMF – Australian Mathematical Foundation Limited
AMOC – Australian Mathematical Olympiad Committee
AMPAI – Australian Mathematical Publishing Association Incorporated
AMSC – Australian Mathematical Sciences Council
AMSI – Australian Mathematical Sciences Institute
AMT – Australian Mathematics Trust
ANSTO – Australian Nuclear Science and Technology Organisation
ANU – Australian National University
ANZAAS – Australian and New Zealand Association for the Advancement of Science
ANZIAM – Australia and New Zealand Industrial and Applied Mathematics
APT – Applied Probability Trust
ARC – Australian Research Council
ARL – Aeronautical Research Laboratories
BA, BEc, BSc – Bachelor of Arts, Economics, Science
CCAE – Canberra College of Advanced Education
CMA – Centre for Mathematical Analysis, Centre for Mathematics and its Applications
CMIS – CSIRO Division of Mathematical and Information Sciences
CSIR – Council for Scientific and Industrial Research
CSIRO – Commonwealth Scientific and Industrial Research Organisation
DAM – Division of Applied Mathematics
DipEd – Diploma of Education
DMS – Division of Mathematical Statistics, Division of Mathematics and Statistics
DPhil, DSc – Doctor of Philosophy, Science
DSTO – Defence Science and Technology Organisation

FASTS – Federation of Australian Scientific and Technological Societies
FRS – Fellow of the Royal Society
IAS – Institute of Advanced Studies
ICE-EM – International Centre of Excellence for Education in Mathematics
ICIAM – International Congress on Industrial and Applied Mathematics
IMO – International Mathematical Olympiad
MA, MBA, MEc, MLitt, MSc (or MS) – Master of Arts, Business Administration, Economics, Letters, Science
MELA – Mathematics Education Lecturers' Association
MERGA – Mathematics Education Research Group of Australasia
MISG – Mathematics-in-Industry Study Group
MSI – Mathematical Sciences Institute
NSW – New South Wales
PhD – Doctor of Philosophy
QUT – Queensland University of Technology
RAAF – Royal Australian Air Force
RANC – Royal Australian Naval College
RMC – Royal Military College of Australia
RMIT – Royal Melbourne Institute of Technology
ScD – Doctor of Science
SGS – School of General Studies
SRI – Summer Research Institute
TCE – Tasmanian Council of Education
UNE – University of New England
UniSA – University of South Australia
UNSW – University of New South Wales
UTS – University of Technology, Sydney
UWA – University of Western Australia
WFNMC – World Federation of National Mathematics Competitions

Journal abbreviations in the endnotes generally follow those in the publications of the American Mathematical Society.

Chapter 1

Mathematics and the Beginnings of the Colonies

The first mathematician in Australia, or at least the first person who has previously been recognised and labelled as such, was Morris Birkbeck Pell, the foundation professor of mathematics at the University of Sydney. He arrived in Sydney in 1852. Some time before that, in the 1820s, the New South Wales government astronomer Carl Rümker was very capably applying his mathematical skills in his professional duties.

Indeed, in the eighty years from the time Lieutenant James Cook sailed into Botany Bay in 1770, there were many mathematically trained citizens or visitors carrying out duties in astronomy, surveying, meteorology, navigation, commerce, census taking and teaching. This chapter constitutes a survey of their work—the period up to the founding of the University of Sydney. But consideration must first be paid to the period before white settlement of Australia.

For the fifty thousand years before Cook and other British and European visitors, the land was inhabited by Aboriginal people on the mainland and Tasmania and Islanders north of the mainland. They had arrived during the last ice age and for unknown reasons remained largely insulated from the Malays moving into the Indonesian Archipelago and, much later, the Chinese, the Hindus and the Muslims who traded no further south than Timor.

Early writings on Aboriginal counting systems perpetuated myths that the languages and hence counting itself included no number beyond two. The writers' own evidence very often did not support this. Across the country, tribal languages varied in their ability to handle numbers, with many concerned more particularly to demonstrate a qualitative approach to relationships and groupings of commodities and people.[1] Most groups counted by fives. Some systems had specific words for five, ten, fifteen, twenty, thirty, forty and in some cases one hundred and one thousand, and others incorporated words for hand and foot or used actual hands and feet as counting aids. (The English language still uses "hand" and "foot" as measures.) Many of the languages counted to five and beyond using words for one and two and then conjuncts of these, leading to the misinterpretations of Aboriginal numeracy. Besides these, there is some evidence that the Yolngu people of north-eastern Arnhem Land travelled to Macassar, now Ujung-Pandang in south-western Sulawesi, and dealt with the people there long before any Europeans came and as a consequence were familiar with Macassan numbers. Apart from simple counting, the numbers were used in trade, for calendar calculations and in battle strategies.[2]

The many languages of the Aboriginals and Islanders included other concepts that may be

described as mathematical: the recognition of relationships between members of one tribe and from tribe to tribe,[3] the use of inequalities, the reporting of position and time, comparisons of dimensions such as mass, length and capacity, and description of shapes.[4] There were no written languages, however, and probably for that reason there was no systematic development of mathematics.[5]

Tales of the early explorers

Cook himself should be included in any survey of early Australian mathematics. One biographer, Rupert Gould, described him as "at once the last of the early great navigators and the first of the modern scientific explorers",[6] and many biographies justifiably refer to him as a mathematician. His early formal training was brief, just "writing and the rudiments of arithmetic", but after going to sea in 1746 he studied elementary navigation for himself, to the extent that as master's mate he would have known more than the captains under whom he served. He subsequently distinguished himself in the Gulf of St Lawrence and Newfoundland, and "spent his spare time during the winters of 1759 and 1760 . . . in reading mathematics (including Euclid) and astronomy".[7]

James Cook, the scientist, is perhaps best known for his careful observations of an eclipse of the Sun on 5 August 1766 and for his subsequent calculations. Cook was situated in the Burgeo Islands near Cape Ray, Newfoundland. The results were sent to John Bevis in London who compared them with similarly accurate observations made at Oxford. Using an eclipse in this manner allowed the two sets of readings to be set at the same point in time and this enabled an accurate determination of the longitude of Cook's original observation point.[8] The method and the results were communicated to the *Philosophical Transactions of the Royal Society* and published in 1767. The note begins: "Mr. Cook, a good mathematician and very expert in his business"[9].

This and other talents put Cook in good stead to command *Endeavour* on its voyage to the South Pacific to observe the transit of Venus across the face of the Sun, due to occur on 3 June 1769. Fifty years earlier, the transit had been predicted by Edmund Halley, later to become Astronomer Royal and after whom the comet is named. Observations of the transit from various points around the globe were to enable the calculation of the distance of the earth from the Sun in a manner first suggested by Kepler.

The voyage was undertaken by the British Admiralty at the behest of the Royal Society, and the Admiralty gave Cook the second motive of discovering, if possible, the "Southern Continent". Furthermore: "If it were inhabited, he was to cultivate friendly, but cautious, relations with the natives; and, with their consent, to take possession of it in the King's name."[10]

The transit of Venus, lasting almost six hours, was duly and successfully observed from Tahiti and, after three months in the vicinity, Cook sailed westward and then southward to become the first white man to sight New Zealand since Abel Tasman in 1642. He chose a homeward route that took him toward Van Diemen's Land but *Endeavour* was blown northward and Cook proceeded up the east coast of New Holland, as the land had been called since the Dutch discoveries of the first half of the 17th century. He anchored in Botany Bay on 28 April 1770. After traversing the whole eastern coast, Cook took formal possession on 22 August and named the land New South Wales.

Yet James Cook was not the first scientist with a mathematical bent to visit Australia. The first significant use of mathematical methods in Australian waters was by Tasman when he

discovered Van Diemen's Land in 1642. Tasman was one of the first to use logarithms, which had been devised by John Napier about 25 years earlier largely to simplify spherical trigonometry for use in navigation. Tasman was able to produce charts of his voyages with longitudes more accurately calculated than was otherwise possible until Cook's methods of 1766 came to be widely known.[11] William Dampier, who inadvertently explored the north-west coast of Australia in 1688 and then returned in 1699 on assignment for the British Admiralty, was also recognised as an accomplished navigator and map maker.

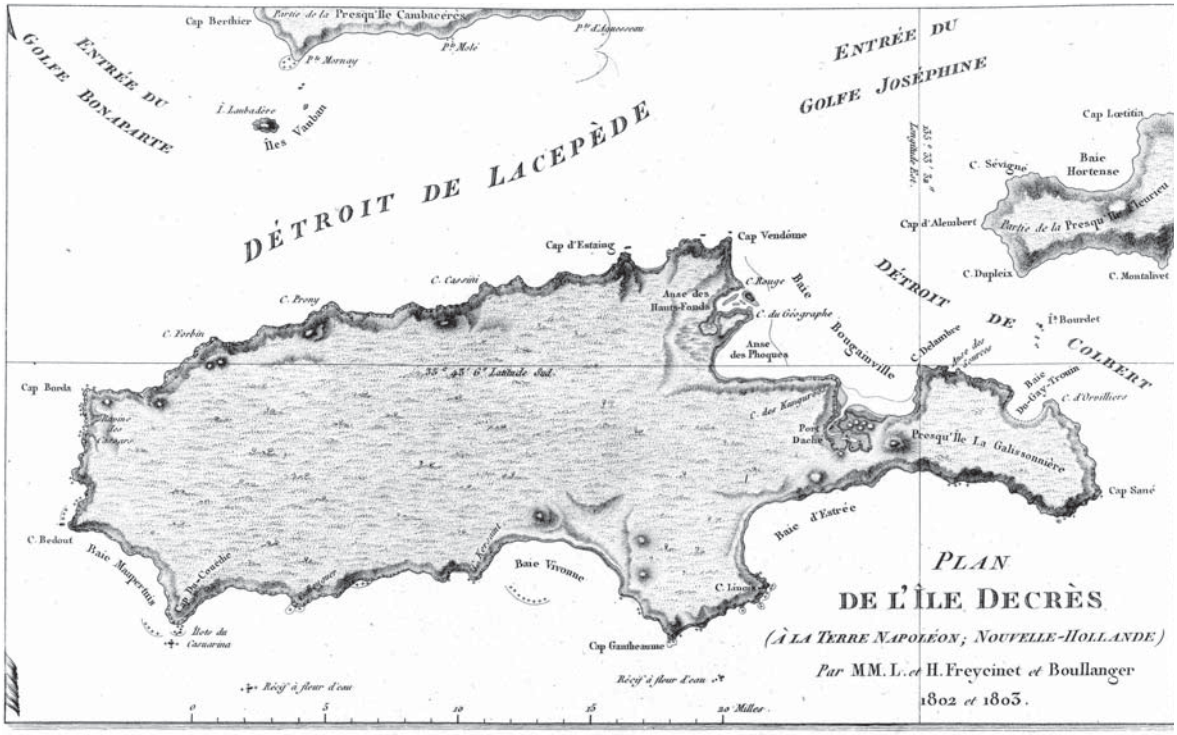
Accompanying Cook in *Endeavour* was the great naturalist Sir Joseph Banks. He was the first to suggest the transportation of convicts to New South Wales following the American War of Independence in 1776, which had stopped the sale of British convicts to planters there. On 26 January 1788, Captain Arthur Phillip accordingly established a colony at Sydney Cove, Port Jackson, having moved on from Botany Bay where he had arrived eight days earlier.

Within a few days, Jean-François de Galoup, Comte de La Pérouse, entered Botany Bay in command of the frigates *L'Astrolabe* and *La Boussole*. His crew of 114 included sailors, scientists, engineers, physicists, astronomers, naturalists, draftsmen and clergymen, and a mathematician. This reflects the scientific nature of La Pérouse's mission, undertaken at the direct request of his friend King Louis XVI. But when they arrived in Botany Bay there was no mathematician aboard. Gaspard Monge, who was pre-eminent in French mathematics at the time, had been one of the original company when La Pérouse set out two and a half years earlier, but poor health forced him to disembark at Tenerife in the Canary Islands. He soon returned to Europe.[12] Monge had set sail with La Pérouse in his role as the French government's examiner of naval cadets. He was the founder of modern descriptive geometry and worked also in calculus and the theory of machines, besides being a distinguished chemist and a political activist. Monge died in 1818 but if he had stayed aboard with La Pérouse his life would have been very much curtailed, to the great detriment of mathematics and French society, because La Pérouse sailed out of Botany Bay on 10 March 1788 and he, his crew and his ships were never seen again.

In England ten years later, Joseph Banks prevailed upon a young botanist, Robert Brown, to sail to New Holland with Lieutenant Matthew Flinders. Brown spent nearly four years in the colonies, collecting specimens around Sydney as far north as the Hunter River, as well as in Van Diemen's Land, on Norfolk Island and on the west coast.[13] Brown achieved great eminence on his return to England, first as continuing protégé to Banks and in his own right following Banks' death in 1820.

In 1827 he observed the persistent movement of tiny particles caused by the suspension of pollen grains in water even though there was no evidence of external hydrodynamic effects. Independently, Albert Einstein and the Polish physicist Marian Smoluchowski analysed this phenomenon in 1905 and explained it as being due to random collisions with the surrounding water molecules. Brown's observations became known initially as Brownian movement and then as Brownian motion. The subsequent mathematical theory, the study of stochastic processes, has very modern applications such as in the theory of option pricing. A further Australian connection, which anticipated Einstein's discovery, is described in the next chapter.

Matthew Flinders, who ferried Brown to Australia in *Investigator*, himself obtained renown for his observational skills, longitudinal calculations and ability as a surveyor and chartist. In 1802 he and the Frenchman Nicolas Baudin, having been sent by their respective governments for the purpose, both explored the coasts off South Australia, referred to until then only as "the unknown coast". Baudin died on the return voyage and his charts were not completed and



Louis de Freycinet's 1811 map of Kangaroo Island showing Baudin's place names. Cape Borda is on the northwest coast and Cape Cassini on the north coast. The vehicle ferry that now runs from Cape Jervis on the mainland to Penneshaw at the eastern end of the island might have become known as that from Cape d'Alembert to Cape Delambre. (Royal Geographical Society of South Australia; supplied by the State Library of South Australia)

published until 1807, in *Voyage de Découvertes aux Terres Australes*, much of the work being carried out by others who had accompanied him. They used French place names throughout, often the names of academicians and classical scientists. Flinders' own charts were not published until 1814, in *A Voyage to Terra Australis*, and he acknowledged Baudin's primacy for many of the discoveries. This is the book in which Flinders advocated the name "Australia".

If Baudin's place names had prevailed, there would be today in and around Spencer Gulf (or Golfe Bonaparte) such sites as Laplace and Pascal Bays, Fermat and Lagrange Islands, and capes named for D'Alembert, Delambre, Monge, l'Hôpital, Legendre and Euler, all recalling mathematicians of the highest order. Flinders' charts were superior, however, and the second edition of Baudin's *Voyage*, in 1824, reverted to Flinders' names.

There were some exceptions—many of Baudin's names were maintained on Kangaroo Island, including Cape Borda and Cape Cassini. Jean-Charles Borda (1733–1799) was a French mathematician and geodesist whose "Borda counts" of votes are still used today in electoral analysis. Gian Domenico Cassini was a seventeenth century Italian astronomer and geometer who obtained French citizenship in 1673 and began a dynasty of three further generations of Cassinis, all notable astronomers and geodesists. Jacques Cassini, son of Gian Domenico, like his father "never admitted to the value of the theory of gravitation" of Newton, Huygens and others. [14] This is exemplified in the father's "ovals of Cassini", still referred to today,

which are curves of the fourth degree designed originally as alternatives to Kepler's ellipses in orbital theory.

Finally, while in South Australia mention might be made of its third governor, Captain George Grey. Born in Lisbon, Portugal, in 1812, he was educated at the Royal Military College, Sandhurst, as an engineer and served with the British Army in Ireland. In 1837 he sailed from Plymouth in *Beagle* as leader of a government exploration expedition to Western Australia. (*Beagle* is famously associated with the English naturalist Charles Darwin, whose voyage to Australia aboard that ship had taken place the previous year.) Grey was governor of South Australia from 1840 to 1845 and later served two separate terms as governor of New Zealand. In between, he was governor of Cape Colony and High Commissioner for South Africa, and was knighted in 1848. After a few years in England, he retired to New Zealand in 1870 but then entered politics, serving as premier there from 1877 to 1879.

Throughout his life, Grey kept up a very strong interest in science, including mathematics. He studied quaternions at the age of 62 and, while premier of New Zealand, wrote extensive annotations in both volumes of Clerk Maxwell's *Treatise on Electricity and Magnetism*, published only shortly before in 1873.[15] He was a personal friend of Charles Babbage, Charles Darwin, Charles Lyell and Richard Owen, eminent British scientists, and he corresponded extensively with Florence Nightingale on the need to maintain statistics.[16] Babbage Island, off the West Australian coast at Carnarvon, was named by Grey during his voyage of exploration in 1837.

School and adult education in the colonies

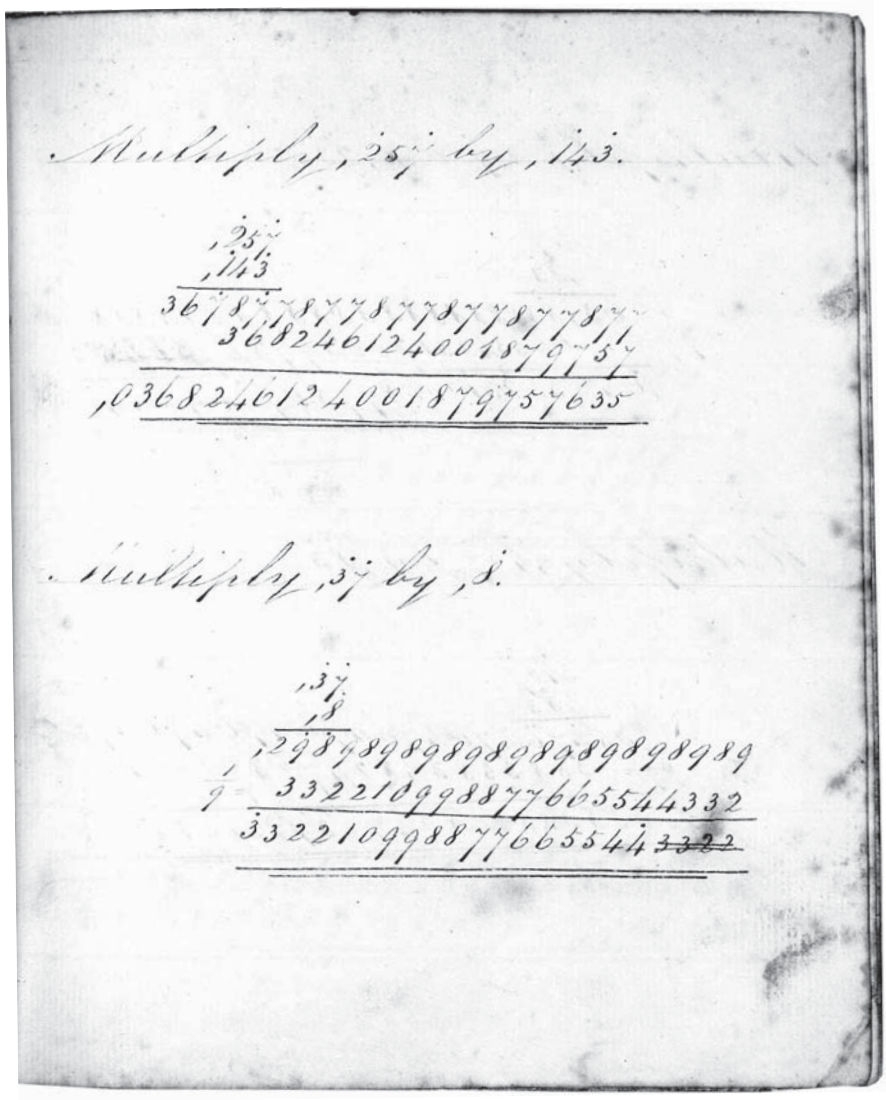
Formal education began in Australia within a few years of Governor Arthur Phillip's establishment of a British settlement at Port Jackson. By 1800 there were almost one thousand children of school age in Sydney and the arrival of the third governor, Philip Gidley King, in that year heralded further interest and an expansion in education. That was the year in which the first private-venture school appeared. "Such schools" wrote Adam Barcan, in *Two Centuries of Education in New South Wales*,

> taught the basics—reading, writing, arithmetic. Soon more ambitious private schools appeared, often calling themselves "academies". The academies taught "modern" or commercial subjects, such as English, writing, bookkeeping, French and mathematics, which might include geometry and trigonometry, and sometimes geography or astronomy . . . John Mitchell and James MacConnell opened an academy in 1804 to teach "English grammatically, Writing, Book-keeping after the Italian mode, French grammatically, and Mathematics".[17]

Progress in education was continued by King's successor, William Bligh. Among his reforms was the introduction of government salaries for elementary school teachers. Evening schools, some specifically designed for further adult education, opened between 1806 and 1808 and by this time there were also schools on Norfolk Island and in Van Diemen's Land. The rebellion of officers of the New South Wales Corps in January 1808, resulting in Bligh's overthrow as governor, interrupted these educational advances and in the two years that followed the percentage of children attending school fell to its lowest since 1791.[18]

Lachlan Macquarie took over as governor of New South Wales in January 1810, until 1821. "Advanced" education for the children of those families that could afford it was by then well established, although schools tended to be short lived. One of the most successful, lasting from 1819 to 1825, was Laurence Halloran's Academy, which provided "Classical, Mathematical and Commercial Learning" to "young Gentlemen". The emphasis in curriculum and teaching method was not surprisingly an imitation of the prevalent English values, with the approach to

(a)



(a) A page from John Campbell's arithmetic work book, 1817, illustrating the multiplication of recurring decimals, and (b) a page from one of his later school books, 1819.

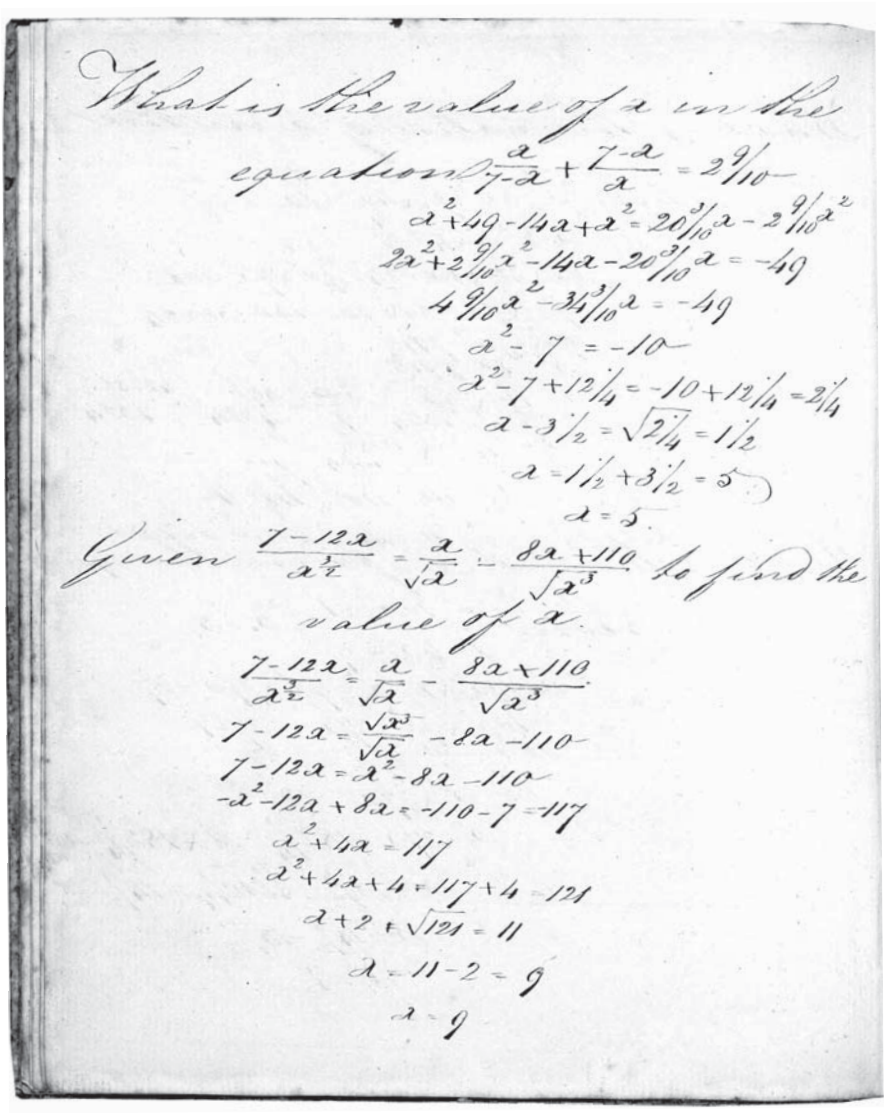
His father, Robert Campbell, first arrived in New South Wales from England in 1798 but returned to England with his family in 1805. After completing their schooling, the children returned to Sydney. (Mitchell Library, State Library of New South Wales)

arithmetical topics in particular traceable to Robert Recorde's methods of the sixteenth century. (Mimicry of English fashions in the teaching of mathematics in schools would be the custom in Australia until the 1960s.[19])

Educational development until the 1820s had been marked by the significant but non-controversial role played by religion. With the full support of Macquarie, the Anglican clergy dominated the system as part of the established church, although a number of Catholic and other denominational schools had been operating for many years. In 1825 the position of the Church of England was cemented by an edict from Lord Bathurst, secretary of state for the colonies, to be implemented by Thomas Hobbes Scott in the form of the Church and School Corporation.

Scott came to New South Wales first in 1819 to assist in an inquiry into Macquarie's administration. He came again in 1825 following his return to England and his ordination

(b)



into the Church of England. He was probably the first to pronounce on a future university in Australia when, still in England in 1824, he suggested that one of Sydney's academies be organised with a view to its eventual transformation into a university, and that until that time arrived colonial youths who wished to enter a university could be provided for by a system of "King's Scholarships" tenable at Oxford or Cambridge.[20] He also recommended the establishment of trade schools.

The Church and School Corporation was not generally well received, particularly as it allowed for one seventh of all colonial lands to be placed under the control of the church. This did not fit in well with Macquarie's emancipist policy, continued by his successor Sir Thomas Brisbane, which saw former convicts comprising the largest section of society and enjoying their period of economic and political gain. A spokesman for the emancipists was William Charles Wentworth, who was later to be identified with the founding of the University of Sydney. According to a

history of the University, he "depicted Scott and his Corporation in the liberal press as a bunch of brigands about to plunder the wealth and lands of the colony."[21] The opposition of activist ministers of other churches, notably Father John Joseph Therry and the Presbyterian John Dunmore Lang, newspaper campaigns, court battles and financial difficulties finally led to the withdrawal of the Corporation's charter in 1829, although it persevered with lessening authority until 1833. Yet, as the *History* acknowledged,

> Despite the many obstacles which confronted it during its brief existence the Church and School Corporation did manage to improve the educational facilities of the colony. The plan which Scott had drawn up, initially, had envisaged a comprehensive range of educational institutions catering for the needs of people of different ages, social class, and vocational destination. Alongside this scheme what was achieved seems a dismal failure. Measured against the situation which existed before 1825, however, the picture of the Corporation's achievements is one of limited advance made in the face of extreme difficulties.[22]

Scott was to be significant in the development of education in Western Australia, as well. He opened the first school in that colony when, returning to England in 1829, his ship was forced to call at the Swan River settlement for repairs. He remained there for nine months.

Sir Thomas Brisbane was succeeded as governor of New South Wales by Ralph Darling in 1825 and Sir Richard Bourke in 1831. The 1830s were a decade of agitated confusion and debate over the role of religion in education and over educational policies in general. William Grant Broughton, who had succeeded Scott as archdeacon of New South Wales in 1829 and was appointed first Bishop of Australia in 1836, could not agree with the Irish National System of state schools that Bourke was intent on introducing. That system was described by the Melbourne historian Albert Austin as follows:

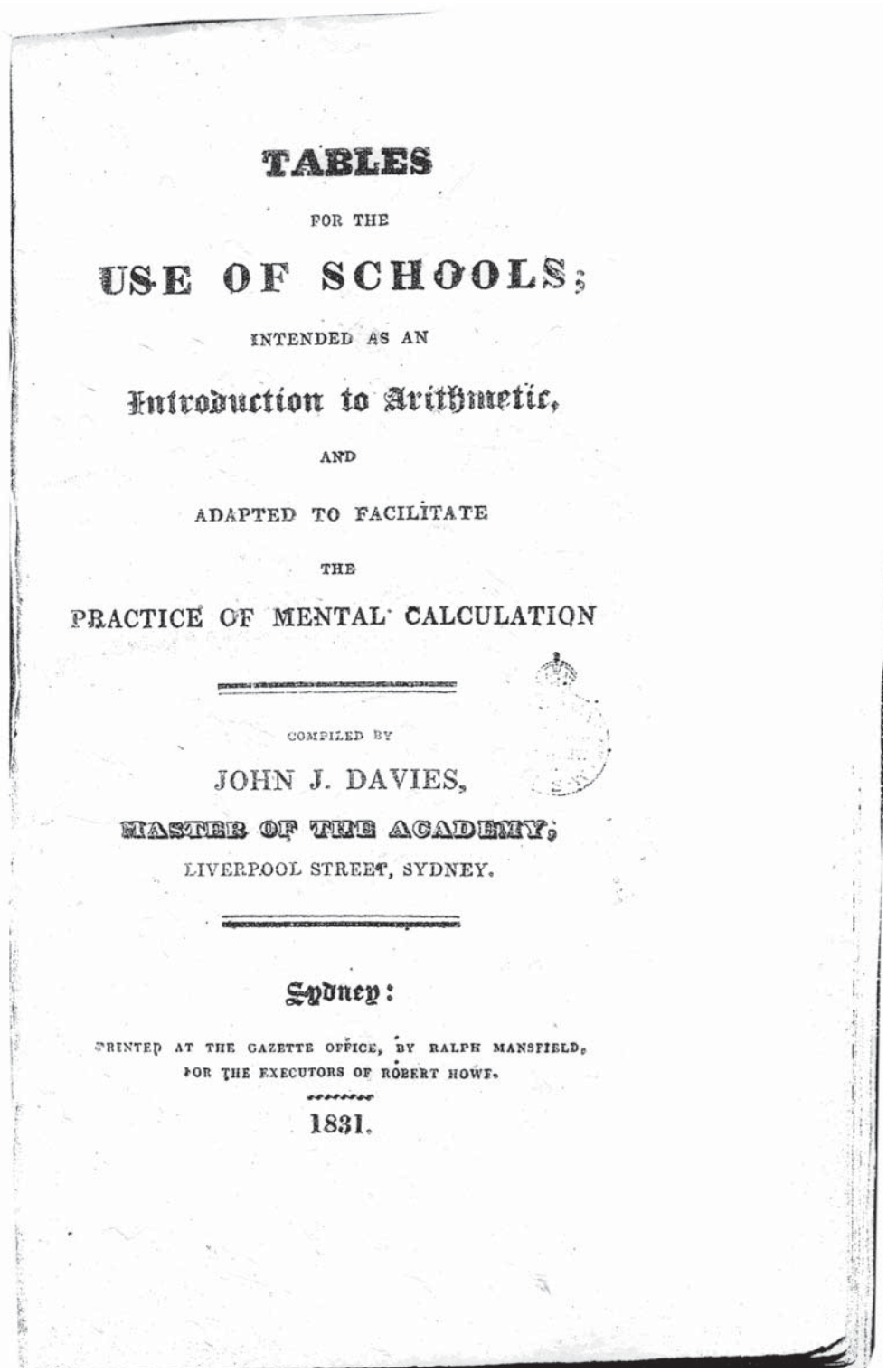
> The essential feature of these schools was the attempt to bring together children of all sects for a general, literary education which, while Christian in spirit, was undenominational; facilities were provided for the separate religious instruction of the children of each sect.[23]

Broughton and the whole Anglican clergy were joined in opposition by the Presbyterians, led by Lang, and by Congregationalists, Baptists and Methodists, but not by the Catholic church. When Bourke finally relented, the result was the development of separate school systems for the various denominations, and one for the "non-conformists", all receiving state aid.

Despite the educational debate raging in the background, the 1830s were notable in seeing the establishment of corporate colleges that offered secondary education with commercial and practical overtones. There was a growth in the number of private-venture schools throughout the state, though they mostly offered elementary education only, often specifically for girls, and there were early attempts at teacher training and adult education.

A textbook published in Sydney at this time appears to be the first mathematics book produced in the country. Certainly, it is the first Australian schoolbook of which a copy has survived.[24] In full, its title was *Tables for the Use of Schools, intended as an Introduction to Arithmetic and adapted to facilitate the Practice of Mental Calculation.* Consisting of just 22 pages, it was "compiled by John J. Davies, Master of the Academy, Liverpool Street, Sydney" and is dated 1831. Davies does not claim credit for the tables—in the Introduction, he states: "Anxious to avoid appropriating to himself the least merit, upon the score of invention or arrangement, the Compiler confesses himself indebted for both to the labours of the Reverend Dr. Bell."[25]

Early in the decade, and as a final effort under the auspices of the Church and School Corporation, Broughton was able to open two "King's Schools", in Sydney and Parramatta. The latter was a boarding school, still operating today. The intention was that successful students,



TABLES

FOR THE

USE OF SCHOOLS;

INTENDED AS AN

Introduction to Arithmetic,

AND

ADAPTED TO FACILITATE

THE

PRACTICE OF MENTAL CALCULATION

COMPILED BY

JOHN J. DAVIES,

MASTER OF THE ACADEMY,

LIVERPOOL STREET, SYDNEY.

Sydney:

PRINTED AT THE GAZETTE OFFICE, BY RALPH MANSFIELD,
FOR THE EXECUTORS OF ROBERT HOWE.

1831.

Cover page of Davies' *Tables for the Use of Schools*, 1831. (Mitchell Library, State Library of New South Wales)

having attended between the ages of nine and 16, would be equipped to undertake a university education "at a collegiate establishment projected for the future".[26]

In November 1831, Lang began classes in his Australian College. The teaching was organised into four departments—among which arithmetic and bookkeeping were to be taught in the mercantile department and mathematics, geography and natural philosophy in the mathematical and physical department. The level of instruction was stated as "rising to that of a university", but that was never to be attained.

Henry Carmichael was one of three schoolmasters whom Lang brought to Australia to staff the college. He was to be master of the classical department. For Carmichael, this and his other projects in Sydney were to be opportunities for enlightened educational reform, in his eyes at least. A graduate in theology from the United Colleges of St Leonard and St Salvator in the University of St Andrews in 1820, he was also widely read in educational theories of the time and in science and philosophy. On his voyage to Sydney aboard *Stirling Castle*, he organised that for five days each week he would give instruction in arithmetic and geometry to a multitude of artisans who were to be involved in the construction of the Australian College. He delighted in the fact that some of those pupils had "completed . . . six books of Euclid and mastered logarithms".[27]

The Australian College fell into decline, largely due to Lang's strict sectarianism and differences with Carmichael over educational policy. In 1834, at the end of his contract to Lang, Carmichael left to open his own non-denominational Normal Institution. The Australian College continued with new teachers recruited by Lang, but closed in 1841. It reopened in 1846 and closed for the last time in 1854. W. W. (later Sir William) Burton, a judge of the Supreme Court of New South Wales, wrote in 1840: "The number of students in the College during the year 1838, was 116 . . . In the mathematical class, Euclid's *Elements* and Bland's *Geometrical Problems* were used as text books. In the course of the year, about 46 attended the classes for Natural Philosophy and Mathematics."[28]

A principal aim of the Normal Institution, and understood at the time as implicit in the name itself, was the training of teachers. There were four classes of instruction, of which Class 3 was for those "who have commenced fractional arithmetic, and who may wish to acquire a knowledge of the elements of general mathematics—mensuration, algebra, trigonometry, surveying perspective, use of the globes, book-keeping, etc."[29] Although the school received considerable praise at the time for its enlightened and liberal approach to education, for example in presenting the Bible only as "always present as a book of reference", the Normal Institution would last only about ten years.

The mid-1830s saw the opening of the Sydney College. Its headmaster was William Timothy Cape, Sydney's "leading teacher" at the time. Like the King's Schools and the Australian College, the Sydney College saw itself as a conduit to higher studies. Also around that time, the first Catholic bishop in Australia, John Bede Polding, founded a secondary school, St Mary's Seminary.

Carmichael is best remembered for pioneering adult education in New South Wales, and particularly for his association with the Sydney Mechanics' School of Arts which held its first meeting in March 1833. Its origins were those shipboard lessons on *Stirling Castle* and the subsequent encouragement given by Bourke, following instructions from London. Bourke became its patron, the surveyor-general Sir Thomas Livingston Mitchell its president, and Carmichael its vice-president. The object of the School of Arts was initially "the diffusion of

scientific and other useful knowledge as extensively as possible throughout New South Wales", but its appeal soon tended to be more to the general enlightenment of the middle classes than to the colony's artisans. Its lecture program for 1838 included "Chemistry, Poetry and Drama, Natural History, Architecture, Phrenology, Mechanical Philosophy, Political Economy, and the Use of the Celestial and Terrestrial Globes".

The first such institution in Australia, the Hobart Town Mechanics' Institute, had opened years earlier, in July 1827, with aims that included "lectures on natural and experimental philosophy". It was flourishing in March 1830, with some 200 enrolled members and a planned program of lectures on "mechanics, agriculture, chemistry, hydraulics and physics".[30] Others followed at Newcastle in 1835, Adelaide 1838, Melbourne 1839, Brisbane 1849 and Perth in 1851.

From 1840 to 1843, Australia experienced its first major economic depression. Sir George Gipps had succeeded Bourke as governor of New South Wales in 1838 and was forced from 1842 to cut per capita government aid to schools, although total government expenditure on education continued to grow. Membership of all the mechanics' institutes that had opened in the 1830s declined during the 1840s. Competition between the various denominational school systems, moves to reintroduce the Irish National System, and the need for some overseeing authority that would also have regard to the educational needs of the sparsely populated interior, led to the establishment in 1844 of a select committee of the Legislative Council of New South Wales to look into the state of education in the colony. "The Committee", wrote Barcan,

> found that the curriculum in the elementary schools was generally reading, writing, arithmetic, English grammar, geography, and occasionally history. Religious instruction was, of course, important. Girls were usually taught needlework . . . The inclusion of grammar and geography suggests that some training for commercial life was attempted.[31]

It was not until 1841 that a high school opened for girls to learn more than the "polite accomplishments". James Rennie had opened the College High School, for boys, in 1838, and added the girls department three years later. Barcan reported that "The curriculum included the 'ornamental and useful' subjects but added 'Classics, Sciences, Philosophy, Botany, Arithmetic with Mathematics and Algebra'."[32]

Yet mathematics teaching for either boys or girls was hardly seen as essential by some. One witness to the select committee, the mayor of Sydney, James Robert Wilshire, responded as follows to one of the committee's questions. "Q.62. With regard to mathematics and general branches of knowledge how far do you think the system ought to extend? — I do not think the system ought to extend to mathematics, at least the teaching of mathematics should not be paid for by the State. I think a good English education should be given comprehending reading, writing, arithmetic, geography, and history."[33] What Wilshire understood by "mathematics", beyond arithmetic, is unclear.

The select committee recommended the establishment of a central board of education to implement the Irish National System, the introduction of an inspection system and further training for teachers. The first recommendation immediately met resistance, as before, from the Anglican and Methodist churches, and now also from the Roman Catholic church, although it gained the support of many citizens. Reform of the New South Wales educational system would not come about until 1848, by which time there were 75 Church of England schools, 43 Presbyterian schools, 39 Roman Catholic schools, 22 Wesleyan schools, three "Colleges and Grammar Schools" (that is, the major corporate schools), and some 250 private schools.Four of the private schools were in the Moreton Bay District and 36 in the Port

Phillip District—today's Queensland and Victoria. On average, the schools had less than 50 pupils each.[34]

Economic conditions across the country improved in the late 1840s, to be bolstered even further by discoveries of gold in the early 1850s. Reforms took place across the gamut of society and particularly so in education. Broughton's opposition to a system of national schools had been replaced by a spirit of compromise and Lang's opposition had completely dissipated. Under Governor Sir Charles FitzRoy, who succeeded Gipps in 1846, the denominational schools in New South Wales, notably those under the jurisdiction of the Anglican, Catholic, Presbyterian and Methodist churches, came within the control of the Denominational Schools Board, although its main task in the end was the distribution of government grants. More regulation was applied in the state school system which was the responsibility of the Board of National Education, established in January 1848.

With some exceptions in the detail, educational development through the rest of the continent largely mirrored the situation in the east.

Certainly, during all of this time there was very little in the way of separate educational progress in the Port Phillip District since the colony of Victoria did not come into being until July 1851. By then, New South Wales had its Board of National Education and its Denominational Schools Board and at the separation of the colonies their operations were taken over by corresponding Victorian boards. Queensland was not proclaimed a colony separate from New South Wales until December 1859 and its educational administration until then remained in Sydney.

In 1825 Van Diemen's Land gained its independence from New South Wales. Although the island colony was by then generally known as Tasmania the name was not changed officially until thirty years later. The Church and School Corporation had also operated there but its collapse brought particular problems. The established church ran all 29 schools (in 1836), and fought against any grants of aid to other denominations. Successive governors George Arthur (appointed in 1824), Sir John Franklin (1837), Sir John Eardley-Wilmot (1843) and Sir William Denison (1847) fought against "the intolerant, overbearing spirit of the Protestant Episcopal Church".[35]

Austin summarised the situation as follows:

> Essentially, by 1849, Van Diemen's Land educational affairs had reached the same stage of development as New South Wales educational affairs. In both colonies clerical opposition had thwarted the attempt to create a thorough-going system of national schools, and had prevailed upon the government to support a dual system. But whereas in the older colony a substantial organisation had been created to handle the dual system, conditions in Van Diemen's Land could only be described as chaotic.[36]

The crisis eased by the end of 1853 with the establishment by Denison of a Central Board of Education that would oversee a modification of the Irish National System.

While transportation of convicts to New South Wales ended finally in 1850, it was not until that year that transportation to Western Australia began, and it was to continue until 1868. In the mid-1840s the population of Perth numbered around 4,500 of whom more than 90 per cent were Protestant. There were two "Colonial Schools" and nine private schools but with a highly disproportionate number of pupils in Roman Catholic schools. This was a source of both admiration and envy for the Protestants. Proposals by governors Frederick Irwin (appointed in 1847) and Charles Fitzgerald (1848) led to a dual system of education as in the eastern colonies, which in this case would lead much more rapidly to a separate system of Roman Catholic schools.

South Australia became a crown colony in 1842. The settlement was distinguished from the beginning by its lack of a convict base and a desire for equality of its settlers in the matters of religion and education, to be financed by subscription. This idealism could not be maintained and by the mid-1840s successive governors George Grey and Frederick Robe were obliged to institute state aid for denominational schools. Their successor, Sir Henry Fox Young, was nonetheless able within a few years to bring about a separation of church and state and establish a Central Board of Education to administer a scheme along the lines of the Irish National System. It was "a mark of South Australia's distinctive character," wrote Austin, "that by the end of 1851 it was the only Australian colony whose revenue was not being used to support denominational schools."[37]

The Board of National Education that had been established in New South Wales had, as one of its early major responsibilities, the task of training school teachers. William Wilkins was appointed headmaster of the Sydney Model School, situated in Fort Street, to undertake this work. In 1851 his suggestion of an apprenticeship scheme known as the pupil-teacher system was adopted and six years later those pupil-teachers and others were able to receive expanded formal training at Fort Street. The course included sections on school management; the English language; geography; "Science of Common Things"; elementary mechanics; and arithmetic and algebra (comprising "Vulgar Fractions, Decimals, Proportions; Application of these rules to Mensuration, &c., Algebra to Quadratic Equations"). The mathematics was taught by John Sanders Jones. It was in these classes "that the practical origins of Sydney Teachers College are to be found."[38]

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This completes a review of Australian educational development up to the 1850s. It is a relevant time to pause because of the grand changes that would come about with the discovery of gold.

There had been finds of gold in Australia before 1851 and silver, lead, iron and coal were already being mined in great quantities and exported, but it was the discoveries of gold in February that year near Bathurst and then in August near Ballarat that began Australia's gold rush in earnest, and this in turn led to a level of maturity that would bring on self government. The eminent historian Manning Clark wrote of the new conditions:

> At the same time the discovery of gold was causing British officials to have second thoughts on the future constitutions of the Australian colonies. By the end of 1852 the Secretary of State accepted the view that the most loyal, respectable, and influential members of the community wanted responsible self-government. He was influenced, too, by the discovery of gold, which would, he believed, stimulate the advance of population, wealth, and material prosperity, with unparalleled rapidity. He therefore invited the legislative councils of New South Wales, Tasmania, South Australia and Victoria to draft new constitutions and submit them for approval and ratification by [the British] parliament.[39]

Between 1855 and 1857, the first elected parliaments under responsible government for each of these four colonies met for the first time.

Mathematics and science in early Australia

Outside the educational system, much of the very early interest in science and the arts in Australia can be associated with a small number of well-educated, adventurous and conscientious patrons. Two of these, both state governors, were particularly relevant to the further progress of science in the country.

Sir Thomas Makdougall Brisbane succeeded Macquarie as governor of New South Wales in November 1821. He had been elected fellow of the Royal Society in 1810 and had maintained an interest in science, particularly astronomy and mathematics, since his student days at the University of Edinburgh and the English Academy, Kensington. He had keenly appreciated the colonial posting so that he might study the southern skies and he demonstrated this keenness by himself paying for two astronomers, Carl Rümker and James Dunlop, to accompany him to Sydney.

Christian Carl Ludwig Rümker was born in the north German town of Stargard on 18 May 1788. He served for six years as an officer and teacher of navigation aboard the British man-of-war, *Benbow*, before returning to Germany in 1819 to work for two years as a teacher of mathematics at the School of Navigation in Hamburg. There he heard of Brisbane's need for an assistant, for which he quickly and successfully applied. Dunlop, born in 1793, was a Scot who at the time of his recruitment by Brisbane had little knowledge of scientific astronomy but had a talent for mechanics.

Brisbane promptly built an observatory at Parramatta in Sydney's west. The observational work was generally carried out by Rümker and Dunlop under the supervision of Brisbane who took responsibility for the transmission abroad of their findings. Brisbane is credited with Australia's first publication in physics, in the *Philosophical Transactions*. This was an 1823 report on pendulum experiments for the determination of the force of gravity, carried out at the observatory. Meteorological observations, perhaps the first in the country, were conducted there from October 1822 to March 1824.[40]

Within a few days of his arrival in the colony, Brisbane accepted the offer to become president of Australia's first scientific body, the Philosophical Society of Australasia, already established in July of that year. Its aims were to inquire "into the various branches of physical science of this vast continent and its adjacent regions", but it became "a small scientific club consisting of ten members besides Brisbane. Meeting in turn in their houses, lending books to one another, reading and discussing papers, they encouraged one another in the pursuit . . . of their scientific interests."[41] Within two years it entered a long state of dormancy, not to be revived until 1850.

Two years after Brisbane's return to England in November 1825, Rümker, who had been Brisbane's "private astronomer" but had in fact fallen out with both Brisbane and Dunlop in 1823, was appointed the first government astronomer in Australia. Charles Stargard Ruemker, as he generally styled himself in Australia,[42] turned out to be an exceptionally talented mathematician and astronomer. He is credited altogether with 88 communications to the Royal Astronomical Society, including the notification of several new comets for which he received the Society's silver medal. His most notable achievement at the time was the calculation of the orbit of Encke's comet, which was first observed in Marseilles in 1818 and was only the second comet, Halley's being the first, whose return was accurately predicted. It was Dunlop who actually observed the return at Parramatta on 2 June 1822, only a month after operations began there. The *Report on the Progress of the Mathematical Sciences*, by "M. Fourier"[43] in 1823, quoted in *The Sydney Gazette and New South Wales Advertiser* on 22 January 1824, lauded this accomplishment and the fact that the comet was observed "in positions very near those which had been anticipated".[44]

According to the historian Ann Moyal, Rümker was also "fractious"; he was the target of Australia's first allegation of scientific plagiarism:

> A disagreement however with the president of the [Royal Astronomical] society over the authorship of some of Rümker's work at Parramatta led to his dismissal as Government Astronomer in 1830, and . . . Rümker returned to Germany to become successively director of the Hamburg School of Navigation and director of the Hamburg Observatory in 1833.[45]

James Dunlop succeeded Rümker in the Parramatta observatory. He was considered to have contributed the major part of the observations for which Rümker sought credit. In his own right, he produced a catalogue of southern nebulae, star clusters and double stars which won him the gold medal of the Royal Astronomical Society in 1828 but a serious illness curtailed his activity in 1835 and from early 1839 he effectively ceased his work for the observatory. It closed in 1847. Whatever the truth of the allegations against Rümker, 20 years after his dismissal he was welcomed back to the Astronomical Society. The Astronomer Royal, Sir George Airy, in "a diplomatic statement, which was doubtless intended to cover the Society's embarrassment at its own shabby treatment of Rümker" noted that "no greater misfortune has happened to Southern Astronomy than the conclusion of that engagement."[46]

Rümker was elected a foreign member of the Royal Society in 1855. He died on 21 December 1862 in Lisbon, and might well be remembered as Australia's first practising mathematician. Dunlop died in 1848.

It was during Dunlop's term as government astronomer that the Sydney Mechanics' School of Arts was formed with Sir Thomas Mitchell as president. A remarkable and long-lasting episode in Mitchell's life demonstrated his mathematical and engineering aptitude. Shortly after he relinquished his position with the School of Arts in 1836, he was in London and, in conversation with the vice-president of the Royal Society, mentioned the Australian boomerang. "The path of the Bomerang [*sic*] through the air was enough to puzzle a mathematician," the vice-president had commented.[47] Mitchell subsequently made a study of the implement, recording for example that "in its rotary motion the centre of gravity was quite clear and apart from its surface." He designed a screw propeller for use in air or water based on the principle of the boomerang that would, he claimed, be "free from the impediment of lateral resistance". It was not until 1852 that his propeller could be tested properly, on the steamer *Keera* in Sydney Harbour, and in that and subsequent trials in England it performed well. Yet the propeller was never adopted. One of Mitchell's biographers, Cecil Salier, wrote:

> It was pointed out to Mitchell, in 1853, that the double curvature of the Boomerang propeller seemed "likely to defy mathematical investigation," and so far as I have been able to ascertain, the propeller has never been used in a practical way on any considerable scale.[48]

Carl Rümker, 1788–1862, Australia's first practising mathematician.

Another governor who was an early Australian patron of science was Tasmania's fifth governor, Sir John Franklin. Matthew Flinders' stepmother was Franklin's aunt and Franklin had served under Flinders with distinction as a midshipman aboard *Investigator*. He is best known for his 5,000 kilometre trek across the arctic north of Canada from 1819 to 1822 in search of the Northwest Passage, an exploit which gained him a fellowship of the Royal Society. He was knighted following a second voyage to the Arctic in 1825 and served as lieutenant-governor of Van Diemen's Land from 1837 to 1843.

The short life of Sydney's Philosophical Society of Australasia was matched by that of the Van Diemen's Land Scientific Society, formed in 1829 but surviving only two years.[49] However, under the patronage of Franklin the Tasmanian Society of Natural History was formed in 1837. Its meetings were held in Government House and it published Australia's first scientific journal, the *Tasmanian Journal of Natural Science*, in 1842 with its costs subsidised by Franklin. With the encouragement of Eardley-Wilmot, Franklin's successor as governor, its members went on to form the Botanical and Horticultural Society of Van Diemen's Land in 1843 and a year later with royal consent the name was changed to the Royal Society of Van Diemen's Land for Horticulture, Botany and the Advancement of Science. This was the first royal society outside Britain.

Franklin is also credited as the effective founder of the Tasmanian system of state primary instruction and his government established scholarships that allowed Tasmanians to study at English universities.[50] He endowed Christ's College in Hobart, designed to provide a basis for university education. It "lasted ten years as a miniature academic corporation with a small quota of fellows, junior fellows and scholars studying theology, mathematics and the classics,"[51] and was revived in the late 1870s as an "undemoninational institution". It finally evolved in 1933 into the first residential college, by then called Christ College, of the University of Tasmania.

The establishment of Hobart's first observatory is also due to Franklin and in this there is a connection with one of the greatest mathematicians of all, Johann Carl Friedrich Gauss (1777–1855). In 1840 Captains James Clark Ross and Francis Rawdon Moira Crozier sailed into the River Derwent aboard *Erebus* and *Terror* as part of the British Admiralty's intention to set up a chain of magnetic observation points. This was in response to an international campaign for a worldwide network of such observatories, which in turn was the result of a six year collaboration in terrestrial magnetism by Wilhelm Weber and Gauss at the University of Göttingen. Weber was appointed professor of physics there in 1831, joining Gauss who had been director of the Göttingen observatory since 1807. Franklin welcomed Ross and Crozier and requested them to establish a magnetic observatory, which became known as Rossbank Observatory, in the grounds of Government House. The observatory closed in 1854.

Franklin's attempts "to foster culture and to fabricate social cement"[52] were not popular with the Colonial Office and he was not given a further term. He returned to England in June 1844 and undertook a final, fateful voyage to the Arctic from 1845 to 1847 aboard the two ships *Erebus* and *Terror* that Ross and Crozier had brought to Van Diemen's Land. In circumstances that are still not fully understood, Franklin and his crews were lost though later search expeditions were able to ascertain that he had indeed found the sought-after Northwest Passage.

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The areas of application of mathematics that were an essential concern to the early colonists were astronomy, commerce, surveying and statistics. There was little early developmental work of a properly mathematical nature in commerce in Australia (except perhaps for the writings of

Morris Pell, described in Chapter 2), but there were some serious quantitative contributions in surveying and geodesy within the first hundred years of colonisation.

There were for example the papers of the surveyor Martin Gardiner in the 1860s and 1870s. Those papers and an earlier article by the Victorian surveyor Clement Hodgkinson will be described in Chapter 3. The first issue of the journal of Sydney's Survey Club, *The Surveyor*, did not appear until 1888; it contains an article with extensive mathematical content, though its authorship is not known.[53] Around the same time, George Handley Knibbs, an extraordinarily gifted surveyor, born in Sydney in 1858, was contributing articles on surveying, among other mathematical interests, to the *Journal of the Royal Society of New South Wales*. He became the country's first Commonwealth Statistician and his career will be described in Chapter 8.

There is a much more extensive history of statistics in Australia. The modern discipline of statistics arises from the need to interpret and analyse data gathered from a huge raft of sources and where possible to use the results of the analysis for predictive purposes. The 19th century is notable for exhibiting the progression from the mere collection of data, an admirable innovation in its own right, to the application of advanced mathematical techniques for their analysis. The Australian experience bears this out.

It begins with the earliest days of the colony. Arthur Phillip's instructions, on his appointment as "Captain-General and Governor-in-Chief of New South Wales" in 1787, required him to make regular statistical reports to the secretary of state in Britain on all aspects of population numbers, land usage and trade figures. Accountability for personnel and matériel was seen as an essential aspect of the transportation of convicts to such a distant colony.

> The type of statistical material produced by Phillip can be seen in his early reports. On 9 July 1788 in his fourth dispatch to Lord Sydney at the Home Office, Phillip included, along with an account of population numbers, tables relating to livestock in the settlement, to a general return on the four companies of marines and to a return on the sick and the dead since the landing. The following day, reporting to the Admiralty, he referred to the inclusion with his dispatch of 'the weekly accounts'. On 28 September a Commissariat return was sent to the Home Office on the state of stores and the number of persons being victualled at Sydney and Norfolk Island. A detailed return of the whole population was included in Phillip's dispatch dated 25 July 1790; it . . . numbered the population in categories of men, women and children classified as military, civil or convict. Phillip's first return with details of land grants was dated 5 November 1791; it listed the names of 87 settlers who had been granted land in New South Wales and Norfolk Island with details of their status, marital situation, date of settling, size and location of grant and area in actual cultivation. The following year on 16 October the return was able to indicate what crops were being grown on the cleared ground.[54]

It is understandable then that Phillip has been called "the first Australian statistician"[55] and why the Newcastle historian Jack Camm was to write "Australians in the nineteenth century were among the most counted people in the world; rarely have so few been counted so often."[56] Almost every year until 1825, various components of the population, such as convicts, free persons or landholders, were counted by "musters", requiring all to assemble at certain places for a complete count. Agricultural information was collected at the same time. "For example, a return in 1800 . . . gave numbers for sheep, cattle, horses, goats, hogs, acres in wheat and acres of maize to be planted, according to ownership by government or individuals."[57] The government in Van Diemen's Land conducted similar but separate musters.

As the population increased so the number of "muster-stations" increased, to 16 in 1823 and 20 in 1825. The time during which the count was taken also increased, to about six weeks

already in 1819. There was a consequent decline in accuracy. And yet in 1825 the records state with contradictory certitude that 5,203 persons were *not* included in the count.[58]

The first modern census in Australia, authorised by legislature and compelling returns from all residents (except serving military personnel and their families, and Aboriginals), was held in New South Wales in November 1828. It followed the model that by then had been established in Great Britain. There were further censuses in New South Wales in 1833 and then every five years from 1836 until 1861, and then every ten years until the end of the century. These included inhabitants of Moreton Bay District until 1861 and of Port Philip District, until 1851. Tasmania conducted its first census in 1841, South Australia 1844, Western Australia 1848, Victoria 1854 and Queensland in 1861.

The conduct of the early censuses and the reporting of their results were the responsibility of the colonial secretary (or the colonial treasurer in Tasmania, and registrar-general in Western Australia and Queensland). There were other avenues for the presentation of statistics. In particular, from 1822 there was a responsibility for British colonies around the world to submit statistical returns to the secretary of state for the colonies in the form of a *Blue Book*, named simply for the colour of its covers. New South Wales and Van Diemen's Land produced *Blue Books* in that year. The information was supplied under the following headings:

Abstract of Nett Revenue and Expenditure
Schedule of Taxes, Duties, etc.
Military Expenditure
Establishment
Schedule of the Fees, etc.
Population
Exports and Imports
Currency[59]

The *Blue Books* were compiled retrospectively from groups of returns completed by officials in various districts and forwarded to each colonial secretary. Western Australia produced its first *Blue Book* in 1834, South Australia in 1840 and Victoria in 1852. The latter was more formally titled *Statistics of the Port Phillip District, (Now the Colony of Victoria) for the Year 1850*.

Other volumes of statistical information were often even more detailed than the *Blue Books*. The earliest such was produced in Van Diemen's Land, where, in response to a request from Governor Arthur for a statistical coverage of his period of office, the colonial secretary produced the *Statistical Return of Van Diemen's Land for the Years 1824 to 1835*. It contained 46 tables.[60]

In 1848 in New South Wales, the registrar-general assumed the responsibility for collecting the returns and in 1858 the New South Wales *Statistical Register* was first published by the then incumbent, Christopher Rolleston (1817–1888). The first issue of the *Statistics of the Colony of Victoria* had already appeared in 1854, edited by William Henry Archer, and subsequent issues were produced annually under that name until becoming the Victorian *Statistical Register* in 1874. There was also in 1854 a "curious volume" of 447 pages produced by Archer entitled *The Statistical Register of Victoria, From the Foundation of the Colony with an Astronomical Calendar for 1855*.[61]

With Archer and Rolleston, the gathering of statistics in Australia became more properly regulated and "scientific". In fact, Rolleston presented a paper at one of the first meetings of the Philosophical Society of New South Wales, on 10 December 1856, on the "science of statistics".[62] Quantitative arguments were only in terms of comparisons between complete tables

of data, with little in the way of summary statistics, but the paper had some definite modern tones. For example:

> The value of hypothesis and conjecture is to point out the direction in which observation will be most probably fertile in discovering truth, demonstrating error, or striking out new paths of investigation; and it is the result of observations thus guided that present us with these facts calculated to illustrate the condition and prospects of society, and to direct governments in their endeavours to promote the welfare of mankind.

This was the beginning in Australia of statistics as its own area of mathematical application, a story whose development is taken up in Chapter 3.

Chapter 2

Mathematics and the Rise of the Universities

Four universities were established in Australia in the 19th century, in Sydney, Melbourne, Adelaide and Hobart. Their first professors of mathematics had interests that extended to actuarial science, astronomy and electoral reform and one went on to gain a Nobel Prize for physics. Each was the sole teacher in his department for much of the time, and together they are the pioneers of mathematics in Australia.

The University of Sydney, 1852–1902

In the opinion of Sir Charles Nicholson, the first vice-provost of the University of Sydney, the University was the result of a natural line of evolution from Halloran's Academy, established in 1819, and the Australian and Sydney Colleges of the 1830s.[1]

William Charles Wentworth, whose initiative was primarily responsible for the establishment of the University, had been a member of the founding committee of the Sydney College and as early as 1838 had urged the establishment of a colonial university. A decade later, on 4 September 1849, Wentworth put forward a proposal in the New South Wales Legislative Council that the Sydney College, then struggling to remain viable, be converted to a university. His model was the University of London in regard to its non-sectarian principles and affiliated university colleges for professional studies, but he envisaged an intrinsic teaching role as well as examining and the conferring of degrees, which were the main functions of the older university.

The community's reaction was mixed. There was an acknowledged need for local legal and medical training but the fate of the Australian and Sydney Colleges suggested that a university could not be sustained. The Anglican and Roman Catholic churches were keen to train their own clergymen, and saw a colonial university as useful for that purpose, but had already taken their own steps in this regard. Bishop Broughton's plans to extend the King's Schools had been transformed a few years earlier into the establishment of a school of divinity named St James College, with a widened scope: it was "designed to satisfy a want in the means to a liberal education in New South Wales for the young men of the colony destined for the medical and legal professions, as well as for the pulpit and public life."[2] The aims of St Mary's Seminary had been broadened along similar lines.

The Legislative Council appointed a select committee, chaired by Wentworth, to consider the matter and its detailed and very favourable report was tabled just 15 days after the committee's formation. The report included the recommendation that chairs "be established immediately in

classics and mathematics (this professor being considered Principal of the University); chemistry; natural history; experimental philosophy and civil engineering; and anatomy, physiology and medicine (comprising one chair). A chair of modern history and political economy, and a chair in modern languages were also envisaged for the future."[3] The combining of mathematics and classics into one chair was a point of criticism in subsequent letters to *The Sydney Morning Herald*.

The report distanced itself from any connection with the Sydney College and it insisted upon absolute non-sectarianism to the extent that no clergyman could be a member of the proposed university senate. Denominational affiliations would be supported through a system of external colleges which would carry out general teaching as well as studies in divinity, with responsibility to the central university.

As much as for the speed with which it was presented as for the uproar among the clergy, the resulting "Bill to Incorporate and Endow a University to be called 'The University of Sydney'" was lost on its second reading, on 4 October 1849.

Another university bill was presented by Wentworth in August the following year, with John Dunmore Lang an unexpected advocate in its favour. Lang had recently returned to Sydney after three years in Britain, had reopened the Australian College with newly recruited teaching staff, and had been elected to the Legislative Council. He strongly promoted the model, based on the University of London, in which a new local university would be mainly an examining body; the Australian College would of course be affiliated. When the new university developed along other lines, Lang became its strongest critic.

Wentworth insisted the University of Sydney should undertake its own undergraduate teaching, but conceded that this need no longer be in the area of professional studies:

> In the light of the lack of suitable colleges for affiliation the University would have its own secular, non-sectarian college attached, and the professors would impart instruction, not in professional subjects, but in the classical, mathematical and scientific studies of a general or liberal education.[4]

The bill nonetheless provided also for affiliated denominational colleges. Regarding studies in medicine, for example, it allowed that "persons from medical institutions or schools in Sydney, as approved . . ., were to be admitted as candidates for the University's degrees in medicine, on presentation of a certificate of completion of a course of instruction prescribed by the Senate."[5]

Wentworth also relented on having clergy as members of the university senate. Its size was set at 16, of whom at most four would be ministers of religion. The bill was duly passed in the Legislative Council and was enacted by the governor, Sir Charles FitzRoy, on 1 October 1850.

By early the following year, the newly constituted senate of the University of Sydney, with an ineffective Edward Hamilton as provost and the highly effective Charles Nicholson as vice-provost, began planning for the University and its associated college. The buildings of the Sydney College in Hyde Park were to be rented for two years. As the centenary history of the University recorded,

> [In] the first instance the instruction provided by the college [would] be confined to the Greek and Latin languages (along with Greek and Roman history); mathematics (pure and mixed); and chemistry and experimental philosophy. It was proposed that one professor should be appointed in each of these fields or departments. The classical professor was to be Principal of the College with a salary of £600 p.a., the mathematical professor was to receive £500 p.a., and

> the professor of experimental philosophy and chemistry and other lecturers were each to receive £300 p.a. Each professor was to receive a half of the fees arising from the students attending the lectures, excepting the professor of experimental philosophy and chemistry who was to receive three-fourths of such fees.[6]

The chemistry professor was expected to augment his salary with outside earnings (or "extra-mural teaching"), but by the time he was appointed the differential was discarded and all professorial salaries were increased by £150.

Matriculation to the University was by examination in "mathematics (arithmetic, algebra and geometry), and classics (Greek and Latin authors, and English grammar)" and there would be "a series of scholarship examinations, which were likewise restricted to classical and mathematical studies." Among requirements for the degree of Bachelor of Arts, candidates "were to be examined in classics or mathematics; in natural philosophy (statics, dynamics, hydrodynamics, pneumatics, and physical astronomy) and chemistry (in its general principles); and in logic . . . and moral philosophy."[7]

The senate set in train steps for the selection of the three "Professors of the University College", but hoped to begin lectures early, by October 1851, with local appointments in classics and mathematics. To this end, it advertised in *The Sydney Morning Herald* of 11 April that year for candidates for "the office of Mathematical Lecturer". Ivan Turner, when he addressed the University on the occasion of its centenary, listed the applicants as follows:

> Rev. H. Carmichael M.A. (St Andrews), who was brought to Sydney by Dr Dunmore Lang to teach in the Australian College;
> Rev. T. Aitken M.A. (Glasgow), Headmaster of the Normal Institution, Elizabeth Street, Sydney;
> Rev. T. Makinson M.A. (Cantab.), a teacher in St Mary's Seminary;
> Rev. H. Porter B.A. (Cantab.);
> Mr. J. M. O'Brien.[8]

Turner stated, "Porter, Makinson and a new candidate, Kempster Knapp, were, in that order, the most suitable candidates."

The interest in mathematics of the first on the list, Henry Carmichael, has been noted in Chapter 1. In his letter of application he described his studies in mathematics at the University of St Andrews and declared that his "standing ... corresponded with that of Senior Wrangler at Cambridge".[9] Whatever his standing, Carmichael could later have claimed to be the first in New South Wales to publish a note of some mathematical interest; it concerned barrel making.[10]

The letters of application of the candidates are all held in the University's archives.[11]

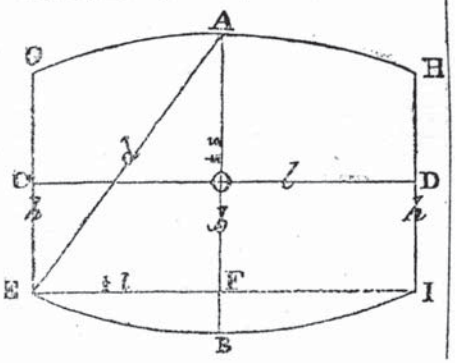
Thomas Cooper Makinson, born at Manchester, England, in 1809, had graduated from St John's College, Cambridge, in 1835. He was ordained in the Church of England in 1836 and came to Australia in 1838 as a direct result of an appeal by Bishop Broughton. Ten years later, he converted to Roman Catholicism and took the position at St Mary's Seminary.

Henry John Porter, born in 1816, had obtained his BA in 1838 from Pembroke College, Cambridge, having been educated before that at the Merchant Taylors' School in London and then Ealing School in Middlesex. He had taught at Bath in Somerset, been ordained by the Bishop of London in 1841 and arrived in Australia in 1848. Porter was elected to membership of the Philosophical Society of New South Wales in 1856.[12] Kempster Knapp (1821–1875) had been educated at Christ's Hospital, Sussex, and then Sidney Sussex College, Cambridge. After "nine terms" there he had gained a position as a naval instructor and served seven years as a

on the part of wine merchants and wine coopers, to the following details in aid of the right construction of casks having their contents ranging according to a decimal scale of admeasurement; because the general adoption by the wine trade of casks so constructed would greatly promote the convenience and otherwise advance the interests of the colonial winist.

In the annexed sectional diagram of a cask, let

A be the centre of bung-hole,
AE, or d, the diagonal,
CD, or l, the length,
AB, or b, the bung-diameter,



GE, or h, the head-diameter,
AF $\frac{1}{2}(b+h)$=S i.e. half the sum of bung and head diameters,
and AF,=$\frac{1}{2}l$= half the length.

Let, moreover. the letter g represent the contents of a cask in imperial gallons; then, premising that a cask containing 144 imperial gallons has been found to have a diagonal of 40 inches, and that the contents of casks vary as the cubes of their diagonals, the following formulæ, with the aid of the above symbols, are easily deducible, viz. :—

Log. g=3 log. d—(2.647818)$\frac{2}{3}$= log. $(l2+s2)$—(3.550908)

Log. d=1·3 log. g+0.882606=$\frac{1}{2}$ log. $(l2+s2)$—(0.301030)

Log. l=$\frac{1}{2}$ } log. $(2d+s)$+log. $(2d-s)$ }
Log. s=$\frac{1}{2}$ } log. $(2d+l)$+log. $(2d-l)$ }

Where it is evident that d being constant, l and s may vary, and that d, l. and s being constant, b and h may vary. Hence d and l being constant, the shape of the cask will depend on the ratio between the Bung and Head Diameters.

From these formulæ, I have calculated the following Table of Admeasurement for casks of given capacities, and of three different shapes—which will be found, by the working cooper, of easy application to the construction of casks such as the preceding observations are intended to recommend,

HENRY CARMICHAEL.

TABLE giving the admeasurement of three descriptions of Casks, having Capacities from 1 to 1000 Imperial Gallons, when the ratio of the length of the Cask to the Sum of the Head and Bung Diameters is that of three to four; or $l : s :: 3 : 4$,

Contents in Imperial Gallons. (g)	Diagonal (d) in inches. $d=\sqrt[3]{\frac{g}{0.0\,0\,9}}$	Length (l) in inches. $l=\frac{6}{5}d$.	Head Diameter, in inches (h). When $b=d$. $h=\frac{1}{2}l$.	Head Diameter, in inches (h). When $h:b::7:9$ $h=\frac{7}{10}d$.	Head Diameter, in inches (h). When $h:b::3:4$ $h=\frac{4}{7}l$.	Bung Diameter (b) in inches. When $b=d$.	Bung Diameter (b) in inches. When $h:b::7:9$ $b=\frac{9}{10}d$.	Bung Diameter (b) in inches. When $h:b::3:4$ $b=\frac{4}{3}h$.
1	7.6315	9.1578	4.578	5.3420	5.233	7.6315	6.8684	6.977
2	9.615	11.520	5.760	6.730	6.583	9.615	8.654	8.777
3	11.006	13.207	6.603	7.704	7.547	11.006	9.906	10.062
4	12.111	14.533	7.266	8.477	8.304	12.111	10.900	11.071
5	13.049	15.659	7.829	9.134	8.350	13.049	11.745	11.933
10	16·441	19.728	9.864	11.508	11.273	16.441	14.797	15.031
15	18.820	22.584	11.292	13.174	12.905	18.820	16.938	17.207
20	20.715	24.858	12.429	14.500	14.204	20.715	18.644	18.939
25	22.314	26.776	13.388	15.619	15.301	22.314	20.083	20·401
30	23,712	28.454	14.227	16.598	16.259	23.712	21.341	21.679
40	26.100	31.320	15.660	18.270	17.897	26.100	23.490	23.862
50	28.114	33.736	16.868	19.679	19.278	28.114	25.303	25.704
60	29.876	35.851	17.925	20.913	20.486	29.876	26.889	27.315
70	31.451	37.741	18.870	22.015	21.566	31.451	28.306	28.755
80	32.881	39.457	19.728	23.017	22.547	32.881	29.593	30.062
90	34.200	41.040	20.520	23.940	23.451	34.200	30.780	31.270
100	35.422	42.506	21.253	24.795	24.289	35.422	31.880	32.385
125	38.157	45.788	22.894	26.710	26.164	38.157	34.342	34.886
144	40.000	48.000	24.000	28.000	27.428	40.000	36.000	36.571
150	40.650	48.780	24.390	28.455	27.874	40.650	36.585	37.166
175	42.686	51.223	26.611	29.880	29.270	42.686	38.418	39.027
200	44.640	53.568	26.784	31.248	30.611	44.640	40.176	40.813
250	48.075	67.690	28,845	33.652	32.965	48.075	43.268	43.955
300	51.087	61.304	30.652	35.761	35.031	51.087	45.979	46.708
400	56.230	67.476	33.738	39.361	38.558	56.230	50.607	51.410
500	60.570	72.684	36.342	42.399	41.534	60.570	54.513	55 378
600	64,360	77.232	38.616	45.052	44,133	64.360	57.924	58.843
700	67.760	81.312	40.606	47.432	46.464	67.760	60.984	61.952
800	70.844	85.013	42.506	49.590	48.578	70.844	63.760	64.772
900	73.680	88.416	44.208	51.576	50.524	73.680	66.312	67.364
1000	76.320	91.584	45.702	53.424	53.334	76.320	68.688	69.778

Portion of Henry Carmichael's 1857 paper in *The Sydney Magazine of Science and Art* —the first paper with some mathematical content published in New South Wales.

mathematics teacher; he later returned to Cambridge and took out his BA in 1854. John O'Brien's letter included no details of his background, and a letter from Sir Edward Deas Thomson (public servant and parliamentarian, who became vice-chancellor in 1863 and was chancellor from 1865 to 1878) apologised that Rev. Thomas Aitken was inadvertently included, whereas he had applied for the "Classical Lectureship".

There were other late applicants, not mentioned by Turner. Andrew Watson (the first name is uncertain from the letter in the archives) had attended Trinity College, Cambridge, but left in 1842 before completing the degree. Robert Horniman, who included the names of William Cape and Dunmore Lang for testimonials, had studied at Plymouth and Portsea, also without completing, but subsequently taught classics and mathematics in England. Another letter from Deas Thomson proposed Roger North for the position, without providing any details.

However, the senate did not proceed with the early opening of the university and wrote to all applicants on 11 July that no immediate appointment would be made.

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The selection committee designated by the senate for the permanent appointments consisted of Sir John Herschel, Sir George Biddell Airy, Henry Malden and Henry Denison. Both Herschel and Airy were Cambridge University graduates in mathematics (in fact, both were senior wranglers and Smith's prizemen[13]), with notable subsequent achievements in mathematics, although both by profession became astronomers. Malden was a classical scholar who was active in the establishment of the University of London as an examining body. Denison was a graduate of Oxford University who was chosen presumably because of his local knowledge; then living in London, he had previously been secretary to Governor FitzRoy. The senate's instructions on the required qualifications of the foundation professors left the committee in no doubt:

> We consider it most important that the Classical and Mathematical Professors should bring with them the prestige of high academical distinction at one of the universities of Oxford or Cambridge. And we hope we shall not inconveniently fetter your choice by confining it to first-class men at either University in Classics, and the first ten wranglers in Mathematics at the University of Cambridge. We also think it important that the gentlemen should be Masters of Arts of not more than six years' standing, and that there should have been no material interruption to the pursuit of their academical studies up to the time of their appointment by you.[14]

The committee distributed 500 copies of a booklet describing the three positions at the Universities of Oxford, Cambridge and Edinburgh, at University College and King's College, London, and at Trinity College, Dublin, as well as in their own private correspondence, and they received 63 applications: 24 for the post of principal and professor of classics, 26 for the chair in mathematics, and thirteen for the position of professor of chemistry and experimental philosophy.[15]

There was little doubt on the committee regarding the strongest candidate for "Professor of Mathematics and Natural Philosophy". They chose Morris Birkbeck Pell, a 24 year old lecturer at Magdalene College, Cambridge, and a fellow of St John's College, Cambridge. Pell accepted the appointment on Christmas Day 1851, married Jane Juliana Rusden on 17 February 1852, set sail from England aboard *Asiatic* on 16 March and arrived in Sydney on 10 July.[16] He gave his first lecture in mathematics in Australia on 13 October 1852, at 10.00am.

William Charles Windeyer (later Mr Justice Windeyer, the first graduate of the University and its chancellor in 1895) was at that first lecture, and wrote in his diary: "Went to a lecture at 10 with Mr. Pell who amused as well as instructed, think I shall like him".[17]

The committee had some difficulty in selecting the professor of chemistry and experimental philosophy, but settled on John Smith, a graduate of the University of Aberdeen, Scotland. His testimonial from there included the following: "the Senatus Academicus of Marischal College and University find that John Smith, A.M. and M.D. of this University, greatly distinguished himself when a student of the Faculty of Arts, gaining various prizes, among others the highest in Natural History, Mathematics and Natural Philosophy."[18] Smith's title was changed to Professor of Chemistry and Experimental Physics in 1854. In 1882, when his department was split, he was appointed Professor of Experimental Physics.

There were greater problems in determining a recommendation for the university principal and professor of classics. The final choice was John Woolley, an outstanding Oxford University graduate and at the time headmaster of the Norwich Grammar School. The committee was aware that Woolley's nomination would not be well received, as he was an Anglican clergyman. However, the nomination was ultimately accepted. ("We must try to satisfy the jealousy of the Catholics by naming one of their Body as Secretary and Registrar," wrote Provost Hamilton.[19])

Woolley was to play an important role in the development of the University although his career would be cut short at a relatively young age. He drowned in the Bay of Biscay in 1866 when the ship on which he was returning to Sydney from a visit to Britain was lost in a storm. One of his other great interests in Australia was the School of Arts movement. He joined the Sydney Mechanics' School of Arts, then in serious decline, in 1853, was elected vice-president two years later and through his work there fostered a revival of community concern.

Before any lecture had been given in the new university, the professors requested that they be known as professors of the University, rather than of the University College, and the senate agreed. Although a role for affiliated denominational colleges was maintained, this essentially quashed the concept that Sydney University would be mainly an examining body while also conducting classes in its own college.

In his inaugural address to the new university, during a ceremony on 11 October 1852, Woolley affirmed his agreement with the senate's concept of "a classical-mathematical version of a liberal education . . . tempered by a new humanism":

> Moreover, disciplines selected by the University of Sydney for its foundation chairs . . . were well adapted to this end. The study of mathematics when united with the study of philology formed "a perfect discipline of reflexion". While mathematics was the "discipline of necessary reasoning", philology was the discipline of "the probable and contingent". With the addition to these of the science of chemistry and experimental physics, which acted as a corrective to any tendency to build upon "uncertain or incomplete induction", the University had provided "a comprehensive and balanced mental discipline".[20]

This narrow curriculum was maintained for a number of years, disregarding the need for professional studies, and became the source of vigorous criticism by William Cape, foundation head of the Sydney College, and others. Cape, writing to *The Sydney Morning Herald* in 1857, was particularly critical of the University's devotion to classics and "pure" mathematics and called for a public inquiry into the matter.[21]

In September 1859, the Legislative Assembly set up a select committee to inquire into the state of the University. By then, Charles Nicholson was provost. His title was changed to vice-chancellor in 1860.

The select committee included Cape and Dunmore Lang. Although critical of the lavish building program then under way, of the "inconsistency" in having sectarian colleges affiliated with the University, and of the structure of the senate, there was little reference in its report to

problems in the curriculum. In fact, Woolley, in response, pointed to recent educational reforms at the universities of Oxford and Cambridge which "had been by way of additions rather than innovations, and classics and mathematics still constituted their principal studies" and, furthermore, the "system of the ancient universities . . . did not require any modification in its adaption to the conditions of the colony."[22]

Manning Clark, more than a century later, was vehement in his condemnation:

> At the universities of Sydney and Melbourne, the heads of the governing bodies and the professors were exiles from the Old World. They were interpreters of the science and culture of the Old World. They introduced their students to the civilization of Europe, never thinking to encourage them to be pathfinders of a new civilization in their adopted country.[23]

With specific regard for the ramifications for mathematics across Australia, the mathematics educators Ken Clements, Lindsay Grimison and Nerida Ellerton were equally fervent:

> This acceptance of Old World criteria for the definition of school and university mathematics would have enormous implications for the future of mathematics education in Australia. Elementary school arithmetic would be relevant in the colonial primary schools only to the extent that syllabuses and textbooks written thousands of miles away, by authors who knew nothing of the harsh realities of colonial life, could have meaning; higher secondary school and university mathematics in Australian institutions would be virtually identical to higher mathematics courses taken by a tiny percentage of privileged children at home . . . Implicit in the decisions made by the colonial education administrators was the notion that mathematics was, essentially, a culture-free pursuit, and that higher mathematics should be studied by academically capable, white male students only.[24]

Morris Birkbeck Pell

Morris Pell's maternal grandfather, Morris Birkbeck, emigrated from England to the United States of America in 1817 and founded the prairie settlement of Albion, Illinois. Pell was born there on 31 March 1827. His grandfather's older brother was George Birkbeck, whose lectures for working men led to the founding of the Glasgow Mechanics' Institution, the first such in Britain, in 1823. A year later, he founded the London Mechanics' Institution, which became Birkbeck College in the University of London.

When the young Pell's parents separated in 1835, he went with his mother first to Poughkeepsie, New York, and then, in 1841, to Plymouth, England, where he attended the Plymouth Subscription Classical and Mathematical School. He was admitted to St John's College in March 1845 as a sizar (on reduced fees, but assigned to wait on one of the fellows) and became senior wrangler in January 1849. He gained second place in the examination for the Smith's prize and as a result was elected to a fellowship at St John's in March 1850. It was just two years later when Pell sailed for Sydney with his new wife, his mother and two sisters.

Only 24 students had matriculated for the new university's first lectures in October 1852. According to Ivan Turner,

> Pell found the mathematical preparation of the university students low because of the poor state of secondary education. He developed courses in mathematics at pass and honours levels. The mathematical topics for the first bachelor of arts degree awarded by the university included arithmetic in all its branches, logarithms, algebra to quadratic equations and the first four books of Euclid. The subjects in his honours courses were more diversified and advanced as Pell kept in touch with the courses being offered in Cambridge, London and Edinburgh. They also reflected his own research interests: calculus of variations, probability, finite differences,

Morris Birkbeck Pell, 1827–1879. (University of Sydney Archives)

differential geometry, optics and astronomy. He specialized in problems on mortality rates and life expectation. He published *Geometrical Illustrations of the Differential Calculus*[25] for his students and won repute as a fine teacher.[26]

A more accurate account of Pell's research interests was given by Oliver Lancaster,[27] the first professor of mathematical statistics in the University of Sydney. In active pursuit of those interests, but with no formal training in the area,[28] Pell became consultant actuary to the Australian Mutual Provident Society (AMP) a year after his arrival in Sydney. He resigned from that position in 1869 and took on a similar role with the Life Association of Australia, which some years later evolved into the Mutual Life and Citizens' Assurance Company Limited, known as the MLC. This involvement in life insurance and actuarial work led also to his becoming a director in two building societies. Nearly all of Pell's eleven publications, listed by Lancaster, are in these areas and the associated fields of demography and mortality.

In fact, wrote Lancaster, "Pell must be regarded as the most important commentator on mortality in Australia before 1900." The others who might have laid claim to that title were the government statisticians of the time. They contributed a number of useful investigations, such as that described in Henry Hayter's 1878 paper on infant mortality.[29] Clare Bellis, author of a history of actuaries in Australia, wrote that Pell's work for the AMP gave him the distinction of being the first actuary in the country, although, according to Bellis, William Archer in Melbourne was also a candidate for that title.[30]

Other articles written by Pell concerned the economics of the development of the railway system, the stability of dams and vibrational spectra and energy dissipation in crystalline solids. The last of these,[31] wrote Cecil Salier in 1932, was "greatly admired by the few who are capable of appreciating such subjects".[32] A discussion of Pell's actuarial work was given by Bellis and a wider analysis of his work by Eugene Seneta, Lancaster's successor at Sydney University.[33]

The civic affairs of the colony were another area in which the young professor took a responsible interest. For example, he chaired commissions of inquiry into the administration of the Surveyor-General's Department in 1855 and into a train derailment near Parramatta in 1858. He was admitted as a barrister of the Supreme Court of New South Wales in 1863, after just nine months of preparation, and he was responsible for praiseworthy reforms as chairman of the Sydney City and Suburban Sewage and Health Board in 1875.

Soon after his arrival in New South Wales, Pell asserted his interest in the teaching of

mathematics in secondary schools, a precedent that would be keenly followed by his successor professors of mathematics in Sydney. Along with Woolley, he was critical of the general state of secondary education. In fact, Woolley wrote in 1854: "The anxious father finds, indeed, a university; but in vain he looks for a high school."[34] The Legislative Council subsequently (in August 1854) established a Select Committee on Education. Ivan Turner summarised Pell's statements in his evidence to the committee:

> [In] the 202 schools in the colony arithmetic was taught in all, but algebra and geometry were taught in only seven. Less than 400 pupils out of about 4,700 had any knowledge of "higher" mathematics (elementary algebra and geometry) and less than 1,000 pupils could work sums involving the compound rules in arithmetic. He urged the Commission to recommend the establishment of a secondary school of the English grammar school type, maintained out of taxation, free from any religious influence, with a staff appointed by the Government, and an elected body of Trustees.

Turner continued that this was no doubt "the reason why in the Sydney Grammar School soon thereafter to be founded on this pattern the professor of Mathematics became, and is to this day, ex-officio a Trustee of the school."[35]

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Ill health brought about Pell's retirement in 1876, by which time 20 students had graduated with first-class honours in mathematics. There were still fewer than 60 matriculants a year to the University, and all had to study mathematics for at least two years. Those taking third-year mathematics were by then required to study conic sections, differential calculus, dynamics, higher algebra and trigonometry.[36]

His last year in office was not a happy one. Although "remembered by his students as a master of his subject and a singularly lucid lecturer,"[37] the disquiet of his colleagues at the end was apparent. Charles Badham came to the University of Sydney as professor of classics and logic in 1867, as successor to Woolley, and quickly stamped his conservatism on the University. He wrote to Deas Thomson in July 1876:

> As to the Mathematical lectures, I feel quite persuaded that Pell will go on as he had begun; some days blank, some days a show of lecturing, but without any real work. On Wednesday next, you will have to decide whether this is to go on, or whether you should invite Harlin hither, and whilst he is on the way, ask Scott to deliver lectures.[38]

In October, Thomas Harlin, who graduated BA and ninth wrangler from Peterhouse College, Cambridge, in 1856 and was at the time headmaster of Brisbane Grammar School, accepted the office of assistant professor of mathematics. There was more concern over Pell's actions late in the year regarding papers for the University's junior and senior public examinations. He had agreed without authorisation to pay someone else to carry out his marking of the papers with the result that the senate, when this was reported to it, withdrew the papers from Pell and handed them to William Scott.[39]

Pell died on 7 May 1879. Badham makes it clear that he was not unappreciative of Pell; he wrote a highly laudatory obituary which appeared in the *Sydney Mail* on 17 May 1879 and which perhaps explained the actions described here: Badham wrote that Pell's body was "for many years almost crippled by an injury to the spine—an injury which, by extending to the brain, eventually carried him off at the age of fifty-two." Pell's injury had occurred in an accident in 1863, 16 years before his death.[40]

During his 24 years as professor of mathematics, Pell had only two assistants. The first was William Scott from 1860 to 1862 and intermittently from mid-1872 when Pell first informed the University senate of his inability to lecture due to illness. The other, George Robarts Smalley, taught in 1865 and was also an examiner in mathematics, with Pell, from then until 1870.

The British Astronomer Royal, Sir George Airy, who already had associations with Sydney through his work on the selection committee for the professors of the new university and before that with regard to the establishment of a successor to the Parramatta observatory, had recommended Scott for the position of astronomer in the new Sydney observatory. He was the first trained astronomer to work in Australia since Carl Rümker's departure.[41] Scott had held a mathematics lectureship in Sidney Sussex College, Cambridge, and had been third wrangler in 1848. He was ordained into the Church of England in 1850 but maintained an interest in mathematics through coaching, and accepted the position in Sydney in 1856. He resigned as Sydney's astronomer in October 1862 and was succeeded in that position by Smalley, who was also a recommendation of Airy's.[42] In 1865, Scott became warden of St Paul's College in the University of Sydney and began a long association with the Royal Society of New South Wales. He died in 1917, aged 91.

Smalley, born in 1822, had been educated at St John's College, Cambridge. He went to Capetown, South Africa, as an astronomer in 1846 and became professor of mathematics at the South African College, later the University of Capetown, in 1851. He taught mathematics in King's College, London, from 1854 to 1862. Besides his duties as Sydney's government astronomer, Smalley did significant work in geodesy when he was associated with Sir Charles Todd (1826–1910) in the fixing of the boundary between South Australia and New South Wales in 1868. He was also active in the Royal Society of New South Wales until his death in 1870. (Charles Todd was yet another of Airy's recommendations for a position in Australia, this time as Supervisor of Telegraphs and Astronomical Observer in South Australia.)

A final word regarding Morris Pell: his grandson Morris Plomley (born 1879) married Winifred Pickburn (born 1884) who was a second cousin once removed of Neville de Mestre. From 1997 to 2003, de Mestre was professor of mathematics at Bond University, Queensland.[43]

Theodore Thomas Gurney

The second professor of mathematics at the University of Sydney was Theodore Thomas Gurney, born on 10 October 1849 in London. He gained numerous scholarships for study at St John's College, Cambridge, graduated as third wrangler in 1873 and was elected to a fellowship in the college the following year. His father, Thomas William Henry Gurney, was 23rd wrangler at St John's in 1837, lectured in mathematics at Bassishaw in London and was vicar of Clavering and Langley, villages in Essex.

Among Gurney's rivals as Pell's replacement was Horace Lamb, who had taken the position of first Elder Professor of Mathematics at the University of Adelaide a year before. In fact, Lamb had been in the position for only six months when he wrote, in September 1876, to Sir George Gabriel Stokes at Cambridge offering himself for the Sydney chair[44] although Pell had not by then officially vacated it. Stokes and Sir Charles Nicholson comprised the selection committee but Stokes made no mention of Lamb in correspondence on the matter in February of the following year. In a letter to Nicholson, evidently in London at the time, he wrote: "The order of application is Spence, Stuart, Gurney but the order of standing is Spence, Gurney, Stuart."[45]

(It is probable that the last was either George Henry Stuart of Emmanuel College, Cambridge, fifth wrangler and Smith's prizeman in 1874; or James Stuart of Trinity College, third wrangler in 1866, and, from 1875 to 1889, professor of "Mechanism and Applied Mechanics", which was in effect the first chair in engineering at Cambridge University. Spence was probably William Michael Spence who was admitted to Pembroke College, Cambridge, in 1867, was third wrangler in 1871, and was called to the bar in 1874.[46])

The relationship between Stokes and Lamb, formerly teacher and student, is not fully understood. Besides the above incident, there is the fact that when Lamb applied for the Adelaide position he had sought a reference from Stokes, but his request went unanswered.[47]

Gurney departed from Southampton early in April. He is still remembered in the Manly district of Sydney as the builder of a "magnificent stone residence overlooking all the beauty of Middle Harbour . . . built regardless of cost,"[48] known now as the Dalwood Home but originally named Clavering after his father's village. Dalwood Home is an assessment centre for children with learning disorders. Gurney Crescent winds around the hill on which the home sits, and off Gurney Crescent there is Clavering Road—lasting memorials to one of Australia's earliest mathematicians. Gurney Way in Cambridge is also named after him.

Stokes' letters show that Gurney was not the first choice of the selection committee but, even so, he did not fulfil the expectations of him. His 25 years as chair of mathematics were notable for a total lack of creative enterprise in mathematics. Ivan Turner quotes as follows from a letter in the library of St John's College, written to the selection committee for Gurney's successor prior to his retirement in December 1902:

> There is very considerable activity in all other branches of Science here . . . but research in mathematical matters is absolutely non-existent. The present professor, Gurney of your College, has held the Chair for 25 years. Mentally equipped with every gift except ambition, he has, as you know, never published a line.[49]

Gurney did however play his part in the affairs of the university. He was a member of the senate and of numerous university committees and was largely responsible for the revitalisation of the university musical society in 1889; with his wife he was active in work and negotiations that led to the founding of the Women's College.

He also acted for a short time as a consultant actuary[50] and fulfilled other responsibilities outside the University. Turner vividly recounted an occasion on which Gurney gave evidence at a coroner's inquest:

> In the great fire at Anthony Hordern's Emporium, 10th July, 1901 a young man was trapped 120 feet from the ground and had to jump, with fatal result. Professor Gurney was asked to explain to the coroner the victim's chances of survival if better rescue means had been available—i.e. better than some sort of sheet held about two feet from the ground. Gurney's evidence, printed in the Sydney Morning Herald of 26th July, 1901, was to the effect that the probability of survival under those conditions was very small—surely as striking an example of mathematics applied to a real life (or should I say a real death) situation as we could wish for!

For the first few years, Gurney had no assistance with his teaching, which for many would have been a reason in itself for having little research output. Student numbers increased, from 81 in 1881 to almost 250 in his last year, and the number of courses increased proportionately. In 1902 the mathematics department "was providing lecture courses for students in the faculties of Arts, Science and Engineering. There were separate lecture courses in the Faculty of Arts in first, second and third years: in each of first and second year there were courses at three standards

A, B, C. The B and C courses formed the pass course and were examined in December; the A course was an honours course examined in March . . . The courses in Science and Engineering were selections from those offered in Arts." Twenty-six students graduated with first-class honours in the 25 years that Gurney was professor of mathematics.

In 1880, the first full time lecturer in mathematics was appointed to share teaching duties with the professor. The lecturer was Henry Ebenezer Barff, who had graduated from the University with first-class honours and the Prize in Mathematics in 1876. This was "An Annual Prize of £10 for proficiency in Mathematics among incepting Bachelors", according to early *Calendars* of the University. It had been donated by Pell and was first awarded in 1861.

Born in Tahiti in 1857 to missionary parents, Barff filled the new teaching position only for one year. He became the University's registrar in 1882 and served also as the university librarian until 1914. Barff was greatly mourned by the university community when he died in 1925. Ill health had caused his resignation as registrar only a few months earlier after 45 years service to Sydney University.

Barff was succeeded briefly as lecturer in mathematics by Herbert Louis Power Elles, a graduate of Trinity College, Cambridge, who in turn was followed by Francis John Horner. Horner had entered St John's College, Cambridge, as a sizar in 1872 and obtained his BA in 1876. Born in Bath, England, in 1852, he was the grandson of William George Horner who is remembered for his publication in 1819 of a method for the approximation of the roots of a polynomial

Theodore Gurney, seated left, with the professors of the University and third year students, 1881. (The University of Sydney Archives)

equation. Francis Horner was at Sydney University from 1881 to 1886, and he died the following year. (Neville Horner Fletcher took honours in mathematics at Sydney University in 1950 and a PhD in physics from Harvard University. He held a personal chair in physics at the University of New England from 1963 to 1983 before moving on to the CSIRO and then the Australian National University. He is Francis Horner's second cousin, twice removed.)

Horner was joined by a second lecturer, Robert George Goggs from Christ's College at the University of Cambridge, where he was 14th wrangler in 1880. He changed his surname to Pemberton in 1895 and ended his days as principal of the Tutorial and Correspondence College in Vancouver, Canada. Before coming to Sydney, Goggs in 1883 had been science master at Melbourne Grammar School. He acted for Gurney during his absence abroad in 1884 and was "Evening Lecturer" in 1885, the first year in which evening lectures were offered. One of the students in that first evening class was Peter Board, who graduated with second-class honours in mathematics in 1889 and was Director of Education in New South Wales from 1905 to 1922.

Other lecturers in mathematics during Gurney's tenure of the chair were Arthur Newham, who was assistant lecturer responsible for evening classes from 1886 to 1908, and Elphinstone McMahon Moors, who was appointed assistant lecturer in 1887. Both were promoted to assistant professor in 1908 in recognition of their "long and efficient service".

Newham, born in Leicestershire in 1860, had studied at Clifton College, Bristol, and entered St John's, Cambridge, as a sizar in 1879. He graduated BA as 16th wrangler in 1883 and was to remain at the University of Sydney until 1914 when he took twelve months leave of absence due to ill health and subsequently retired.

Melbourne-born Moors was a year older than Newham, and had a BA from the University of Melbourne. He had travelled to Cambridge, enrolled in St John's College and graduated BA in 1884 as 29th wrangler. An accomplished actuary, who gained his fellowship of the Institute of Actuaries around 1897 and would later be responsible for introducing actuarial studies into the University, Moors also had interests in astronomy. He was secretary of a committee established by the Australasian Association for the Advancement of Science to observe a total eclipse of the Sun on 29 April 1911 and was a member of an advance party that took 16 days to reach Vavau, an island group belonging now to Tonga, for that purpose.[51]

For shorter periods, there was also assistance from George C. Halliday, acting lecturer in 1887; William Edwin Brunyate, acting professor in 1892; and Alex McAulay. McAulay was professor of mathematics and physics in the University of Tasmania from 1896 to 1924, and acting professor at Sydney University in 1900. Brunyate and McAulay, as Goggs had done earlier, deputised for Gurney during his sabbatical leaves.[52] Brunyate went on to achieve great distinction. Born in Barton-on-Humber, Lincolnshire, in 1867, he had entered Trinity College, Cambridge, in 1885 and graduated as second wrangler and second Smith's prizeman in 1888. He was a fellow of Trinity College from 1890 to 1896 and was called to the bar in 1894, having returned from Australia. Brunyate served in Egypt during World War 1, was knighted in 1916, and served as vice-chancellor of the University of Hong Kong from 1921 to 1924.

When Gurney retired due to failing health, he was appointed professor emeritus. He donated his library of "about forty volumes of standard works" to the University[53] and returned to England with his wife Johanna, whom he had married in Sydney in 1879. They lived at Chesterton Hall, a grand old home in the Cambridge area and former residence of Johanna's first husband. Both were to die there, Gurney on 4 September 1918 and his wife four years later.[54]

The University of Melbourne, 1855–1922

By 1852 New South Wales had a population of more than 200,000, and a university. The population of Victoria was almost 170,000 and within two years would exceed that of New South Wales, as a result of the gold rush. And it did not have a university. It was inevitable, according to Geoffrey Blainey, who was commissioned to write the history of the University of Melbourne for its centenary in 1955, that Victoria would take steps for the creation of a university once Sydney had done so.

The lieutenant governor of Victoria, Charles La Trobe, was a devotee of natural science and literature and sympathetic to the call for establishment of a second Australian university. In November 1852 he appointed his friend, Hugh Culling Eardley Childers, to oversee the passage through the Legislative Council of Victoria of a bill to set up a committee to inquire into the matter. Childers was Victoria's auditor-general although he was just 25 years old and had arrived in Melbourne only two years earlier. He had previously held the post of inspector of denominational schools and had earned a reputation as an industrious administrator and an authority on education. By February 1853 the bill for the establishment of the University of Melbourne, which was largely a copy of the corresponding bill in Sydney, had been enacted. Blainey wrote:

> Emulation of Sydney was the immediate but not the only motive in creating the university. Its more practical advocates believed that it would further the knowledge and exploitation of the natural resources of the continent, prepare the colony for responsible government, and train students who wanted to enter the professions but who otherwise must go to Europe. To the liberals a university was one of the vital institutions of western civilization, which cultivated the intellect and taste, and taught men to love knowledge for its own sake. In addition to these secular aims the founders believed that a university was a moral force . . .[55]

The abandonment of the purely secular principles that had marked the establishment of Sydney University, when in 1854 it allowed affiliated colleges that provided religious instruction, was noted with dismay in Melbourne. The Victorian government was determined that there would be no sectarian influence on its new university and it set about creating what would be for its first 20 years "probably the most secular university in the British Dominions, and certainly more secular than any British university". It stipulated "that the university council should have no more than four clergymen amongst its twenty members; and the council itself . . . decreed that professors must neither be 'men in holy orders' nor lecture on religious topics inside or outside of the university."[56]

The first chancellor of the University of Melbourne was Sir Redmond Barry, a towering but enigmatic figure through the mid-19th century in Melbourne and the person often credited as the founder of its university.[57] He remained chancellor until his death in 1880. Childers was vice-chancellor. In determining the foundation professors for its preferred curriculum, the council was keen to go beyond the early emphasis in Sydney on mathematics and the classics. While not neglecting these disciplines, there would also be from the outset a chair covering the natural sciences, namely botany, geology, chemistry and zoology rather than chemistry alone, and a fourth chair in the moral sciences (modern history, literature, political economy and logic).

The London-based selection committee again consisted of Malden, Herschel and Airy, as for the Sydney appointments, augmented this time by the English politician Robert Lowe and the Victorian chief justice, Sir William a'Beckett, who was visiting Britain. They were to operate under instructions that included the following:

> The Council has come to the determination to invite gentlemen from the Mother Country to fill the different Chairs . . . It is considered expedient that the persons whom you may deem eligible for the office be men not in holy orders, of approved worth and moral standing, and of such stability of character as to command respect . . . A devotedness, on the part of those selected, to the cause of literature and the interests of the University, is deemed to be of great moment, inasmuch as those interests must be held paramount to any pointing to prospective individual advancement, by taking pupils, imparting instruction by public lectures, or otherwise, which are all strictly prohibited . . . A total abstraction from political or sectarian interference must be rigidly enjoined. And . . . it will be considered desirable that the Professors should be men under middle age, of approved diligence in tertiary pursuits, graduates of one of the Universities of Oxford, Cambridge, London, Dublin, Edinburgh, or Glasgow, and designated by some particular excellence in their collegiate career; accustomed, if possible, to the inculcation of knowledge (with clearness and readiness) in the Department to which they propose to apply themselves; and . . . of such habits and manners as to stamp on their future pupils the character of the loyal well-bred English gentleman.[58]

The committee received 90 applications for the four chairs and its selections were endorsed in Melbourne. The only Cambridge appointment was Henry Erskine Rowe, who was to be professor of classics and ancient history, but he died from the effects of the voyage five weeks after arriving in Australia. The other three were at the new Queen's College in Belfast. They were Frederick McCoy, professor of natural sciences; William Edward Hearn, professor of modern history and literature; and William Parkinson Wilson, who was to be professor of mathematics (pure and mixed).

Wilson, and presumably his colleagues also, had, "weighed prospects of a greater personal influence and a trebled salary against academic exile".[59] Whether or not they considered themselves exiled, all four (Martin Howy Irving having been appointed professor of classics in place of Rowe) were to accept their new home and position with enthusiasm and to become prominent in Melbourne society. Initially, though, the new professors' salaries, which consisted of £1,000 a year and free housing, were a cause of some ill will in Melbourne. *The Age* wrote that it would have been better to educate all the students of the new university in Oxford or Cambridge, and would have cost only half as much.

Teaching began on 13 April 1855 and it was Wilson who gave the first lecture, less than three months after his arrival. Only 16 students had matriculated and five of those abandoned their studies after six months. The matriculants had been successful in "Arithmetic, The Elements of Algebra, and the First Two Books of Euclid", as well as in their classical studies. In their first year they studied "Geometry and Geometrical Trigonometry" and "Algebra and Analytical Trigonometry"; in second year, "Analytical Geometry and Differential Calculus, with Applications"; and in their third year, "Applied Mathematics". The numbers graduating with a BA, the only degree offered in the first instance, rarely exceeded ten for the first dozen years of the University.[60]

Various reasons have been given for the paucity of student numbers besides the obvious: until 1905, only about two per cent of Australian children had attended secondary schools.[61]

As one reason, it was claimed that the curriculum had an emphasis on the classics, which hardly suited a population enhanced and enthused by the gold rush. In fact, just three days after he gave his first lecture, Wilson joined Hearn in issuing a pamphlet which sought to remedy the causes of the University of Sydney's "want of success" and urged that the study of classics be made optional. This, along with a similar proposal a few years later, was rejected by the university council.[62] They argued with more success that for matriculation to the University it should be

allowed that either mathematics or classics be omitted. By 1862 matriculation entailed passing any six of papers in English, Greek, Latin, French, German, arithmetic, algebra, Euclid, history and geography, provided not both French and German were included.[63]

The cost of attending was another deterrent, despite a generous scholarship scheme sponsored by the University itself. And, as in Sydney, the quality of preparatory secondary schooling for the few whose families could afford it was inadequate. In consequence, no "son of a working man" attended until 1865.

Furthermore, women were not admitted until 1881 although the principle to admit them was established in 1878 after almost a decade of debate. At that time, a committee of the council, while acquiescing in a recommendation of a government inquiry into education, "reserved the university's right to preclude females from lectures unless at least twenty applied to do a certain course."[64] It was also 1881 when the University of Sydney agreed to admit women to its courses, but the University of Adelaide had done so, with some opposition, since its founding in 1874.[65]

William Parkinson Wilson

Wilson was born at Peterborough in Northamptonshire, England, probably in 1826 since his date of baptism is known as 1 February of that year. He went to St John's College, Cambridge, as a sizar and was senior wrangler and first Smith's prizeman in 1847. In August 1849 he was appointed as the first professor of mathematics at Belfast, where he also founded and directed an observatory, and in 1850 published *A Treatise on Dynamics*. With his Cambridge background and interests in astronomy matching those of both Herschel and Airy, members of the selection committee, it is not surprising that Hershel wrote to Airy: "For my own part, I cannot see how it is possible to find a better man or [one] more completely uniting every qualification than Professor Wilson."[66]

In Melbourne, Wilson's duties also included the teaching of natural philosophy "illustrated by models and experiments". The two year course included lectures on mechanics, hydrostatics, pneumatics, heat, meteorology, optics, astronomy, electricity and magnetism. Besides university teaching, he set and marked matriculation papers in mathematics and he joined the other professors in giving weekly lectures to teachers of primary schools. Wilson was the first president of the professorial board, in 1856, and was president again from 1868 to 1871.

Australia's first university engineering program, a three year course leading to a Certificate in Civil Engineering, dates from 1861 in Melbourne, and Wilson was primarily responsible for its planning. Two of his early students were also associated with it.

The first was Henry Martyn Andrew, who matriculated to the University of Melbourne in 1861 and graduated with a BA in 1864. His course had included two of the subjects in civil engineering and in July 1864 he was invited to lecture in the new program. From 1868 to 1872 he studied at St John's College, Cambridge, and was then for a short while professor of mathematics at the Royal Agricultural College in Cirencester. He was headmaster of Wesley College in Melbourne from 1875 to 1882 and then professor of natural philosophy at the University of Melbourne until his death at sea, aged 43, while travelling on leave to England in 1888.

William Charles Kernot was a contemporary of Andrew's. He went on to gain an MA in 1866 and his Certificate of Civil Engineering the same year, becoming the first qualified engineer produced by the University. In 1882, he was appointed the first professor of engineering there.

According to the *Australian Dictionary of Biography*, "Wilson deplored what he termed an

William Parkinson Wilson, 1826?–1874. (Trinity College Archives, University of Melbourne)

'incomplete' university without residential colleges to provide moral and religious education, the encouragement of study after graduation, tutorial teaching, training for the clergy, and the cultivation of 'university spirit and feeling'."[67] He became secretary of a committee to found an Anglican college at the University and the result, Trinity College, was opened in 1872 with Wilson as a trustee and secretary of its first council. He also served on a royal commission on fine arts in 1863–1864.

Like Pell in Sydney, Wilson was appointed as a consulting actuary, in his case to the National Mutual Life Association of Australasia, formed in 1869,[68] but his major activities outside his university duties were in astronomy. Within two years of arriving in Melbourne he was advocating that city as the site for the observatory in the southern hemisphere that had been planned by the Royal Society in London. This was the content of a paper[69] that he wrote for the Philosophical Institute of Victoria, an organisation with which he was to have a long association.

There was already an observatory in Melbourne. In 1853 Robert Lewis John Ellery had been appointed by the Victorian government to establish an observatory at Williamstown on Port Phillip Bay. A second observatory was set up in 1858 on Flagstaff Hill on the western edge of the city, satisfying the personal ambition of Georg Balthasar von Neumayer, a well qualified Bavarian ship's officer who had studied at the Hamburg Observatory and School of Navigation where Carl Rümker was director. Industrial development caused both sites to become unsuitable and in 1860, with the authoritative support of Wilson, it was determined that the two observatories should merge and be relocated to the Botanic Gardens, on Melbourne's Domain. The new observatory was completed early in 1863 and Ellery was to remain its dedicated and successful director until 1895. Von Neumayer accepted a position in Hamburg in 1864.

Behind Wilson's fervent advocacy was his knowledge that the Royal Society was intent on setting up a large telescope to investigate the composition of clusters and nebulae that had been observed by Sir John Herschel at the Cape of Good Hope in the 1830s. Herschel and the astronomer royal, Sir George Airy, were members of a large committee that eventually acceded to Melbourne as the site, largely because of its new wealth derived from the gold rush. The Victorian government contributed £5,000 towards the cost of what soon became known as the Great Melbourne Telescope, ordered from Dublin in 1865 and operational from August 1869.[70]

The Great Melbourne Telescope continued in operation until the end of World War 2 when it was sold as scrap and transported to the Mount Stromlo Observatory near Canberra. There, it was fully upgraded to become one of Australia's most sophisticated optical telescopes and, although few original components remained, it continued to be known by its original name. The Great Melbourne Telescope was destroyed along with the rest of the observatory in bushfires in January 2003.

Wilson maintained his astronomical interests until the end. In December 1871, he was in charge of an expedition to Cape Sidmouth in north Queensland to observe an eclipse of the Sun, and three years later he established an observatory at Mornington, south of Melbourne, as a participant in nationwide observations of the transit of Venus. Just two days after that, on 11 December 1874, having reported his findings to Ellery and having commenced the marking of some matriculation examination papers, he died of apoplexy, aged 48.[71]

After Wilson's death, the acting professor of mathematics was Frederick Joy Pirani. Born at Birmingham, England, on 23 December 1850, he had and moved to Melbourne with his parents in 1859. He was one of 90 candidates who "presented themselves" for examination for matriculation to Melbourne University in October 1866 and February 1867; of the 44 who passed, Pirani was one of six who "passed with credit".[72] He graduated with a Certificate of Civil Engineering in 1870, a BA in 1871 and an MA in 1873, the same year in which he was appointed lecturer in mathematics and logic. Two years later his position was changed to lecturer in logic and natural philosophy. With Henry Andrew, Pirani wrote a school text on elementary geometry that went to four editions[73] but his papers in the journals of the Royal Society of Victoria, dated 1876 to 1882, indicate a predilection for physics, and electricity in particular. He died in Melbourne on 6 August 1881, aged 30, after being thrown from a horse.

Pirani was acting professor for only six months. Just ten days after Wilson died, the council of the University determined to send a telegram to Cambridge University's professor of astronomy and geometry, John Couch Adams, asking him to find a successor. The telegram went out the next day. In full, with added punctuation, it read: "Professor Wilson dead. Please select best

man procurable any university, not in orders. Duties Melbourne University calendar."[74] By the end of January, Adams had chosen Edward John Nanson and the selection was immediately endorsed by the council. "[Its] uncharacteristic pace and a selection committee of one were hard to understand," wrote Melbourne historian Richard Selleck recently. He added that one of the council members had put forward the names of eight others, all of whom had recently gained fellowships at Trinity College, Dublin, for consideration for the chair, apparently with no response.[75]

Edward John Nanson

Edward Nanson was born on 13 December 1850 at Penrith in Cumberland, England, and entered Trinity College, Cambridge, in 1870, obtaining his BA as second wrangler and second Smith's prizeman in 1873. The following year he was appointed professor of applied mathematics at the Royal Indian Engineering College at Cooper's Hill in Surrey and a year after that was appointed to replace Wilson as professor of mathematics, pure and mixed. Nanson arrived in Melbourne in June 1875.

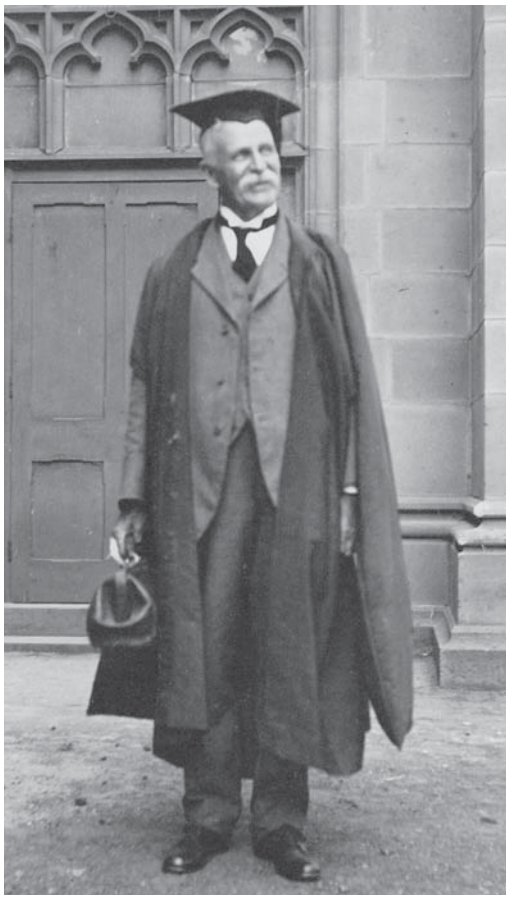
He was described by a biographer as a "disciple of Cayley, Sylvester and Salmon . . . of the dominant English 'aesthetic' school of pure mathematics whose great achievements were in formal algebra and its applications in geometry."[76] Nanson was a regular contributor to the *Messenger of Mathematics* and the proceedings of the royal societies of London, Edinburgh and Victoria, and from 1881 to 1889 was an examiner in the Faculty of Arts at the University of Sydney.

He is also remembered for his work in the area of electoral reform. He belonged to the school of Thomas Hare and John Stuart Mill and as such was an advocate of proportional representation and of preferential voting to achieve a quota in multi-member electorates. He spoke at public meetings, published numerous pamphlets[77] and analysed contemporary elections in the press. His ideas were embodied in an electoral reform bill introduced in the Legislative Assembly of Victoria in August 1900 and in the first Commonwealth electoral bill drafted in 1901 but amendments to the bills led to the dropping of his theories.[78] Nanson's proposals for electoral reform are still pertinent to research in the area.[79]

One of Nanson's first students and one of the best in his long tenure of the chair, Samuel Alexander, was to gain renown as the foremost British philosopher of his time. He was born in Sydney in 1859, moved to Melbourne around 1863, and began an arts course at the University of Melbourne in 1875, winning prizes in all subjects attempted. Without completing the degree, Alexander sailed to England, won a scholarship for study at Balliol College, Oxford, and "obtained first classes in mathematical and classical moderations ... and in *literae humaniores*". He became professor of philosophy at the University of Manchester in 1893.[80]

Robert James Allman Barnard was another of Nanson's early students. He was born at Kew in Victoria in 1866 and graduated from Melbourne University in 1888 with a BA and first-class honours. Barnard gained an MA two years later and in the same year was appointed lecturer in mathematics and natural philosophy at Queen's College in the University. He combined this with a similar appointment at Ormond College in 1897 and was to maintain a relationship with these colleges throughout his life. For much of the year 1903, Barnard undertook advanced study in Cambridge and at the Sorbonne University in Paris.

Barnard became the first professor of mathematics in the newly founded Royal Military College of Australia, at Duntroon, now a suburb of Canberra, in 1911 and held the post until 1922 when falling numbers of cadets following World War 1 led to his retrenchment. Shortly



Edward Nanson, 1850–1936, taken around 1916. (University of Melbourne Archives)

afterwards, he was appointed to a senior lectureship in mathematics at Melbourne University, taking him through to his retirement in 1933.

With Nanson, Barnard was a leading spirit in the formation of the Melbourne Mathematical Society at a preliminary meeting on 19 June 1906, being its secretary-treasurer until the society's demise in 1911. Nanson was its first president. The Society was revived in 1924 as the Mathematical Association of Victoria, again with Barnard as secretary and then president in 1935–1936.[81] He was also a capable and active astronomer and could read in twelve languages including Russian and Japanese. Robert Barnard died of a sudden heart attack in 1945.[82]

Edward Nanson retired in December 1922, around the time Barnard joined the department. He was by then in his 48th year as chair of mathematics, still the longest period of tenure by a professor in the University's history. Described as "kind but reserved in manner, mild in temperament,"[83] he was nonetheless a forceful figure on university boards. The story of the election in 1881 of the president of the professorial board, resulting in Nanson being struck "three or four times" causing his lip to bleed, is told in detail by Selleck.[84]

Nanson's successor in the chair, John Henry Michell, had also been one of his students. He was appointed to the department in 1891 as an "Independent Lecturer in Mixed Mathematics" and for most of the time the two were responsible for all the teaching in mathematics. Charles Weatherburn was one who helped out: he taught evening classes from 1917 to 1921.

Edward Nanson died in 1936. He and his family were the first inhabitants of Grosmont, which became the university staff club in 1952 and was renamed University House in 1953. He was married twice and had ten children, including nine daughters. One of these, Joan Wettenhall Nanson, born in 1913, worked at Melbourne University and, 76 years after leaving Grosmont, in November 1998 joined a reunion of those who had previously lived in University-owned homes. Her father's life and hers together span well over 150 years and their working lives in the University covered almost 100 years.

The University of Adelaide, 1876–1909

The University of Adelaide was established in 1874, a time when the population of South Australia was approaching 205,000. The University's origins can be traced directly to the time, two years earlier, when representatives of the Baptist, Congregational and Presbyterian churches founded a college to provide post-secondary education for training in the Christian ministry. In the two years of general studies that were to be followed by three years of theological studies, there were courses in the classics, in philosophy and English literature, and in mathematics and natural science.

The latter were taught by Reverend James Jefferis, who had studied at the Congregational New College in London and who, from the time of his arrival in Adelaide in the early 1860s, was a passionate proponent of federation for Australia. The popularity of the College's general studies in the secular community led to a request for financial assistance from the local pastoralist and copper magnate, Walter Watson Hughes, and he responded in magnificent fashion.

Hughes pledged £20,000, allowing the aims of the College to be rapidly expanded to encompass a university. Hughes himself favoured the concept and declared that his gift should be used to endow two chairs, one in classics, comparative philology and literature, the other in English language and literature and mental and moral philosophy, and he named his preferences, two local ministers, for the positions.[85]

He became discouraged, however, and left Adelaide early in 1873. His endowment remained behind and was matched by the wool broker and philanthropist, Thomas Elder. The new university council determined that Elder's gift would also finance two chairs, one in mathematics (pure and applied) and the other in natural science, "especially Geology and Mineralogy; the Professor to give lectures in Chemistry also". As well, lecturers were to be appointed in history and political economy, botany, animal physiology, and engineering and surveying. As Walter Duncan and Roger Leonard wrote, on the occasion of the university's centenary,

> These decisions were fundamental to the nature and purpose of the new University, and have shaped its history. The system of Faculties and Lectureships meant that the University would teach as well as examine. London's non-sectarian spirit was to be emulated, but not its academic organisation, which left teaching to constituent colleges. The range of courses offered, including the projected Faculties of Law and Medicine, showed that the University was meant to be entirely self-sufficient: it was not to be a mere supplement to the two universities already at work in the eastern colonies.[86]

The University's first permanent building did not open until 1882, but teaching began on 28 March 1876 in temporary accommodation in the Teachers' Training College. There were eight matriculated students enrolled for the BA, and 52 "non-graduating" students.

The council of the University had entrusted the search for the first two Elder professors to a small British committee, with the selection of a mathematics professor left largely to two of Britain's finest mathematicians. These were Isaac Todhunter, a fellow of St John's College, Cambridge, senior wrangler there in 1848 and doyen of textbook writers for his time; and Peter Guthrie Tait, then professor of natural philosophy in the University of Edinburgh, and formerly a student of Todhunter's and senior wrangler at Peterhouse, Cambridge, in 1852. From 22 applications, they determined a short list of six: three Cambridge men, two from Dublin and an Australian, namely Frederick Pirani at the University of Melbourne.[87] They chose 26 year old Horace Lamb, and he was in Adelaide in time for those first lectures. Lamb would fulfil with distinction Todhunter's expectations when he wrote to the agent-general for South Australia in

London in October 1875, "I have made the acquaintance of Mr Lamb, and am sure he will be in every respect an excellent professor."[88]

As the first Elder Professor of Natural Science, the British committee chose another Cambridge graduate, Ralph Tate, whose interests were mainly in geology.

Horace Lamb

Lamb's date of birth is given in different sources as either 27 or 29 November 1849.[89] He was born at Stockport, in Cheshire, England, and received his first schooling at the Stockport Grammar School. A junior classics master at the school, Frederick Slaney Poole, was to be influential in Lamb's decision to come to Australia. In 1867, Lamb won a classical scholarship to Queen's College, Cambridge, but instead went for a year to Owens College, Manchester, where he was persuaded to study mathematics. He gained a scholarship for Trinity College, Cambridge, in 1868, graduated with his BA as second wrangler and second Smith's prizeman in 1872, and was in consequence elected as a fellow and lecturer in the college.

In the two years that Lamb lectured at Trinity College, he established a reputation for originality in the material he taught and innovation in its presentation. He taught hydrodynamics, not in the conventional form that he had received from George Stokes and James Clerk Maxwell, but incorporating the latest theories and results of Hermann von Helmholtz and William Thomson (Lord Kelvin). Those lectures became the first edition of Lamb's *Treatise on the Motion of Fluids*, published in Cambridge in 1879 while he was in Adelaide. The book went through five further editions from 1895 to 1932, greatly enlarged and retitled *Hydrodynamics*, and remained a prescribed text in the University of Adelaide until 1970. It is still listed as one of the references for Edgar Smith's third-year applied mathematics course at La Trobe University.

As was the case for all fellows in the colleges of Cambridge, marriage would oblige Lamb to resign his fellowship. Lamb was to marry Elizabeth Foot of Dublin and Slaney Poole, who had migrated to South Australia where he became a "bush clergyman", wrote to Lamb in 1875 suggesting he apply for the chair of mathematics in the new university. Although Poole was one of Lamb's early teachers, he was only three years older and became a lasting friend. He wrote the details of Lamb's coming to Australia in a letter to the editor of *The Adelaide Advertiser* of 10 December 1934,[90] shortly after Lamb died. The Lambs arrived in Adelaide in March 1876, having travelled to Melbourne aboard the 3,000 ton steamship *Australia* in the record-breaking time of 43 days, 11 hours.

Early editions of the Adelaide University *Calendar* record Lamb's first-year course in mathematics as "Geometry, Algebra and Trigonometry". The second-year course consisted of the "higher parts of Algebra and Trigonometry, Elementary Analytical Geometry, and (if time permits) the elements of the Differential Calculus". Lamb also taught natural philosophy. The course consisted of "Statics, Kinematics, Hydrostatics, the Elements of the Science of Heat, Elementary Astronomy" in first year and "Heat, Sound and Light" and "Magnetism and Electricity" in alternate years as a second-year (or third-year) course. The *Calendar* further stated:

> In each of these courses the lectures will be illustrated as far as possible by experiment. In the Second Year's Course opportunity will be given to the students, as far as possible, of practising physical methods of observation, and of becoming acquainted with the use of various instruments.

Lamb's teaching of natural philosophy was at his own instigation: he wrote in a letter to the University registrar in 1885 that "the teaching of Experimental Physics was undertaken by

me *proprio motu*, without any suggestion from the Council".[91] He had previously, in 1879, rejected the vice-chancellor's suggestion that he accept the additional title of Professor of Natural Philosophy. His workload at that time was already 13 contact hours per week in mathematics and seven in physics, including the practical work.

At the University of Sydney, Pell had also taken on the teaching of natural philosophy, mainly Newtonian physics, optics and astronomy, more adeptly than John Smith, the professor of chemistry and experimental philosophy, could manage, but there was little emphasis on laboratory work. The situation was similar in the University of Melbourne, except that Wilson was keener to make use of experimental modelling on apparatus bought by the University in its first year. However, Horace Lamb is credited as a pioneer in Australia for his introduction of a complete course of physics and for his guidance in the design of a physics laboratory. His choice of apparatus for the laboratory showed a great familiarity with overseas innovations. It is known, for example, that Lamb often visited Edward Nanson in Melbourne, with whom he had studied at Trinity College, and following one such visit ordered apparatus he had seen at the Melbourne International Exhibition of January 1881.[92]

There are differing versions of Lamb's skills as a teacher, although "inspirational" seems to be a common epithet. Ren Potts belonged to a long line of Lamb's successors at Adelaide and when he wrote the story of mathematics there one hundred years after Lamb's arrival, he included the following anecdote:

> One of the members of Lamb's first class at Adelaide wrote: "Lamb was a wonderful teacher; he was carrying out at that time a good deal of his work in hydrodynamics. He was an excellent lecturer, very clear, very lucid, and, as he had to deal with somewhat raw material, it was a difficult task for him." Another of his first students wrote that Lamb "would fill the blackboard with an algebraic problem, written too speedily for us to follow. He would then turn and say, 'Is that clear?' We had to say 'yes', when one impudent fellow said, *sotto voce*, 'Clear as mud!' The professor, seeing the doubtful looks on our faces, would rub off the figures and start all over again—a little more deliberately.[93]

In its opening year, the University of Adelaide experimented unsuccessfully with evening classes for its students, and then opted instead for evening lectures for the general community. Although Lamb was less than enthusiastic,[94] he nonetheless participated fully, demonstrating his breadth of knowledge with the following public lectures:

1877 Sound as the Physical Basis of Music
Optics, with Special Reference to the Theory of Vision
1878 The Earth and our Knowledge of it
1879 Demonstrations in Physics
1882 The Scientific Principles Involved in Electric Lighting, and in the Electric Transmission of Power
1884 Acoustics

Each was in fact a series of weekly lectures, seven on Sound and five on Optics for example, and the audiences often numbered 50 or more.

In 1884, Lamb was elected a fellow of the Royal Society, and the following year was granted one year's leave by the University of Adelaide to visit Europe. The strength of the farewell he received, detailed by Potts, suggests that there was little expectation of his return to Adelaide. He was presented with an address "engrossed upon vellum":

Professor Lamb, M.A., F.R.S. – Dear Sir

We who have enjoyed the rare privilege of sitting at the feet of so able an instructor as yourself gladly avail ourselves of the occasion of your departure for England to enjoy a well-earned holiday, to express in some slight form our high appreciation of your ripe scholarship and the universal esteem in which you are held. The zeal displayed in the discharge of your arduous duties, and the interesting and happy manner in which you have delivered your able lectures, will not soon be forgotten by those who have attended them. Your ready and generous assistance in times of difficulty and the kind interest you have always shown in our welfare, have become bywords to us who in the pursuance of our studies have come under your care. It is therefore with mingled feelings of pleasure and regret that we join in wishing Mrs. Lamb and yourself a very pleasant journey, and we trust that at no distant date we shall have the pleasure of seeing and hearing you again.

Horace Lamb, 1849–1934.

This address is now again in the possession of the University. A "fine silver rose bowl" that had been presented to Lamb while he was in Adelaide is also now a prized University memento. It was obtained as a result of a visit by Potts in 1966 to the home of the widow of Horace Lamb's son Henry, a well known artist and one of six of Lamb's seven children to be born in Adelaide.

While in England, Lamb resigned his Adelaide position to become professor of mathematics at Owen's College, Manchester. This was where he had first been encouraged to study mathematics. He remained there until his retirement in 1920, then went to Cambridge as an honorary fellow, was knighted in 1931 and died on 4 December 1934. *The Times* in its obituary referred to him as one of the "brightest ornaments" of mathematical science.

In 1973, Australia's leading seismologist of the mid-20th century, Keith Bullen, summarised Lamb's contributions in seismology alone as follows:

> In addition to solving numerous problems of direct hydrodynamical interest, as well as others of direct interest to electromagnetism and elasticity theory, Lamb applied many of the solutions with conspicuous success in geophysics. His much quoted paper of 1904[95] gave an analytical account of the propagation, over the surface of an elastic solid, of waves generated by various assigned initial disturbances. The cases he studied beared intimately on earthquake wave transmission, and this paper is regarded today as one of the fundamental contributions to theoretical seismology. Modern attempts to interpret the finer details of earthquake records rest heavily on it. Another famous paper, published in 1882,[96] analyzed the modes of oscillation of an elastic sphere. This paper is a classic in its completeness, and it recently rose to new prominence when free earth oscillations of the type Lamb had described were detected for the first time on records of the great Chilean earthquake of 1960.[97]

Much of the work described by Bullen, such as the 1882 article mentioned here, was undertaken while Lamb was in Adelaide.

When Lamb returned to England, he retained for many years an involvement with the activities of the University of Adelaide. One of his responsibilities there was to act on behalf of the university library in its purchases in Britain. And he was instrumental in the choice of his successor.

William Henry Bragg

Australia's most noted mathematician of the 19th century was Horace Lamb, the first Elder Professor of Mathematics at the University of Adelaide. Australia's most noted physicist of the early 20th century was William Bragg, the second Elder Professor of Mathematics. Lamb was just 26 when he was appointed; Bragg was only 23.

He was born on 2 July 1862 at Westward near Wigton in Cumberland, England. Raised by his uncle in Leicestershire, he won scholarships to the local grammar school and to King William's College on the Isle of Man. He subsequently entered Trinity College, Cambridge, on a scholarship and graduated third wrangler in 1884. The following year he was awarded a first in Part 3 of the tripos.[98]

There were at least two Australians at Trinity College at the same time as Bragg was a student there. In fact, the senior wrangler in 1884 was William Fleetwood Sheppard, born in Sydney and educated in Brisbane, who became known for "Sheppard's corrections" in the calculation of statistics from grouped data. The other Australian was Sydney Talbot Smith from Adelaide, whom Bragg met while playing lacrosse and was to meet again in Adelaide, again playing lacrosse.[99]

The circumstances under which the "youngster" Bragg applied for the position in South Australia are recorded by Duncan and Leonard:

> At the end of 1885 he was going one morning along King's Parade to attend a lecture by J. J. Thomson at the Cavendish and was joined on the way by the lecturer himself. J. J. Thomson asked if Sheppard ... was going in for the Adelaide post of mathematics and physics which Horace Lamb was just resigning. "I was astonished at the suggestion", Bragg later wrote, "it had not occurred to me that anyone so young might be eligible ... Then I asked J. J. whether I might have a chance, and he said he thought I might. So, when the lecture was over, I went and telegraphed an application—it was the last day of entry."[100]

In fact, the very eminent Joseph John Thomson (later Sir Joseph, 1856–1940) together with Horace Lamb and Sir Arthur Blyth, the South Australian agent-general in London, constituted the selection committee for the chair, and Bragg was duly appointed over two other applicants, shortlisted from an original field of 23.[101]

There would have been scant regard paid to the opinion of an anonymous correspondent in the Adelaide *Register* of 13 October 1885, who wrote: "I believe the interests of the Adelaide University and an encouragement to native talent and industry would be promoted by seeking a successor ... amongst the distinguished graduates of the Australian Universities as much as by importing one from England. I am certain a qualified native would have more influence in rendering our University more national than it is at present."[102]

Sheppard had not applied for the position, but there was an Australian applicant, William Sutherland (1859–1911), who had been born in Glasgow but educated at the University of Melbourne and then University College, London. He returned to Melbourne in 1882 and is noted for his work in physical chemistry that led to the development of the "Sutherland potential" and "Sutherland's constant". He also discovered the diffusion equation that Albert Einstein developed

and applied in his discussion of Brownian motion in 1905. Einstein's approach was the same as Sutherland's, who presented his solution to the meeting of the Australasian Association for the Advancement of Science (AAAS) in Dunedin, New Zealand, in 1904.[103]

Thomas Ranken Lyle was another unsuccessful candidate for the chair that Lamb vacated. Lyle was born in Northern Ireland in 1860 and received the highest honours available in mathematics and experimental science from Trinity College, Dublin. He was assistant lecturer in mathematics and mathematical physics at the Catholic University College, Dublin, before coming to Australia in 1889 to succeed Henry Andrew as professor of natural philosophy in the University of Melbourne. He held that position until early 1915 when he was forced to retire due to lameness resulting from injuries received as a representative rugby player in Ireland from 1885 to 1887.[104] Lyle received an ScD from Trinity College, Dublin, in 1905, became a fellow of the Royal Society in 1912 and gained a knighthood in 1922; he died in 1944. The Australian Academy of Science recognises his contribution to Australian science by awarding the Lyle medal, instituted in 1935, for outstanding achievement in mathematics or physics by a scientist in Australia. Sutherland, incidentally, had also applied for the chair of natural philosophy in Melbourne, won by Lyle, and was acting professor there between the terms of Andrew and Lyle.

One of the other two short listed candidates, along with Bragg, was the Cambridge cricketer John Frederick Adair (1851–1913), who was later appointed as a demonstrator in physics at the University of Sydney, on Thomson's recommendation. He held that position from 1887 to 1890.

More than 50 years later, in a letter to Thomson to congratulate him on his 80th birthday, Bragg recounted the story above of the circumstances leading to his application for the Adelaide position and wrote:

> Perhaps you were the one who asked a certain Adelaide man—then visiting London—whether the Council of the University of Adelaide was likely to prefer a senior wrangler who occasionally disappeared under the table after dinner to a young man who had so far shown no signs of indulging in the same way. The Adelaide man was Sir Charles Todd, whose daughter I married a few years afterwards.[105]

It is not clear who this senior wrangler was. He was also once described by Bragg as "not safe with the bottle", and Lamb was to write: "By far the ablest man in the list was excluded ... on personal grounds."[106]

Physicists always count Bragg among their own, but without justification as far as his earlier career was concerned. Different accounts of the precise position to which he was appointed were given by Potts, by Duncan and Leonard and by the biographers Stanley Tomlin and Edward da Costa Andrade. Potts pointed out that Horace Lamb had been described in university *Calendars* as Elder Professor of Mathematics, responsible for mathematics, pure and applied, and that Bragg on his arrival in 1886 was listed in that year's *Calendar* still as Elder Professor of Mathematics; a year later he was described as "Elder Professor of Pure and Applied Mathematics, who shall also give instructions in Physics". By 1899, but not before then, Bragg was the Elder Professor of Mathematics and Physics. Tomlin skipped over the 1886 *Calendar* reference to Bragg and gave only the wider label of 1887. According to Duncan and Leonard, however, "On his appointment, Bragg was startled to find that the Elder Chair was now one in Mathematics and Physics, and long afterwards he used to tell how busy he had been on the voyage out to Adelaide, trying to find out something about the latter subject." Andrade told the same story.

Whatever his title on arrival, Bragg was involved from the outset in physics teaching despite

The Adelaide Lacrosse Club, formed in June 1885. W. H. Bragg is standing, third from left; S. Talbot Smith is sitting, third from left. (State Library of South Australia)

his professed ignorance. The time spent in the Cavendish laboratories with J. J. Thomson prior to accepting the Adelaide position, although only "for a couple of terms after I had taken my degree,"[107] suggests very strongly that the "ignorance" was indicative more of his reputed shyness than serious ill-preparedness. In his detailed analysis of this issue, the Melbourne physics historian John Jenkin pointed out that although Bragg himself preferred to be known initially as professor of mathematics alone, the advertisement he had answered was headed "Elder Professor of Mathematics and Experimental Physics".[108]

Bragg did little research in his first years at Adelaide, in either mathematics or physics, concentrating instead on instrument making for his physics laboratory when he had time away from his teaching, and sport. He played tennis and golf and is credited in part with introducing lacrosse to South Australia. He married Gwendoline, daughter of Sir Charles Todd, in 1889 and successfully took up painting with her. Ten years later, with his passion for physics inflamed, Bragg and Todd conducted joint experiments in wireless telegraphy, the first in South Australia. They successfully transmitted a radio communication over five miles.

Bragg succeeded Nanson as an examiner in the Faculty of Arts at the University of Sydney from 1890 to 1893. He had met Nanson in January 1887 when he travelled by train to Melbourne; he continued by boat to Sydney and is recorded as having had discussions with Richard Threlfall FRS, professor of physics there from 1886 to 1898, but not with the mathematician Gurney. He would have been interested to receive a first-hand report on discussions towards the founding of AAAS.[109]

It was during the early 1890s that Bragg's interest turned seriously to physics.[110] As S.G. Tomlin described it:

> [He] developed a flair for expounding the subject both in formal classes and in public lectures often enlivened with experimental demonstrations. Electromagnetism interested him; one day in 1895 he was experimenting with a Hertzian oscillator when he was visited by Ernest Rutherford who was on his way to Cambridge and had worked on radio transmission at Christchurch, New Zealand. It was the beginning of a valuable lifelong friendship.

Bragg's fame would come in research into x-rays and other ionising radiations, dating from 1904 when he gave a seminal presidential address to Section A of AAAS at Dunedin, the same meeting at which William Sutherland had presented his diffusion equation. Bragg's address was titled "On some recent advances in the theory of the ionization of gases":

> He discussed the penetration of matter by α and β particles, concluding that the massive α particles, unlike the β and γ rays, would move undeviated through a gas until all the energy was lost through ionization of the gas molecules, and consequently α particles of a given initial energy should have a definite range in the gas.[111]

The ideas expounded at that time led, within three years and while still in Adelaide, to a fellowship of the Royal Society. He resigned his Elder chair in April 1908 to become Cavendish Professor of Physics at the University of Leeds.

During 23 years in Adelaide, Bragg was assisted in teaching mathematics by only four others.

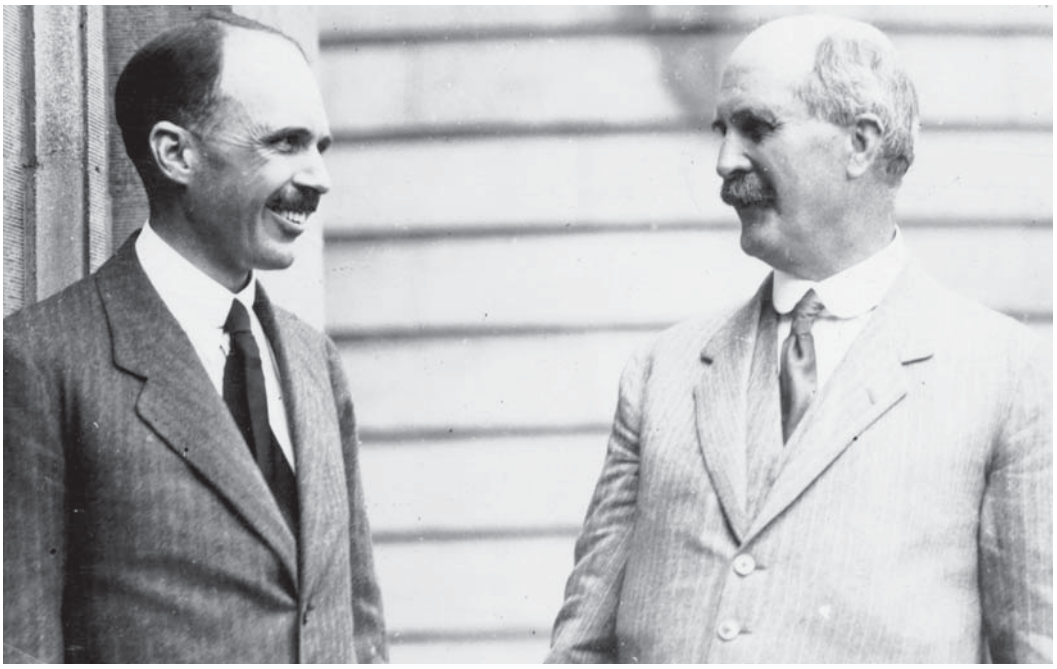
Robert William Chapman was appointed assistant lecturer in mathematics and physics in 1889. In 1910, having moved to the engineering faculty some years before, he succeeded Bragg with the title "Elder Professor of Mathematics and Mechanics". Bragg considered Chapman to be one of his greatest discoveries.

James Bernard Allen was born in Adelaide in 1871. After graduating from the University of Adelaide with honours in mathematics and physics, he spent three years in research work with Threlfall in Sydney. Allen returned to Adelaide and served as assistant lecturer in mathematics and physics in the University from 1898 to 1901. From then until his death from typhoid fever in March 1912, he was a highly regarded lecturer in mathematics and physics in the Perth Technical School.[112]

Allen was followed by John Percival Vissing Madsen (1879–1969), lecturer in mathematics and physics from 1901 to 1903. He gained first-class honours and the university medal in mathematics at the University of Sydney, and first-class honours in physics and engineering as well, before heading to Adelaide to begin what developed into a distinguished career of research and administration in science and engineering. He became a collaborator in x-ray research and atomic particle physics and was a lifelong friend of William Bragg's. From 1920 to 1949, he was professor of engineering in the University of Sydney and was primarily responsible for the government decision in 1937 to establish the National Standards Laboratory.

The fourth of Bragg's assistants was Herbert James Priest, who obtained a BA with first-class honours in mathematics from the University of Adelaide in 1904, having taken out a BSc two years before. He was appointed lecturer and demonstrator in mathematics and physics in 1905 and in 1909, on Bragg's resignation, was acting professor of mathematics for a year "when the whole of the mathematical work, including the final honors classes, was put into my hands."[113] After a short stay in Sydney, Priest went overseas for further study before becoming lecturer-in-charge of mathematics and physics at the Perth Technical School. That lasted only one year, and in 1914 he was appointed lecturer in mathematics at the University of Queensland.

Honours degrees were introduced in the University of Adelaide at the turn of the century. Priest was one of the first recipients. Others included Herbert William Gartrell (honours in



William Henry Bragg, right, and his son, William Lawrence Bragg. (Rare Book and Manuscript Library, University of Pennsylvania)

1902), who was a lecturer in mining and mathematics at Adelaide in 1910 and was appointed professor of mining and metallurgy in 1938; John Raymond Wilton (1902), who would become professor of mathematics at Adelaide in 1919; John Stoward Moyes (1905), who became Bishop of Armidale and chancellor of the University of New England; and the "famous son of the famous father",[114] William Lawrence Bragg (1908).

Lawrence Bragg, as he was always known, was born in Adelaide on 31 March 1890. He went with his parents to England in January 1909 and entered Trinity College, Cambridge. Father and son together were to initiate the study of x-ray crystallography, for which they received the Nobel Prize for physics in 1915.

William Henry Bragg moved to University College, London, in 1915 as the Quain Professor of Physics, and to the Royal Institution of Great Britain in 1923, where he was the Fullerian Professor of Chemistry and director of the Davy-Faraday Research Laboratory. He was knighted in 1920, was president of the Royal Society from 1935 to 1940, and died in London on 12 March 1942.

Bragg's knighthood was awarded as much for his wartime contribution as his scientific eminence.[115] He was an original member of the British Board of Inventions and Research, which had been established in 1915 to provide expert scientific assistance to the Royal Navy, and, as the wartime "Resident of Research" at the Admiralty experimental station at Hawkcraig Point in Fife, Scotland, he conducted his own laboratory with a team that developed the hydrophone for submarine detection.

Lawrence Bragg died in 1971. The Australian Institute of Physics established the Bragg Gold Medal in 1992 in fitting memory of William and Lawrence Bragg.

The University of Tasmania, 1893–1923

The Hobart High School opened in 1850 with the aspiration, like Christ's College which had been established ten years earlier, of developing into a university. One of the school's founders, William Crooke, was vigorous in his demands that the newly formed Legislative Council work towards initiating a comprehensive university along the lines of those just commencing in the colonies to its north.

Instead, the more modest Tasmanian Council of Education (TCE) was established in 1859 as an examining body for a qualification to be known as an Associate of Arts. This was little more than a certificate of matriculation for fifteen year olds but over the next 30 years allowed 47 of its holders to gain generous scholarships for study at English universities. The TCE saw itself as the precursor of a Tasmanian university and through the 1870s and 1880s there were persistent moves to have the change come about. A bill to this effect was passed in the House of Assembly in 1875 but did not reach the Legislative Council, largely due to Anglican interest in the revival of Christ's College instead. Further legislative attempts in 1882 and 1884 were also unsuccessful.

A recurring theme in submissions for the establishment of a university was the low cost to the community, because the university was proposed to be an examining body only and as such would be a simple extension of the TCE. Even the examiners, it was argued, could be supplied cheaply from among university graduates in the local community.[116] Opposition centred logically on the concurrent need for university level teaching. A government proposal in 1886 to cease the funding of scholarships for overseas study because of considerable abuse of the system favoured those who sought an immediate teaching institution. By 1889, a compromise was agreed to and a bill drafted to establish an examining university with subsequent teaching dependent on finance. The bill passed through the parliament and the University of Tasmania was able to date its founding as 1 January 1890.

But in practice only "the idea of a university" had been established. Richard Davis, writing for the centenary of the university, summarised the situation as follows:

> Tasmania now had a university, but what a start! No endowments were made, only a minute annual grant subject to the whim of cost-cutting politicians in a recession. Public opinion was hardly supportive, though the *Mercury* and the *Tasmanian News* were now behind the university. A building had still to be found and financial prestidigitation was needed to acquire staff. Moreover, the protagonists of university education were divided amongst themselves and about to participate in a vigorous power struggle.[117]

The struggle was between the "moderates", who essentially constituted the council of the TCE and were enabled to continue as the council of the new university, and the "revolutionaries", who hoped "to clear out the old guard and wipe out the errors of the past". The latter's interest was in an immediate teaching university. The moderates went about their preparations for the management of the university, while at the same time continuing their examining for the TCE. The legislation had determined that half the university council was to be elected by the parliament and half by a senate "of at least fifty local graduates", and the revolutionaries maintained that the preparations should be deferred until the new council was elected.

The moderates were led by Sir Lambert Dobson, Chief Justice of Tasmania and president of the old TCE. He was elected as chancellor of the University, without waiting for the new council to assemble, and the principle was reaffirmed that they should "advance step by step, first constituting an examining university and then as funds offered, gradually teaching with

lecturers and then chairs". Elections to the new council were completed by the end of 1890, but still it required the persistence of the revolutionaries, led by a Presbyterian minister, James Scott, for planning to proceed beyond little more than continuing the operations of the TCE.

During 1891, the council devised programs for courses leading to a BA and a BSc and in early 1892 advertisements were placed in newspapers in Australia and New Zealand, but nowhere else overseas, for three lectureships: one in classics (Latin and Greek) and English literature; one in law, history and political economy; and the third in mathematics and physics. The successful candidates were to be chosen directly by the council.

Fifteen applications were received for the position in mathematics and physics, and the choice, well ahead of the rest on the final ballot, was Alexander McAulay. An earlier ballot had led to a short list of four: McAulay, R. W. Chapman, E. G. Hogg and an unidentified "Love". The latter was almost certainly Ernest Frederick John Love (1861–1929), a lecturer in natural philosophy at the University of Melbourne from 1888 until 1927 and older brother of A. E. H. Love, who was noted for his contributions to the mathematical theory of elasticity. Hogg and Love apparently withdrew before the final ballot.[118] Robert William Chapman was at that time a young lecturer in Adelaide about to embark on a distinguished academic career there.

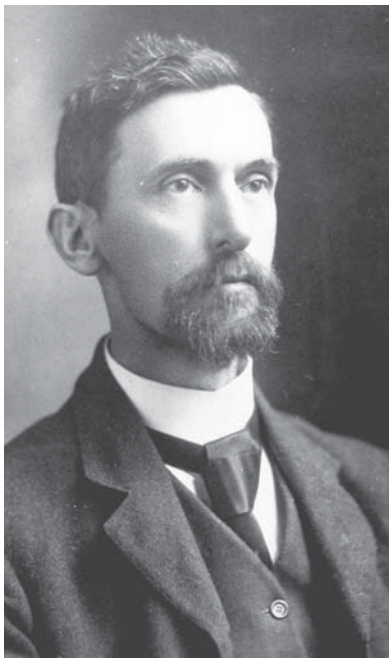
Evelyn Granville Hogg, born in Salisbury, England, in 1863, had graduated in 1888 with a BA from Trinity College, Dublin. He was lecturer in mathematics and physics at Trinity College in the University of Melbourne from 1889 to 1901, except that during 1900 he was acting professor of mathematics and physics in the University of Tasmania, replacing McAulay who spent that year in Sydney. Hogg and McAulay together carried out a magnetic survey of Tasmania in the following year. Then, during 1902, Hogg was acting professor of mining engineering in Hobart before going to Christ's College, Christchurch, as senior mathematics master. He held that post until 1928, contributing numerous papers to the *Transactions and Proceedings of the New Zealand Institute*, and died in 1951.

There was a much earlier candidate for the position of professor of mathematics. As part of the deliberations of the original council in 1890, wrote Davis with tantalising lack of detail, a "premature applicant for a non-existent chair of Mathematics was sent about his business."[119] This was a reference to "S. Fiddian Esq. MA Camb.", whose application was "ordered to lay upon the table as the Council was not in a position at present to make any such appointment."[120] Samuel Fiddian was well qualified to seek the post: he had graduated BA as 16th wrangler from St John's College, Cambridge, in 1867 and at the time of his application was headmaster of Creswick Grammar School, north of Ballarat in Victoria. Fiddian died in January 1904.[121]

Alexander McAulay

McAulay was born on 9 November 1863[122] at Luton, in Bedfordshire, England. An older brother was Francis Sowerby Macaulay FRS (1862–1937), a pioneer in algebraic geometry.[123] Alexander McAulay began studies in engineering at Owens College, Manchester, before being drawn to Gonville and Caius College, Cambridge, due to his growing interest in mathematics. He graduated with his BA, as 19th wrangler, in 1886, was placed in the second class of Part 2 of the mathematical tripos in 1887 and in 1888 was appointed lecturer and tutor in mathematics and physics at Ormond College in the University of Melbourne. Further studies there led to an MA in 1889.

McAulay arrived in Hobart on 1 January 1893, ready for the commencement of lectures in March to "a dozen, possibly as low as six" matriculated students. A few more had enrolled



Alexander McAulay, 1863–1931.

by the end of the year, but there were none in the BSc program. McAulay's intramural lectures were to a group who attended only out of interest, and on payment of the appropriate fee.

It was a requirement of the lecturers that they offer extension courses outside the University, and McAulay is reported as spending 20 hours preparing apparatus for his extension lectures on electricity in Launceston and Hobart.[124] The course was well received in Hobart, but in Launceston, where the lecturers were expected to spend two days each fortnight and where there had always been some hostility towards the expense of a university in the south, McAulay was "a complete failure". Like the other lecturers, McAulay was also required to set and mark the junior and senior public examinations for Tasmania's high schools. According to Davis, he "calculated that it took him eighteen hours to set six papers, seventy hours to mark them, plus another fifteen hours supervising the examinations."[125]

Despite bruising financial curbs, persistently low student numbers and threats by government to shut down the University, in 1896 McAulay and his colleagues were appointed as full professors with privileges approaching those of the mainland chairs. McAulay had every intention otherwise of leaving the University. He prepared a document titled *Application and Testimonials*,[126] dated 10 October 1896, which began: "Gentlemen, I have asked friends in England to forward the present application to the electors of any vacant post for which they think I should wish to apply." It continued:

> My main reasons for wishing to obtain a post different from that which I hold at the present time are two. The well-known depression in Australia affects the stability of the recently created University of Tasmania, and renders its continued existence uncertain. Its only funds are those provided by the State, and there is a determined endeavour in Parliament each year to bring it to an end as a teaching body, solely for the sake of financial economy. Also the University is too poor to maintain anything that can be dignified by the name of a mathematical library, so that I am seriously handicapped in my original work.

The parlous state of the University was acknowledged in an accompanying testimonial from Sir Lambert Dobson. One of the other testimonials was from P. G. Tait: "besides possessing an extensive knowledge of Mathematics, [McAulay] is a Mathematician in the highest sense of the word: a man of exceptional resource and clearness of mental vision, associated with an altogether unusual amount of originality."

Two years later, McAulay showed interest in a chair in mathematics and mathematical physics at Victoria University College in Wellington, New Zealand, that was advertised in English papers. His brother, F. S. Macaulay, had cabled news of the vacancy prior to the appearance of similar advertisements in "colonial papers".[127] He would later also apply for the chair in the University of Sydney that was won by H. S. Carslaw.

In the event, McAulay was never to take permanent leave of Tasmania. As well as gaining

his promotion in 1896, he also received part-time teaching assistance in the person of Henry Charles Kingsmill who volunteered to travel weekly to Launceston to lecture on experimental mechanics to non-degree students.[128] An unsuccessful candidate in the first ballot for the original lectureship, Kingsmill lectured full time in 1898–1899 and was lecturer in surveying in the University of Tasmania from 1904 until his death in 1909.

Kingsmill was born in Ireland and educated at Cambridge. He served on the university council on two occasions and was Tasmania's government meteorologist from 1892. In the latter role, he was a member of a scientific advisory committee that included William Bragg from Adelaide and the Commonwealth Statistician, Sir George Knibbs, convened for the purpose of making recommendations on standard procedures to be adopted in the Commonwealth Bureau of Meteorology that was about to be established.

The University of Tasmania *Calendars* list others who were to share the teaching with McAulay. Most longstanding of these was John Hilton Mackay, who held a masters degree in civil engineering from the University of Melbourne. He was appointed lecturer in "Physics, Applied Mechanics, etc." in 1904 and was then lecturer in "Mechanical Engineering, Applied Mechanics, Mechanical Drawing and Physics" until 1920.

McAulay meanwhile was furthering his research interests. In the 1890s he had been embroiled in an international debate over the virtues of quaternions as opposed to the modern vector methods that replaced them. Quaternions had been introduced in the 1840s by Sir William Hamilton, and McAulay's first of many contributions in the area was in 1885. He introduced the extension to octonions in a text[129] written in 1898 and the further extension to multenions in three papers published in the early 1920s, intending these to be the basis of a second text. He wrote the article on quaternions in the eleventh edition of the *Encyclopaedia Britannica* in 1910 and compiled tables of logarithms and other information that remained in print for 50 years.[130] Brian Abrahamson, who was appointed foundation professor of mathematics at Flinders University in Adelaide in 1966, was a more recent Australian exponent of the "quaternionic arts", but he was more realistic about their applicability.[131]

Nearly all of McAulay's papers were given a context within physics, and in the 1920s his interests turned to relativity. However, "his most lasting memorial", according to his biographer,

> was his pioneering interest in hydro-electric power development in Tasmania, about which he wrote to the Hobart *Mercury* in 1905. On the family property, Kanna Leena, at Shannon in central Tasmania, he studied the flow and fall of water from Great Lake. As a consequence of his advocacy the first major hydro-electric station was completed at Waddamana, close to their property, in 1916.[132]

McAulay's chair, originally in mathematics and physics, was changed to mathematics alone in 1919. Almost without warning, he lost his sight in 1923 to the extent that he was obliged to write to the vice-chancellor in November that year stating that he was no longer able to carry out his university duties. He was appointed to a research chair and colleagues from Melbourne in particular rallied around in a vain bid to obtain for him an FRS.[133]

He retired in 1929. His wife Ida, whom he married in February 1895, was a leading feminist and the first president of the Tasmanian Women's Suffrage Association. Their son, Alexander Leicester McAulay, was born in Hobart on 15 November 1895. Leicester, as he was known, was educated at the University of Tasmania (BSc, 1916), Gonville and Caius College, Cambridge (BA, 1921) and the University of Manchester (PhD, 1921), and was appointed lecturer in physics in the University of Tasmania in 1922. He was professor of physics there from 1927 to 1959.

Alexander McAulay died of cerebral haemorrhage on 5 July 1931 and Leicester died in 1969.

≈

Twelve years into the 20th century, universities had also been founded in Brisbane and Perth so that each of the six colonies, by then states of a federated Australia, had a university. Their stories and the continuation of the stories of Australia's four 19th century universities will be given in Chapter 4.

Chapter 3

Mathematics Outside the Universities

There were four universities in Australia by the end of the 19th century and in the University of Adelaide, if not in the others, world-class research in mathematics was being achieved. In all four, mathematics was being taught at a level comparable with British universities. Beyond that there were some mathematical contributions to the Royal Societies being founded around the country and, towards the end of the century, to the Australasian Association for the Advancement of Science, the forerunner of ANZAAS.

Government statisticians in the eastern states in particular were also setting standards that would be viewed with admiration in Britain and elsewhere.

Australia's royal societies

The secretary of the Philosophical Society of Australasia during its short existence from 1821 to 1822 was Henry Grattan Douglas, a medical practitioner who arrived in New South Wales in 1821 and served as a magistrate until 1825. After 20 years back in Britain, he returned in 1848 and became secretary of the revitalised and renamed Australian Philosophical Society from 1850 to 1855 and of its successor, the Philosophical Society of New South Wales, from 1855 to 1865.[1] On his return to Sydney, he had urged William Charles Wentworth to argue for the foundation of the University of Sydney, and he served on the senate of the University from 1853 to 1865. Douglas saw his role in reviving the philosophical society as complementing the establishment of a university in Sydney. Charles Nicholson was in the chair at the first meeting on 19 January 1850.

The change of name to the Philosophical Society of New South Wales reflected the autonomy being granted to the other Australian colonies around that time. During the next eleven years, seven or eight meetings were held each year, with a total of 100 papers presented by 42 contributors. Membership peaked at 186 in 1858, falling to just over 100 in 1866.[2]

Douglas died in 1865. One year later there was a further name change in an attempt to revive flagging interest in the society. In a two way move, the unpopular term "philosophical" was discarded and, royal patronage having been sought and obtained, at a meeting on 12 December 1866 the Philosophical Society of New South Wales emerged as the Royal Society of New South Wales. George Smalley, the government astronomer at the Sydney Observatory and, for a short while, assistant to Morris Pell at the University of Sydney, was instrumental in bringing about the change.[3]

The "Fundamental Rules" of the society were "to receive at its stated meetings original papers on subjects of Science, Art, Literature and Philosophy . . . and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions." In practice, this led to two streams of contributions, as the anthropologist Adolphus Elkin wrote on the occasion of the society's centenary:

> On the one hand, workers carried out their observations and studies in the fields of natural history, palaeontology, astronomy and mathematics (including geometry and statistics) for the sole purpose of adding to our knowledge and understanding of phenomena, whether or not their results had any bearing on the development of Australia's resources. Indeed, the first paper given to our Society after being designated Royal was entitled "Non-Linear Coresolvents". The writer was the Chief Justice of Queensland, an F.R.S. Papers on the anthropology and languages of the native peoples of Australia and the Pacific were also accepted.
>
> On the other hand, many papers and anniversary addresses for thirty years and more after the revival of the Philosophical Society in 1850 were concerned with matters on which the development of the Colony did depend: particularly, on storing and reticulating adequate water; on geological surveys indicating or confirming the presence of valuable metals, minerals and coal; on improved and increased means of transport and communications; and on safeguarding public health.[4]

The Society's first publication was the single-volume *Transactions of the Philosophical Society of New South Wales, 1862–1865*, which appeared in 1866. Papers read to the Society before that were often published in the local press or in *The Sydney Magazine of Science and Art*. For example, Pell's papers, "On the application of certain principles of political economy to the question of railways", read on 11 July 1856, and "On the construction of dams",[5] read on 13 October 1858, appeared in volume 1 (1858) and 2 (1859), respectively, and these were the only two volumes published. (Pell had been an ordinary member of the council of the Society for 1860–1861 and then served as one of two honorary secretaries for most years up to 1870.) Annual publication began in 1867: *The Transactions of the Royal Society of New South Wales* for ten years, and then *The Journal and Proceedings of the Royal Society of New South Wales* to the present day.

The Chief Justice of Queensland, whose paper[6] was the first to appear in the *Transactions of the Royal Society of New South Wales*, was Sir James Cockle. He had already published a paper[7] on a similar theme in Victoria.

Cockle, born in Essex, England, on 14 January 1819, received a BA from Trinity College, Cambridge, in 1842, and was admitted to the bar in 1846.[8] After practising law in England for 16 years, he was appointed to the post in Queensland and held it from February 1863 to June 1878. Before he arrived in Australia, he had published over 50 papers in mathematics, and he had been elected a fellow of the Royal Astronomical Society and member of the Cambridge Philosophical Society. He was awarded his FRS shortly after his arrival, published a further 35 papers while on the Queensland bench and was president of the Queensland Philosophical Society for almost the whole period of his residence there.

> In presidential addresses [to the Queensland Philosophical Society] he urged the value of pure scientific research and of the study of the history of science; he exhorted the society to embrace the largest possible field of inquiry, and to exhibit a universal scientific tolerance.[9]

On his return to England and until his death in 1895, Cockle devoted himself to mathematics, including a term as president of the London Mathematical Society from 1886 to 1888. His main mathematical interests were in the solution of polynomial equations and in differential

equations, but, as Michael Deakin from Monash University wrote in 2002, "very little of his research writing has lasted, and it is doubtful if much of it had even contemporary impact."[10] He is remembered in Brisbane Grammar School's "Cockle Prize for Mathematics", which he endowed in 1874.

Elkin's mention of "observations and studies in . . . mathematics (including geometry and statistics)" no doubt refers in part to the writings of Martin Gardiner. In those first *Transactions*, Gardiner had a 65-page paper titled "'Geometrical Researches' in four papers, comprising numerous new theorems and porisms, and complete solutions to celebrated problems". At the beginning of the paper, he wrote: "I think it proper to mention, that early in 1862 I forwarded enunciations of the theorems in papers 2 and 3, and some of those of paper 4, to the President of the Queen's College, Galway, and to Professor Chasles. I sent also enunciations of the principle porisms and theorems in papers 1 and 2 to Sir James Cockle, the Chief Justice of Queensland, immediately after his arrival in the Colony." Then at the end of the paper, he wrote: "Sir William Hamilton, the Astronomer Royal of Ireland, has given much attention to the problem of this paper", and he compared Hamilton's methods and results with his own. So Gardiner was well acquainted with the literature and the relevant authorities, to the extent that in 1867 it was Gardiner who read Cockle's paper on co-resolvents to a meeting of the Royal Society of New South Wales;[11] yet very little if anything has previously been written about him.

Gardiner was born in Dublin around 1833, studied civil engineering at Queen's College, Galway, and worked for the Grand Trunk Railway Company and other railways in eastern Canada before coming to Australia. In Victoria, and later New South Wales and Queensland, he worked as government surveyor of roads and railways and in particular assisted in the survey for the line from Cairns to Kuranda. He was admitted to membership of the Philosophical Institute of Victoria in June 1859 and remained a member of its successor, the Royal Society of Victoria, in 1860. His first papers were written for the *Transactions* of those bodies. In New South Wales, he moved first to West Maitland and then to Sydney, and is listed as a member of the Royal Society there in 1867 and 1868. He had been elected to membership of the Philosophical Society of New South Wales in December 1862.[12] Gardiner described himself in his first papers as "formerly Science Scholar, Queen's College, Galway" and later as "Member of the Mathematical Society of London", while in a letter to *The Brisbane Telegraph* (1 August 1879), in which he described some of his survey work in Canada and Australia, he signed himself as "(late) Computer to the Trigonometrical and Geodetic Survey of Victoria".[13] Gardiner presumably returned in later life to Victoria since his last known paper, in 1893, again with a geometrical theme, was in the *Proceedings of the Royal Society of Victoria*.

The list of his known published work is given here as a note.[14] The first of the 16 items is dated 1859 but Gardiner had earlier presented a bound volume of three papers in 40 pages entitled *Geometrical Papers* to the Melbourne Public Library.[15] Gardiner's work is generally very detailed and difficult to fathom, and none of it has lasted. He wrote in his introduction to *Geometrical Papers* that he had endeavoured to bring the work to the notice of William Parkinson Wilson in the University, but, in the manner of countless academics when similarly approached, "the learned proffessor [*sic*] did not wish to enter into the details of my methods."

Elkin's mention of statistical publications is a reference to the New South Wales registrar-general Christopher Rolleston who for some years contributed monthly figures on the "Health of Sydney", as well as other papers on the history of savings banks, statistics and sanitation.[16]

There were other relevant 19th century contributions to the Royal Society of New South Wales. In particular, towards the end of the century there were a number of papers by Gaston Fleuri,[17] who remains unidentified except that he described himself as "Licencié ès-sciences mathématiques and Licencié ès-sciences physiques, Sydney, N. S. Wales".

The Royal Society of Victoria was formed almost seven years before its sister organisation in New South Wales. It in fact had two coexisting precursors. The Mechanics Institution was the venue in June 1854 for a meeting chaired by the mayor of Melbourne which decided to form the Victorian Institute for the Advancement of Science. Its purposes were to include the provision of a means of communication between "persons engaged in the pursuit of science", as well as "the cultivating of a refined taste among the people of Victoria".[18] Redmond Barry was at that time the acting Chief Justice of Victoria and he was elected president of the new body. By the end of the year there were 82 members, but it was decided to amalgamate with the Philosophical Society of Victoria, which had first met in August and which, at the time of amalgamation, had 132 members. Many belonged to both organisations; for example, Victoria's surveyor-general, Captain Andrew Clarke, was president of the Philosophical Society and vice-president of the Victorian Institute. The new body was called the Philosophical Institute of Victoria. The first paper of mathematical interest published in Victoria was by the district surveyor, Clement Hodgkinson in 1855; it gave a detailed analytical basis for new tables related to railway earthworks.[19]

After "five years . . . of consolidation for Victorian science",[20] in August 1859 the Philosophical Institute sought a royal charter and was consequently enabled, at a special meeting on 23 January 1860, to make a final name change, to the Royal Society of Victoria.

One of the projects adopted by the Philosophical Institute five years earlier, as outlined in Chapter 2, resulted from the perceived need for an enhanced observatory, as strongly urged by Wilson. He had joined the Philosophical Society of Victoria soon after his arrival in Melbourne in 1855, was a vice-president of the Philosophical Institute of Victoria the following year, and remained a member of the Institute and subsequently the Royal Society, and often a member of its council, for the rest of his life. Frederick Pirani was also a much-appreciated member in the 1870s,[21] as later were Edward Nanson and his successor as professor of mathematics in the University of Melbourne, John Henry Michell.

In 1915, there was a contribution[22] to the *Proceedings* by Charles Weatherburn, who was to become professor of mathematics in the University of Western Australia, but since Michell's time there has been little involvement of any mathematicians or statisticians in the Royal Society of Victoria, either organisationally or in contributions to its publications.

The origins of the Royal Society of Tasmania have been described in Chapter 1, although that name was not adopted until 1911. Prior to that, there was the Royal Society of Van Diemen's Land for Horticulture, Botany and the Advancement of Science which became the equally cumbersome Royal Society of Tasmania for Horticulture, Botany and the Advancement of Science in 1855 when the name of the colony was changed. Publication of its *Papers and Proceedings* dates from 1849. In the last decades of the 19th century and into the 20th century, many papers were published analysing voting systems, in particular the Hare-Clark system adopted in Tasmania in 1896. These include numerous papers and reports by the government statistician Robert Johnston and two surveys by Nanson.[23] The professor of mathematics in the University of Tasmania, Alexander McAulay, also had a number of papers in the *Papers and Proceedings*.[24]

The Adelaide Philosophical Society was set up in 1853 and the Queensland Philosophical Society in 1859. They received the royal assent in 1880 and 1884, respectively, becoming the Royal Society of South Australia and the Royal Society of Queensland. Charles Todd was president of the Royal Society of South Australia in 1882 and Horace Lamb in 1884; and Henry James Priestley, foundation professor of mathematics in the University of Queensland, was president of the Royal Society there in 1922.

It is necessary to jump forward some years to be able to include here the Royal Society of Western Australia. It was established in 1913. On 13 May that year a general meeting of the Natural History and Science Society of Western Australia determined that it should alter its designation to accord with the status of similar societies in all other states. The secretary wrote soon after to the governor, Sir Harry Barron, that the "foundation of a modern University in this State makes the present an appropriate time to apply for the Royal assent", and this was received on 18 November. The predecessor organisations were the Mueller Botanic Society, 1897–1904; the West Australian Natural History Society, 1904–1909; and the Natural History and Science Society of Western Australia, 1909–1913, each with its own journal.

The very first paper to appear in the *Journal and Proceedings of the Royal Society of Western Australia* (called the *Journal of the Royal Society of Western Australia* after the first ten volumes) was titled "The approximate summation of series in which each term is a function of the corresponding term of an arithmetical progression".[25] The journal reflects the Society's main interests in the biological and earth sciences, and no paper designated as mathematical has appeared in it since that first one in 1914. Its author, Maurice A. Browne, obtained his BA with second-class honours in the natural science tripos at Cambridge University in 1907, and three years later came to Australia where he took various temporary posts such as an instructorship in physics at the Perth Technical School. He was an applicant for the position of "Lecturer-Assistant" in mathematics and physics at the University of Western Australia in 1913.[26]

At the time the paper was published, Browne was the "Government Smelter" and honorary secretary of the revamped society. The vice-president was Alexander David Ross, professor of physics and mathematics at the University from its inception in 1912 until 1929. Ross was later the president of the Society on three separate occasions: 1916–1917, 1923–1924 and 1940–1941.

Of all Australia's royal societies, only that in New South Wales has had a continuing involvement of academic mathematicians. From the University of Sydney, Thomas G. Room (as he appeared on the membership list) was an executive member in the 1940s while in the last 50 years or so, those who served in executive capacities included Bruce Bolt, Keith Bullen, Alex Reichel and Bill Smith-White, as well as the government astronomer Harley Wood, who taught part time there. A great many of the early mathematics staff of the New South Wales University of Technology had some involvement either as council members or contributors to the Society's journal. The former included Geoffrey Bosson, Jim Griffith, Austin Keane and Gus Low. In more recent years, Ted O'Keefe from Macquarie University has been a member of council; and Will Smith from the University New South Wales, John Loxton from Macquarie University and Denis Winch from the University of Sydney have served as president.

Contributors to the Society's *Journal and Proceedings* have included (in alphabetical order) Felix Behrend, Pietro Cerone, Fred Chong, Des Clarke, Charles Groden, John Jaeger, Austin Keane, Alex Klotz, Angus Low, Max McKay, Sid Morris, Harry Mulhall, Simon Prokhovnik, Dansie Sawkins, Hans Schwerdtfeger, Will Smith, Bill Smith-White, George Szekeres,

THE JOURNAL

OF

THE ROYAL SOCIETY

OF

WESTERN AUSTRALIA.

VOL. I.

THE APPROXIMATE SUMMATION OF SERIES, IN WHICH EACH TERM IS A FUNCTION OF THE CORRESPONDING TERM OF AN ARITHMETICAL PROGRESSION.

By

MAURICE A. BROWNE, B.A.

(Read April 21st, 1914.)

Harmonical Progressions.

The height of a column of air of unit cross section may be shown, by the integral calculus or otherwise, to be equal to $\mathrm{K}.\log\frac{P}{P'}$, where P is the pressure at the bottom, P' the pressure at the top, and K a constant. But the same height may be expressed as the sum of the heights of n short columns of air of equal mass. If the weight of each is w the pressures at the centres of the sections will be approximately $P-\frac{1}{2}w$, $P-\frac{3}{2}w$, etc., and by Boyle's Law their heights will be :—

$$\frac{\mathrm{C}}{P-\frac{1}{2}w},\quad \frac{\mathrm{C}}{P-\frac{3}{2}w},\quad \ldots\ldots\quad \frac{\mathrm{C}}{P-(n-\frac{1}{2})w},$$

where C is another constant. The sum of these heights is the total height.

$$\therefore\ \frac{\mathrm{C}}{P-\frac{1}{2}w}+\frac{\mathrm{C}}{P-\frac{3}{2}w}+\ldots+\frac{\mathrm{C}}{P-(n-\frac{1}{2})w}=\mathrm{K}.\log\frac{P}{P-nw}$$

$$\text{or,}\ \frac{1}{P-\frac{1}{2}w}+\frac{1}{P-\frac{3}{2}w}+\ldots+\frac{1}{P-(n-\frac{1}{2})w}=\frac{\mathrm{K}}{\mathrm{C}}.\log\frac{P}{P-nw}$$

The first page of Browne's 1914 article in the *Journal and Proceedings of the Royal Society of Western Australia*.

Coleridge Wilkins, Denis Winch and Alf van der Poorten. Impressively, Alex Reichel, Geoffrey Bosson and Jim Griffith have been recipients of the Society's Archibald Ollé Prize for the member who submitted the best paper in any year; they won the prize in 1958, 1959 and 1964, respectively.

Winners of the Society's Edgeworth David Medal included Eric Barnes (in 1954), Robert May (1968), Barry Ninham (1969), Allan Snyder (1974), Ross Street (1976), and Peter Hall (joint winner, 1986); John Jaeger received its Walter Burfitt Prize in 1947. Tom Cherry and Harrie Massey delivered the Society's Pollock Memorial Lecture in 1949 and 1952, respectively.

In its centenary year, 1959, the Royal Society of Victoria instituted a medal for scientific research. The medallists have included Keith Bullen (in 1965), Allan Snyder (1974), and the Melbourne University reader Paul Pearce, a specialist in statistical mechanics and combinatorics (1995).

The Australasian Association for the Advancement of Science

Across the Tasman, the New Zealand Institute, established in 1867, had linked several "sister societies" there and by the 1870s the movement had begun for the creation of an Australasian scientific society.[27] It was a time of evident technological progress—the steam engine, photography, electricity, the telegraph—and of extensive newspaper interest in science, engineering and the arts. There had already been cooperative scientific ventures in telegraphy, meteorology and astronomy. Intercolonial exhibitions, in Melbourne in 1866 and Sydney in 1870, mirrored the great expositions held a few years before in London and Paris.

William Branwhite Clarke FRS had been pivotal in steering the Royal Society of New South Wales through the 1860s and 1870s and, at his death in 1878, was followed in that role by Archibald Liversidge FRS, initially professor of geology and mineralogy and then professor of chemistry in the University of Sydney during the period 1874 to 1907. Liversidge had joined the Society in 1872 soon after his arrival in Sydney from England. In 1884, after having first "mooted the question" some years earlier, he wrote: "I would venture to suggest . . . that we might try to bring about a federation or union of the members of the various Scientific Societies in Australia, Tasmania, and New Zealand, into an Australasian Association for the Advancement of Science . . . with a view to hold the first general meeting in Sydney, on the hundredth anniversary of the Colony."[28] Such a possibility had also been raised at a meeting of the Philosophical Society of New South Wales in August 1866: John Smith, professor of chemistry and chair of the meeting, "said he had no doubt that at some future time there would be an Australian Association for the Advancement of Science, but he did not suppose we had the material for it yet."[29]

In 1886, there were 38 scientific societies in Australasia and all but four agreed to join the new association in response to the action initiated by the Royal Society of New South Wales. The first general meeting of AAAS took place from 27 August to 5 September 1888 in the University of Sydney with "805 members and 45 ladies" in attendance.[30]

Following the pattern of the British Association for the Advancement of Science which had been formed in 1831, the representative sciences were divided into ten sections, the first of which, Section A, consisted of astronomy, mathematics, physics and mechanics. The name change to ANZAAS (replacing "Australasian" with "Australia and New Zealand", but virtually never written out in full) took place in 1930. The arrangement of the sections varied over the years and more sciences were added, but Section A was to include mathematics up to the time of the movement for the formation of the Australian Mathematical Society at a sectional meeting in

1955, and beyond. In 1969, a general reorganisation saw "Mathematical Sciences" become Section 8 and in 1985 "Mathematical and Physical Sciences" were combined as Area 2.

The nature of the early meetings of Section A has been described by the Melbourne science historian Rod Home as follows:

> The pattern set for Section A at the initial meeting, reflecting as it inevitably did certain general features of the physico-mathematical sciences in Australia at the time, was generally maintained at subsequent congresses up to the First World War. Meetings continued to be dominated by senior staff of the observatories and university physics departments. (The senior mathematics professors, T. T. Gurney from Sydney and E. J. Nanson from Melbourne, were conspicuous by their absence, although at most meetings there were some mathematical papers on the programme.) The number of speakers was generally small and the better-known people were called upon, year after year, for contributions.[31]

Home went on to point out the usefulness of many of the papers presented as broad surveys of their authors' fields, such as William Bragg's 1904 presentation on radioactivity, and commented that Alexander McAulay and H. S. Carslaw, professors of mathematics in Hobart and Sydney, were regular contributors. Furthermore, "A small group of schoolteachers, of whom the most prolific was E. G. Hogg of Christchurch, helped maintain a modest flow of mathematical papers."[32] In fact, Hogg, whose mathematical attainments in Melbourne and Hobart have been noted in Chapter 2, was a prolific contributor and a leading organiser within AAAS in the first decades of the century.

Gaston Fleuri, who has been mentioned for his contributions to the Royal Society of New South Wales in the 1890s, was also at the early AAAS meetings. He gave papers titled "On Stokes' theorem" at the fifth meeting in Adelaide (1893) and "An elementary exposition of the theory of power series" at the sixth meeting in Brisbane (1895). Sir Robert Ball, then the Lowndean Professor of Astronomy and Geometry at Cambridge University, gave a paper at the 1905 meeting titled "On a form of the differential equations of dynamics".

All of Australia's professors of mathematics in those years played significant roles. For example, the presidents of Section A included Bragg, in 1892 and 1904, McAulay in 1895, Robert Chapman (Bragg's successor at Adelaide) in 1902, Horatio Carslaw (Gurney's successor at Sydney) in 1913 and Henry Priestley in 1921. These, and Nanson too, contributed papers at various meetings. At the fifteenth meeting in 1921, the first after World War 1, of the 15 papers presented in Section A, four were from Priestley, including his presidential address, and four from Charles Weatherburn, then lecturing in Melbourne and later to be professor of mathematics in the University of Western Australia.

Government and other statisticians

With self-government, the responsibility for the Australian colonies to prepare statistical returns for the Colonial Office lapsed. Instead, there was a need to produce statistics and censuses for their local requirements and later to coordinate these among the different colonies. Three names stand out in relation to this work: William Henry Archer and Henry Heylyn Hayter in Victoria and Sir Timothy Augustine Coghlan in New South Wales.[33]

Archer was born on 13 November 1825 in London. He migrated to Melbourne in 1852 after gaining actuarial experience as a clerk in the Medical, Invalid and General Life Assurance Company and then as managing actuary in the Catholic, Law and General Life Assurance Company. He soon found favour with Lieutenant-Governor La Trobe and in January 1854 was

appointed assistant registrar-general. Five years later he became registrar-general and held that position for 15 years.

One of Archer's first duties, before self-government had been attained in Victoria, was to put into practice the Legislative Council's requirement that all births, deaths and marriages be registered. He drew on his English experience in making recommendations for this purpose, for example that local registries serve districts corresponding precisely to those for data collection in censuses, and he personally toured the colony recruiting deputy registrars. He recognised that, after these and other social data had been collected, "then will come the necessity of analysing it, classifying it and deducing from it the general laws that govern our existence in relation to health, disease and morals."[34]

William Henry Archer, 1825–1909. (University of Melbourne Archives)

Archer's involvement in the original publication in 1854 of the *Statistics of the Colony of Victoria* has been mentioned at the end of Chapter 1. Similar surveys continued until 1872 and there was in particular the landmark year 1861 in which the volume was systematised in a manner to be maintained for the rest of the century. The "general thrust" in the presentation of the statistics had developed over the three preceding years:

> During this period, the space devoted to statistics. . . grew by some 275 pages. New material included: vital statistics; population material from the census; much more detailed information on foreign trade relating to value, quantity and country of origin or destination; a section on wages and prices; employment and power in manufacturing; and sundry statistics on migration, railways, intestate estates and banking.[35]

In New South Wales, Christopher Rolleston's *Statistical Register* emulated Archer's approach to the publication of official statistics; he recognised Archer's superior skills in a letter to him in 1859: "I don't pretend to compete with you in the field of statistics. I am rather a humble disciple".[36]

South Australia published its first Statistical Register in 1859 and Queensland in 1860. Moves initiated in South Australia led to a meeting of representatives of these four colonies in Melbourne during October and November in order to unify the content and form of presentation of the colonies' statistical returns. Archer was in the chair. Further testimony to his standing was his coordination of censuses in Australia: Victoria, New South Wales, South Australia and Tasmania each held a census on the same day, 7 April 1861, and each census form had a largely similar structure. Except for Tasmania, there was a common census day again in 1871.

Archer had converted to Roman Catholicism in 1848, while still in London, and remained committed to Catholic causes throughout his life. He maintained broader scientific interests in botany and zoology, and twice served on the council of the Royal Society of Victoria, in 1861–1863 and 1891–1893. He was compulsorily retired in 1878, having reached the position

of secretary of lands and survey in 1874, and undertook numerous new projects. He began a legal practice, having graduated in law from the University of Melbourne in 1867, formed an unsuccessful life assurance company, and stood in vain for parliament in 1880.[37] Archer died on 29 April 1909.

When Archer left the registrar-general's office in 1874, the statistical branch was established as a separate organisation in the Chief Secretary's department, and Henry Hayter was appointed Victoria's first government statist. He was born in England on 28 October 1821, migrated to Melbourne in 1852, began working for the Victorian registrar-general in 1857, was appointed assistant registrar-general in 1859, and held the position of statist until his death in 1895.[38]

Hayter renamed the annual volume of Victorian statistics the *Statistical Register* and set about extending its coverage in a manner that would bring him the respect of authorities in Britain as well as of his Australasian counterparts. He was an adviser to the New Zealand government on statistical reporting in 1872 and a witness for the British House of Commons inquiry into the reorganisation of statistical collecting in 1879.

Colin Forster and Cameron Hazlehurst, in their survey of Australian statisticians and the development of official statistics, described Hayter's own account in 1879 of the task he undertook:

> First, there were government departments which provided statistics in their annual reports and sometimes published them independently; they nevertheless provided statistics for the Government Statist on forms provided by him. Foremost in this group were Customs (trade statistics) and Railways. Other government authorities provided unprocessed or semi-processed material: one hundred and seventy local authorities returned figures on agriculture, manufacturing, private schools and population numbers on the Statist's forms—there was, for example, a schedule for each agricultural holding; statistics of crime were obtained from the police who filled in a form for each individual—27,000 a year; prisons, friendly societies, banks and savings banks all made returns; tables on births, deaths and marriages were compiled by the Statist's officers from the raw returns at the office of the Registrar General. Some statistics were obtained more directly by the Statist: the decennial census was carried out by him; . . . data on wages and prices were collected by the Statist's staff from newspapers and journals, with the assistance of police in country areas; information on religion was obtained by correspondence with the heads of the different denominations.[39]

Hayter was assisted in the collection and compilation of these figures by a permanent staff of eight, and by "a French calculating machine, *L'Arithmomètre*, by Thomas de Colmar of Paris".[40]

His reputation was enhanced by the production, each year from 1874, of the *Victorian Year Book* which began as an annotated summary of tables from the *Register* and grew to include statistics from other Australasian colonies and then from "other British dominions and Foreign countries throughout the world" for the purposes of comparison with the corresponding Victorian information. Despite the esteem with which Hayter came to be viewed, a recurring lack of objectivity in the making of those comparisons led to some resentment, especially in New South Wales, and was a major reason behind that colony's appointment of its own statistician.

Timothy Coghlan was born in Sydney on 9 June 1855 and educated at Cleveland Street Public School and the Sydney Grammar School.[41] He had already had a distinguished career as a civil engineer in the Department of Public Works and was "a good mathematician [with] some literary attainments", when he was controversially appointed to head the newly created "Statist's Office" in 1886.[42]

Within a year, Coghlan had transformed a *Statistical Register* that had not changed its basic structure since Rolleston's 1862 edition into a far more orderly and systematic volume, akin to Hayter's in Victoria. From 370 pages in 1885, the New South Wales *Register* grew to 594 pages in 1889 and 1,251 pages in 1904.[43]

Sir Timothy Coghlan, 1855–1926, taken around 1885. (National Library of Australia)

In Tasmania, the government statistician and registrar of births deaths and marriages, from 1882 to 1918, was Robert Mackenzie Johnston (1843–1918), "a most productive and original worker in both the natural and social sciences".[44] Johnston and Coghlan together formulated the occupational classification to be adopted for the 1891 census, to take place on the same day in all Australian colonies. Ten years earlier, there had been disagreement over this classification, emanating mostly from New South Wales, so the new accord marked an important achievement in cooperation that would be adapted by the first Commonwealth census in 1911. It also "symbolised the end of about forty years of statistical leadership from Victoria".[45] Coghlan's *General Report on the Eleventh Census of New South Wales* (1894), with his analysis of the 1891 census, was acknowledged as the most comprehensive of all the colonies' reports.

In 1887, Coghlan published an analogue of Hayter's *Year Book*, under the title *The Wealth and Progress of New South Wales 1886–87*, the first of 13 such volumes. They were noted for the breadth of the statistics they contained, relating to all colonies of Australasia, as well as for the historical insights into all aspects of those figures, and of the country itself. From 1890, there was a companion series of eleven annual volumes, called *A Statistical Account of the Seven Colonies of Australasia* (with the last two, following federation, called *A Statistical Account of Australia and New Zealand*). Their purpose was "to exhibit at a glance the position held by each Colony individually, and by the country as a whole, with regard to all matters connected with its moral and material welfare."[46] These were the precursors of the first Commonwealth *Year Book* in 1908.

Coghlan's position as Australia's most eminent government statistician at the turn of the century was emphasised by his dominance at a conference of statisticians held in Hobart in 1902 and by the calls for his advice on a projected federal bureau of statistics. He declined an offer to be Australia's government statistician in 1905 and instead took the position of New South Wales agent-general in London. He was knighted in 1914 and died in London on 30 April 1926.

Writing in the bicentennial issue (1988) of *The Australian Journal of Statistics*,[47] Chris Heyde of the Australian National University described the work of these early government statisticians and emphasised the application they made of the statistics they collected. For example, there had been unease expressed in the 1880s and 1890s regarding evidence of an unusually slow rate

of Australian population increase. The prevailing "greatest depression for half a century" was seen as a temporary cause but Coghlan was able to demonstrate that both immigration and the birth rate in New South Wales had fallen seriously. This generated a "major furore" and the study "was hailed in the *Journal of the Royal Statistical Society* in 1898 as a pioneering work with no equivalent in Britain."

Outside the government departments, there were other 19th century contributors to the discipline of statistics within Australia or with Australian connections. They were described in some detail by Eugene Seneta, of the University of Sydney, also in the bicentennial issue of *The Australian Journal of Statistics*.[48] Erastus Lyman de Forest (1834–1888), for example, was to become known as an American mathematical statistician, but shortly after graduating from Yale University in 1856 he spent some five years in Australia teaching mathematics at the Melbourne Church of England Grammar School. There is some evidence that de Forest's later publications on actuarial mathematics could be traced to interests of William Parkinson Wilson, first professor of mathematics at the University of Melbourne, in this area. Seneta wrote, furthermore, that:

> De Forest anticipated some work of William Fleetwood Sheppard (1863–1936) on graduation by linear compounding and least squares fitting. Sheppard . . . was born near Sydney, although he was sent to study in England at an early age. There is therefore some basis for regarding Sheppard's corrections for grouping as an Australian invention.[49]

Sheppard has been mentioned in Chapter 2 in connection with William Bragg's application to the University of Adelaide.

Seneta wrote also of William Stanley Jevons (1835–1882), a noted English political economist and logician, who made major contributions as well in economic statistics. He spent almost five years in Sydney, from October 1854 to April 1859, in which time he worked as a gold assayer at the Sydney Mint and developed various interests, such as meteorological data collection, wet-plate photography and music.[50] He was elected to membership of the Philosophical Society of New South Wales in 1856 and was well acquainted with Morris Pell and John Smith from the local university. Jevons had studied under Augustus de Morgan at University College, London, before coming to Australia, but "it was in Australia that he came to realize the fundamental nature of mathematics" and when he returned to London it was for further study with de Morgan towards completing his BA.[51]

Jevons' best work in Australia was a highly regarded 52-page article[52] summarising his observations of climate, based largely on his own collection of data. He described his intention as being "to group together general information as to the winds, rains, rivers, floods, the geographical features of the country, and the meteorological circumstances of this part of the globe". For his later contributions in economics, logic and statistics, Jevons was elected a fellow of the Royal Society in 1872.

William Farrer

One of Australia's greatest scientists of the late 19th and early 20th centuries—the wheat breeder William James Farrer—was born on 3 April 1845 in Westmoreland, England. He attended Christ's Hospital School in London and "made exceptionally good progress, gaining a gold and a silver medal for mathematics."[53] The medals are held by the Mitchell Library in Sydney. He then entered Pembroke College, Cambridge, in June 1864 and in the mathematical tripos of 1868 graduated BA as 29th wrangler.[54] After a year's study for a medical degree, in 1870 ill health led Farrer to migrate to Australia. He intended to become a sheep farmer but by 1875

William Farrer's gold medal for mathematics. (Mitchell Library, the State Library of New South Wales, Sydney)

began instead to travel the country as a licensed surveyor. During that time he became interested in experimental wheat breeding.

In 1886 Farrer took this up full-time as a hobby and in 1898 joined the New South Wales Department of Agriculture as a wheat experimentalist.[55] Most of his research is written up in the *Agricultural Gazette of New South Wales*.[56]

Some 20 years before Farrer began experimenting in earnest, Gregor Mendel had formulated his laws of genetics, recognised now as the first instance of biomathematics, but it was not until 1900 that Mendel's laws came to be widely known. Farrer knew nothing of them until around 1905, when he wrote:

> It seems to me from what I can see of Mendel's theory of heredity, that the consideration I . . . gave to the matter of fixing varieties led me to adopt the system which, for all practical purposes, Mendel's theory indicates as being the best. The practice was adopted from what appeared to me to be common-sense considerations. I certainly had not Mendel's theory to work upon.[57]

Farrer was able to develop hardy, disease resistant strains of wheat that were adapted to local conditions and capable of yielding a significantly superior crop.[58] The use of these varieties along with improved cultivation methods raised wheat output in Australia from 738,000 tonnes in 1890 to 3,923,000 tonnes in 1920. Having regard to Farrer's background in Cambridge mathematics, J. P. Shelton wrote: "There can be no doubt that Farrer's ultimate success in wheat-breeding was, to a large extent, the outcome of his early scientific training, which developed in him a logical clarity of thought that later enabled him to place his breeding work upon a systematised and logical basis."[59]

He died on 16 April 1906.

Chapter 4

Mathematics in the Universities in the First Half of the Twentieth Century

Chapter 2 dealt with the establishment of Australia's first four universities. Twelve years into the 20th century, there were universities in Queensland and Western Australia as well and in 1938 the New England University College, forerunner of the University of New England, first took in students.

Canberra University College, which through an association with the Australian National University became its School of General Studies, predated the New England University College by eight years but the story of mathematics there is told in a separate chapter devoted to colleges and universities in Canberra. The formation of the Australian National University itself and that of the University of New South Wales also occurred in the first half of the twentieth century, but only just, and their stories are also left to later chapters.

The University of Queensland, 1911–1946

Studies in the University of Queensland began in March 1911, a consequence of the passage of the University of Queensland Act on 10 December 1909.[1] Argument for and against a university in Brisbane had by then been proceeding for some 40 years, reflecting the lack of urbanisation in that state. Almost 40 per cent of the workforce in 1901 was engaged in primary industry and basic technical skills were a greater need than anything of an intellectual or academic nature.

Even so, for those 40 years the government had in fact been conducting local examinations for British universities. In 1893 the Queensland University Extension Movement was formed with the aim of providing public lecture courses, which would make available "all the advantages of a university training without the expense", and would, in the minds of its council, ultimately lead to the establishment of a university. Within a few years, the "Extension" was sponsoring classes leading to Sydney University matriculation qualifications and in 1901 it began examinations for degrees of the University of Melbourne. Its crowning achievement was the staging of the University Congress in 1906, attended by 149 delegates from all walks of life. According to the historian Malcolm Thomis, there was general acceptance of the need for a university that "laid stress on scientific and technical education rather than a study of the classics".[2]

The introduction of the 1909 university bill can be traced back directly to the congress of 1906 although many at the time of the congress, including the premier, could see no urgency in the matter. In the end, as much as anything else it was the need for a fitting tribute on the

occasion of the state's golden jubilee that allowed the bill's passage.[3] The University's first chancellor was Sir William MacGregor, "a colonial administrator of vast experience", who was also the state governor.

The initial intention, during seven years in which the government agreed to take full responsibility for financing the University, was that there would be four professors and ten lecturers within three faculties—arts, science and engineering. William Bragg, who had left his Adelaide post some two years before, and the Queensland agent-general in London headed a committee of "British professors" chosen to select the professors. The University today promotes the fact that Ernest Rutherford was offered the chair in mathematics and physics. The full story is told by Thomis in his history of the University's first 75 years:

> On his own initiative [MacGregor] encouraged the agent-general to take a trip to Manchester to make Professor Ernest Rutherford an offer of £200 above the advertised £900 salary if this would bring him to Queensland. The bid failed, for the agent-general had to report that Rutherford had recently rejected a £3,000 offer from another would-be employer.[4]

Instead, from 25 applicants for professor of mathematics and physics,[5] the University chose Henry James Priestley, "an Englishman of illustrious lineage whose mathematics was strong and whose physics was described as 'sufficient'; he was said to be a good lecturer, to have an attractive personality, . . . a wife, and good social qualifications."[6] His application included a testimonial from Horace Lamb.

Notable among the other applicants were the Australians Samuel McLaren, then at Birmingham; Frederick Wheatley, then teaching at Rockhampton Grammar School in Queensland; and Richard Daniel Kleeman. McLaren and Wheatley are described elsewhere in this book. Kleeman was born in 1875 at Rowlands Flat, South Australia. A successful physicist, he was a student of Bragg's at the University of Adelaide and later had three joint publications with him. Alexander David Ross was also an applicant, but would instead shortly gain the chair of mathematics and physics in the new University of Western Australia. Another with an Australian connection was Joseph J. E. Durack who was a demonstrator in physics at Sydney University in 1899; he went on to Cambridge and was professor of physics in the University of Allahabad, India, from 1920 to 1922. Finally, there was Duncan MacLaren Young Sommerville, a geometer and professor of pure and applied mathematics at Victoria University College, Wellington, New Zealand, from 1915 until his death in 1934.

The two who came closest to Priestley in the estimation of the selection committee were Kleeman and Durack. Kleeman and Priestley were the only two names short listed by the committee from among the British applicants[7] but in the end the university senate voted 14 to five for Priestley over Durack.[8]

The committee's other recommendations were for chairs in classics and chemistry, and they suggested that a professor of engineering be sought locally. By the end of 1911, 14 lecturers or assistant lecturers had also been appointed, including Thomas Parnell in physics.

Henry James Priestley

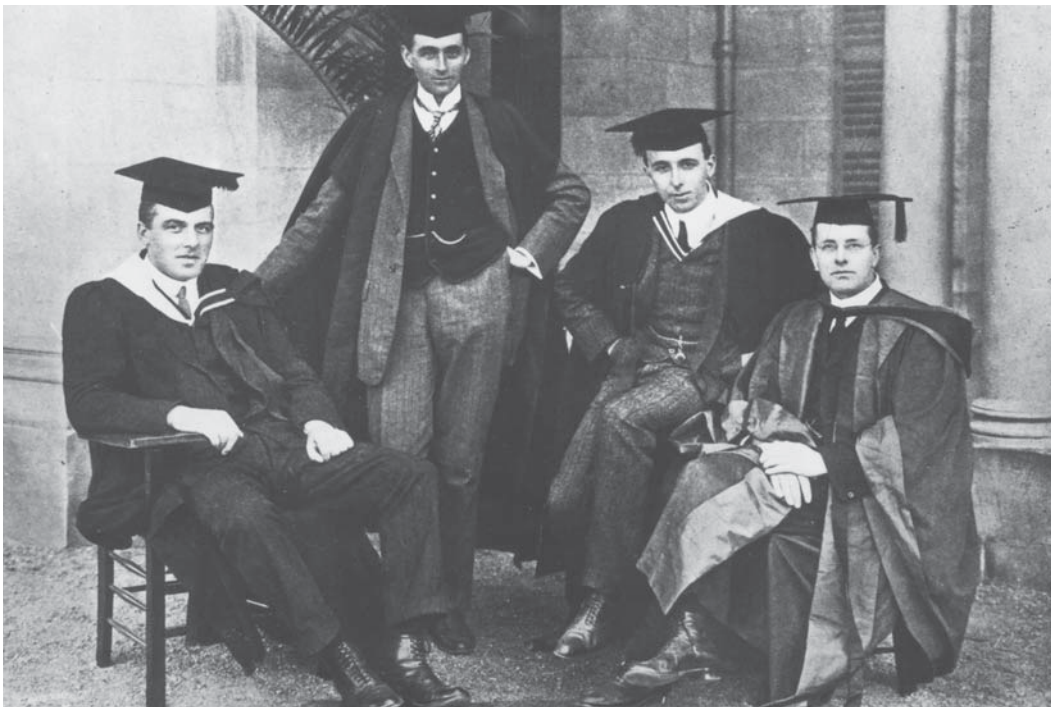
Henry Priestley was born at Stroud Green in Middlesex, England, on 10 April 1883. He attended Jesus College, Cambridge, and took his BA as fifth wrangler in 1905 and the following year was placed in the second division of the first class in part 2 of the mathematical tripos. In 1907, he became junior assistant lecturer in mathematics at the University of Manchester and in mid-1910 was reappointed as senior assistant lecturer. That December, Priestley and his

wife Marjorie left England for the new post in Brisbane. They arrived just four weeks before lectures were to begin.

Students in the three original faculties were all required to undertake three years of study in mathematics and Priestley quickly had to design their courses. He also developed honours courses in the arts and science faculties and a special third-year course in mathematical astronomy for civil engineering students.[9] Priestley's title remained Professor of Mathematics and Physics until the end of 1918, but his involvement in the teaching of physics was minor. Parnell was fully in charge of that area; he became professor of physics in 1919 and held that chair until his death in 1948. Priestley became professor of mathematics and by 1922 the mathematics department was the largest in the University in terms of student numbers.

Priestley's assistants in the first years were Richard Jenkins (Dickie) Lyons, who resigned early in 1914 to take a position at the University of Sydney, and Kenneth ffoulkes Swanwick. Swanwick, born in 1875, was the evening lecturer until mid-1913 and then again from 1921 to 1925; in between, he completed a doctorate in economics in the University of London. In the early years of the University he was appointed temporary evening lecturer not just in mathematics, but also in English, French and formal logic. His place was taken by Herbert Lance Watkins from 1913 until 1916 and then by James Patrick McCarthy until 1921.

Lyons' lectureship was taken by Herbert James Priest, then at the Perth Technical School. He was promoted from assistant lecturer to lecturer in 1919, was acting professor for that year, and took sick leave at the end of 1927. He remained on leave for three years, returning to his home state of South Australia, where he died on 2 December 1930, aged 46.[10]



The first four professors of the University of Queensland. Henry Priestley is third from the left. (University of Queensland Archives)

Priestley's research interests were in applied mathematics and mathematical physics and he maintained a modest output of publications although immersed in administrative duties. He served on the university senate for some ten years, was dean of the Science Faculty for nine years, and was president of the Board of Faculties, later renamed the Professorial Board, for four years. He was also active in AAAS, the Royal Society of Queensland, and the Queensland Association of Mathematics Teachers which he helped form at a meeting on 31 March 1922; he was elected to be its foundation president. His wife was closely associated with the foundation of the University's Women's College. Henry Priestley was just 48 when he died in office on 26 February 1932 after an illness that had lasted for some years.

Eugene Francis Simonds

By then, his successor, Eugene Francis Simonds, had been in the department as a lecturer for more than five years and from the end of 1930 Priestley's health was such that Simonds was acting professor. There were eight applicants for the position won by Simonds in 1926, the strongest of the others being James McCarthy who was at the time again the evening lecturer in the department.[11]

Born at Stonehenge, just south of Glen Innes, on 24 July 1885, Simonds had been educated in the various country schools to which his teacher father was appointed. He became a pupil-teacher and five years later began studies in the teachers' college in Sydney. Concurrently, he undertook an arts course at Sydney University and graduated BA in 1909 with first-class honours and the university medal in mathematics. In the following year he completed a BSc, majoring in physics. He then spent a year as head of the science department at Sydney Boys High School, succeeding Charles Weatherburn[12]. In 1912, Simonds was awarded a Barker graduate scholarship (see page 100) and was probably the first of the early winners not to use it for further study at Cambridge or Oxford.

Ethel Raybould, following her 1927 graduation with a BA. (University of Queensland Archives)

Instead, he enrolled in the teachers' college at Columbia, New York, and after graduating with an MA in education in 1914 taught first at the Cooper Union, a technological institution in Lower Manhattan, and then at City College of New York. In 1917, he took out a PhD from Columbia University with a thesis on continuous groups and differential geometry. After two years teaching at the University of Illinois, Simonds returned to Sydney to fulfil what he saw as an obligation to the New South Wales Department of Education for enabling his entry into university studies.

He was appointed mathematics master at North Sydney Boys High School and remained there, except for a year-long temporary lectureship at Sydney University in 1921, until

gaining the position in the University of Queensland in August 1926. His work at the University, including the introduction of new courses in statistics and actuarial mathematics, was well appreciated and his research, demonstrating a growing interest in statistics, did not diminish. In October 1932, the University appointed him to succeed Priestley without first advertising the vacant chair.[13] Simonds retired in July 1955 and died in July 1980 after a long illness.

At the beginning of 1931, Ethel Harriet Raybould was appointed lecturer in mathematics. She had held a temporary lectureship for the preceding three years following Priest's departure, having been seconded for that purpose from her first teaching position in the Department of Women's Work at the Central Technical College.[14] Raybould had graduated with a BA from the University of Queensland in 1927 with first-class honours in mathematics and the equivalent of a university medal, and was awarded an MA in 1931. She took leave to undertake further studies at Columbia University in New York from 1937 to 1939. After being promoted to senior lecturer in 1951, she enrolled for a science degree and this led to some irregular behaviour on her part. On one occasion, for example, she insisted that her own worked examination paper be returned to her so that she could pass it on to the examiner to be marked; when this was not allowed, she refused to leave the examination room.[15] As a result, Ethel Raybould's contract with the University was not renewed at the end of 1955, but she became one of the University's most generous benefactors when she died in 1987, bequeathing more than $920,000.

James McCarthy, who had been the University's evening lecturer in mathematics on various occasions since 1916, was appointed to a temporary lectureship in April 1932 and a permanent lectureship in 1933. McCarthy was associated with the University almost from its beginning. Born at Ipswich in southern Queensland on 21 April 1895, he enrolled in first year in 1913, and gained a BA in 1916 and an MA two years later. With his BA, he obtained second-class honours but Priestley, when he recommended McCarthy for a senior lectureship as early as 1922, wrote that this "should be disregarded [as] he developed after graduation".[16] A schoolteacher before gaining permanent employment with the University, McCarthy retained those links by being secretary of the Queensland Association of Mathematics Teachers for some 30 years and then becoming its president from 1962 to 1965; he had also been president of the Queensland Astronomical Society. He was promoted to associate professor in 1947 and retired in 1965 ending an association with the staff of the University that lasted over 49 years. McCarthy died in 1983.

Henry Maurice Finucan held a temporary lectureship during 1937, while Raybould was on leave, and gained a permanent appointment in 1946. There were no other staff changes until that time.

The University of Western Australia, 1912–1950

The first serious proposal for a university in the west was made in late 1883 by the well known Sydney businessman Anthony Hordern in connection with his aim to build a railway linking Perth to the southern port of Albany. This initiative was largely overlooked following Hordern's death in 1886 and there was to be no local post-secondary education of any form until the foundation of the Perth Technical School in 1900 and the Teachers' Training College two years later.[17]

At about the same time in 1883, there had been an offer from the University of Adelaide to conduct examinations in Perth but it was not until the mid-1890s that these got under way, and then only at the junior and senior school levels. By 1910, the Perth Technical School, and three other technical schools at Fremantle, Midland Junction and Boulder, had a formal affiliation with Adelaide University by which they offered a full course of instruction towards the

BSc degree and some subjects for the BA. James Bernard Allen, with a BSc from the University of Adelaide, had been appointed lecturer in mathematics at the Perth Technical School in 1901 and was by far the best qualified of the mathematics instructors. In 1910, he joined his student, Frederick George Brown, in reading for honours mathematics from Adelaide "and both obtained a first class pass at the University examinations," according to the School's annual report. "Mr. Brown thereby qualified for the B.Sc. Honours Degree, and Mr. Allen for the B.A. Honours Degree."[18]

The demand that these courses revealed, the relative affluence that came from the opening of goldfields in the Kimberleys, Coolgardie and Kalgoorlie, and a population comparable to those of the eastern states when their universities had opened, all pointed to readiness for a local university. During the first decade of the century the West Australian parliament received the proposal at a number of levels, often with a sympathetic response and sometimes not. The culmination was the appointment of a royal commission in January 1909 "to inquire and report as to the foundations upon which the University should be established."[19] It handed down recommendations in September 1910 and on 15 February 1911 a bill for the establishment of a university was passed, though it did not come into effect to until a year later. The University of Western Australia (UWA) now deems 13 February 1912 to be its date of foundation, as on this day the first senate of the University was constituted.

The person most prominent in campaigning for the passage of the University of Western Australia Act was Sir John Winthrop Hackett. He had been part owner and editor of the newspaper *The West Australian*, was a member of the Legislative Council, and was chair of the royal commission to inquire into the founding of a university. He became its first chancellor, serving in that role until his death in 1916. Hackett's model for the University, that in essence it be an independent teaching institution administered in the manner of the existing Australian universities and not purely an examining body, was confirmed in the report of the royal commission and subsequently by the first senate. The view of the commission was that there should be five chairs: agriculture (to be endowed by Hackett personally); modern languages and history; mathematics and physics; chemistry; and engineering.

The senate subsequently determined that there should be seven chairs, besides the chair of agriculture: mathematics and physics; mining and engineering; biology; history and economics; English; chemistry; and geology. This was the order in which a vote of the senate decided on the disciplines for the agreed number of chairs.[20] At the same time, four lectureships would be advertised: classics and ancient history; French and German; mental and moral philosophy; and veterinary science. The London interviewers for the chairs and lectureships comprised Sir Newton Moore, a former premier of Western Australia and then agent-general in London, and Sir Cyril Jackson, the state's former inspector general of schools.

Although generally disappointed with the quality of the applicants for all chairs, they were able to make a clear recommendation in the case of mathematics and physics: "they recommended W. M. J. Harrison, Fellow of a Cambridge College, if the Senate desired to place the emphasis on the former of the two subjects; if on the latter, they favoured Alexander David Ross of Glasgow."[21] Harrison was, most likely, from Clare College, Cambridge, third wrangler in the mathematical tripos of 1906 and winner of the Smith's prize in 1908.[22] However, the senate chose Alexander Ross.

Alexander David Ross

Ross was born in Glasgow on 7 September 1883. After studying some subjects externally at the University of London, he entered the University of Glasgow in 1902 and was awarded an MSc in 1906 and a DSc in 1910.[23] By the time of his appointment to the chair of mathematics and physics in Western Australia, Ross had about 30 publications, all of them in physics, particularly vacuum spectroscopy and optical astronomy. Physics always remained his discipline of choice. For example, from the early 1920s he had encouraged Australian physicists to join the London-based Institute of Physics and meetings of those members within AAAS and ANZAAS conferences led in 1939 to the formation of an Australian branch of the Institute;[24] but Ross was never inclined to act similarly on behalf of mathematicians.

He was nonetheless diligent in his responsibilities for the teaching of mathematics. Ross had decided to accept wide-ranging commitments within the University and the community, beyond teaching and at the expense of his personal research, but within a year of taking up the position he was obliged to complain of his high teaching load, "twice as many lectures as any other member of the Professorial Staff",[25] and he sought the appointment of an assistant lecturer. George Tattersall, who had been teaching mathematics and physics at the Perth Technical School since 1909, was appointed, but stayed only a few years. His training and inclinations were in chemistry and in 1916 he took up an acting professorship in that department and was there for 25 years. Maurice Browne, mentioned already in connection with the Royal Society of Western Australia, was another applicant for the position won by Tattersall.

Tattersall was followed as assistant lecturer in mathematics and physics by Harold William Sanders, who was to be Elder Professor of Mathematics in the University of Adelaide from 1944 to 1958. Sanders was born on 16 September 1893 and educated at St Peter's College, Adelaide, and the University of Adelaide. Six months after completing a BA with first-class honours in mathematics in 1912 and in the same period almost completing studies for a degree in electrical engineering, Sanders took a lectureship in mathematics and physics in the Perth Technical School. He was at the University of Western Australia (UWA) for five years, appointed as assistant lecturer in 1916 and promoted to senior lecturer the following year, and had responsibility for most of the mathematics teaching. The final year of his Perth appointment, from August 1920, was in fact spent on leave at Cambridge University.[26]

While at UWA, Sanders met and married Isobel Armstrong, one of the university's first women graduates in mathematics. Their younger child, John Veysey Sanders, became a noted CSIRO physicist and crystallographer. Their grandson, Jeffrey William Sanders, oldest of John's four children, received a BSc with honours in pure mathematics from Monash University and a PhD from the Australian National University in harmonic analysis. He is currently a lecturer and tutor at Oxford University in its Programming Research Group.

Ross made other appointments, concurrent with Sanders' tenure. These included Leslie Copley and then Robert Cochran Gray, both of whom had interests mainly in physics and who stayed only a few years each. Then Roland Dale Thompson was appointed assistant lecturer for a year in 1920 and subsequently lecturer in mathematics and physics until 1928. Thompson, born around 1895, was a graduate of the University of New Zealand and had for the preceding two years been on the mathematics staff of that University, first at Canterbury University College, Christchurch, and then at Victoria University College, Wellington.[27]

Two new appointments were made in 1921. Margaret Barr Moir was given a temporary lectureship in March that year, in place of Sanders, and remained with the University

until 1931. Her permanent appointment as lecturer in mathematics and physics was dated from 1 August 1922 and the position was transferred to a lectureship in mathematics alone in early 1929 when mathematics and physics were split into separate departments. Since it is uncertain on what actual day that split occurred, Moir must vie with Edith Lowenstern at the University of Tasmania for the title of first female lecturer in mathematics in an Australian university.

Margaret Moir, born in 1883, had been educated at the Glasgow High School for Girls and the University of Glasgow. She held the degrees of MA with first-class honours in mathematics and natural philosophy, and BSc with special distinction in mathematics, natural philosophy and astronomy. In July 1909, after graduating with her BSc, she was appointed to a Carnegie research scholarship and in July 1911 was promoted to a fellowship, which she held until 1914. Her work in those three years, on the magnetic properties of various steels under different conditions, earned her a DSc from the University of Glasgow. From September 1914 until granted leave of absence for war research work in Portsmouth, Moir was "mathematical mistress" in the Manchester High School for Girls. In January 1919, before obtaining the position in Perth, she had applied for the post of lecturer in natural philosophy in the University of Melbourne.[28]

In October 1931, after eleven years service with the University, Moir was dismissed from the staff, with no prior notice. The chancellor, Sir Walter James, in response to an anguished letter of protest, wrote: "The Government has reduced its subsidy to the University and other income has decreased in sympathy with the all round reduction caused by the prevailing depression. There are no signs of early improvement and retrenchment was unavoidable and urgent ... There was no reflection whatever upon you or your capabilities: the want of funds was the one and only cause."[29] Mathematics, wrote Fred Alexander in his history of the University, was "one of the few established disciplines in which retrenchment of permanent staff took place."[30] Margaret Moir continued to assist the University with its public examinations, but apart from that there is no information available on her life and work after her dismissal.

Around the same time in 1921, Allen Arthur Orton was appointed assistant lecturer in mathematics and physics, having taught part-time during the previous year. He had obtained a BSc with second-class honours from UWA in 1919 and during the same period became the first student to complete three years of study as a trainee at the Teachers' College, Claremont, a forerunner of Edith Cowan University. He spent a year teaching at the Eastern Goldfields High School in Kalgoorlie and was lecturer in charge of mathematics and science at the Teachers' College when appointed to the university position. Orton subsequently obtained a BA, and then an MSc in 1926. Two years later, knowing that his appointment would not be renewed with the break-up of the department into separate departments of mathematics and physics, he resigned to take a position at the University of Otago in New Zealand.[31]

UWA was a major beneficiary of Sir Winthrop Hackett's estate. Funds were not to become available until ten years after his passing in 1916 and the amount realised then was far beyond the expectations of the university authorities. A portion of the endowment was directed to the first expansion of the professoriate, part of which entailed the splitting of the Department of Mathematics and Physics.

Ross continued as professor of physics until his retirement in 1952; he died in Perth on 14 December 1966. The recommendation for the chair of the new mathematics department was to be made on the advice of two of Cambridge University's most able mathematicians, Edmund Taylor Whittaker, second wrangler in 1895, and a student of his, Arthur Stanley Eddington,

senior wrangler in 1904. There were three Australian applicants, one from New Zealand and seven others, all from Britain.

Their recommendation was for Charles Ernest Weatherburn, who was at that time professor of mathematics at Canterbury University College, within the University of New Zealand, where he had been since 1923.

By the time Weatherburn applied for the chair in Western Australia, motivated by health problems of his three sons in Christchurch, he had had 40 papers published; H. S. Carslaw in a letter of reference described him as "one of the most distinguished students who have passed through my hands". Carslaw was also invited by the vice-chancellor to comment privately on the two favoured local candidates, Weatherburn and Edwin Pitman, who by then, aged 31, had been professor of mathematics in the University of Tasmania for three years. Pitman had been taught by Weatherburn and preceded him at Canterbury University College as acting professor. Carslaw did not equivocate in his preference for Weatherburn. The other local applicants were Edwin H. Driver, a graduate of Auckland University College and at that time senior mathematics master at Auckland Grammar School, and Harold Sanders. Sanders, after his earlier term as lecturer in the department, had entered Gonville and Caius College where he completed Part 2 of the Cambridge tripos examinations in 1922, "placed among the list of Wranglers", and after six months study at Bonn in Germany had taken a lectureship in mathematics in the University of Adelaide.[32]

Previously unpublished photograph of Thomas Gerald Room, submitted with his 1929 application for the chair at UWA. (University of Western Australia Archives)

Among the British candidates for the chair were: R. M. Gabriel, a *b** wrangler in 1924, from Queens' College, Cambridge; Harold Vincent Mallison, a noted chess player, *b** wrangler in 1920 from Trinity College, honours graduate of the University of London, and at the time senior lecturer in mathematics at University College, Exeter; William Saddler, a graduate of St Andrews University and Cambridge University, and from 1915 a lecturer in "Applied and Pure Mathematics" at St Andrews; and Thomas G. Room, as he styled himself in his application.[33]

Room was to be professor of pure mathematics in the University of Sydney from 1935 to 1968, but at age 26 was considered to be too young for the chair in Perth. He nonetheless made the final shortlist presented by the selectors, Whittaker and Eddington: it was Weatherburn, Saddler, Gabriel and Room, in that order.[34]

Charles Ernest Weatherburn

Weatherburn was born on 18 June 1884 in Chippendale, Sydney, and educated at Sydney Boys High School and the University of Sydney. He gained his BA with first-class honours and a university medal in 1904, a BSc with first-class honours in 1905 and an MA in 1906. On a travelling scholarship, he then entered Trinity College, Cambridge, and there obtained a BA with first-class honours in 1908. Weatherburn returned to Sydney the following year to teach at his old high school and in 1911 was appointed lecturer in mathematics and natural philosophy

at Ormond College and, a few years later, Trinity College in the University of Melbourne. In 1916, while in Melbourne, he gained a DSc from the University of Sydney for a thesis on the application of integral equations to mathematical physics.[35] It was also while in Melbourne that Weatherburn was encouraged by John Michell, then lecturer in applied mathematics there, to write his *Elementary Vector Analysis*,[36] which was reprinted 14 times before its revision in 1955 and was the first of six highly acclaimed textbooks. Pitman would later describe Weatherburn as a "sort of prophet" in his advocacy of vector analysis.[37]

The financial stringency that led to the dismissal of Margaret Moir in 1931 had a prolonged effect on Weatherburn's management of the department. He was never able to build it to a size that seemed warranted by its responsibilities for the service teaching of mathematics in the science and engineering faculties.[38] For the first few years after her departure, he relied on assistance from the physics staff, Ross himself and the lecturers John Shearer and Robert Rutherford Nimmo, and from then until his retirement in 1950 was dependent almost totally on the assistance of Frank Gamblen.

Gamblen was born in Perth on 22 May 1913. After completing studies in science at UWA, he obtained a DipEd and then proceeded to Cambridge University on a scholarship endowed by Winthrop Hackett. He returned to Western Australia in 1938 to a lectureship, was promoted to senior lecturer in 1947 and reader in 1965. The position was changed to associate professor in 1972. Gamblen retired in December 1978 from a department that had consisted initially of him and Weatherburn alone, but by then boasted three professors, three associate professors, 13 senior lecturers and twelve lecturers. He died on 26 October 1996.

For most of 1935, Weatherburn was granted study leave and was replaced during that period by David G. Mawson, a well qualified New Zealander. During the years 1932 and 1933, Mawson had been acting lecturer in mathematics at Auckland University College replacing Keith Bullen, who had taken leave of absence to carry out research in Cambridge for his PhD.[39] Bullen later became professor of applied mathematics in the University of Sydney.

Frank Gamblen had in fact been an "honorary lecturer" in 1934 while still a senior undergraduate and a year later another exceptional undergraduate, Raymond John Storer, was given that position and title. Born in Perth on 25 August 1915, Storer had studied science at UWA and, after graduating, completed a DipEd and a BA by correspondence. He then held a temporary lectureship in mathematics from 1936 until 1940, but only intermittently while also fulfilling commitments as a teacher in secondary schools. Storer then enlisted in the RAAF and did not return to full-time teaching until 1947 although he had, in the previous year, served the department as a tutor for ex-servicemen. After three years as a senior lecturer in mathematics at the University of Melbourne, Storer returned in 1950 to a similar position at UWA. He remained there until his retirement in December 1980 and he died on 11 April 1997.

The University of Sydney, 1903–1945

Arthur Newham and Elphinstone Moors remained on the mathematics staff with the retirement of Theodore Gurney from the University of Sydney in 1902. Moors introduced a course on Actuarial Mathematics and Statistics around 1913 and in 1916 formally transferred to a lectureship in the Department of Economics, taking his course with him.[40] He retired in 1921 and died on 7 October 1924,[41] and may be counted as Australia's first locally born mathematician.

Both Newham and Moors came to be remembered as "fine lecturers", and Gurney also was never criticised for his teaching, but his failure as a research mathematician, and the consequent

loss of reputation for the department in comparison, no doubt, with the University of Adelaide, "made the University authorities aware that they should seek a successor who not only had done brilliantly in mathematical studies during his period of training at the University, but had already shown his capacity for creative work in Mathematics."[42]

Horatio Scott Carslaw

The response was the selection of Horatio Scott Carslaw to succeed Gurney. Carslaw was born at Helensburgh in Dumbartonshire, Scotland, on 12 February 1870. He graduated with first-class honours in both mathematics and natural philosophy from the University of Glasgow and proceeded to Emmanuel College, Cambridge, where he was fourth wrangler in 1894 and a fellow from 1899 to 1905. He was to maintain an involvement with Emmanuel throughout his lifetime. In 1896 Carslaw was appointed to a teaching position in Glasgow, but took a year's further study at Göttingen, Rome and Palermo before returning to Glasgow where he remained until appointed to the chair in Sydney.[43] He received a DSc from the University of Glasgow in 1899 and an ScD from Cambridge in 1908.

According to John Conrad Jaeger, a student of Carslaw's and later his collaborator and biographer, "Carslaw was elected to the Chair of Mathematics at [Sydney] University in competition with, among others, W. H. Young."[44] William Henry Young was six years older than Carslaw but did not gain eminence as an analyst until some years later, and by appointing him the senate may have been fearful of repeating the frustration of Gurney's tenure. In 1896 Young married Grace Emily Chisholm, who had been a student of his at Cambridge but, because of restrictions on women students, was not allowed to take out a degree there. She travelled to Göttingen where she obtained a doctorate supervised by Felix Klein, and went on to achieve fame as Grace Chisholm Young. Husband and wife together wrote over 200 articles and several books, and Australian mathematics may not have been the poorer for Young's appointment. But Carslaw was already an established researcher by 1903.

Horatio Scott Carslaw, 1870–1954, photographed in Glasgow, probably in connection with his application for the Sydney chair. (University of Sydney Archives)

The source for Jaeger's claim regarding Young is not known; he may have heard it directly from Carslaw. Quite a different overview is provided by the minutes of the university senate. The distinguished selection committee for a "Professor of Pure and Applied Mathematics" included Andrew Russell Forsyth, the Sadleirian professor of pure mathematics at Cambridge; Joseph John Thomson, the Cavendish professor of physics at Cambridge; Horace Lamb, then at Owens College, Manchester; and Herbert Hall

Turner, the Savilian professor of astronomy at Oxford.[45] They recommended the three candidates whom they considered most suitable but requested the power to invite further applicants "whose attainments were superior to those of any of the applicants for the Chair now being dealt with."[46] This suggestion was then abandoned as potentially "unfortunate and damaging to the University", and in the end Carslaw was appointed as a result of a show of hands by the senate, the runner-up being Alexander McAulay from the University of Tasmania.[47]

Besides McAulay, only one other candidate is named in the minutes.[48] That was Richard Cockburn Maclaurin, a graduate of Auckland University College who went on to study at Cambridge and had been foundation professor of mathematics at Victoria University College in Wellington, New Zealand, from 1899. He was president of the Massachusetts Institute of Technology from 1908 to 1920.

In Glasgow, Carslaw had been an inspector of mathematics in secondary schools and he was to retain a concern for school mathematics and general standards of school education throughout his tenure of the Sydney chair. His 80 page report to the International Commission on the Teaching of Mathematics, written in 1914, is evidence of this; it is summarised in Appendix 1. At a meeting on 27 October 1910, Carslaw founded the Mathematical Association of New South Wales as a local branch of London's Mathematical Association and as a base for Sydney's mathematics teachers. He was its president for the next 25 years, except for time spent on leave in Cambridge.[49]

Carslaw's textbooks in geometry and trigonometry were written as much for schoolteachers as for their pupils. From early in the century, strict adherence to Euclid's methods had led to the dividing of "the mathematical teachers of the mother country" into two camps, as Carslaw put it, "the Euclideans and the Reformers", to the extent that "demands are being made in several quarters for the abolition of Euclid's system, and in others for the complete removal of the subject itself from the school curriculum."[50] In addition, Carslaw held the view that there were "difficulties in the teaching of elementary geometry which arise from the Euclidean theory of parallels"[51] and he sought to improve the situation with his writing. He applied his fluency in Italian, obtained during his European studies, to translate Roberto Bonola's *Geometria Non-Euclidea*, with his own comments and additional material, and subsequently wrote his own text[52] on the subject.

T. G. Room, Carslaw's successor at the University of Sydney, wrote an appreciation of these and his other books after Carslaw's death, and referred to the modest preface in *Plane Trigonometry*[53] as "a triumph of meiosis".[54] Carslaw's calculus text,[55] first published in 1905, arose essentially as notes for science and engineering students in the university, but its approach to the subject anticipated countless like-minded books and it was reprinted on five occasions up to 1935.

Clive Davis, born in 1916 and professor of mathematics in the University of Queensland from 1956 to 1983, was interviewed for the Australian Mathematical Society History Project and remembered being lectured by Carslaw:

> I belonged to the first-year honours class in mathematics which was a group of perhaps a dozen people at the time. We had a small lecture room which in fact was adjacent to Carslaw's study and he had an inter-communicating door. Typically he would arrive through this door gowned as was the tradition in the University of Sydney. Soon as he got in, the gown came off and was hurled across the room and we proceeded to work. I found him a very attractive lecturer, I'm sure I learnt a lot from him. He was keen on identifying students who might go further and he appeared to put me in this class.[56]

Carslaw is remembered for much more than his contributions to mathematics education in Australia. Besides his work on non-Euclidean geometry, he had an active and influential interest in progressive rates of income taxation[57] and he gained great respect for his research into Fourier series and their application to the theory of the conduction of heat. In later life he was to simplify and popularise research into operational methods in mathematical physics.

John Jaeger was Carslaw's collaborator in a second phase of research on heat. Jaeger was born in Sydney on 30 July 1907 and achieved a brilliant record as an undergraduate in mathematics and physics at the University of Sydney from 1924. Carslaw had encouraged him away from his early studies in engineering and into science and in 1928, aged only 21, he travelled to England on a scholarship for further study at Cambridge, where he enrolled at Trinity College. Jaeger graduated as a *b** wrangler in 1930 and remained in Cambridge until he gained a lectureship in mathematics at the University of Tasmania in 1936. Carslaw by then had retired to his country property at Burradoo, south of Bowral in New South Wales, but had stayed in contact with Jaeger in Cambridge, including during two earlier visits on sabbatical leave. Their first paper together appeared in 1938.[58]

Carslaw's earlier work on heat had already gained him his reputation for an emphasis on rigour in mathematics as much as for his insight into applied mathematics. Jaeger wrote of this as follows:

> Carslaw's most important contribution to mathematical literature was his *Introduction to the Theory of Fourier's Series and Integrals and the Mathematical Theory of the Conduction of Heat*,[59] which appeared in 1906. The history of this is interesting: Carslaw had for some years contemplated the writing of a Treatise on Conduction of Heat—in doing this he found it necessary to provide a rigorous background for the use of Fourier Series. It is usually considered that the development of rigour in modern English pure mathematics dates from Hardy's *Course of Pure Mathematics*; in fact, Carslaw's work, which many teachers prefer, antedates both this and Bromwich's *Theory of Infinite Series* by two years. In its second edition it was split into two parts, *Fourier's Series and Integrals* and *Introduction to the Mathematical Theory of the Conduction of Heat in Solids*. The Fourier Series contains what probably still is the best English introduction to the theory of functions of a real variable . . . It illustrates very vividly Carslaw's most important characteristic as a mathematician, his love of the "good treatment": for him, mathematics had to be crystal clear in exposition and, subject to its assumptions, rigorous.[60]

The collaboration between Carslaw and Jaeger culminated in the publication of their text *Operational Methods in Applied Mathematics*[61] in 1941. In this, Jaegar wrote, "Carslaw was responsible for the 'Pure' chapters and that on conduction of heat. He remarked that 'the discerning reader' would be able to decide on the authorship of the various chapters by their literary style and, in particular, punctuation."[62] The book was the first in English on the Laplace transform, at that time "a topic of frontline research" but, as Michael Deakin wrote, "by 1955 it was standard fare in undergraduate courses ... and Carslaw and Jaeger's text can take a great deal of the credit".[63]

Carslaw received numerous honours, including a DSc from the University of Adelaide in 1926 and a doctorate of laws from the University of Glasgow in 1928. He declined the offer of a chair at University College, London, in 1923.[64]

Carslaw maintained contact with a number of his former students and colleagues after his retirement to Burradoo in 1935. He was particularly keen to promote the interests of his protégé, Jaeger. In a letter to the university registrar, Walter Selle, in January 1937, he wrote: "[Jack] Somerville has asked me for a testimonial in support of his application for the Math.

and Physics Lectureship at Armidale. I have gladly given him one . . . It is possible that J. C. Jaeger, now at Hobart . . . might be interested. His qualifications are, I think, higher than Somerville's, or, if Smith-White applies, of his too . . . Perhaps you may think fit to send Jaeger any relevant information."[65] Among other letters between Carslaw and Selle was one in 1941 in which they discussed the examiners' reports on Jaeger's DSc thesis; and another in 1945 had regard to Jaeger's application for the chair of applied mathematics at Sydney University, filled by Keith Bullen.

In 1938 Carslaw received a visit from his niece who had travelled from Scotland to meet him. While in Australia she met and married Lynn Walters and their son, Robert Frank Carslaw Walters, was born in 1948. A well known category theorist, Bob Walters was a member of staff of the Department of Pure Mathematics in the University of Sydney from 1975 to 1999, rising to the position of associate professor, and is now professor of mathematics in the Università dell' Insubria in Como, Italy.[66]

To many, but not often in his presence, Carslaw was known affectionately as Cocky Carslaw. Failing eyesight curtailed his research after 1947, and he died on 11 November 1954. On 3 August 1961, the foundation stone was laid for Sydney University's Carslaw Building, an event commemorated by the Australian Mathematical Society by presenting in its *Newsletter No. 10* a bibliography of Carslaw's "chief mathematical work", consisting of twelve books and 29 journal articles.

Shortly after Carslaw's arrival in Sydney, a bequest of £1,000 to the University by Thomas Barker in 1853 became operable for the granting of travelling scholarships. The first recipients, and the first to join Carslaw's staff on a lasting basis after Newham and Moors, were Edward Montague Wellish who took his scholarship in 1907 and Richard Jenkins Lyons in 1908.

Wellish, who anglicised his name from Wellisch around 1920, was born on 14 April 1882 at Darlinghurst in Sydney. He took out a BA with first-class honours and the university medal in mathematics at Sydney University in 1903 and an MA in 1906 while at the same time substituting as evening lecturer when Newham was on leave. He went the next year to Emmanuel College, Cambridge, on his scholarship. There, he worked with J. J. Thomson and was awarded the prized Clerk Maxwell Studentship for research in physics. He graduated BA from Cambridge in 1909 and after five years as assistant professor of physics at Yale University in the USA, returned to a lectureship in Sydney in 1915 replacing Moors who had transferred to the economics department. From 1926 until his retirement in 1946, Wellish was associate professor of applied mathematics. He died of a coronary occlusion on 22 July 1948.[67]

Ivan Turner, mentioned previously as addressing the university on the occasion of its centenary in 1952, was fulsome in his praise of Wellish, describing him as "one of the most brilliant graduates of this University" who sacrificed a career in physics research in the interests of mathematical education.[68] Wellish's publication record bears this out: he had some 15 papers from 1908 to 1917 and then just three more before his retirement in 1946. His first paper[69] was with James Arthur Pollock, an honours graduate in mathematics and physics and later professor of physics in Sydney University from 1899 to 1922. Clive Davis has attributed Wellish's decline in research to disappointment resulting from a clash of methods with those of Victor Bailey, a distinguished experimental physicist in the University.[70]

Dickie Lyons, as he was always known, was born in 1885 and educated at Sydney Grammar School and then Sydney University. He graduated with first-class honours and a university medal in 1906 and used his Barker graduate scholarship to enrol at St John's College, Cambridge, in

1908, gaining his BA in 1911. Lyons returned that year to an assistant lectureship in the newly founded University of Queensland, before taking a lectureship in the University of Sydney in 1914. His early interests were in analysis but, at Carslaw's request, on sabbatical leave in Cambridge in 1926 he studied under the eminent geometer Henry Frederick Baker and, back in Sydney, was subsequently reader in geometry from 1938 until his retirement in 1950. He died the following year. Turner wrote that Lyons inspired in all of his students "something of the passion for mathematics which he himself had in such measure."[71]

Harold Henry Thorne (1891–1953) was the Barker graduate scholar in 1914 and joined Carslaw, Wellish and Lyons in 1920 to make up what would constitute the full-time mathematics staff in the University until 1935. He had undertaken a wartime degree at Cambridge, spending part of the war years with a large team of mathematicians at Farnborough working on aircraft design, and he taught for a year at Sydney Technical College before taking the position at Sydney University. His son, Roger Chapman Thorne, would later also travel to Cambridge on a Barker scholarship. He enrolled in 1950 in Trinity College and graduated with an MA and a PhD in mathematics but died as a roadside pedestrian in a car accident, aged just 30. Two years before, in 1957, he had been appointed to a lectureship in applied mathematics at the University of Sydney, in his father's footsteps.[72]

There were others who worked at various times in the mathematics department during the Carslaw years. Eugene Francis Simonds, professor of mathematics in the University of Queensland from 1932 to 1955, was a lecturer in 1921 while Carslaw was on leave. He had lectured part-time for the few years before that. Another was Henry John Meldrum (1882–1966), who assisted with evening classes for a number of years between 1913 and 1929. Meldrum was just 15 when appointed to be a pupil-teacher at Tumbarumba in southern New South Wales, but by 1912 he had obtained first a BSc and then a BA with first-class honours and the university medal in mathematics at the University of Sydney. He became head of the mathematics department at Sydney Teachers College and was a stalwart member of the Mathematical Association of New South Wales.[73]

Fanny Cohen, 1887–1975, from a portrait by Sir William Dargie. (Fort Street High School)

Another early recipient of the Barker graduate scholarship was Fanny Cohen. She was born in Grafton, New South Wales, in 1887 and passed the senior public examination in 1904 "with first-class honours, and medals for mathematics, algebra and French".[74] She excelled in her university studies in mathematics and geology and in 1909 was appointed junior demonstrator in geology. She then travelled to Cambridge, accompanied by her mother, but was unable to complete her studies in mathematics there when her mother

became ill. She consequently returned to Sydney and worked towards an MA, which she won in 1913. By then, Fanny Cohen had embarked on a distinguished teaching career that would see her be headmistress for 23 years at Fort Street Girls High School. Carslaw's early reference for her was no doubt meant as highly complimentary, but sounds somewhat less so today: "I know of none of my women students who can compare with her as a suitable teacher of mathematics."[75]

Fanny Cohen died in 1975. She was the first woman to gain first-class honours in mathematics at Sydney University and the first to win the Barker scholarship. There were, however, a number of women honours students before her—the first was Jane F. Russell with second-class honours in 1886.

Oliver Lancaster has listed a number of early mathematics graduates, all with first-class honours.[75] Those not otherwise mentioned mentioned hereabouts were: Charles Weatherburn, professor of mathematics at UWA from 1929 to 1950; Maurice Belz, professor of statistics in the University of Melbourne from 1955 to 1963; Oscar Ulric Vonwiller, who began his studies under Gurney and succeeded Pollock as professor of physics in the University of Sydney; William Rowan Browne, a distinguished geologist who was assistant professor and then reader in geology from 1923 to 1949; and Herbert Vere Evatt, who also obtained first-class honours in English and went on to a brilliant career in law and politics.

Ivan Turner was indeed well qualified to describe the history of the department during the university's centenary celebrations. He had been an integral part of it for the preceding thirty years. Born on 14 April 1903, he was educated at Sydney Boys High School and then Sydney University, gaining a BSc with first-class honours in mathematics and second-class honours in physics, then a DipEd and, in 1925, an MSc with first-class honours and the university medal in mathematics. During this time, from 1923 to 1925, he was a demonstrator in physics. With a Barker graduate scholarship, he entered Trinity College, Cambridge, and gained a BA in 1927. Turner returned to Sydney to a lectureship at the Sydney Teachers College, situated within the university grounds, and was associated with that institution for the ensuing 40 years. From 1946 to 1950 he was head of the mathematics department, succeeding Henry Meldrum, and from then until his retirement in 1967 he was the principal of the college. He lectured part time in mathematics within the University on various occasions from 1928 until 1950, and was acting lecturer from 1933 to 1935. After that, on a Carnegie fellowship he attended the London Institute of Education and New College in Columbia University, New York, where he was awarded a PhD in 1939. Turner's research interests ranged over the teaching of mathematics, educational administration and teacher training. Consistent with his own career, he continued to argue well after retirement for the merits of maintaining teacher education within the classical university environment.[77] He died on 25 March 1984 after a short illness.

His son, John Stewart Turner FRS, known as Stewart, was foundation professor of geophysical fluid dynamics in the Research School of Earth Sciences at the Australian National University from 1975 to 1995, and for ten years before that, assistant director of research in the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge. During his doctoral studies at Cambridge on cloud physics as an aspect of fluid mechanics, Turner was supervised by Alan Townsend and Sir Geoffrey Taylor and was closely associated with George Batchelor, head of the Cambridge department, and Bruce Morton, later professor of applied mathematics at Monash University.

When Carslaw retired in February 1935, the University advertised a "Chair of Mathematics

(Pure Mathematics)", with the view that applied mathematics was well catered for by Edward Wellish. Asked for suggestions regarding his replacement, Carslaw wrote: "My ideal is a fairly young Cambridge man—one of the young Fellows—with some teaching experience, keen, and with some personality. Such a man would never regret coming to Sydney."[78] This wish was fulfilled in all respects by the appointment of Thomas Gerald Room.

Unusually for the times, there was no English selection committee appointed to assist the university senate in choosing Carslaw's successor. Instead, it relied heavily on Carslaw's recommendation, which was based on the advice of a large network of British acquaintances. These included G. H. Hardy, G. N. Watson, E. T. Whittaker, Sydney Chapman, F. P. White and J. E. Littlewood. There was strong support among them for Alexander Oppenheim, an Oxford University graduate and at the time professor of mathematics at Raffles College, Singapore, and for Edward Lindsay Ince, remembered today mostly for his classical book on differential equations and as the father of Monica Hughes, a children's science fiction writer. Ince let it be known that he would accept the chair if it were offered to him.

Among those who formally applied for the post were: Reinhold Baer, an eminent algebraist who had trained in Göttingen and held chairs in Princeton, Urbana and Frankfurt; Patrick du Val, another geometer who studied at Cambridge under Baker (but who withdrew his application when offered a position in Princeton); Edward Hubert Linfoot, a number theorist who studied at Oxford and worked at the University of Bristol before his interests turned to mathematical optics; and R. M. Gabriel.[79]

Gabriel had been a shortlisted applicant for the chair in Western Australia, six years earlier, and by this time was reader in mathematical analysis in the University of Leeds. The determination of the senate was that if Room was not able to accept the offer of the Sydney chair, then it was to be offered to Gabriel.[80]

There were also two Australian applicants. With ironic symmetry, one was Charles Weatherburn in Perth, wanting to return home. Carslaw had evidently retained his high opinion of Weatherburn. In a letter of reference written for Weatherburn's application for a Carnegie Corporation Grant in 1935, and included with the application for the Sydney chair, Carslaw wrote: "He was a student here when I entered on my work as Professor of Mathematics in March 1903 . . . He is without doubt the most distinguished of the mathematical graduates of Sydney in the thirty one years during which I have been head of our Department."[81]

The other local applicant was Dansie Thomas Sawkins. Born on 1 August 1880, Sawkins obtained a BA from Sydney University in 1898 with the university medal for mathematics, and an MA in 1900. He went to Queens' College, Cambridge, and graduated 32nd wrangler in 1904. In his letter of application for the chair, he wrote "From 1907 I was occupied under the governments of Siam, the Federated Malay States, & New South Wales as a geodetic surveyor, & since 1918 as a statistician."[82] Sawkins followed Elphinstone Moors as one of the first teachers of statistics in Australia, being appointed to a part-time lectureship in statistics in the Faculty of Economics at Sydney University in 1922 and then to a full-time readership from 1938 to 1946. That also entailed a responsibility to teach a statistics course in the Faculty of Science. Prior to taking the full-time post, he had been "Statist to the Industrial Commission". He was in fact offered a chair in statistics but took the readership instead because, at age 58, his public service superannuation entitlement was more easily retained by doing so. From 1925 to 1938, Sawkins was also part-time lecturer in geodesy in the Faculty of Engineering, and he was to maintain responsibility for teaching in that area when he took on the readership.[83]

Sawkins died in 1950. Eugene Seneta, in his survey[84] of Australia's early statisticians, included a detailed account of Sawkins' work and the use made of it by Weatherburn in his textbook, *A First Course in Mathematical Statistics*. The book, published in 1946, was one of the first of its kind and was very well received. It was based on lectures Weatherburn had given at UWA and prominently acknowledged Sawkins' assistance.

Thomas Gerald Room

Room was born in Camberwell, London, on 10 November 1902 and at school was "a gifted student with a flair for mathematics". He was awarded an exhibition to St John's College, Cambridge, and succeeded well in the tripos examinations, becoming a *b** wrangler in 1923. He was awarded a Smith's prize in March 1925 and was elected to a fellowship at St John's in November of that year, but had already, at the beginning of the year, taken a lectureship in mathematics at the University of Liverpool. Room was appointed a probationary lecturer in mathematics at Cambridge in September 1927 and to a lectureship there in the following year. He held this position until appointed to the chair in Sydney.

At Cambridge, Room was strongly influenced by H. F. Baker and in his later years there carried out intensive research into the geometry of configurations in higher dimensional space. In their obituary of Room, James Hirschfeld and Tim Wall add that he "wrote fundamental papers on the freedom of manifolds and laid the foundations for his book on determinantal loci.[85] The work of this period firmly established his reputation as a geometer of great insight and technical skill." From an early age, Room took on his father's love of scouting and his days at Cambridge are notable also for his scouting exploits. Hirschfeld and Wall gave the following anecdote:

> The regular 'tea-party' held each Saturday afternoon in term time was a distinctive feature of the Baker school. After tea there was always a talk, followed by lively discussion. All members were expected to attend and it was a somewhat formal occasion. One distinguished participant recalls of Room that "On such occasions most of us were properly dressed, but he often used to rush in, rather late, with shorts revealing bare knees because he, as a Scout-master, had been out with his boys." There seems to have been some anxiety on Baker's part lest Room spend too much time on Scouting and not enough on geometry.[86]

Although he was then at Liverpool, Room would almost surely have met Dickie Lyons when the latter went to Cambridge in 1926 to work with Baker. They were very close friends in Sydney and would later be collaborators in wartime intrigue. It is reasonable to suppose that this early friendship was one reason that Room applied for the Sydney position. It may also account for his application for the chair in Western Australia in 1929 if he had thought Perth to be not too distant from Sydney.

Room arrived in Sydney in August 1935 and quickly set about raising the standard of the course there. For example, he introduced a fourth year for honours whereas previously the honours course had been taken simultaneously with third-year studies. Alf Pollard, later professor of economic statistics at Macquarie University, well recalled Room's arrival:

> The change in standards was dramatic. In the year before ours there were 6 first-class honours, and the year before that 5. In our year only one first was awarded, and that policy continued thereafter ... The year was in shock. A meeting was held of the whole honours class to discuss what should be done. Although various drastic proposals were put forward, it was clear we were powerless to do anything.[87]

Pollard was referring to himself as that year's sole recipient of first-class honours.

Wellish, Lyons and Thorne remained on staff with Turner as acting lecturer and they were joined during 1935 by another acting lecturer, Richard Ellis Bodenham (Dick) Makinson who, for the ten years until his death in 1979, was associate professor of physics at Macquarie University. A year later there was a further temporary addition to the staff in Frederick Chong, who had just obtained his BSc there with first-class honours and the university medal in mathematics. He had been a part time demonstrator in physics while completing his BSc.

A fifth permanent staff member was appointed shortly after—William Broderick (Bill) Smith-White. Smith-White was born on 14 April 1909 and was educated in Sydney, gaining first-class honours in both mathematics and physics and the university medal in physics. He was awarded a Barker graduate scholarship and went in May 1930 to Emmanuel College, Cambridge, "following the pattern laid down and insisted upon by H. S. Carslaw". He graduated in 1932 as a *b** wrangler. Back in Sydney during the depression years, Smith-White survived mainly with mathematics coaching jobs and some part-time work at Sydney University before taking a two year appointment as tutor at Trinity College, Melbourne, in 1935.

When Room replaced Carslaw, he immediately requested additional staff and was granted an assistant lectureship, which Smith-White was offered and took up in March 1937.[88] As Hirschfeld and Wall wrote, he proved to be "the mainstay of the department in the area of analysis and differential equations throughout Room's tenure of office".[89] Smith-White was promoted to senior lecturer in 1946 and to associate professor in 1962, forestalling a possible move to become one of the foundation professors of mathematics at Monash University, for which he was shortlisted.[90] He was acting head of department on many occasions and acting professor of mathematics from early October 1966 for five months. Smith-White was also active outside the University: he was an examiner, and chief examiner on occasions, for the New South Wales Department of Education from 1937; he was the editorial secretary of the Royal Society of New South Wales from 1948 to 1950; and he was president of the Mathematical Association of New South Wales in 1950–1951. Smith-White retired from the University of Sydney in 1974 and died on 8 February 1986.

There was to be a very close friendship between Smith-White and Harold (Harry) Mulhall, who joined the department as assistant lecturer in mathematics in 1941. Mulhall was born in Sydney on 27 January 1915 and attended Sydney Boys High School, gaining the maximum pass of four subjects each with first-class honours in his Leaving Certificate. His BSc from the University of Sydney in 1936 was with first-class honours in mathematics and chemistry and the university medal in mathematics and, like Pollard, he had the distinction of being instructed by Carslaw in his last year there and Room in his first. Mulhall then held a tutorship at Trinity College in the University of Melbourne until gaining the Sydney post and, for a few years, taught at the Sydney Technical College.

He held a permanent university position from 1946, initially replacing Dansie Sawkins, and for many years was almost single-handedly responsible for the organisation and teaching of statistics in the Faculty of Science. A PhD from Cambridge University in 1953 precipitated his promotion to senior lecturer and he was appointed associate professor of mathematical statistics at the end of 1964. His Cambridge thesis led to the intriguingly named book *The Physical Anthropology of Southern Nigeria*,[91] less excitingly subtitled *A Biometric Study in Statistical Method*, and he is remembered also for a series of high school textbooks, *A New Mathematics for Senior Forms*, written with Smith-White to cover newly introduced syllabuses in the schools. Mulhall retired in early 1979 and died on 26 December 1995.[92]

In November 1937, Room married Jessica Bannerman. He was known to sign himself occasionally as T. Gerald Room, but she was the only one who dared call him Gerry. For reasons unknown, when Room took on a tutorship at England's Open University after retirement, he was called George.[93]

New England University College

There were moves in the mid-1920s for the establishment of a university at Armidale in northern New South Wales, but ten years passed before there was a more general acceptance of the benefits of scientific and economic research beyond the capital cities. Whether this should be taken up in the first instance in the industrial centre of Newcastle, where Sydney University had already had some success with extension lectures and tutorial classes, or within rural Armidale where an expanding teachers' college had been established in 1929, was of major concern. The better organised and longer-standing bid by Armidale persuaded the senate of the University of Sydney in October 1935 to agree in principle to the establishment of a university college there, and the later offer of the Queen Anne style mansion named Booloominbah and the 74 hectares of surrounding grounds to accommodate the college ensured its happening.[94]

The New England University College, which became the University of New England in 1954, took in its first students in March 1938, to be taught by an establishment of five academic staff members. Jack Murielle Somerville was the lecturer in charge of mathematics and physics.

Somerville was born in Sydney on 5 November 1912. Following studies at the University of Sydney, from which he graduated BSc in 1934 with first-class honours and the university medal in mathematics and first-class honours in physics, and the University of Cambridge (BA, 1936), he returned to Sydney to become a research assistant in physics. From 1938 to 1953, the year he received a DSc from the Department of Physics at Sydney University, he was lecturer and then senior lecturer-in-charge in Armidale and was appointed the first professor of physics at the founding of the University of New England. Somerville died on 15 October 1964.

Frederick Chong joined Somerville as an assistant lecturer in mathematics and physics at the beginning of 1940. Known always as Freddy, he was born on 5 March 1915, completed his Leaving Certificate in Sydney in 1931 and entered the University of Sydney the following year. With his BSc with first-class honours and a university medal, an MSc in 1937 and a Barker graduate scholarship, Chong left for Cambridge that August and obtained his BA there in 1939. He was "very strongly in the running" for a lectureship in Tasmania but the position was withdrawn and he took the job in Armidale.[95]

When Somerville was seconded to Sydney for wartime assistance in August 1941, Chong was promoted to lecturer and for a while was responsible for all the teaching in mathematics and physics. He was then assisted briefly by Herbert Charles Corben. Corben had been born in Dorset, England, in 1914 and educated in Melbourne (BA, BSc in 1934; MA, MSc in 1936) and Cambridge (PhD, 1939). He subsequently lectured in mathematics at Melbourne University as acting dean of Trinity College until 1946, and went on to become professor of physics at Cleveland State University, Ohio, and then at the University of Toronto. He died in 2000.

In 1942 Douglas Walter Noble Stibbs was appointed assistant lecturer in mathematics and physics, although, according to official records,[96] he understood his duties to be in physics only and this caused him "always to be at loggerheads with his present senior, Mr. Chong." Stibbs was in Armidale until 1945, but wartime teaching remained difficult for the department to manage,

with repeated requests for Stibbs to be recalled to his previous position in radio research at Mount Stromlo observatory and Somerville having repeatedly to apply for six-monthly extensions of his secondment. Stibbs himself described any difficulties with Chong to be due only to variable wartime flying assignments that he was required to undertake, the nature of which he was not allowed to recount to Chong.[97] Walter Stibbs, as he has always been known, was born in Sydney on 17 February 1919 and educated at Sydney University where he won the university medal in theoretical physics. He later gained a DPhil from Oxford and in his nine years there befriended and worked with E. C. Titchmarsh. From 1959 to 1989 Stibbs was the Napier Professor of Astronomy at the University of St Andrews in Scotland. Awarded an emeritus professorship at St Andrews, he returned to Australia in 1990, lives now in Canberra and is active still as a visiting fellow in the Mathematical Sciences Institute of the Australian National University.

On 1 January 1944 Nathaniel Wesley (Wes) Taylor was appointed temporary assistant lecturer in mathematics and physics. Taylor was born on 22 April 1922 in Armidale and had been a top student in the college from 1940. He gained his BSc with first-class honours in mathematical physics in 1943 and an MSc in 1946, and was to be one of the first two students of the New England University College to be awarded a PhD when he received his doctorate in 1958 from what was by then the University of New England. Taylor remained with the College, and then the University, until his retirement as a senior lecturer at the end of 1986.

In Taylor's first years on the staff there, the outstanding student was Russell Alexander Smith, who completed his third year studies in 1945, around the same time as Reginald Augustus Smith was appointed a senior lecturer in the department. Reg Smith followed Somerville into the physics department when the discipline was split from mathematics in 1952.

Russell Smith was born in Katoomba, New South Wales, on 17 December 1925 and in Armidale was greatly influenced by Chong, "who turned me into a mathematician". His fourth year of university studies was completed in Sydney where he gained first-class honours in mathematics with a university medal and a Barker graduate scholarship, which took him to St John's College, Cambridge. With a PhD in the qualitative theory of differential equations under the supervision of Dame Mary Cartwright, Smith returned to Sydney University briefly as a lecturer but in 1954 was appointed to a post in pure mathematics in the University of Durham, from where he retired as reader emeritus in 1990. In 1986 he was awarded a DSc from the University of Cambridge on the basis of his published research.[98]

Meanwhile, a lectureship became available at Sydney University in September 1946 and Freddy Chong was the only applicant. His return to Sydney was encouraged by Room since Chong's research interests at that time were in geometry and the two had already been corresponding on a series of papers that Room was writing on quartic surfaces. Chong's position at the New England University College was taken by Alwyn Horadam, who had been one of three students in the first of Chong's first-year honours classes there in 1940. Wes Taylor was another of the three.

Coincidentally, Horadam's interests would also turn to geometry and in 1952 he commenced a PhD with Room as supervisor. Room had a particularly large project in algebraic geometry in mind, requiring the work of a number of assistants. The others he brought in included Tim Wall, who would succeed Room as professor of pure mathematics and who already had a PhD from Cambridge University, and Beverley Bentley. On Wall, Bentley and her future husband Bruce Bolt, there will be more to say later.

Alwyn Francis Horadam, called Horrie by everyone, was born in the Hunter Valley in New

South Wales on 22 March 1923. His first schooling, during the difficult depression years, was in the small town of Roughit, outside Singleton.[99] He attended Maitland Boys High School, distinguished himself in cricket as well as in his academic work and won a scholarship to the New England University College where he undertook an honours degree, majoring in mathematics. This entailed residence in Sydney for the final term of study, after which Horadam taught in various country schools while continuing to study for an MA by correspondence. He was then offered the position in Armidale where, unlike previous incumbents, his teaching responsibilities were stipulated as being solely in mathematics.

By 1949 the Department of Mathematics and Physics had Somerville as senior lecturer-in-charge, Reg Smith as senior lecturer, and Taylor and Horadam as lecturers. There was a new appointment as senior lecturer that year: Roy Clifford Townsend Smith who was to be professor of mathematics and then professor of applied mathematics, for 28 years altogether. Roy Smith was born on 23 October 1920 in Beech Forest in southern Victoria. His father ran one-teacher schools across the state, so that Smith was educated in various schools before attending Melbourne Boys High School from 1934 to 1937 and gaining his leaving certificate with first-class honours in calculus and mechanics, which were two of the four available papers in mathematics, as well as in chemistry and physics. He then attended the University of Melbourne, became an accomplished baseballer and cricketer, and was one of a large number of students there at the time who went on to chairs in mathematics or a related discipline after spending the wartime years at the CSIR Division of Aeronautics. (The CSIR, or Council for Scientific and Industrial Research, was the forerunner of the CSIRO.) Smith was at the CSIR for four years, in which time he gained an MA for his work on elastic stability of thin plates and shells. He then travelled to Oxford where he gained a DPhil with E. C. Titchmarsh as supervisor.

The year after Roy Smith arrived, Mollie Spedding joined the staff. Horrie met Mollie when she arrived in Australia in 1949 to take up a widely advertised lectureship in mathematics and physics in Armidale. They married in May of the following year. Born Eleanor Mollie Spedding on 29 June 1921 in Dewsbury in Yorkshire, England, she had attended Wheelwright Girls Grammar School in Dewsbury and then Girton College, Cambridge, where she graduated with a BA as senior optime, equivalent to second-class honours. During World War 2 she had studied by night for an engineering degree from the University of London, obtaining first-class honours, and by day had worked for Rolls Royce modelling engine stress in aircraft.

Serious research began for Mollie Horadam when she was aged 35, on sabbatical leave in Cambridge in 1956. She attended lectures by John Edensor Littlewood, turned her interest to number theory and within ten years had published over 30 papers on generalised integers. This resulted in her PhD by publication from the University of New England in 1965 and a promotion to senior lecturer.[100] Alwyn Horadam's research in geometry led to his *Guide to Undergraduate Projective Geometry*,[101] published in 1970 and still on many prescribed text lists around the country, but his interests also turned around then to number theory and he became a prolific investigator into Fibonacci numbers and their many extensions. Equally prolific in this area as well as in educational theory and in mathematical applications in medicine, particularly to diabetes research, was his former doctoral student and subsequent collaborator Anthony Greville (Tony) Shannon, who became professor of applied mathematics in the University of Technology, Sydney.

Wes Taylor retired at the end of 1986 and Alwyn Horadam at the beginning of 1987. Both had attended New England University College as students within three years of its opening and

were associated with it and its successor institution, the University of New England, throughout their professional lives. Mollie retired in 1982, was diagnosed with Alzheimer's dementia in 1996 and died on 5 May 2002. The Horadams' daughter Kathy is professor of mathematics at RMIT University in Melbourne.

The University of Melbourne, 1923–1952

Along with penicillin, the Hills hoist clothesline and the Victa petrol-driven lawnmower, the tilt-pad thrust bearing that George Michell invented in 1905 is often listed among the best Australian innovations of the twentieth century. He and his brother John had two of the greatest minds of the time; it was the latter who succeeded Edward Nanson in the chair of mathematics, pure and mixed, at the University of Melbourne.

John Henry Michell

Michell was born on 26 October 1863 at Maldon, an old gold-mining town 40 kilometres south of Bendigo, Victoria. His newly married parents had emigrated from Devonshire, England, in 1854 to join the gold rush. Their surname is pronounced with the stress on the first syllable, which rhymes with "rich". In 1877 the family, which included three older sisters besides his younger brother George, moved to Melbourne where the boys could continue their education.

John attended Wesley College, where the headmaster was Henry Martyn Andrew, and in 1881 entered the University of Melbourne. He obtained a BA with first-class honours in 1884 and, at the urging of Nanson and Andrew, went to Trinity College, Cambridge, accompanied by the whole family. He was just as successful there, becoming senior wrangler in 1887, equal with three other students one of whom was H. F. Baker, and he shared the Smith's prize with Baker in 1889. He was elected to a fellowship of the college in 1890.[102]

Described as an intensely private person,[103] Michell chose to return in 1891 to a lectureship in Melbourne. Over the following ten years, he cemented his reputation as a world leader in the fields of hydrodynamics and elasticity. Nearly all of his publications are dated between 1889 and 1902, the year in which he was elected an FRS. The Melbourne University mathematics historian John Clark summarised his work as follows.

> In hydrodynamics, he worked on the theory of free stream lines, the highest waves in water, and the wave resistance of a ship. In elasticity, his papers were the first to formulate the complete system of fundamental equations in terms of stress components only, he gave the first account of thin-plate theory which was free from questionable assumptions, and he systematized and extended the theory of flexure and torsion of beams.[104]

During this time, George (Anthony George Maldon Michell, 1870–1959) was establishing his

John Henry Michell, 1863–1940.

name as an engineer and inventor, having returned to Melbourne in 1890 for further university studies. His mathematical analysis of fluid motion, viscosity and lubrication led to the patenting in 1905 of the Michell Thrust Bearing, which totally revolutionised thrust technology in the field of marine propulsion.[105] He was also noted for the design of a number of crankless engines. In 1934, George joined his brother as an FRS.

John Michell took up his appointment as professor of mathematics in the University of Melbourne in 1923, aged 59, and held that post until his retirement in 1928 when he accepted the title of Honorary Research Professor. He was the first university professor of mathematics to be born in Australia although R. J. A. Barnard had the title Professor of Mathematics at the Royal Military College, Duntroon, from 1911 to 1922, and his successor as professor at Duntroon, A. D. Gilchrist, had been titled Professor of Engineering and Surveying at the Ballarat School of Mines from 1908. As a lecturer and then professor, Michell's interests turned more towards teaching and to pure mathematics, and he was a keen supporter of the Melbourne Mathematical Society and later the Mathematical Association of Victoria—he gave the inaugural address, titled "Arithmetical foundations of the theory of functions", at the first general meeting on 17 July 1906. Although formal research had ceased for him, his frequent talks to the Association showed a continuing originality.

In retirement, Michell's most rewarding activity was the writing of *Mathematical Analysis*[106] with his former colleague Maurice Belz. The two volumes that constitute the text "form only the torso of the work which the authors projected" and although the manuscript for the third and final volume was largely completed, it was never published.[107] Michell died after a brief illness on 3 February 1940.

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Maurice Henry Belz had joined the mathematics department around the same time as Michell was appointed professor. He was born in Auburn, in the western suburbs of Sydney, on 1 February 1897, attended Sydney Boys High School and gained a BSc from the University of Sydney in 1918, having first studied arts and engineering. He won the university medal in mathematics, was appointed demonstrator in physics in Sydney and two years later was awarded a Barker graduate scholarship which saw him enter Gonville and Caius College, Cambridge. With an MSc from there in 1922, Belz was appointed a year later to a lectureship in mathematics at the University of Melbourne. In 1929, as senior lecturer, he introduced a course in the theory of statistics. For the three years 1933–1935, Belz worked in the London School of Economics and the University of Oslo carrying out research into the application of mathematics to economics.

On his return to Melbourne, he resumed his senior lectureship and taught mathematical economics in the Faculty of Commerce. He was promoted to associate professor in 1940 and in 1948 was appointed head of the first autonomous statistics department in the country. Belz was professor of statistics from 1955 to 1963, the first to hold such a position in Australia apart from Pat Moran at the Australian National University. Moran, incidentally, expressed surprise at the time that there were no other applicants for the Melbourne chair.[108] Belz died in Melbourne on 28 March 1975.[109] When his widow Florence died in 1995 she left a bequest of almost $500,000 to the university for the establishment of a fund to enable statistical study abroad.

Belz's lectureship in 1923 meant there were four full-time staff in the Department of Mathematics. The year before had seen the appointment of Barnard as senior lecturer and there was another new senior lecturer, Gunnar Gunderson, a former student, who was first appointed to take the evening lectures in 1921. Gundersen, as he was known whilst an undergraduate,

matriculated to the University in 1898 and studied in an irregular but laudable fashion from 1901 to 1907 to earn a BSc. He remained in the department 20 years but a debilitating stroke in 1937 saw him move to half pay until his services were terminated five years later. The new professor, Michell, was the fourth member of the department.

The appointment of Barnard, Belz and Gunderson followed the advertising in September 1922 of three lectureships in mathematics "at salaries of £500, £450 and £350 respectively." Besides these three, among the 20 or so applicants were a number who would subsequently go on to positions in mathematics around the country. They included William Statton and Herbert Nietz, both from Adelaide; James McCarthy from Queensland; and Edwin Pitman who later gained fame as professor of mathematics in the University of Tasmania.[110]

Another of the applicants was Winifred Ellen Waddell, born in Cumberland, England, in 1884. She held a BSc with second-class honours in mathematics from Royal Holloway College, London, and taught mathematics at the Melbourne Church of England Girls Grammar School from 1916 to 1940; the school still awards the Winifred Waddell Memorial Prize for Mathematics. She was a tutor at Melbourne University from 1942 to 1945 and much earlier had written an elementary trigonometry book[111] with D. K. Picken. Waddell is best remembered, however, as one of Australia's first conservationists, an area in which her interests continued to grow and in which her renown came after retirement from work in mathematics. She died in 1972.[112]

Many of Michell's students went on to gain distinction in mathematics or a related field. Among them were Samuel McLaren; Joseph Baldwin; Kerr Grant; Glenny Smeal; Harrie Massey; and his successor in the chair, Thomas MacFarland Cherry.

Samuel Bruce McLaren was born in Japan in 1876 and came to Australia with his parents when he was ten years old. He graduated BA from Melbourne University with first-class honours in mathematics in 1897 and went to Trinity College, Cambridge, where he again took out a BA with first-class honours. He held lectureships at University College, Bristol, and at Birmingham University before accepting the chair of mathematics at University College, Reading, in 1913. McLaren's research in aspects of mathematical physics was described as anticipating that of Albert Einstein and Max Abraham,[113] but Cherry, while recognising McLaren's brilliance, would later say: "His work lay mainly in the theory of Radiation, but, as it was on the losing side of the struggle against quantum ideas, its scientific importance was only transient."[114]

McLaren visited Australia in June 1914 for a meeting of the British Association for the Advancement of Science and had a difficult passage back to England following the outbreak of World War 1. He was perhaps the most able Australian mathematician not to survive wartime service, in any war. Despite a "loathing of bloodshed", McLaren resolved to serve in an active capacity and was commissioned as lieutenant in the Royal Engineers. He was attached to an infantry brigade near Abbeville, France. "Absolutely fearless and intrepid to an extent which made him both an anxiety to his brother officers and an inspiration to his men", he was wounded in July 1916 while clearing bombs out of a burning ammunition dump and died in hospital a few weeks later.[115]

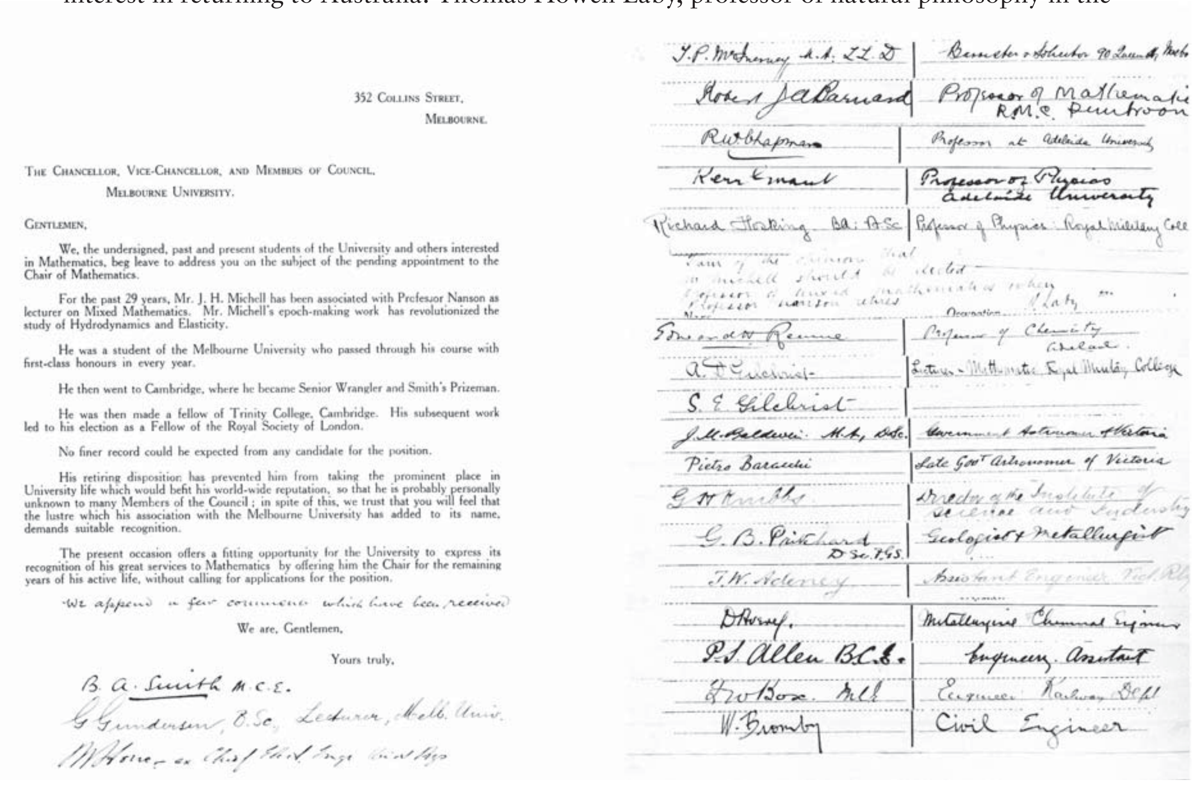
Joseph Mason Baldwin (1878–1945) was Victoria's government astronomer from 1920 to 1943. He graduated from Melbourne University BA (1900), BSc (1901), MA (1902) and DSc (1913).

Kerr Grant was born in Bacchus Marsh, Victoria, in 1878. He gained his BSc with first-class honours in 1901 and then lectured for a year in mathematics and physics in the School of Mines in Ballarat. He obtained an MSc in Melbourne in 1903 and taught at Ormond College in the

University of Melbourne before undertaking further studies at the University of Göttingen. On returning to Australia, Grant lectured in natural philosophy at Melbourne and was then appointed acting professor of physics in the University of Adelaide in 1909 and professor of physics from 1911 to 1948. He was knighted in 1947 and died in 1967.

Not too much is known about Glenny Smeal. He was born on 13 February 1890 and graduated BSc from the University of Melbourne in April 1911 scooping up many exhibitions and prizes—by far the best mathematics student of his day. The university records show that an MSc was conferred on him in April 1926 but give no other details. From 1912 to 1914 he attended Imperial College, London, and he was then assistant lecturer in mathematics at the University of Edinburgh until 1921 when he moved to the University of Leeds. There he was appointed assistant lecturer in graphics and computation in 1921 and then lecturer in statistical method and computation in 1925, one of the first anywhere to teach in that area. He retired in September 1946.[116]

Harrie Stewart Wilson Massey was born on 16 May 1908. He gained his BSc at the University of Melbourne in 1927, followed by a BA and MSc in 1929. Following a PhD from Cambridge University in 1932, Massey took a lectureship in mathematical physics at Queens University, Belfast, from 1933 to 1938, and was then, in a long career at University College, London, successively Goldsmid Professor of Mathematics until 1950, Quain Professor and head of the department of physics until 1972, and head of the department of physics and astronomy until 1975. At the time when Carslaw's successor in Sydney was being sought, Massey expressed interest in returning to Australia: Thomas Howell Laby, professor of natural philosophy in the



352 Collins Street,
Melbourne.

The Chancellor, Vice-Chancellor, and Members of Council,
Melbourne University.

Gentlemen,

We, the undersigned, past and present students of the University and others interested in Mathematics, beg leave to address you on the subject of the pending appointment to the Chair of Mathematics.

For the past 29 years, Mr. J. H. Michell has been associated with Professor Nanson as lecturer on Mixed Mathematics. Mr. Michell's epoch-making work has revolutionized the study of Hydrodynamics and Elasticity.

He was a student of the Melbourne University who passed through his course with first-class honours in every year.

He then went to Cambridge, where he became Senior Wrangler and Smith's Prizeman.

He was then made a fellow of Trinity College, Cambridge. His subsequent work led to his election as a Fellow of the Royal Society of London.

No finer record could be expected from any candidate for the position.

His retiring disposition has prevented him from taking the prominent place in University life which would befit his world-wide reputation, so that he is probably personally unknown to many Members of the Council; in spite of this, we trust that you will feel that the lustre which his association with the Melbourne University has added to its name, demands suitable recognition.

The present occasion offers a fitting opportunity for the University to express its recognition of his great services to Mathematics by offering him the Chair for the remaining years of his active life, without calling for applications for the position.

We append a few comments which have been received

We are, Gentlemen,

Yours truly,

B. A. Smith M.C.E.
G Gundersen, B.Sc, Lecturer, Melb. Univ.

J.P. McInerney M.A. LL.D	Barrister & Solicitor 90 Queen St, Melb
Robert J A Barnard	Professor of Mathematics R.M.C. Duntroon
R W Chapman	Professor at Adelaide University
Kerr Grant	Professor of Physics Adelaide University
Richard Hosking BA: BSc	Professor of Physics Royal Military Coll
Edward H Rennie	Professor of Chemistry Adelaide
A. F. Gilchrist	Lecturer Mathematics Royal Military College
S. E. Gilchrist	
J. M. Baldwin M.A., D.Sc.	Government Astronomer Victoria
Pietro Baracchi	Late Govt Astronomer of Victoria
G H Knibbs	Director of the Institute of Science and Industry
G. B. Pritchard D.Sc. F.G.S.	Geologist & Metallurgist
J.W. Adeney	Assistant Engineer Vic Rly
D Avery	Metallurgical Chemical Engineer
P.J. Allen B.C.E.	Engineering Assistant
[illegible] M.E.	Engineer Railway Dept
W. [illegible]	Civil Engineer

The petition calling for Michell's appointment as professor and the first of five pages of signatures in support. (University of Melbourne Archives)

University of Melbourne from 1915 to 1944, wrote as follows to the vice-chancellor in Sydney: "I have had a cable from Massey asking me if it was intended to create a chair of applied mathematics in Sydney ... I have not heard whether Massey will apply for the pure mathematics chair advertised."[117] Massey was honoured many times by awards of the Royal Society and Royal Astronomical Society, was knighted in 1960, and died on 27 November 1983.

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Tom Cherry, the last of those eminent students mentioned above, was to have a long and celebrated career as professor of mathematics in the University of Melbourne. The circumstances by which he was appointed to the chair are in stark contrast to Michell's, six years earlier.

Michell had been Nanson's deputy for some 30 years and had had his FRS conferred 20 years before, so for all of that time his reputation far exceeded Nanson's. When news reached Kerr Grant in Adelaide of Nanson's retirement a year before it was to occur, Grant quickly wrote to Nanson that by "appointing Michell as your successor the Council will only be doing the right thing towards him: but they will honour themselves in so doing and ensure with certainty that the high reputation of the Melbourne University School of Mathematics will be splendidly upheld." More impressive was a petition organised by Gunnar Gunderson, Bernhard Alexander Smith and William Stone. Smith was a successful engineer who had studied mathematics with Nanson in the 1880s; as a lecturer in hydraulic engineering in the university he came into conflict with the professor, William Kernot, for an over-emphasis on the mathematics behind the topics.[118] Stone also taught engineering in Melbourne and pioneered the development of radiology in Australia. Both were also associated with John Michell's brother, George. Smith was in a professional partnership with George Michell until 1903 and Stone was an assistant in his research on crankless engines.

The petition contained 73 further signatories who were "past and present students of the University and others interested in Mathematics", and implored the council to offer Michell the chair "for the remaining years of his active life, without calling for applications for the position." The signatories included Grant, Laby and Barnard, as well as R. W. Chapman, A. D. Gilchrist, G. H. Knibbs and C. E. Weatherburn. The university council acceded and appointed Michell to the chair in July 1922 with no call for further applicants.[119]

Grant's reference to the "high reputation of the Melbourne University School of Mathematics" was not, incidentally, agreed to by the loyal deputy, Michell himself. In an obviously frustrated reference to Nanson's headship, he wrote:

> The general position is perhaps best brought out by the statement that during the last thirty years, while the Sciences and their applications have grown so enormously, absolutely nothing has been done to improve the School which deals with the foundations of all quantitative science. The scope of the lectures has remained the same, in spite of the great advances in both Pure and Mixed Maths. and the method of teaching has still the frivolous character of pre-scientific days.[120]

Cherry's accession to the chair followed the standard path for the times, but in retrospect bordered on the sensational. He had by then a distinguished record of attainment in mathematics, although he would not have been very well known outside Britain and Australia. Testimonials that accompanied his application were from H. F. Baker, Sir Joseph Larmor, J. E. Littlewood, E. A. Milne, L. J. Mordell, J. J. Thomson and E. T. Whittaker, certainly an eminent assemblage, and Carslaw had also written an unsolicited letter of support.[121] The fact that Cherry belonged to the Melbourne University establishment, his father having been professor of agriculture there some twelve years before, might well have clinched the appointment for him.

There were altogether nine candidates for the chair. They included Wilfred Wilson, described by L. E. J. Brouwer in a testimonial as a founder of infinitesimal geometry; C. A. Stewart, a *b** wrangler from Trinity College, Cambridge, who took John Wilton's position at the University of Sheffield when Wilton was appointed Elder Professor of Mathematics in the University of Adelaide; Frederick Nowlan who had completed a PhD under Leonard Dickson at the University of Chicago; and R. C. J. Howland, then a senior lecturer at University College, London. Belz and Barnard were also candidates.

Outshining all of these was the candidacy of Norbert Wiener. Born in the United States in 1894, Wiener obtained a PhD in mathematics from Harvard University at age 18 and then studied in England and Europe under Bertrand Russell, G. H. Hardy, Edmund Landau and David Hilbert. He would come to be known as the master of the Fourier integral and harmonic analysis and was the inventor of the field of cybernetics. He joined the Massachusetts Institute of Technology (MIT) at the end of World War 1 and was assistant professor there with "some fifty-six titles" in publications when he applied in July 1928 for the chair of mathematics in Melbourne.

Wiener's application was supported by testimonials from the cream of European mathematics. Hardy wrote that he was "quite obviously one of the very best American mathematicians" and there were similar statements from Harald Bohr, Max Born, Constantin Carathéodory, Maurice Fréchet, David Hilbert, Oliver Kellogg, Henri Lebesgue, Paul Lévy, Charles de la Vallée Poussin, Oswald Veblen and Hermann Weyl.

There was one other testimonial, from William S. Franklin, a colleague of Wiener's at MIT. While offering a strong recommendation regarding the quality of Wiener's mathematics, Franklin went on to say: "Professor Wiener is of the Hebrew race, and he has very peculiar traits, but personally he is of the finest grade." Edmund Whittaker in England was a member of a committee to advise the selection committee in Melbourne. He had already written to Sir John MacFarland, chancellor of the university, that there was "no other candidate, or possible candidate, so far as one can see, whose distinction in research is so great as Dr Cherry's." In his final report in October 1928 he wrote: "Two of the candidates, namely Dr T. M. Cherry and Professor N. Wiener, are very distinctly superior to all the others. Mr Wiener however does not appear to have adequate qualifications as a general teacher and administrator. Some of the letters regarding him refer to his 'very peculiar traits' and his lack of administrative experience." There was consequently a unanimous recommendation for Cherry, mirrored in Melbourne by the full selection committee, consisting of Sir Thomas Lyle, D. K. Picken and B. A. Smith, who was mentioned above in connection with the petition organised on behalf of John Michell, together with Michell himself and Nanson.[122]

The English analyst Percy Daniell in a testimonial for C. A. Stewart stated that he was aware that Wiener was also an applicant and that he thought Stewart was more suited to the requirements of the position, and there are other allusions to Wiener's inadequacy as a lecturer in the copious material written about him. Wiener himself was sanguine about the matter and saw the result differently. In his autobiography, writing of perceived barriers against his further progression in America, he continued:

> In default of American offers for an improved position coming through the normal channels, I began to look around and to see if I could not do something for myself elsewhere. The British universities and the universities of the British colonies operate under the legal provision that if any vacancy occurs it must be advertised and the applications of all candidates must be

> considered at least in a formal way. This requirement is not taken too seriously, and in many cases a decision has already been made for all practical purposes at the time the vacancy has been advertised. These advertisements appear on the back pages of Nature and other British intellectual publications. I sent in my name for one vacancy at Kings College in London and for one in Australia, but of course nothing happened.[123]

It would be hard to dispute Wiener's claim that a decision had already been made. Furthermore, except perhaps for Maurice Belz, born in Sydney but with a German father, no professor of mathematics or statistics in Australia was other than of British or Irish background until the appointment of Vienna-born John Markus Blatt as professor of applied mathematics at the University of New South Wales a full 30 years after Cherry's appointment. Richard Selleck, in his history of Melbourne University, gave no details regarding the appointment. He wrote only that "[Cherry's] brilliant Melbourne and Cambridge careers led the London committee to recommend him without reservation, and the Council to appoint him with a minimum of discussion."[124] Norbert Wiener deserved more than that.

Thomas MacFarland Cherry

With the authority that would later come to him as one of Australia's great mathematicians of the mid-20th century, Tom Cherry would with humility describe Michell as "pre-eminent" among those that preceded him.[125]

Cherry was born on 21 May 1898 at Glen Iris, an outer suburb of Melbourne, the second child of Thomas and Edith. His father was the first Professor Thomas Cherry of the University of Melbourne, holding the chair of agriculture from 1911 to 1916. Young Tom attended Scotch College, where he was dux in 1914, and the following year entered the University as a resident of Ormond College.

He graduated with first-class honours in mathematics, greatly influenced by the teaching of Nanson, Michell and Charles Weatherburn, who was then a tutor at Ormond College. His subsequent approach to research in mathematics was also influenced by the master of the College, David Kennedy Picken. Keith Bullen described Picken, who was later involved in appointing Cherry to the chair, as having "a first-class logical brain . . . [He] might have had a significant mathematical career were it not for the inhibiting effect of an unbridled passion for formalism".[126] He was born in 1879, was senior lecturer in mathematics at the University of Glasgow from 1903 and then professor of mathematics at Victoria University College, New Zealand, from 1908. Picken was appointed master of Ormond College in 1915, and held that post until retirement in 1943. He died in 1956.

Cherry had some army and air force service in 1918 during which, in his words, he was enabled "to learn telegraphy and solo whist" and he began studies for a medical degree a year later. He abandoned these in favour of travelling to Trinity College, Cambridge, where he gained his BA as a b^* wrangler in 1922. By 1924, Cherry had a Smith's prize, a PhD and a fellowship of Trinity College which he maintained until 1928. During this time he taught for short periods at the University of Manchester and then the University of Edinburgh, the whole while continuing his research in the ordinary differential equations of dynamics and celestial mechanics. Over the period 1923 to 1938, he published 13 papers in this field, bearing mainly on periodic solutions and relations between different manifolds of periodic solutions, and on the possible complexities of non-periodic solutions.[127]

It was also a time for Cherry to invoke his passion for mountaineering. He climbed the Matterhorn and crossed the French Pyrenees, and, like T. G. Room, was an avid scoutmaster.[128] Years later, he would be president of the Melbourne University Mountaineering Club. Walter Freiberger, a student of Cherry's and later professor of applied mathematics at Brown University in the USA, recalled that Cherry led a party of six students in an attempt on the last unclimbed mountain in Tasmania, Federation Peak, in 1949:

> The Tasmanian Government dropped food for us by air at strategic points. We were in that horizontal scrub about three weeks. It was raining continuously. One has to traverse the bush high above ground (the trees fall over and create a sort of grid). By the time we got to the mountain and started climbing we had run out of food, were cold and miserable, and had to turn back for the long trek home. We were written up in the local papers. Very disappointing. The mountain was climbed very shortly after that by a large party of schoolboys under a master (I forget what school), establishing base camps and able to wait for favourable weather.[129]

Cherry returned to Melbourne, to the chair of mathematics, pure and mixed, in March 1929. Throughout his tenure of this chair, until 1952, he presided over the mathematics standing committee of the University's Schools Board and was responsible for major reforms of the mathematics syllabuses in Victorian schools.[130] He took a keen interest in the work of the Mathematical Association of Victoria, being installed as president immediately upon his return, and this interest was acknowledged in 1956 with his election to honorary life membership of the association.

By 1944, references to "mixed mathematics" had been dropped in favour of "applied mathematics", and in 1952 Cherry's position was changed to professor of applied mathematics, though with some regret on his part. Keith Bullen explained why:

> He regarded himself as essentially a pure mathematician—though his interest was not in modern abstract mathematics—whose tastes led him intermittently to use his analytical skills in a variety of contexts. Where many applied mathematicians nowadays put context first and the mathematics second, mathematical analysis came first with Cherry.[131]

Bullen was well acquainted with Cherry as he had been appointed lecturer in applied mathematics in the University of Melbourne in 1940; six years later he was to become professor of applied mathematics in the University of Sydney. Keith Edward Bullen was born on 29 June 1906 in Auckland, New Zealand, attended local schools and entered Auckland University College in 1923. In gaining his BA in 1925, majoring in pure and applied mathematics, he was the top student across all the colleges of the University of New Zealand. He taught at Auckland Grammar School in 1925, but continued part-time studies at Auckland University College and was awarded an MA with first-class honours in mathematics at the end of 1927. From 1928 to 1931, he lectured in mathematics at Auckland University College and at the same time studied for a BSc, majoring in physics and again receiving first-class honours. In September 1931, Bullen took leave of absence to study at St John's College, Cambridge, returning in 1934 to his position as lecturer and later senior lecturer in mathematics in Auckland.[132] In November 1933 the chair of mathematics there was filled by the geometer Henry George Forder (1889–1981); Bullen at age 27 was a candidate and might well have been offered the chair had Forder declined it.[133]

When he went to Cambridge, Bullen commenced the standard course of study for the tripos, but he sought a more accelerated program. Within a few months, he began work as a research student, with Harold Jeffreys as supervisor, on the travel times of seismic waves taking into account the ellipsoidal shape of the earth. The Jeffreys-Bullen tables[134] that resulted have proven

to be outstandingly accurate. In calculating the ellipticity corrections it was necessary to determine the variation of the earth's density with radius and Bullen's discovery of the discontinuities in the distribution of density established his reputation and became a recurring theme in his life's work.[128] Bullen was back in Auckland when he completed his studies for the PhD and it was not long afterwards that he obtained the position in the University of Melbourne.

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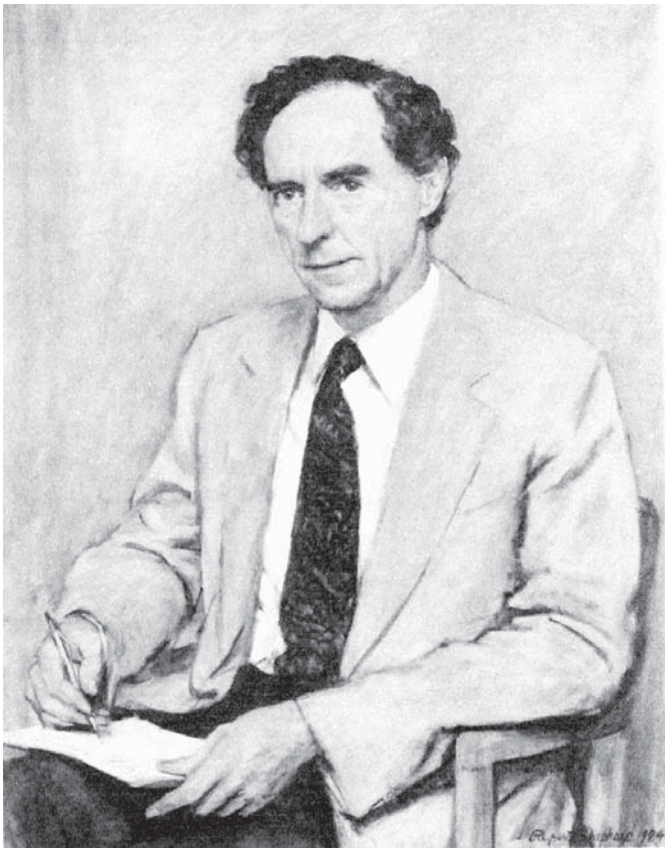
Eight years earlier, Malcolm Livingstone (Mac) Urquhart had been appointed lecturer there, replacing R. J. A. Barnard. Born on Cape Barren Island, Tasmania, in 1902, Urquhart had attended the Hutchins School in Hobart, worked briefly as a surveyor and railway engineer, and entered the University of Tasmania in 1923. He soon changed from his original engineering course to science and graduated BSc in 1926 with majors in physics and applied mathematics. Two years later, Urquhart left Australia to study the then new subject of wave mechanics at Bristol University, but, with his work towards a PhD nearly complete, he discovered quite accidentally that results the same as his had a short time before been described in an Italian journal. He was thereby unable to submit his work and it has been speculated that the resulting disappointment may well have led to his refusal to publish any of his later research findings.[136]

Returning to Australia to the post in Melbourne, Urquhart soon distinguished himself by the quality of his teaching. A later colleague, David Elliott at the University of Tasmania, wrote that he "was very fond of the Socratic method. He had a wonderful facility for stripping all the non-essentials from a mathematical problem, so that he could consider it in its simplest and most fundamental terms."[137] The period 1932 to 1943 that Urquhart taught in Melbourne, with Cherry, Gunderson and Belz and later the senior lecturers Keith Bullen and Russell Love, as well as a number of senior tutors and tutors, was remarkable for the honours graduates who went on to chairs in mathematics or mathematical science around the world.

Two of these, George Keith Batchelor and Richard Henry (Dick) Dalitz, became fellows of the Royal Society and corresponding members of the Australian Academy of Science.

Batchelor was a "towering" figure in the field of fluid dynamics. After graduating from Melbourne University in 1940, and obtaining a master's degree a year later, he undertook four years of wartime work at the Aeronautics Division of the CSIR at Fishermans Bend, a suburb of Melbourne. His work there, on fluid flow problems in aircraft engines, was undertaken in large part with Albert Alan Townsend, a physics graduate of the University of Melbourne, and was to inspire much of their subsequent work together. Batchelor travelled to Cambridge, with Townsend following, and both undertook research supervised by Sir Geoffrey Ingram Taylor. By 1948, Batchelor had made "major theoretical advances", and his essay describing them won him a fellowship at Trinity College, a PhD, the Adams Prize, publication as a book,[138] a lectureship in the mathematics faculty at Cambridge and, in 1957, his FRS. He stayed at Cambridge for the rest of his life. In 1959, he was made reader in fluid dynamics and in 1964 professor of applied mathematics. He retired in 1983. Batchelor is particularly remembered for founding the *Journal of Fluid Dynamics* in 1956, and remaining its editor until 1999, and for his part in establishing the Department of Applied Mathematics and Theoretical Physics at Cambridge University, thereby having applied mathematics recognised as an experimental science.[139] Batchelor was born in Melbourne on 8 March 1920 and died in Cambridge from Parkinson's disease on 30 March 2000.



George Keith Batchelor, 1920–2000 from a portrait by Rupert Shepherd, 1984.

Townsend also had a distinguished career at Cambridge and gained an FRS in 1960.

Dick Dalitz, born at Dimboola in Western Victoria on 28 February 1925, entered the University of Melbourne in 1942 and left in October 1946 for Cambridge, having already had some success in research on the flow of compressible fluids under Cherry's supervision. With his Cambridge PhD gained in 1950, he was appointed lecturer in mathematical physics at Birmingham University. Noted for decisive contributions to the phenomenology of elementary particle physics, Dalitz became a Royal Society Research Professor at Oxford University in 1963 after a period with the Enrico Fermi Institute for Nuclear Studies in the University of Chicago. He was elected FRS in 1960 and was awarded the Hughes Medal of the Royal Society in 1975. Dalitz, who died on 13 January 2006, was one of three in his class of 1941 at Scotch College, Melbourne, to gain the FRS.[140]

The other two were John Robert Philip and Alan Kenneth Head, both of whom had distinguished careers in CSIRO. Philip completed only two years of mathematics in his undergraduate engineering course at Melbourne University but his reputation was as an environmental physicist and mathematician (and poet).[141] He died when struck by a car in Amsterdam in June 1999, aged 72, having just completed two weeks as a visitor at the Centre for Mathematics and Computer Science there. Head's work also showed a mathematical bent: he gained his PhD at the University of Bristol with a thesis that developed the first quantitative theory of the development of cracks in metals.

Others of this era who gained overseas chairs were Herbert Charles Corben, who has previously been referred to in connection with the New England University College, Walter Frederick Freiberger and Geoffrey Stuart (Geof) Watson.

Freiberger was born in Vienna on 20 February 1924 and went to Clare College, Cambridge, in 1950 after gaining a BA in 1947 and an MA two years later at the University of Melbourne. Like Batchelor, he obtained a PhD under G. I. Taylor. In 1955 Freiberger took a research position in the Division of Applied Mathematics at Brown University in Providence, Rhode Island, and began a varied career there that encompassed computer science, statistical meteorology and actuarial mathematics. While continuing to hold a substantive appointment as professor of applied mathematics, Freiberger turned also to medical statistics in the 1980s and became professor of community health in the Brown medical school. Since 1965, he has been managing editor of the *Quarterly of Applied Mathematics*.

Watson was born in Bendigo on 3 December 1921 and graduated from Melbourne University in 1942. He gained a PhD from North Carolina State University in 1951 and a DSc from Melbourne University in 1967. He had returned there from North Carolina, to a senior lectureship in statistics, and in 1954 took a senior fellowship at ANU. Three years later he left for England and North America, taking positions at the University of Toronto and the Johns Hopkins University before being appointed to the chair of statistics at Princeton University in 1970. A specialist in the application of mathematics and statistics to the natural sciences, particularly geophysics, molecular genetics, and animal behaviour, Watson died on 3 January 1998 four weeks after a heart attack. In April that year he was to have been awarded an honorary DSc from the Australian National University.[142]

Besides Batchelor, Dalitz and these three, all of whom gained distinction overseas, the following students of the same period in Melbourne at some time held chairs in Australian universities: Angas Hurst, Harry Levey, Russell Love, Gordon Newstead, Fenton Pillow, Rainer Radok, Phil Silberstein, Roy Smith and Kevin Westfold. Pillow and Radok also held chairs outside Australia. Smith has already been introduced here and all the others, except Newstead, will appear again later in these pages.

Gordon Henry Newstead (1917–1987) was a collaborator of John Jaeger's, joining him at ANU as professor of engineering physics from 1965 to 1970, while Jaeger was dean of the Research School of Physical Sciences. Newstead had previously been professor of electrical engineering in the University of Tasmania. His degree in 1939 from the University of Melbourne was in engineering but as part of his studies there he obtained first-class honours in "Mixed Mathematics III".[143]

Elizabeth Hebden Mann, Graham James Odgers and Andrew Crowther Hurley are three further mathematics honours students of that time who gained great distinction in their fields of science.

Mann, born at South Yarra, Melbourne, in September 1922, made a career in mathematics at the University of Cambridge. Her schooling was at the Melbourne Girls Grammar School and then Clyde School, Woodend, with extra tuition in mathematics from Winifred Waddell. While completing her PhD in Cambridge with a thesis on the elastic theory of dislocations, Mann met Abraham David Yoffe and they were married in mid-1949. Abe Yoffe had studied chemistry at Melbourne University and was also to gain eminence at Cambridge.

Odgers, born in 1921, became an astronomer. He moved to Victoria, British Columbia, around 1950 and was awarded a DSc by the University of Victoria in 1998.

Of these three, only Hurley forged his career in Australia. He was born in Melbourne on 11 July 1926, one of six talented siblings. He went to Cambridge after excelling in mathematics, physics and chemistry in Melbourne and completing an MA under Hans Schwerdtfeger, who had taken up a senior lectureship in mathematics in 1948, with a thesis titled *Finite Rotation Groups and Crystal Classes in Four Dimensions*. This was to be the title of his first publication[144] and initiated a lifelong interest in the applications of group theory within theoretical chemistry. Following a year at the Massachusetts Institute of Technology, he spent the years from 1957 until his death in 1988 with the CSIRO, being appointed principal scientific officer at the early age of 31.[145]

One of Andrew Hurley's siblings was an older brother, David. He was a classmate of Elizabeth Mann's at the University of Melbourne and was to spend more than twenty years in the mathematics department of UWA. He retired from there at the end of 1988 as an associate professor in applied mathematics. David George Hurley was secretary of the Australian Mathematical Society from 1977 to 1979; he was born in 1923 and died in February 2000.

Mac Urquhart, meanwhile, would no doubt have been content to remain on staff at the University of Melbourne but he contracted tuberculosis in 1943 and returned to Hobart to recover. Four years passed before he was able to resume a career in mathematics, at which time he took a lectureship in the University of Tasmania.

Eric Russell Love was both student and teacher at Melbourne University during Urquhart's time. He was born in London on 31 March 1912 and came to Australia with his family in 1922. He completed his schooling as dux of Melbourne's Scotch College and went on to gain honours in mathematics at the University of Melbourne in 1933. He was taught by Cherry, Picken and Barnard, as well as Urquhart, but remembered Urquhart as "different":

> different in dress, different in the things he talked about, different in the ways he conducted lectures, different in the ways he spent his time. Whether he set out to be different or not . . . he left a quite distinctive image in our memories. He surprised us by expecting us to consider a certain theorem in analytical dynamics 'beautiful'. He astonished us by describing how he had had the task of deducing, from a survey of the ruins of an aeroplane, how the crash had come about. He rampaged about commercialism and meaningless slogans in advertising . . . His mind was restless and critical, and he did everything to stimulate us into thinking.[146]

On a travelling scholarship, Love attended Trinity College, Cambridge, and gained his PhD there in 1938 having shared the Smith prize with Harry Raymond Pitt. He taught briefly at Queen Mary College, University of London, and then Durham University before taking a lectureship in mathematics at Melbourne University in 1940. After a period of civilian war service, he was promoted to senior lecturer in 1945 and, in November 1952 when Cherry became professor of applied mathematics, was appointed professor of pure mathematics. His outstanding contribution to the theory of fractional calculus, begun at Cambridge, would continue throughout his long working life.

The other lecturer during this distinguished period, although necessarily at the very end of it, was Felix Adalbert Behrend. He had arrived in Fremantle in August 1940, one of over 2,500 men aboard *Dunera*. The story of the passage of this ship from Liverpool with its "cargo" of refugees, who were destined to enrich Australia's cultural, artistic and scientific profile, has been told many times. In particular, Hans Lausch, a Monash University mathematician and historian who has made a study of refugee mathematicians in Australia, has written of Behrend's experiences.[147] On board *Dunera*, Behrend gave lectures in number theory and the theory of

relativity (with his class using the backs of soup can labels to take notes). Taken to the internment camp at Hay in southern New South Wales, he contributed with enthusiasm to a school for his fellow detainees, teaching up to the level of second year university to prepare students for examinations of the University of Melbourne.

Behrend was born in Berlin on 23 April 1911. At school there he began a lifelong friendship with Bernhard Neumann who was appointed in 1962 as foundation professor of mathematics at ANU. Behrend studied mathematics, physics and philosophy at the Universities of Berlin and Hamburg and obtained a doctorate from the University of Berlin in 1933, but he was forced to flee from Nazism in September 1934. He travelled first to Cambridge, then to various European centres, working as an actuary, furthering his studies and meeting the leading mathematicians of the day. After gaining a second doctorate from Charles University in Prague, the imminent outbreak of war again entailed a move to England where he was interned in June 1940.

Behrend was appointed to a tutorship in mathematics at the University of Melbourne in 1942 and to a lectureship the following year. His research interests were originally in number theory but later broadened to analysis in general and to axiomatics. He was promoted to senior lecturer in 1948 and associate professor in 1954, and would have been a strong candidate for a personal chair but illness led to his premature death on 27 May 1962, aged just 51.[148]

Some years younger than Behrend, Rainer Radok and Walter Freiberger were also passengers on board *Dunera* and also interned on arrival in Australia. Freiberger attended Behrend's classes in Hay, as did other *Dunera* internees who were to make careers in mathematics or mathematical science in Australia. These included Julius Guest and Gerald Schaefler, who taught at the Royal Melbourne Institute of Technology; Mendel Weisser, who was an econometrician at the University of New England; and Hans Adolph Buchdahl, a noted theoretical physicist who spent 20 years in the University of Tasmania before taking a chair at ANU in 1963. The University of Melbourne archives contain detailed notes of the courses Behrend gave at Hay, and at another camp at Tatura in northern Victoria, together with the rolls he kept of attendance at his classes and marks obtained. Behrend threw nothing away—also in the Archives are the notes he took of Erwin Schrödinger's physics lectures in 1929.[149]

This episode of ten years or so in the history of mathematics at the University of Melbourne has been defined by the period of tenure of Mac Urquhart's lectureship, but it would be naive to attribute too much credit to him alone for the excellence that came out of it. Richard Dalitz and Elizabeth Yoffe (née Mann), for example, were keen to acknowledge Cherry as the source of the standards there,[150] and Bullen was effusive on this point.[151] Fenton Pillow would agree but spoke also of a combination of good teaching by Urquhart, Cherry and others, and three further causes.[152]

First was the fact that Melbourne University, through Cherry, also had a tight control of mathematics standards in schools to the extent that the top students of the time were encouraged to obtain scholarships that allowed them to remain at high school for two post-matriculation years of further study. Some were able to manage this extra study without a scholarship. Second, the three-year honours course in mathematics at Melbourne University was entirely distinct from the pass course and its standard was such that from the end of the 1930s it alone of the Australian university mathematics courses allowed entry directly into postgraduate work at Cambridge, with no requirement to complete the tripos for a BA.[153]

But third, and most important, for many there was real life interplay between university studies and permanent or vacation work at the CSIR Division of Aeronautics at a time when

valuable contributions could be made to the war effort, making manifest the relevance of their mathematics.

Many stayed on at the division for up to ten years after the war, often interrupting this work for CSIR-sponsored study in Britain. Pillow, for example, worked there alongside Batchelor and Townsend as well as Levey, Love, Mann, Radok, Silberstein and Smith. For part of the time, he taught at the University; he recalled having Dalitz as a vacation student and lecturing to Freiberger who was a part time university student and full time in the division. Elizabeth Yoffe described the times in part as follows:

> War broke out, and stopped all civilian travel, so for five years the Melbourne graduates were not dispersed in the normal way, but busy on problems of war. They were also safe from attack while many of their contemporaries in England lost their lives. It is not surprising that there was a sudden rush to Britain when peace came, an invasion of keen young scientists and engineers, whole ship loads of them. For example, out of 100 passengers on the *Waiwera*, September 1946, twenty five or so were Rhodes Scholars bound for Oxford, being one from each state for each of the war years.
>
> There were great opportunities for us then, as the war had interrupted the development of the major scientific discoveries preceding it.[154]

Tom Cherry's role in all aspects of this period was crucial. The Division of Aeronautics was established at Fishermans Bend in 1940 and the relationship that developed with the Department of Mathematics in the University of Melbourne was due to Cherry. His own research benefited greatly:

> Because the airplane played such an important role in the war, the development of the jet engine and supersonic flight was thought to be of crucial importance. The field bristled with unsolved problems which could only be solved by combining mathematical analysis (that might be done using Cherry's students) and pioneer engineering (that might be initiated by graduates from Sydney and Perth). Perhaps Cherry's most important work arose out of ARL contact. Using the Legendre transformation, he linearized the compressible flow equations, thereby greatly simplifying the solution process. While this work was not immediately applicable, it stimulated others to take up problems that had been previously regarded as too difficult.[155]

"ARL" stands for the Aeronautical Research Laboratories, attached to the Commonwealth Department of Supply; it replaced the CSIR Division of Aeronautics in 1949. There were other wartime agencies that also attracted Melbourne's young mathematicians: Love worked for two years from 1942 at the Munitions Supply Laboratories, as did Mann for a short while before entering Melbourne University, and Mann, Dalitz and Cherry were associated from time to time with the work of CSIR's Lubricants and Bearings Section, situated within the University.[156]

One of Cherry's biographers and a long time member of the mathematics department in Melbourne, Jim Cross, wrote that in World War 2 Cherry "worked on aspects of military research, among them the mathematics of the klystron and of. . . arrays of radar aerials, the use of calculating machines . . . and operations research." [157]

Among the distinguished graduates of Melbourne University in this period, it is apposite to mention also Betty Lovell Gent, John Joseph Mahony and William Wilson (Bill) Wood. Gent was born in Melbourne on 16 April 1921, attended Melbourne Church of England Girls Grammar School, finishing there as the top student in the state, gained a BA in 1942 and an MA in 1943 from the University of Melbourne and became a research officer in the Division of Aeronautics in 1944. As Betty Cumming, she was then a tutor and lecturer in mathematics at Melbourne University from 1945 to 1961 and a lecturer in mathematics at Monash University from 1962,

promoted to senior lecturer in 1966, until her retirement in 1983. She died after a short illness on 16 February 2003.

Mahony, born on 15 July 1929, was at least five years younger than most of those described here but had a similar training in Melbourne and later a fine professorial career in Brisbane and then Perth. He was also a product of the ARL, being another vacation student of Pillow's and then a scientific officer there from 1951 to 1957. Slightly younger still, Wood was born in London on 1 January 1931 and came to Australia in 1947. He studied at the University of Melbourne and then joined the ARL where he remained until 1965 except for the period 1953–1956 when he undertook ARL-sponsored PhD studies with George Batchelor in Cambridge. In 1965 Wood was appointed reader in mathematics at the University of Melbourne, a position he held until his retirement in 1994.

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By 1952, Cherry's position had changed to professor of applied mathematics, Love had been appointed professor of pure mathematics and there was a separate department of statistics, so the profile of mathematics in the University of Melbourne was quite altered. Joe Gani had come and gone as a lecturer—the beginning of a distinguished academic career that is documented elsewhere in these pages. There were three senior lecturers besides Felix Behrend and Hans Schwerdtfeger. They were Archibald Brown, who went on to a chair at the Australian National University (details in Chapter 7), Charles Angas Hurst and Frederick John Daniel Syer. Hurst's career and Syer's are described in Chapters 5 and 6.

Eleanor Swindells Hutton was a lecturer in the department in 1952 and had been since 1948, the first woman to be appointed to such a post in mathematics in Melbourne, although women had held tutorships there since Sylvia Sarah Martin (née Reilly) did so in 1926. Hutton was first appointed as a tutor in 1938, was promoted to senior lecturer in 1960, and retired soon after. For some years, there were just two in the department with the rank of lecturer, Hutton and another woman, Margaret Lester, whose career ran largely in parallel with Hutton's.

Maurice Belz's department of statistics consisted of him alone for a year or so. By 1952 he had been joined by Geoffrey Watson as senior lecturer and Rupert Thomas Leslie as lecturer. Leslie would later join the CSIRO Division of Mathematical Statistics as deputy to Evan Williams and was then professor of statistics at the University of Strathclyde until his retirement in 1983. Francis Emeric Binet was senior tutor in Belz's department and Alison Grant Doig, a niece of the great physicist Kerr Grant, was the research assistant.

The beginnings in Victoria, if not the whole of Australia, of operations research as an academic study are attributable in large part to Belz. Bruce Craven, who was appointed senior lecturer after Behrend's death and for over thirty years was the university's most prominent practitioner of operations research, is fond of recalling the "notable pioneer occasion when Alison Doig (now Harcourt) and others undertook a cutting stock optimisation by a simplex method calculated by hand, with a tableau stretching across a room."[158] Doig graduated from the University of Melbourne with a BA (1950), BSc (1952) and MA (1958) and was later a senior lecturer in statistics there.

The University of Adelaide, 1910–1944

Robert William Chapman was 23 when he was chosen as assistant lecturer in mathematics and physics to share the teaching with William Bragg. He would succeed Bragg in the Elder Chair in Mathematics and Mechanics.

Chapman was born at Stony Stratford, Buckinghamshire, England, on 27 December 1866. He obtained a BA from the University of Melbourne in 1886, with first-class honours in mathematics and physics, and two years later graduated with an MA and a Bachelor of Civil Engineering. His first position at the University of Adelaide came in the following year and at the same time he taught mathematics at the South Australian School of Mines and Industries, which had been established next door to the university in 1888. With a preference and great aptitude for applied problems, Chapman was appointed lecturer in engineering in Adelaide in 1901 and in 1907 became the University's first professor of engineering.

His appointment as Elder Professor in the two disciplines of mathematics and mechanics in 1910 was, according to Ren Potts, an "obvious economy measure" at a time when the University was in financial difficulties. Bragg's responsibilities in physics were accorded a separate chair, filled by Kerr Grant. Chapman's teaching load included lectures on railway engineering and strength of materials in addition to nine hours a week of mathematics, yet he took part in a wide range of activities within the university and in the broader educational, industrial and civic life of South Australia.[159] In 1919 he was able to merge his academic interests by producing a text on astronomy for surveyors.[160] Known affectionately as Chappie,[161] he was reappointed professor of engineering in 1920 and retired in 1937. He was knighted that year, and died in 1942.

John Raymond Wilton

With an improvement in its financial position following the end of World War 1, in 1920 the University was able to appoint a professor of mathematics having responsibilities in no other field. The choice was John Raymond Wilton.

Wilton was born at Port Fairy, Victoria, on 2 May 1884 and spent his early years at Mount Barker, South Australia. He began studying engineering at the University of Adelaide but instead, in 1902, completed an honours degree in mathematics and physics under Bragg who described him as "having had the greatest natural genius for mathematics among any of his students during his more than twenty years in Adelaide."[162] On Bragg's suggestion, Wilton entered Trinity College, Cambridge, in October 1904 with the aid of a sizarship, and he gained his BA as fifth wrangler in 1907. He then completed Part 2 of the natural sciences tripos, rather than proceeding with the mathematics tripos, and obtained first-class honours in physics. This was later viewed by his biographers as a "serious mistake" as he would otherwise have attained distinction as a mathematical analyst much sooner.

Wilton worked in the Cavendish laboratory in Cambridge until being appointed to an assistant lectureship in mathematics at Sheffield University in 1909. He began publishing in partial differential equations, hydrodynamics and elliptic functions and was awarded a DSc from Adelaide in 1914, but his work was interrupted by the outbreak of war:

> The war affected him very deeply, and he suffered as a pacifist. He had been doing some X-ray work in a hospital before conscription was introduced, and he hoped to be allowed to continue it, but the tribunal before which he appeared directed him to St. George's Hospital, London, where for two years, till the end of the war, he was kept copying "cases" from one book into another. His financial resources were small and he suffered many privations.

In 1919, Wilton gained a lectureship in mathematics at Manchester under Horace Lamb, and at the end of that year was offered the chair in Adelaide. He quickly took upon himself the reorganisation of the University's mathematics courses, unchanged from those he had attended 20 years before, and he was influential also in changes to curricula in the state's school

mathematics. Wilton's preference was for the teaching of pure mathematics and he was happy to pass over the teaching of all applied mathematics to Harold William Sanders, when Sanders was appointed lecturer in mathematics in 1923.

Only eight students graduated with honours in mathematics from the University of Adelaide in the 24 years that Wilton held the chair. These included Herbert Walter Nietz and Josiah William Statton (both of whom graduated in 1921); Colin Kerr Grant and Andrew Paul Guinand (both 1932); and Maurice Chadwick Gray (1940).

Nietz served for many years as senior master in mathematics at Adelaide High School. He had been assistant lecturer in mathematics in the University prior to Sanders' appointment and ended his working life as a lecturer in the Teachers Training College; he died in 1964. Grant was the son of Sir Kerr Grant and became reader in geophysics in the University of Melbourne and Guinand was to be the foundation professor of mathematics in the University of New England.

Statton and Gray became longstanding members of the mathematics department in the University. Apart from a period of war service, Statton was a schoolteacher before obtaining his degree. He then taught at the South Australian School of Mines and was appointed assistant lecturer in mathematics in 1927. In 1941 he was promoted to a lectureship, and he was reader in mathematics from 1950 to 1957. Gray had also worked for the education department in South Australia after obtaining his pass BSc in 1933. He returned to teaching briefly with his honours degree and then took an appointment as assistant lecturer in mathematics in the university in 1943. He was subsequently promoted to lecturer and then senior lecturer and wrote *The Art of Algebra*[163] with Brian Abrahamson in 1971.

Although Wilton did not encourage a large number of students into honours mathematics, he gained great recognition for his own abilities. His interests were to move towards analytic number theory, prompting the doyen in the field, G. H. Hardy, to write that he was "a fine mathematician, with admirable tastes and a natural inclination towards deep and difficult problems. He might perhaps have made a bigger name if . . . he had been content to work in fields which offer cheaper rewards."[164] In Tom Cherry's opinion, Wilton's standing as a research mathematician in Australia was second only to Michell's.[165]

The sad tale of Wilton's final years was told sympathetically by Potts, with Sanders' help:

> In 1934, Wilton was attacked by ill-health and his mathematical research was halted. A long paper, "On the ζ-function of Riemann", had been accepted for publication but returned to him for some revision. Seven years later he was able to begin working through it again and he remarked that he had "seen something that he had been looking for for years". The same evening he had a paralytic stroke which left him with speech and memory seriously impaired. Only those who knew him intimately could tell adequately of the courage and determination with which he fought his way back from that serious illness. In the words of H. W. Sanders, "As he recovered slowly he found that he had to learn mathematics afresh, even his multiplication tables. I remember him once (months after his breakdown) counting up by fours to sixteen and then stumbling, and on another occasion making an integral sign and saying that he had a vague idea that it meant something, but not the slightest idea what . . . He faced all his difficulties with a courage and serenity that were saintly."

Wilton's recovery was such that he was able to return almost to a normal lecture program in 1944, but that April he died of another stroke. Tim Wall, later professor of pure mathematics in the University of Sydney, knew Wilton as "a very eminent mathematician" and had lectures from him on coordinate geometry in that last academic term—"He'd put a figure up on the board and then he wouldn't be able to connect with it, so there were long silences; it was

really a very painful experience, probably for him and for everyone else . . . He didn't want to be prompted from the front rows."[166]

Wilton was awarded a DSc from Cambridge in 1930 and in 1934 was the first recipient of the Lyle medal of the Australian National Research Council. In a tribute at his death, the Faculty of Arts of the University of Adelaide acknowledged Wilton as "a scholar of powerful and sensitive intellect who united highly specialized learning with a broad and deep culture, and a gentleman of unassuming demeanour, warm sympathy, just judgment and steadfast devotion to principle." His personal mathematics library, offered for sale by Mrs Wilton, was snapped up by Edwin Pitman in Hobart and contributed to the relative excellence of the University of Tasmania's collection.[167]

Sanders and Statton, and Gray in the later years, carried an extremely heavy teaching and administrative load when Wilton's health declined. But then, in Potts' words, "mathematics was in for a shock, a shot in the arm, which was to lift it to an activity equal to that anywhere in Australia." The cause was the appointment, in 1940, of Hans Wilhelm Eduard Schwerdtfeger as assistant lecturer in mathematics to teach the Evening Mathematics 1 course.

Schwerdtfeger was born on 9 December 1902 in Göttingen, Germany. After beginning an engineering course during the dire post-war period of hyperinflation, he managed to matriculate to the university there and commence studies in mathematics. He completed them at the University of Bonn where he obtained his DrPhil in 1934, supervised by the pioneering topologists Felix Hausdorff and Otto Toeplitz. Schwerdtfeger then gained a position back at the University of Göttingen, but fled from Nazism, though not a Jew, because of his abhorrence at the treatment of his colleagues there. With his wife Hanna and young son Peter, who became professor of meteorology at Flinders University, he spent three years in Prague where he befriended Felix Behrend among others, before having to move on again, first to Switzerland and then France. The distinguished mathematical physicist, Max Born, approached Sir William Bragg on Schwerdtfeger's behalf and secured the assistance necessary for the family's migration to Australia.[168]

After a short and "desperate" time in Sydney, Schwerdtfeger was able to take up the position in Adelaide. He soon graduated from his evening duties to teaching courses in third-year and fourth-year mathematics, often replacing outmoded Cambridge topics with the latest European ones. His versatility showed in his fourth-year lectures with courses on group theory, Möbius transformations, automorphic functions, non-Euclidean geometry and topics in mathematical physics.

Schwerdtfeger left for a senior lectureship in the University of Melbourne at the end of 1947, but left a remarkable legacy in Adelaide. He had enticed Tim Wall away from medicine, Ren Potts away from engineering and Alan James, who became professor of statistics in the University of Adelaide, away from physics. He also had an important influence on the career of the eminent Sydney University physicist Stuart Thomas Butler who, in graduating BSc from the University of Adelaide in 1945, gained first place in all three of his final year subjects—pure mathematics, applied mathematics and physics.[169] Schwerdtfeger spent ten years in Melbourne. He left in 1957 to become professor of mathematics at McGill University, Montreal, and in 1983, aged 81, returned to Adelaide to live out his remaining retirement as visiting research fellow in the Department of Pure Mathematics. He was accompanied back to Australia by Hanna who had attended his lectures in Adelaide and at McGill University had became a highly regarded mathematics lecturer in her own right. Hans Schwerdtfeger died on 26 June 1990.

Harold Sanders replaced Wilton as Elder Professor of Mathematics in 1944. More importantly for the future of Australian mathematics, and offering further testimony to the influence gained in a short time by Schwerdtfeger, he was able to urge successfully that he himself be replaced by a Hungarian refugee, then living in Shanghai, named George Szekeres.[170]

The University of Tasmania, 1924–1947

When Alexander McAulay's failing eyesight obliged him to cease teaching towards the end of 1923, the University appointed Arthur Henry Shakespeare Lucas as acting professor. Lucas was born at Stratford-on-Avon in Warwickshire, England, in 1853 and studied at the universities of Oxford (BA, 1874; MA, 1877) and London (BSc, 1879). He came to Australia in 1883 to be mathematics and science master at Wesley College, Melbourne, then held posts at Ormond and Trinity Colleges in the University of Melbourne, Newington College in Sydney, and finally Sydney Grammar School, where he was headmaster from 1920 to 1923. He was aged 70 when he took the Tasmanian position. A noted botanist and ornithologist as well as a capable mathematician, Lucas died in Albury, New South Wales, in 1936.

Hugh Davison Erwin, with a BA, BSc from the Royal University of Ireland, and a local graduate, Bertram Whitington, had been part-time lecturers in the department from April 1923 following McAulay's offer of £250 from his own salary to allow a reduction in his teaching load.[171] Erwin was given a temporary full-time appointment in 1924 and this was converted to a permanent position in 1925, but held only for that year. At the time, he was a "brilliant teacher"[172] at the Hutchins School, which today stands alongside the university.

Lucas continued as acting professor during 1925. He joined McAulay on a large university committee to consider applications and recommendations from "the Committee of Selection in England" to choose McAulay's successor. There were nine applications received in London and four in Hobart.[173] Regarding the British applicants, "an exhaustive and masterly report in 17 typed pages" was provided by the eminent statistician Karl Pearson, at that time Galton Professor of Eugenics at University College, London. He recommended two candidates "as suitable for the post and likely to make a success of it": Louis Melville Milne-Thomson, then senior lecturer in mathematics in the Royal Naval College, Greenwich; and Paul Dienes, a Hungarian and at the time senior lecturer in mathematics at the University of Wales, Swansea.

Pearson's preference was for Milne-Thomson. The committee in Hobart had to choose between him and the best of the Australian applicants, E. J. G. Pitman, who was then lecturing at Trinity and Ormond Colleges, Melbourne. Pitman, aged just 28, had spent two days in Hobart at the invitation of the committee and was strongly supported by McAulay as capable of "achieving the highest kind of Mathematical research". However: "After weighing all available evidence at two lengthy meetings, your Committee recommends confidently that Mr Milne-Thomson receive the appointment." Milne-Thomson, who had spent his early years in New Zealand, was duly offered the position but when he subsequently declared himself unavailable it was Pitman who was appointed. [174]

Milne-Thomson retired from a chair of mathematics at the Royal Naval College in 1956 and took numerous visiting appointments including a period as visiting professor in the University of Queensland in 1969. Dienes became professor of mathematics at Birkbeck College in the University of London.

Edwin James George Pitman

Pitman was born in Melbourne on 29 October 1897 and attended the Kensington State School and then South Melbourne College. He had his first taste of serious mathematics there due to the headmaster's penchant for taking his better students through Cambridge tripos examination papers on Saturday mornings (and studying Shakespeare in the afternoons).[175]

Like Cherry who was just a year younger, Pitman gained a scholarship to Ormond College at the University of Melbourne and came under the sway of Nanson, Michell, Weatherburn and Picken. The two had the opportunity to go up to Ormond in the same year but Weatherburn suggested they go in successive years, Cherry going first, because otherwise "we'd be merely sharing all the prizes".[176] In the event, each was the only member of his honours class. War service overseas with the 14th Battalion of the AIF from 1918 to 1919 interrupted Pitman's studies so that he did not complete his BA until 1921, but he then followed that in successive years with a BSc and an MA.

Before completing the MA, he was appointed acting professor of mathematics at Canterbury University College within the University of New Zealand. When he did not gain the permanent chair, he returned to Melbourne to the joint positions of tutor in mathematics and physics at Trinity and Ormond Colleges and part-time lecturer in physics in the University. In gaining the chair in Hobart, Pitman became the first professor of mathematics in Australia to have no prior overseas study, other than the nine months at the London School of Economics where he had studied sociology during demobilisation.

Pitman was to become Australia's leading scholar in the embryonic field of statistics, with major contributions to the theory of estimation and non-parametric tests of significance. His introduction to statistics was described by his former student and later good friend Evan Williams in an obituary:

> As head of a small department of mathematics in a poorly-funded university, he had from the beginning a heavy teaching load. In addition, as a condition of accepting the appointment, he was required to have some knowledge of statistics and to be prepared to teach the subject. Pitman, who had attended only a few lectures in the subject at Melbourne and was not impressed, nevertheless agreed to these conditions and regularly gave courses in statistics, often to only one or two students at a time.
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> About two years after his appointment, an experimenter at the State Department of Agriculture . . . brought him some data and statistical analyses from field trials on potatoes, together with a copy of R. A. Fisher's *Statistical Methods for Research Workers*. Pitman checked the calculations and studied the Fisher book, which led to continuing collaboration with the Department of Agriculture on its field trials. Pitman later described himself as 'a mathematician who strayed into Statistics'.[177]

Edwin J. G. Pitman, 1897–1993.

Jane Pitman, in an interview for the Australian Mathematical Society History Project, gave more credit to Williams saying that her father had to study the subject much more deeply to give the "very able" Williams a satisfactory

third-year course in statistics. She also gave a strong example of the isolation felt by Pitman in Tasmania: at an ANZAAS conference in Adelaide in 1936 he met Alf Cornish, later chief of the Division of Mathematical Statistics in CSIRO, and this was the first opportunity for either of them to have serious discussion with another research statistician.[178]

Pitman took a very active role in university administration. He was chairman of the professorial board for much of the time that Edmund Morris Miller was vice-chancellor. Miller had joined the University in 1913 and was professor of psychology and philosophy from 1928 to 1945. He was elected vice-chancellor in 1933 and considered Pitman to be "almost obsessional" in his opposition to him. Pitman in turn considered that Miller exercised too much authority.[179] By 1934, the University had outgrown its original site at the old Hobart High School and Pitman was responsible for reviving an earlier proposal to move it to the present site on a former rifle range at Sandy Bay. He continued to urge Miller to lobby the government towards this end but it was not until the mid-1940s that some science departments were enabled to relocate to Sandy Bay and it would be another ten years before the university had completed its piecemeal move, and even then only to temporary accommodation.[180]

That was around the time, early 1956, that Pitman was a member of a committee of the university council whose findings contributed to the summary dismissal of the philosophy professor, Sydney Sparkes Orr, on a morals charge. Repercussions continued through the courts for ten years, though Pitman retired in 1962 and had little further involvement in the case.[181] In his history of philosophy in Australia, the Sydney mathematician James Franklin (lecturer at the University of New South Wales since 1988, promoted to associate professor there in 2003) described Orr as "an appalling and deceptive" person whose "incompetence in philosophy" was well known to his Australian colleagues. He nonetheless garnered their support and received a monetary settlement from the University of Tasmania in 1966, shortly before he died.[182]

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For the first 20 of his 36 years as professor of mathematics, Pitman's department never increased beyond two members, including himself. He had to fight his way onto a selection committee for a new lecturer in mathematics in 1928—the university council at that time saw no reason to have any academics on such committees—and then had to argue the merits of a woman candidate whose application had been put aside. That was Edith Rita Lowenstern[183] who was given the position over the protestations in particular of H. D. Erwin, an earlier incumbent, still a part-time assistant in the department and by then a member of the university council.[184]

Lowenstern was born around 1908 and held an MA from the University of Melbourne, where she was a tutor in mathematics in 1927. Appointed from 1 January 1929, she has not previously been recognised as Australia's first female full time lecturer in mathematics (with Margaret Moir at UWA also a claimant for that title). However, she is often acknowledged as the University of Tasmania's first woman to join the staff as a full-time lecturer, although there was a move, which Pitman averted, to give her part time status during the Depression years.[185] Lowenstern resigned at the end of 1935 but, as Edith Rita McArthur, returned as a tutor in the department during 1943 and 1944. She later endowed the Edith Rita Lowenstern Prize for mathematics at the University.

In February 1936 John Conrad Jaeger was appointed to replace Lowenstern as lecturer in mathematics. He had spent the previous six years in Cambridge engaged on research in theoretical physics, predominantly quantum mechanics, but, according to his application for the Tasmanian position, he saw his chief interests as being in the use of differential and integral

equations, analysis and the theory of Bessel and general hypergeometric functions in problems of applied mathematics.[186] For three years he had also acted as supervisor in mathematics at Emmanuel College, Cambridge. The breadth of his knowledge is indicated by an accompanying reference from Harold Davenport, a number theorist, who wrote: "I know him to be an exceedingly competent and widely read Pure Mathematician."

Jaeger had visited Hobart briefly in 1928 en route to England, considered it to be "one of the most delightful places in Australia", and, at a time when jobs were scarce, was happy to take a position in a small university. Pitman and Jaeger were neighbours when Jaeger moved to Hobart. Their relationship was respectful and friendly, but was never close. They shared the extensive teaching load in pure and applied mathematics, but not their research interests.[187] For Jaeger, these coincided instead with those of his teacher Carslaw and their collaboration began soon after Jaeger moved to Hobart; he was to write of Carslaw: "I, of course, owe more to him than to any other person. He was the ideal Mentor, human, kindly, knowledgeable about everything."[188]

Jaeger was promoted to senior lecturer in July 1944 and associate professor in January 1949. Eighteen months later, he was appointed professor of applied mathematics but in January 1952 moved to Canberra to take up Mark Oliphant's invitation to be the foundation professor of geophysics at ANU. (Keith Bullen had previously indicated that he had no interest in setting up a geophysics department there.[189]) On his retirement at the end of 1972, Jaeger moved back to Tasmania but poor health, failing eyesight and the passing of his second wife necessitated his return to Canberra in late 1978. He died on 15 May in the following year.

The University's *Calendar* for 1946 lists Andrew Paul Guinand, later professor of mathematics in the University of New England, as a lecturer in mathematics but after a year's delay he declined the appointment.[190] Peter Sprent joined the department in that year as a tutor, was acting lecturer the following year and then lecturer in mathematics until the end of 1955. He later became professor of mathematical statistics in the University of Dundee, Scotland, where his first graduate student was Wendy Catchpole. She gained an MSc there, and later a doctorate from the University of New South Wales, and is currently with the Australian Defence Force Academy in Canberra.

Henry (originally Heinrich) Francis Joseph Löwig, born in 1904 in Prague, came to Australia as a refugee, was appointed lecturer in mathematics in the University of Tasmania in 1947, became a senior lecturer in 1952 and resigned in 1955 to take the chair of mathematics in the University of Alberta, Canada. He held that position until his retirement in 1970 and he died in 1995. Mac Urquhart also joined the department in Hobart in 1947 following his recuperation from tuberculosis.

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The story of the University of Tasmania and the stories of the other six universities of this chapter will be continued in Chapter 6. The Australian National University dates from 1946 and the University of New South Wales from 1949. Since the University of New England was not proclaimed until 1954 and since Canberra University College never became a university in its own right, although it operated from 1930, there were just eight universities in Australia in 1950. With the reclassifications and mergers that took place in the 1980s, along with the establishment of new universities *ab initio*, there were another 30 universities in the country by the end of the century. Although some do not have substantial departments of mathematics or statistics, they will all be considered in Chapters 6, 7 and 9, some in more detail than others.

Chapter 5

Australia's Mathematicians in World War 2

Many Australian mathematicians served their country through world wars and other wars, whether in military service or in a civilian capacity, in some cases interrupting university studies to do so. There are many records of service ably performed and there are accounts, too, of derring-do, some wise, some not so wise. More importantly for the annals of mathematics, there are instances of Australian mathematicians' development of areas of application of mathematics whose very existence is a result of the needs of war or which received great impetus at times of war.

Three such areas are sketched below, along with some Australian mathematicians' contributions. The first is cryptography, or the making and breaking of codes, a study that can be traced back at least to the days of Julius Caesar. It is fundamental to the secure transmission of data, which is now an economic necessity as much as a military one, and mathematical research in the area continues at a great pace. The second is operational research, now known outside England as operations research or management science. The name in the first instance referred specifically to the research of wartime operations, but it now refers to an area of study in its own right dealing with all manner of problems concerned with optimisation, for example the minimisation of cost or of time or the maximisation of personnel resources. The third area concerns public health: such fields as demography and epidemiology.

There is a fourth area of involvement of mathematicians in war, making use specifically of their training in applied mathematics, and of no lesser importance. These were the scientists who participated in rocket or ballistics research, aeronautical engineering, or the development of radar, to take a few examples. Finally, there were the teachers: the chapter ends with a tribute to the "Bailey Boys" and their lecturers at the University of Sydney.

There are many examples also of contributions of Australian mathematicians to World War 1. These are documented throughout the book within their general biographical notes.

Individual exploits

When it comes to individual wartime exploits, Australian mathematics might lay claim to the deeds of Les Woods, although he had not at that time left New Zealand. He was born in 1922, 40 kilometres from Rotorua, with the name Leslie Colin Woodhead, and he came to Australia as senior lecturer in applied mathematics at the University of Sydney in 1954. Two years later, he was appointed the second Nuffield Professor of Mechanical Engineering at the New South

Wales University of Technology, soon to become the University of New South Wales. Woods was very active in the formation of the Australian Mathematical Society in 1956, but left Australia at the end of 1960 to become Foundation Fellow in Engineering Science at Balliol College, Oxford, and, in 1970, Professor of Mathematics (Theory of Plasma) at the University of Oxford. He subsequently returned for many visits to New Zealand and Australia and for a short time held the position of deputy head of mathematical sciences at the New South Wales Institute of Technology, concurrently with his Oxford post.

Woods enrolled at the University of Auckland in 1940 but volunteered for the Royal New Zealand Air Force at the end of that year. He used various devices to argue his way in at the age of 18, when the required age was 21, and to pass the eye examination, given his astigmatism. It was three years before he saw active service in the Pacific. In that time, Woods completed his studies for a BSc and in the 18 months that followed, in between flying Kittyhawk missions from Bougainville over Rabaul, completed extramural studies for an MSc. Woods published the story of his wartime shenanigans, along with all the serious bits in a very full life, in *Against the Tide*,[1] in 2000.

Basil Rennie was born in London on 24 December 1920. He came to the University of Adelaide as senior lecturer in mathematics in 1950 and, for four years from 1961, was professor of mathematics at the Royal Australian Air Force Academy, Point Cook, which offered the BSc and Bachelor of Engineering degrees of the University of Melbourne. Rennie is best remembered for the 20 years he then spent in the foundation chair of mathematics at the Queensland University College in Townsville, which was to become the James Cook University of North Queensland. He died in 1996.

An old friend and fellow student, John Parker, wrote to Rennie's widow, Barbara, in January 2000 of his memories of Basil. His letter included some insight into the workings of Cambridge University that will be useful to the uninitiated:

> Basil matriculated in 1938, a year before me. I believe he got a Senior Scholarship, £100 p.a., a lot of money in those days. A word here about how maths undergraduates were put through the hoop at Peterhouse and, presumably, throughout the University. The course lasted 3 years and there were two types of undergraduate. The clever ones skipped Part 1 of the Tripos, taking "Mays" in their first year and then Part 2 after which the man got his BA, probably as a Wrangler (a first) or at least an upper second (a 2.1). Part 3 was taken in the third year and this postgraduate year could be viewed as a stepping stone to a Ph.D. The second type of chap spent his first year on Part 1, his second on "Mays" and Part 2 in his third year ending up with possibly a first but far more likely a 2.1 or 2.2 or even a third.
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> But when the War broke out all this went for a Burton. Thus some of my 1939 mathematical colleagues just stayed for one year, taking Part 1 and then calling it a day and opting for military service. Others were advised to spend two years at Peterhouse . . . skipping Mays. This was tough going; two of us followed this route both landing up with 2.1 BA degrees. Meanwhile Basil, in his second year took Part 2, graduating as a Wrangler and then went on to take Part 3 in his (1940) postgraduate year. I believe he got a "star" (distinction) but am not sure.

Parker goes on to mention Rennie's subsequent war service in the Far East, where he was an acting petty officer with the Fleet Air Arm of the Royal Navy, and the two games of correspondence chess they played together during those years apart. Barbara Rennie still has Basil's record, in his own hand, of those two games. (Both employed the Ruy Lopez opening; Rennie drew with the white pieces and then lost with the black.) Later in the same letter, Parker recounted a tale of their joint experience with the College Boat Club: "I . . . got to know Basil

as a keen if distinctly unconventional oarsman. He invigorated our Boat Club by proposing a lot of controversial ideas such as the 'Syncopated Six', where you had three staggered pairs of oarsmen sitting in the Eight, with gaps between the pairs, each pair rowing one third of a stroke behind the pair in front. Typical Basil—a super scientific idea but it didn't go down with the powers that be." It was largely the prospect of sculling down the River Torrens that attracted Rennie to Australia.

Rennie was followed as professor of mathematics at the RAAF Academy by Maurice Norman (Maurie) Brearley, born in Perth on 21 January 1920. Brearley's entry into the RAAF was as conniving as could be imagined.[2] He initially took advantage of the exemption from military service provided to students of approved technical courses to complete his studies in engineering at the University of Western Australia, but, having completed his degree in December 1941, determined in March 1943 to enlist. He foresaw a number of difficulties. After graduation he had joined the de Havilland Aircraft Company in Sydney, and was thus in a reserved occupation, prevented by law from leaving it, and in any case his engineering degree precluded entry into the RAAF as an aircraft trainee. Furthermore, his father, Sir Norman Brearley, a Western Australian aviation pioneer and at that time a group captain in the RAAF, would surely not approve of the move. And he was colour blind.

Brearley's solution was to enlist under the name Maurice Burnett, with a fictitious birth date and a fictitious next of kin. He avoided the need for a letter of discharge from his employer by affirming that his last place of employment was a monastery where he had been training for the priesthood (though he was not a Roman Catholic). Incredibly, a few weeks later Brearley was asked by the RAAF to report for a medical and aptitude examination at the Woolloomooloo Recruiting Centre in Sydney. He later wrote:

> This was a big hurdle, for it would involve a test for colour-blindness. To prepare for this I persuaded a friend to borrow from the library of the CSIRO National Standards Laboratory the Ishihara Colour-Blindness Test book. She and I went through it together and I noted the number she said I should see on each page. The last four pages of the book appeared to me to contain nothing but arrays of randomly coloured dots, but my friend assured me that on each page a continuous line of similarly coloured dots could be seen wending from one side to the other, performing on the way sinuous curves of discouraging complexity. At my request she made tracings of these lines on transparent paper, and over the course of several weeks I memorized them thoroughly, drawing and re-drawing them and checking my efforts by superposing on them the master copies.

This ruse had to be called upon during the examination, and it worked. Somewhat surprised himself at this, Brearley determined "to admit my failing if I were made a navigator or a pilot of multi-engined aircraft, lest I should have to read complicated colour-code signals with other lives depending on my ability to do so." After more lies and deception, concerning for example the misplacement of his birth certificate, Brearley was ordered to report for duty on 19 June 1943.

It is just as incredible that when his flight training was completed, and having lived for almost twelve months as Maurice Burnett, Brearley confessed to the great hoax, to his father as well as to his superiors in the RAAF, and was able to receive his commission as pilot officer under his real name. He served for a year with 77 Squadron in New Guinea, Halmaheras and North Borneo.

At age 27, Brearley decided to convert himself into a mathematician, in his words, and he "cadged a job" in applied mathematics at the University of Sydney on the strength of his engi-

neering degree.[3] Studies there led to a BSc with honours and a university medal in 1952 and a scholarship to Cambridge where he obtained a BA in 1954. A lectureship with the University of Adelaide followed and then the position with the RAAF Academy at Point Cook from the beginning of 1966.

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There were many others who went on to achieve distinction in mathematics in Australia and who served in the armed forces in World War 2. Often, it was the war that perversely led to their undertaking university studies via the Commonwealth Reconstruction Training Scheme. Suitably qualified personnel who had been on active service for five years were eligible for discharge to attend university. The government paid course fees and other expenses and a stipend of £3 5s a week. This was the first instance of a substantial commonwealth government contribution to university funding and was designed to enhance the skills of the workforce in a growing economy as much as to assist individual servicemen and women.

One who used the scheme was Ted Hannan. Born Edward James Hannan in Melbourne on 29 January 1921, he went from school to a job as a bank clerk, before enlisting in the Australian Army in 1941. He saw active service as a lieutenant in the infantry in New Guinea, on one occasion being wounded in an ambush and evacuated from the front.[4] Following repatriation to Melbourne in 1946, Hannan enrolled in the Faculty of Economics and Commerce at the University of Melbourne. After graduation in 1948, he again took on a bank job, this time as a statistician, and was not to make his mark on academia for some years.

Reynold Gilbert (Reyn) Keats was another former bank officer who used the Commonwealth Reconstruction Training Scheme after the war. He was born in Port Pirie, South Australia, on 15 February 1918 and worked in the Adelaide Savings Bank where he gained qualifications in accountancy ("mainly to placate my parents") before enlisting in the 2/48th battalion of the AIF in 1939. Keats saw active service as a signalman in Tobruk, El Alamein and New Guinea, ending the war as a lieutenant in charge of signals and an instructor in signals at Maroochydore, north of Brisbane.

He was aged 27 when he attended his first university lecture, "still nominally a bank clerk," but the bank was not interested in his attending university even though Keats pointed out that he would be studying science, including the new subject of computing. "I was told in no uncertain terms that computers would never be of interest to banks," he wrote, so his career as a bank clerk "terminated".[5] With his government-sponsored BSc from the University of Adelaide, Keats in 1948 began 13 years as a research scientist, ending as principal scientific officer at the Weapons Research Establishment in Salisbury and Woomera, South Australia, and including three years in the Mathematical Assessment Division of the Royal Aircraft Establishment, Farnborough, UK. One of his projects in Salisbury, the formulation of mathematical models for the flight of the guided missiles then known as Bloodhound, Red Duster and Red Shoes, among others, was to form the basis of his PhD thesis on stationary linear systems. However, Keats' distinguished academic career was still ahead of him.

James Henry (Jim) Michael was particularly grateful for the Commonwealth training scheme. He was born near Port Augusta, South Australia, and left school, aged only 14, to work on his family's sheep property. During the war, he served with the 2/7th field regiment in Egypt, Syria and Palestine, earning the Africa Star with clasp, and then at Tarakan in the Pacific, earning the Pacific Star. Towards the end of his active service in the AIF from 1940 to 1945, he took advantage of the army's educational program to matriculate and pass first-year university

mathematics. Michael graduated BSc with first-class honours in mathematics in 1951, gained an MSc in 1953 and by 1957 had gained the University of Adelaide's first PhD in mathematics. A year later he was appointed lecturer in mathematics there. His wartime experience led to an involvement with competitive rifle shooting that continued throughout his life.[6]

Frederick John Daniel Syer was to gain a reputation in the teaching of engineering mathematics at the University of Melbourne. He was born on 25 December 1902 and studied intermittently for a BA DipEd, as well as towards a BSc, during the 1920s and 1930s while on a studentship from the Victorian Department of Education and teaching at schools across the state. Syer spent over four years with the RAAF as navigation instructor, scientific observer and research officer for which he was awarded an MBE (Member of the Order of the British Empire) for research on radar and meteorology. He joined the full-time staff of the University of Melbourne in February 1946 and in the following two years completed his BSc studies with the aid of a grant from the Commonwealth Reconstruction Training Scheme.[7] His first duties for the University were as "Temporary (Post-war) Lecturer". He then became "Senior Lecturer (in charge)" at the Mildura branch of the University, an entity that existed only between 1947 and 1949 at the RAAF training camp there. Margaret Lester, one of the first women appointed to a lectureship in mathematics in the University of Melbourne, was a member of Syer's small department in Mildura and Edward Nanson's daughter, Joan, was secretary to the warden.[8]

Andrew Paul (Andy) Guinand was born in Renmark, South Australia, on 3 March 1912. After graduating from the University of Adelaide in 1933, and having excelled in gymnastics, rowing and bicycling as well as mathematics, he won a Rhodes scholarship to the University of Oxford. One of the examiners for his thesis was the renowned number theorist G. H. Hardy and Guinand later claimed that his oral examination was postponed because Hardy was required for

Fred Syer taking a class on the Mildura campus of the University of Melbourne.
(University of Melbourne Archives)

"Flight Lieut. A. P. Guinand keeping his tryst on the steps of Eros in Piccadilly Circus." (Argus Newspaper Collection of Photographs, State Library of Victoria)

a game of cricket. After further study at Göttingen and Princeton, he joined the Royal Canadian Air Force, returned to England and was navigator on many missions. Guinand did not return to Australia until 1955, when he was appointed professor of mathematics at the University of New England.[9]

Another Australian mathematician who served with the Royal Canadian Air Force was Albert Laurence (Larry) Blakers, born on 2 January 1917 in Perth. In the days when Charles Weatherburn constituted the entire mathematics staff of UWA, Blakers obtained first-class honours and was in fact the first mathematics honours student in the University. He had planned then to go to Cambridge for further study but with the outbreak of war, and following two academic terms as junior lecturer in the University, went with Weatherburn's assistance to Princeton University where he was awarded an MA in 1942. Rather than remain in the US, where he was likely to be drafted into the American army, he went then to Canada and enlisted in the Royal Canadian Air Force, which he served as a flying officer within the National Research Council of Canada until 1945. He returned to Princeton after the war and was awarded his PhD there in 1948.[10] In 1952 Blakers was offered, and accepted, the chair of mathematics at UWA following Weatherburn's retirement.

One of the great stories of heroism to come out of the war involved another West Australian, Ray Storer. His academic career at UWA had only just begun when he joined the RAAF in

1940. He trained as a pilot while serving as an instructor in navigation and meteorology and was posted to Geraldton in Western Australia and then Nhill in Victoria, where he switched to Hudson bombers. He joined 2 Squadron following the Japanese attack on Darwin in April 1942 and sustained a leg wound when, flying as navigator and second pilot, his Hudson was hit by tracer shells. Three of the squadron's eight Hudsons did not return from that mission and aluminium fragments which Storer carried in the leg for the rest of his life were a constant reminder of the action he had seen and was yet to see. In February 1945, Storer joined Flight 200 at Leyburn, Queensland, to give clandestine air support in occupied territories. He happened to be on other duties a month later when his American Liberator bomber took off on a mission to North Borneo. The aircraft, with its eleven-man crew and an army observer, was lost on its return flight.[11]

Maxwell Herbert (Max) McKay also flew with the RAAF. He was born on 2 January 1924 in Willoughby, New South Wales, attended North Sydney Boys High School where he was highly successful in the Leaving Certificate of 1941 (his second attempt, the first a year before being not at all successful) and joined the RAAF, where he was trained as a fighter pilot, soon after. McKay went to England following the Battle of Britain, switched to being a bomber pilot and flew Stirlings over North Africa. From there he was posted to 148 Squadron (RAF) in Italy, dropping supplies to the underground movements in Albania, Greece, Yugoslavia, northern Italy and southern France. University studies in Sydney began after the war. McKay was with the New South Wales University of Technology, and then the University of New South Wales, from 1954 until the end of 1966 when he became foundation professor of mathematics at the University of Papua New Guinea.[12]

Cryptography

Thomas Gerald Room's involvement in codebreaking for the Australian military has now been well documented with the government's declassification of the relevant archives in the 1990s. Before that, Room's service in this general capacity was well enough known, but he personally stayed quiet on his knowledge of codes except for a lunchtime lecture he gave to the Sydney University Mathematical Society (appropriately, SUMS) in 1963 and a talk on ABC radio around the same time.

Presumably, and properly so, Room's colleagues at the time knew little of his wartime work. Ivan Turner, in his address for the centenary of the University of Sydney, wrote of "the difficult war years when Professor Room and Mr Lyons were on secondment to national service," although elsewhere on the same occasion he was a little more specific: "During the war (1941–1945) he [Room], with R. J. Lyons, was seconded for special service with the Central Bureau."[13] More was known by the time Room died in 1986.[14]

At the beginning of World War 2, there was no central signals intelligence organisation in Australia. In January 1940, in circumstances that are not fully known, Room and Dickie Lyons began an unofficial codebreaking group at Sydney University. They were soon joined by two others: Arthur Dale Trendall, who was professor of Greek and later, from 1948, the university's first professor of archaeology, and Athanasius Pryor Treweek, a lecturer in classical Greek who was well qualified also in mathematics. After the war, Treweek obtained a PhD from the University of London for research into the Greek mathematician Pappus of Alexandria.

Both Room and Lyons had needed to learn Japanese with great speed and efficiency. Room was happy to give credit to Margaret Lake, a lecturer at the teachers college within Sydney

University grounds and an occasional lecturer in the oriental studies department, who accomplished the task of teaching him Japanese in two terms, or around eight months. Lyons presumably had the same teacher.

By October 1940, the group's activities had been officially recognised by the Australian Army and already military intelligence would pass on intercepted Japanese messages for decipherment. By April of the following year, a cryptanalysis unit, known as the Special Intelligence Bureau, had been set up by the Royal Australian Navy under Eric Nave, who had been involved with considerable success in the interception and decoding of Japanese messages since 1923. Sydney mathematicians Peter Donovan and John Mack, in their detailed analysis[15] of the background to Sydney University's involvement in military intelligence and of the activities of Room and his group, disclosed the minutes of a secret meeting held in Melbourne on 2 May 1941. It was attended by six senior military personnel, including Commander Nave, together with "Professor Roon" and "Major Treweeke". (The same misspellings occur frequently in those minutes.) The meeting expressed appreciation "of the progress made by the unofficial Sydney group, which was started without any assistance", and Room and Treweek, speaking also for Lyons, indicated their willingness to join Nave's bureau in Melbourne, subject to suitable arrangements being made with the university authorities.

Consequently, in August 1941, the group was absorbed into the Bureau's activities. Treweek had earlier been commissioned as a major in the Sydney University Regiment, part of the Australian Militia, but Room, Lyons and Trendall remained as civilians. In fact, Room negotiated that he retain the title of "Professor", and that he retain his professorial salary. Room was sent soon after to Bandung, in Java, as part of an exchange of information with Dutch codebreakers, and then to Singapore to study the work of the longstanding Far East Combined Bureau, a British joint service codebreaking and intelligence centre.

Some detail of the work of Nave's bureau was given by the high-ranking Australian codebreaker, Geoffrey Ballard:

> Tucked away under the roof of Victoria Barracks, Melbourne, this unit had the task of decyphering the diplomatic and commercial traffic passing between Tokyo and the Japanese embassies in various countries of the Pacific region.
>
> The observations and reports of Japanese diplomats, as well as the instructions they received from Tokyo, provided a most valuable "window" on Japan's aggressive intentions in the Pacific. The unit's most spectacular achievement was said to be the decyphering of a message dated December 4, 1941, from Tokyo to the Japanese Consul-General in Sydney, ordering him to destroy all his codes and cyphers—a sure indication of the imminence of hostilities.[16]

The "imminence of hostilities" was of course borne out by the Japanese attack on Pearl Harbor three days later, although Nave was later to say that "the Japanese Navy had mounted a massive deception exercise to prevent anyone realizing that Pearl Harbor was a target."[17] There were other successes that may be attributed at least in part to the codebreakers in Melbourne: they assisted in the decrypting of a number of messages in 1941 and 1942 regarding cash transfers from Japanese accounts in a number of South American countries, particularly Argentina, Chile and Peru, to cover the expenses of pro-German and pro-Italian initiatives, and a week before the Battle of the Coral Sea they deciphered messages detailing the organisation of the Japanese forces in the region.[18]

In April 1942, General Douglas MacArthur, allied commander-in-chief in the Far East and Pacific, created an army and air force signals intelligence facility in Melbourne, named Central

Bureau, containing Australian and US codebreakers. A few months later, the bureau, along with MacArthur's headquarters, moved to Brisbane. It was situated in huts on the Eagle Farm racecourse, organised in a manner similar to the famous Bletchley Park, surrounded by wire fences and patrolled by Australian military.

> Central Bureau was divided into four main sections: Traffic Analysis, employing six officers and sixty ORs [other ranks] . . . ; High-Grade Codebreaking under Major Sinkov, employing thirteen officers and sixty ORs (including a tabulating machine section), of which roughly a third were Australians; Air-Ground Codebreaking under Nave, with the naval air side led by a US Army major, the army air by an Australian major and a meteorological section under Professor Room; and Collateral Intelligence, employing four officers and six ORs, shared between the Australian Army and the RAAF.[19]

Major Abe Sinkov, mentioned here, was an American cryptographer who had worked with the US War Department from the early 1930s and had led the first US delegation to Bletchley Park. He had a PhD in finite group theory from George Washington University. Room's meteorological responsibilities concerned the decoding of Japanese messages that indicated weather conditions at sites of future air raids.

Trendall and Treweek remained in Melbourne with the diplomatic section of Nave's original bureau. Treweek worked primarily within FRUMEL (the Fleet Radio Unit, Melbourne), responsible for intercepting and decoding messages from the Japanese navy. Lyons also did not proceed to Brisbane, but instead returned to Sydney University. Donovan and Mack quote from a letter written by him to the vice-chancellor on 19 November 1942:

> However, before Commander Nave, the Head of the Bureau, left, I had the satisfaction of receiving from him what may be called a contingent invitation to go to the Foreign Office. When the decision was made to transfer control of the Office to the Americans Commander Nave told Room that if he were willing to go to London he could get him placed at the F.O. I was not surprised to hear this, because Room's intellectual power is phenomenal, but I was exceedingly gratified when he announced that the offer included me, adding that this was for my part in some rather spectacular success we had had earlier in the year. Room's immediate reaction was to accept enthusiastically, and for one thrilling morning I thought we were in for the super experience. However, when Room had weighed all the pros and cons of the proposal, he decided that much though he would have liked to go to London, his gifts could be used more effectively in Australia, and the invitation lapsed.[20]

Lyons' mention of "some rather spectacular success" appears to refer to "the first indication after the Battle of the Coral Sea that the Japanese Army would attempt to reach Port Moresby by the Kokoda Trail while the Japanese aircraft carriers would be sent somewhere else. USN cryptographers subsequently worked out that the 'somewhere else' was Midway" and this was to be the turning point in the war in the Pacific.[21]

Trendall recruited other Sydney University personnel to his diplomatic codebreaking group, notable amongst them being Eric Stephen Barnes. Barnes was born on 16 January 1924 in Cardiff, Wales, came to Sydney in 1929 and graduated from Sydney University in 1943 with first-class honours in mathematics and French. Although recommended for university medals in both subjects, the recommendation was rejected "because he had taken three and not four years for the honours courses."[22]

Barnes joined the Citizen Military Forces and served with Trendall with great distinction for three years, 1943–1945. He later recalled that he was commissioned as a lieutenant "because of his success in cracking a Japanese code that had baffled the British experts at Bletchley Park."[23]

After the war, Barnes taught for a year at Sydney University and then departed in August 1947 for Cambridge.

Donovan and Mack also wrote of Room's involvement in the design of codes for coast watchers around the country, and of his interest in obtaining, for the use of his university, one of the IBM tabulating machines used at Central Bureau. However, the Faculty of Science at the time saw no great need for such a machine.

Room was released from service at Central Bureau on 12 October 1945, following the surrender of the Japanese, and returned soon after to his professorial duties at the University of Sydney. During his absence, Edward Wellish had acted as professor and head of the department. The secretary of the Department of the Army wrote to the vice-chancellor at the time "to place on record its appreciation of the very valuable contributions made by Professor Room to the Allied War Effort since 18 August 1941."[24]

Operational research

David Mellor, in his volume in the series *Australia in the War of 1939–1945*, wrote: "Among the many new applications of science in the war of 1939–45 few had a more far-reaching influence on tactics than operational research. For the first time in history . . . the methods of scientific research were applied on a large scale to the study of the performance of new types of equipment and to the operations of war."[25] He quoted also from Sir Charles Goodeve:

> Operational research was really born out of the Battle of Britain. As is well known, we had in 1940 few fighter aircraft compared with the number that would have been required to defend our shores against an air invader. We had very good fighter pilots and very good aircraft, but, with the equipment and methods used prior to 1940 it would have been impossible to obtain sufficient interceptions to defend our shores. The most important new feature that came in was, of course, radar. This equipment by giving ample warning, permitted the retention of aircraft on the ground until needed and then by plotting the positions of the enemy and defending aircraft, enabled a "ground control" to direct the aircraft to a position where the enemy could be sighted visually. The planning of this sequence of operations involved careful analysis of training and operational experiences and involved a full analysis of the technical possibilities of the equipment. But the process of combining these factors required mathematical calculations beyond the experience of the ordinary commanding officer. Accordingly a small party of half a dozen scientists was attached to Fighter Command to study and refine the deployment and the operational orders . . . It is estimated that radar itself increased the possibility of interception by a factor of about ten; but that, in addition, this small operational research team increased the probability by a further factor of two.[26]

The British experience was rapidly brought to Australia. Two operational research groups were established within the Australian Army, and four in the Air Force.

The Army Operational Research Group was attached to the Royal Artillery and headed by David Forbes Martyn, who had previously been chief of the radiophysics division in CSIR, the precursor of CSIRO. It began its activities on 1 June 1942, having recruited to itself "science graduates with honours in physics and mathematics . . . most of whom retained their civilian status",[27] until it had about 14 members. Its activities were largely restricted to weapons research and radar. The group's members were, for example, posted to different operational areas to advise on the tactical use of radar and the information gained from it.

The second army group, the Operational Research Section, was placed in the Branch of the Master-General of the Ordnance. It consisted initially of a team of three who had trained with

the British Army Operational Research Group and was later enlarged to include Australian officers with research experience.

One of these was Henry Maurice Finucan. Born on 6 July 1917 in Brisbane, he was outstandingly successful at school and university. After gaining first-class honours in mathematics at the University of Queensland in 1937, he went to Balliol College, Oxford, as a Rhodes scholar and, on completion of his studies there, spent two terms at Cambridge studying general biometrics and the design of agricultural experiments. Finucan returned to Australia towards the end of 1940 and in March 1942 enlisted in the army, serving in Australia, New Guinea and Borneo as an anti-aircraft gunner. In July 1942, he was promoted to sergeant and became an instructor in the Army School of Radiophysics. In September that year he was commissioned with the rank of lieutenant. Then in March 1944 Finucan was transferred to the Operational Research Section. He was demobilised the following October, at which time he held the rank of captain, and while awaiting demobilisation applied for and was appointed to a lectureship in the mathematics department of the University of Queensland.[28]

The Royal Australian Air Force Operational Research Group was established quite late in the war, on 18 January 1944, but more use was then made of it than had been the case with either of the army groups.

One member of the team of researchers gathered together for the purpose was then squadron leader Clive Selwyn Davis, later promoted to wing-commander. From 1956 he was professor of mathematics in the University of Queensland, but at that stage he was not too long graduated from the University of Sydney. Following his receipt of first-class honours in mathematics in 1937, first-class honours in physics in 1938 and an MSc in mathematics in 1939, Davis travelled to England on a CSIR scholarship. His intention was to return to Australia and work in the Aeronautical Research Laboratories, but he soon enlisted in the Royal Air Force. After two tours of duty flying heavy bombers in the Middle East, leading to the award of the Distinguished Flying Cross, he acted as liaison officer for operational research within the RAF. He was posted back to Australia in mid-1942 to apply his experience in the RAAF.[29]

Clive Davis, photographed after obtaining the state's second best Leaving Certificate pass (top in mathematics, second in physics) in 1934. (Sam Hood Collection, State Library of New South Wales)

Another of the members was squadron leader Alexander Renfrew Miller. Born on 4 September 1915, he graduated with an MSc with first-class honours in mathematics in the University of Melbourne in April 1938, briefly held a tutorship in the University and by October had entered Gonville and Caius College, Cambridge, as a research student. He gained his PhD in June 1941 for a mathematical study of certain physico-chemical problems and was appointed to Britain's Ministry of Home Security, Research and Experiments Division, to conduct research on the theory of

explosions. In July 1942, he was appointed to carry out operational research with the RAF as a scientific officer in the Directorate of Scientific Research of the Ministry of Aircraft Production. After serving in India and being invalided back to England in August 1943, Miller was made available on loan to the Australian government to join Davis and others.

Much of Davis' work in the Operational Research Group was carried out as section leader for about a year in New Guinea, with overall command taken by J. C. Bower. Miller's story hereabouts is taken from his unsuccessful application[30] in October 1945 for the position of professor of applied mathematics in the University of Sydney. He wrote:

> I left the United Kingdom in December 1943, spent two months in Canada and the United States studying recent research and development there relating to the air forces, and reached Australia in February 1944. Since then I have been in charge of the operational research section at R.A.A.F. Command (the R.A.A.F component of Allied Air Forces, S-W.P.A [south-west Pacific area]) ... My duties there have included the direction of the research of all members of the section at R.A.A.F. Command, advice to the A.O.C. [air officer commanding] on scientific developments and advice based on the analysis of air operations and the performance of weapons. In addition, since April 1945 I have exercised oversight of the other three operational research sections within the R.A.A.F.

One of those other sections was started in the First Tactical Air Force area with N. J. Loveday as leader. Mellor wrote: "There can be no doubt that operational research influenced wartime policy of the R.A.A.F. to a sufficient degree—at a late stage in the war at least—to justify its existence . . . Through the work of Bower, Miller, Davis and Loveday, operational research won the good opinion of many air force administrators."[31] He gave detailed and quantitative descriptions of a number of the group's projects.

For Davis there was then to be another flying stint, in command of a Darwin-based special duties flight of Liberator bombers. In 1946, at the end of hostilities, he gained a scholarship to Cambridge, where he graduated with a PhD in 1949. Nothing further is known of Alexander Miller.

Some have described Patrick Alfred Pierce (Pat) Moran as Australia's greatest contributor and administrator in the field of statistics. He was also involved in wartime operational research. Moran was born and educated in Sydney, travelled to Cambridge University in September 1937 and remained in England throughout the war. He was an experimental officer with the Ministry of Supply from 1940 to 1942 when he met up again with Clive Davis, whom he had known in Sydney. Davis assisted him to obtain a position with the Australian Scientific Liaison Office (ASLO), run by the CSIR in London, in late 1943. His duties were to liaise on general physics, including radar, and operational research:

> He covered a great diversity of applied physics including vision, camouflage, army signals, quality control, road research, infra-red detection, metrology, UHF radio propagation, general radar, bomb fragmentation, rockets and asdics. More valuable to him later, however, was the operational research and associated subjects. Every few months he visited each of the operational research sections in Fighter, Coastal, Bomber, Tactical and Training Commands and he was also accredited to the U.S. Bomber, Fighter and Tactical Air Force Commands.[32]

Moran left the ASLO in June 1945. After a year at Cambridge, he took a position as senior research officer at the Institute of Statistics at Oxford University. He had continued his studies during the war years in both analysis and statistics and remained in active research at Oxford until late 1951, when he moved to Canberra as foundation professor of statistics at the Australian National University.

Public health statistics

The foundation professor of mathematical statistics at the University of Sydney, Henry Oliver Lancaster, was born in Sydney on 1 February 1913, and educated in various schools in rural New South Wales. He was intensely proud of his extended family, which included Sir John Forrest, the first premier of Western Australia, and Edward William Mattner, president of the senate in federal parliament in the early 1950s.

Lancaster's initial university studies were in economics. He had intended to become an actuary, but just four weeks into the course he transferred to the Faculty of Arts where he took the honours class in mathematics, taught by Carslaw and Lyons. Seeing no future as an academic, he transferred again at the end of the year, to the Faculty of Medicine from which his father had graduated nearly 35 years before. A junior fellowship in medicine at the Prince Henry Hospital in Little Bay, Sydney, allowed the young doctor to pursue interests in pathology, with evidence already of a substantial interest in the application of statistics. Then, on 31 July 1940, Lancaster joined the Australian Imperial Forces as a medical officer.

He spent a year in the Middle East, in Alexandria and Nazareth, as a pathologist with the 9th Australian General Hospital, returning to Australia in February 1942. According to his *Recollections*,[33] Lancaster's first use of statistics was in Townsville: "Major T. E. Lowe and I investigated the incidence of eosinophilia and found that it was usually caused by hookworms or strongyloides. I also investigated the incidence of intestinal protozoal infections. Here a statistical problem was to compare incidences in the four classes of troops according to whether or not they had been in the Middle East or New Guinea, a problem in 2 x 2 x 2 tables; higher orders could occur if several parasites were considered." This work led to his first publications, two papers with co-author Lowe in the *Medical Journal of Australia*, 1944.

Then, in 1944 in New Guinea: "I made a survey of more than a thousand native troops and civil workers from different areas and surprised the army Director of Pathology . . . by reporting the results in systematic form with properly drawn graphs and means and standard deviations correctly computed." Lancaster's interest in demography developed at this time. He saw possibilities for the application of physics or chemistry to demography, and realised the need to learn more mathematics:

> I began a serious study of pure mathematics. So in 1944 after a break of 14 years I borrowed Caunt's *Infinitesimal Calculus* from our adjutant, C. J. Stevens, later principal actuary of the Australian Mutual Provident Society, and found that I could remember an encouraging amount of mathematics after only a little practice. In 1945, I enrolled as [an] external student in the second-year honours course at Sydney University. There was plenty of time in the evening to study mathematics, sitting with a kerosene lamp in hot humid conditions. I obtained a high distinction in Mathematics II . . . Books I remember having liked are Hardy's *Pure Mathematics*, Bromwich's *Infinite Series*, Wood's *Calculus* and Sommerville's *Conic Sections*.

After two years in New Guinea, Lancaster's war service ended with the rank of major in April 1946. There is a fine pencil sketch, titled "Pathologist (Major Henry Oliver Lancaster) 1944", by the famous war artist Nora Heysen in the Australian War Memorial, Canberra. His statistical work during this time could perhaps have received more notice, since much later Edwin Pitman would claim that there had been no statistics in the Australian war effort.[34] Pitman was referring mainly to his offer, not taken up, to introduce statistical quality control into the government's munitions factories.

Oliver Lancaster subsequently gained a temporary appointment in the School of Public

Nora Heysen's sketch of Lancaster, 1944. (Australian War Memorial)

Health and Tropical Medicine at Sydney University, where he could continue his demographic work, "it being understood that my first year would be spent in acquiring expertise in medical statistics". So he also resumed his studies in mathematics:

> I attended the courses in applied mathematics under Professor K. E. Bullen FRS, who gave very clear lectures and who was a help and encouragement to me then and for many years later.
>
> I also attended the lectures of Professor T. G. Room FRS in pure mathematics, principally geometry . . . I have always been greatly impressed by Room's lectures and his virtuosity. No other lecturer in Australia has seemed to me to have such a command of the subject in hand.

He was awarded a BA in 1947. Further studies in "the pure half of the Mathematics IV course" followed, although Lancaster avowed at that time that he had no interest in becoming a professional mathematician. In July 1948, he left for a year in England as a Rockefeller Fellow in Medicine at the London School of Hygiene and Tropical Medicine.

The scientists

Harrie Massey, who had been a student of Michell's at the University of Melbourne, was one of three Australians who worked on the development of the atomic bomb. The others were Eric Henry Stoneley Burhop and the eminent physicist, later to be appointed governor of South Australia, Mark Oliphant FRS. Burhop was born in Hobart in 1911 and, like Massey, educated in Melbourne and Cambridge, where he graduated with a PhD in 1938. He lectured in natural philosophy at the University of Melbourne from 1936 to 1942 and then took the wartime post of officer-in-charge of the CSIR Radio Research Laboratory in Melbourne.

Massey, Burhop and Oliphant all worked on the Manhattan Project, the "Tube Alloys" scheme in particular, in the USA in 1944–1945. Also involved was another who would make a great mark on Australian physics, Ernest William Titterton, the foundation professor of nuclear physics at the Australian National University. After the war, Burhop was a lecturer and then reader in mathematics at London's University College until 1950, when he was appointed reader in physics. He was promoted to professor in 1960, retired in 1978 and died in London two years later.

John Conrad Jaeger, like T. G. Room, is a striking example of a civilian mathematician who stayed in Australia and made a substantial contribution to its war effort. When war broke out, Jaeger and Edwin Pitman together constituted the mathematics staff of the University of Tasmania and the extensive collaboration with Carslaw had been operative for some years.

This collaboration was itself worthy of mention by D. P. Mellor. He wrote of "mathematical formulae developed by Dr Jaeger and Professor Carslaw, who some years before had made a special study of the conduction of heat".[35] This led to scientists in the CSIR National Standards Laboratory, including Jaeger himself, devising new goggles, with lenses of tinted, infra-red absorbing glass, which allowed their wearers to detect aircraft silhouetted against the sun. "These goggles, when tested in experiments carried out in conjunction with anti-aircraft defences . . . in which a dive bomber attacked from the sun, were found to improve the efficiency of the gun crew. The goggles were adopted first by the navy and later by the other two Services."

While still in Hobart, Jaeger undertook several military projects that made use also of his early inclination towards engineering. This work included problems concerned with the production of charcoal, in which he carried on work initiated by Leicester McAulay, and the fracturing of sandstone rollers used in newsprint production. Regarding the second of these, Jaeger's biographer, the Canberra physicist Mervyn Silas Paterson, wrote that the most interesting feature "lies in the way it reveals the effective combination of Jaeger the engineer singling out the essential elements of the problem and Jaeger the applied mathematician dealing with the theoretical questions posed."[36] The solution of these two problems led to a number of publications while at the same time Jaeger continued to publish on the conduction of heat. In December 1941 he received a DSc from the University of Sydney.

About one year later, Jaeger was requested to join the CSIR Radiophysics Laboratory in Sydney for full-time investigation of the generation and propagation of radio waves.

> At the Radiophysics Laboratory, the centre for radar research and development in Australia during the war, Jaeger was involved in a variety of theoretical problems. Some of these, such as the calculation of currents and potentials in electrical circuits, arose out of equipment design and development. However, Jaeger's main contributions were in the two areas of antenna patterns and radio wave propagation. He became involved in the wave propagation and absorption work initially through [F. W. G. White (later Sir Frederick), head of the Laboratory], whose

> responsibilities for ionospheric prediction had come to include the problem of predicting the lowest usable high frequency for radio transmission above 2MHz, a requirement of the armed services.[37]

There was also work on the effect of wind on nocturnal cooling and on diffusion in turbulent flow between parallel planes. The National Standards Laboratory was in the same building as the Radiophysics Laboratory, and it was during this time that Jaeger contributed to the design of the new lenses for goggles, mentioned above.

In September 1943, Pitman requested Jaeger's return to Hobart. He had been managing the department with the assistance only of three part-time lecturers and had discontinued all teaching in third-year subjects, a situation which, he wrote, would be "impossible to continue ... without a full-time lecturer."[38] Jaeger returned to the University of Tasmania in April 1945.

Eric Russell Love had only recently joined the department of mathematics at Melbourne University as a lecturer when he found himself seconded, in 1942, to the Munitions Supply Laboratories (later called the Defence Standards Laboratories) at Maribyrnong on the outskirts of Melbourne. There he worked on a variety of mathematical problems in armaments and equipment.

> For example, one of his tasks was to explain the failure of certain gyroscopes used in automatic pilots in aircraft; the problem came down to calculating the stress concentrations near defects in the gyro spindles, and to deal with the problem involved the enlargement of the then existing tables of Legendre functions. In 1944, he was transferred to the Aeronautical Research Laboratories, Fisherman's Bend, where he worked with J. P. O. Silberstein and others with the express purpose of enquiring into aircraft engine and propeller vibration.[39]

Josef Philipp Otto (Phil) Silberstein was born in Vienna on 5 July 1920. His first substantive job in Australia, in 1939 after leaving Austria with his twin brother and having spent just nine months in London, was with the newly formed CSIR Division of Aeronautics as a junior laboratory assistant. At the same time, he studied engineering in the evenings at "Melbourne Tech", now RMIT, but after two years transferred to the University for a BA with mathematics honours, still studying part-time. The degree was completed in 1944. Silberstein took three years absence in the late 1940s to obtain a Cambridge PhD and, back at the ARL, attained the position of principal scientific officer in 1955. Five years later, Silberstein embarked on an academic career and in 1966 was appointed professor of mathematics in the University of Western Australia.[40]

Many of the "others" at the Aeronautics Division at that time have been mentioned previously in connection with the University of Melbourne: they included George Batchelor, Dick Dalitz, Betty Gent, Julius Guest, David Hurley, Elizabeth Mann, Fenton Pillow, Rainer Radok and Roy Smith.[41] The future Canberra geophysicist Mervyn Silas Paterson was also there.

Dalitz, in the summer of 1944–1945, worked with a group on fluid flow problems, under Batchelor.[42] Mann began work in the division in December 1942, having previously spent a summer there, and returned briefly in 1949 after time off to complete her Cambridge doctorate.[43]

Pillow was a research officer there from 1943 to 1947 and senior research officer from 1950 to 1953 working for much of the time on problems of compressible flow and hydrodynamic stability. He spent the intervening years at Cambridge studying towards his PhD. Gent researched wind tunnel interference problems. Radok, following his internment, served in the Australian Army from 1942 to 1945 while studying part-time at the University of Melbourne; he subsequently worked in the division until 1950, and again from 1953 to 1955. Smith was in

the division from 1941 to 1948 and then began a long career in the University of New England, where he was professor of mathematics from 1957.

Walter Freiberger was another: he served in the Australian Army from 1943 to 1945 and was released early so as to join the division. His first-year university studies were completed while in the army and the rest of his course while working at Fishermans Bend on structural problems related to the Mosquito fighter. He and Radok in fact began there as assistants to Silberstein, although they did not get on well together.[44] Freiberger remained with the ARL until, having gained an MA from the University of Melbourne, he departed for Cambridge on a scholarship in 1950.[45] He returned in 1953 for two more years at the ARL before moving permanently to Brown University in the USA.

This chapter began with stories of Les Woods and Basil Rennie, who came to Australia after the war. Another who was to gain eminence in Australian mathematics but did not arrive until some time after the war was Herbert Sydney (Bert) Green. He came to Adelaide in August 1951 to take up the chair in mathematical physics. He had previously worked with Max Born in Edinburgh from 1945, where he obtained his PhD and a DSc two years later, and with Erwin Schrödinger in Dublin in 1950–1951. In between, he spent a year at the Institute of Advanced Study in Princeton, continuing the work on quantum mechanics and quantum field theory that had been initiated with Born. Green was born on 17 December 1920 in Ipswich, England, and completed his BSc with first-class honours in mathematics at the Imperial College of Science and Technology, London, soon after the war started. He joined the RAF in 1941 as a meteorological officer with the rank of flying officer and spent most of the war on the Isle of Man advising the RAF on flying hazards such as wing icing. As Angas Hurst recalled: "Bert's experience there remained with him throughout his career and gave him special insights into environmental questions and, more remotely, into problems in cosmic ray physics that were out of the normal run."[46]

Bailey's radar courses

In Oliver Lancaster's *Recollections*, he lamented that in his Leaving Certificate mathematics examination in 1929 at West Kempsey Intermediate High School he was placed second to Jack Somerville, who, when war broke out, was lecturing at the New England University College. In August 1941, he was seconded to Sydney to be one of the assistants in the radiophysics courses conducted by Victor Albert Bailey, professor of experimental physics in the University of Sydney from 1936 to 1953.

Some 300 servicemen passed through Bailey's courses.[47] Initially they had been carried out by the Radiophysics Laboratory, but the assistance of the university was called on when the task became too large. There were six courses, of three to six months duration, during the period from September 1941 to March 1944. Graduates of the courses were commissioned as radar officers in one of the three services and in many cases were sent to the front.

Two of Bailey's other assistants, besides Somerville, were Dick Makinson, by that time in the physics department at the University of Sydney, and Bill Smith-White.[48] Their work for Bailey was additional to their university duties.

One of the tutors in the course, who later became Bailey's assistant director, was Alfred Hurlstone (Alf) Pollard. Pollard was born in Melbourne on 9 August 1916, but grew up on Norfolk Island and was educated in Sydney at Canterbury High School. He was the state's top

student in the Leaving Certificate of 1932 and in Room's first honours year won a BSc with the university medal in mathematics and a Barker graduate scholarship. However his family's circumstances did not allow him to take up the scholarship. Instead, with a letter of introduction from H. S. Carslaw, Pollard took a position with the MLC Assurance Company where he gained his actuarial training. At the age of 23, he had passed all papers towards his fellowship of the Institute of Actuaries.

"Out of the blue," he was invited by Bailey two years later to take the appointment in radiophysics despite having not covered the area in his university course. When that work came to an end in early 1944, Pollard joined the RAAF and spent two years as a flight lieutenant in acoustic research, another area initially foreign to him, in a laboratory at the University of Sydney. On his discharge from the RAAF he returned to the MLC.[49] In 1966 Pollard was appointed foundation professor of economic statistics and, in 1968, director of actuarial studies at Macquarie University. The biography of the brilliant Alf Pollard continues in Chapter 9.

The servicemen who went through Bailey's courses referred to themselves as the "Bailey Boys". They were mostly volunteers from around the country who had completed just one or two years of university studies. Walter Fielder-Gill was a Bailey Boy and has written their story, together with an account of the courses themselves:

> It was no mere service course, but combined theory and mathematical rigour, supplemented with practical exercises. Bailey made it clear in his introductory lecture that it would be no easy option . . .
>
> Bailey lectured on circuit theory, including analyses of series and parallel and more complex circuits using differential equations and a vector approach to the steady state; on the use of operators and complex numbers; on resonance, filters, transformers, networks, D-Y transformation, bridges, coupled circuits, transmission lines and chains; and on reflection, attenuation, matching, efficiency, and wave generation. Bailey's notes included some 125 numbered mathematical equations. Smith-White lectured on aerials of various types and their radiation patterns, with attention to arrays, reflection, refraction and the ionosphere. Makinson lectured on vacuum tubes, covering such topics as diodes, triodes, tetrodes, pentodes, cathode ray tubes and thyratrons . . . He also lectured on modulation and demodulation and noise, and radio tube testing and fault locating . . . Somerville gave about twenty-five lectures purely on amplifiers and oscillators . . . power output, distortion, efficiency, modulation methods, design of transformers, phase inverters . . .
>
> Pollard also taught Fourier series and integrals applied to periodic functions, Fourier integrals for non-periodic functions (e.g. pulses), and the building up of square, rectangular, triangular, sawtooth and other waves from a fundamental sine wave by progressively adding harmonics of appropriate amplitude.
>
> During the course, there were one-hour examinations on electricity and magnetism, and in mathematics—integration, differential equations, operators, time delay of pulses, Fourier theory, transmission lines and amplifiers and oscillators.[50]

Bailey himself maintained a long friendship with Smith-White and other university mathematicians. Apart from his major work on the ionosphere, he had a lifetime fascination with numbers and wrote papers in that area and in other areas of mathematics. Born in 1895 in Egypt, Bailey had studied at Oxford and came to Australia in 1924 as associate professor of physics at Sydney University. He retired from the University in 1961 and died in Switzerland in 1964.[51]

Charles Angas Hurst, always known as Angas, was a Bailey Boy. He was born on 22 September 1923 in Adelaide and was educated at Scotch College, Melbourne, before the war, and the University of Melbourne after it. Hurst answered a newspaper advertisement for university

students to enlist in the RAAF to assist with "radio direction finding" and ended up in the second batch of about 35 from all over Australia attending one of Bailey's six month "pressure courses" in theoretical and experimental radiophysics. He then went to Richmond in New South Wales for a further three-month course in radar and, still not 20 years of age, was commissioned as a pilot officer. His first job was as commanding officer of a radar station on the front line in New Guinea, on the D'Entrecasteaux Islands, never having seen a radar station before. Hurst returned to Australia and held a number of further posts as commanding officer and technical officer in radar stations, before ending his service in early 1946 as a flight lieutenant.[52]

He returned to Melbourne, obtained his BA with honours in 1947 and a BSc a year later, and then travelled to Cambridge to study for a PhD, coincidentally with Basil Rennie. Hurst accepted Tom Cherry's personal offer of a senior lectureship in mathematics at the University of Melbourne in 1952 and five years later went to a similar position in mathematical physics at the University of Adelaide. He was promoted to reader in 1961 and to professor of mathematical physics in 1964.

The experiences of Robert Philip (Phil) Loh as a student at Melbourne University for a year followed by attendance at one of Bailey's courses and then being sent to New Guinea were very similar to Hurst's. After the war and having completed his university studies, Loh taught mathematics and physics at the Bendigo School of Mines for seven years. He then gained experience in operations research with the Colonial Sugar Refining Company and was in the Department of Applied Mathematics at the University of Sydney for 20 years, teaching operations research until his retirement in 1983.

The University of Western Australia's David Hurley, a close friend of Hurst's as undergraduates, and John Makepeace Bennett, who was foundation professor of computer science in the University of Sydney from 1961 to 1986, were also Bailey Boys. Bennett would later say that he learnt all he knew of Fourier analysis from Pollard and Pollard returned the compliment by attending Bennett's second SILLIAC computer course at Sydney University in 1956.[53]

Charles Leonard Hamblin was another Bailey Boy: he began at the University of Melbourne before the war and returned afterwards to complete his studies in mathematics, physics and philosophy. He became a philosopher and computer scientist of considerable renown, teaching at the University of New South Wales, and is particularly remembered for his invention of the reverse Polish notation for computations.

Chapter 6

Post-war Mathematics in the Older Universities

This chapter completes the stories of mathematics in the six universities, one in the capital city of each state, which have been introduced in the earlier chapters. It also describes mathematics in the University of New South Wales, established in 1949 as the New South Wales University of Technology, and the University of New England whose antecedent, the New England University College, was established in 1938. Together with the Australian National University, which is treated separately in Chapter 7, these were the nine universities in the country prior to the establishment of Monash University in Melbourne in 1958. During the 1950s, there were also university colleges operated by the University of New South Wales in Newcastle and Wollongong.

It was the report of the commonwealth government's Murray Committee in 1957 that gave the impetus to the founding of Monash University and other universities in the 1960s and 1970s and led to autonomy for the university colleges in Newcastle and Wollongong. Their stories and those of the later universities of the 1980s and 1990s are given in Chapter 9.

The University of Sydney, from 1946

One of the most contentious periods in Australian mathematics began with the arrival of Keith Bullen as professor of applied mathematics in the University of Sydney.

That post had to be advertised in 1945 because of the ill health of Edward Wellish, who had served under Carslaw and then Room since 1907. In correspondence between Room and the university registrar, Walter Selle, in July 1944, the latter suggested that John Jaeger "might be offered a readership" in replacement of Wellish, since Jaeger was "at present . . . on the premises working in the National Standards Laboratory on some important research work in Radio Physics."[1] For reasons that will become apparent, Room preferred that a chair be advertised.

Jaeger's was one of eight applications. Alexander Miller, a pioneer of wartime operations research in Australia, was an applicant, along with Mark Appleby, then professor of mathematics in the University of Malta, and George J. Kynch, then at the University of Birmingham but later to hold chairs at the University College of Wales, Aberystwyth, and the University of Manchester Institute of Science and Technology. The selection committee, which included Room, Sir John Madsen and the physicist Oscar Vonwiller, came up with a shortlist of two, ultimately recommending Bullen over Jaeger. The Department of Mathematics in the University of Sydney thus

became the first in the country to have two professors, although the original appointee was intent on retaining a level of superiority.

Bullen was awarded a special MA degree from the University of Melbourne shortly before leaving there and he would later receive honorary DSc degrees from the University of Auckland and the University of Sydney. In a reference on his behalf for the Sydney position, Harold Jeffreys wrote: "He is a candidate for the Royal Society, which implies that at least six Fellows consider him worthy of election, and I myself consider his election somewhat overdue." The fellowship was confirmed in 1949. He also became a fellow of the Australian Academy of Science at its foundation in 1954, as did Room.

Bullen received many other fellowships, honours and awards and held many prestigious international posts. While he was president of the International Association of Seismology and Physics of the Earth's Interior, there was a series of nuclear tests conducted by the United States at Bikini in the Marshall Islands. Bullen and Thomas Noel Burke-Gaffney, from the Riverview Observatory in Sydney, were involved in recording and interpreting the seismic waves that were produced,[2] and Bullen used his international standing to request with some success that future such explosions be announced in advance so that they could be used for scientific purposes.[3] The suggestion earned Bullen the scorn of some of his more socialist-minded colleagues.[4]

There was an intense and lasting antipathy between Room and Bullen dating back to within a few years of Bullen's taking the chair. On 27 November 1950, Bullen wrote to the registrar of the University: "Circumstances have brought me to the point where I feel I must seek some elucidation of the definition of my office in the University of Sydney. In consequence, I wish to request discussion, on relevant matters, between the Vice-Chancellor, Professor Room and myself." The meeting took place on 6 December.[5] Four months later, on 28 March, Room wrote to the chancellor informing him of his intention to resign within a few weeks. His letter spelt out the cause of the ill feeling:

> Last December the Vice-Chancellor laid down conditions for running the Department of Mathematics which are unworkable, and are moreover in flat contradiction of the conditions I was offered before coming here, namely, that if and when a Professor of Applied Mathematics was appointed, I should be Head of the Department of Mathematics.
>
> When Associate Professor Wellish retired, a Chair of Applied Mathematics was created, because, there being then no rank of Associate Professor, only so could a salary be offered that would attract a man of Professor Wellish's quality to the post. The subsequent history of the Department made it clear that unless a definite order of seniority is established, no workable scheme can be devised with two Professors in the Department.

Room had in fact by then accepted the chair of mathematics at the University of Belfast. But he withdrew his resignation on 27 June,[6] and subsequently the mathematics department was split into separate departments initially called the Department of Mathematics (Pure Mathematics) and the Department of Mathematics (Applied Mathematics).

The two initially shared the teaching of mathematics subjects in all three years of the undergraduate course. By 1956, it had been agreed to offer separate third-year subjects, but this was to bring further acrimony when Room proposed that his department offer two subjects. The first was Pure Mathematics (which includes Statistics). As regards the second, Bullen wrote: "To my amazement, the proposals included a subject, to be taught by the Department of Pure Mathematics, and described, not as Pure Mathematics, but as 'Mathematics III (Pure Mathematics and Natural Philosophy)', the syllabus for which included essentially the same Applied Mathematical topics as those at present taught by my Department in the subject Mathematics

III."[7] Room had condescendingly offered that both departments in conjunction might teach the second subject. In the end, there were two new subjects, Pure Mathematics III and Applied Mathematics III.

According to one of Bullen's biographers, the distinguished mathematician turned geophysicist Anton Hales, Bullen's early leaning had been towards pure mathematics but "it was not long before mathematics had become ... a tool rather than an end."[8] Bullen saw applied mathematics as an investigative branch of science which had "affinities" with pure mathematics, but:

> It also has close affinities with other branches of science such as Experimental Physics, Mechanical and Aeronautical Engineering, Astronomy, Geophysics, Chemistry, Geology, and so on. And it overlaps with all these branches, just as it does with pure mathematics.

However, he continued, "the spirit of applied mathematics does not thrive if it is tied too closely to any one of its many neighbours", including, of course, pure mathematics. These quotations are from Bullen's paper, "The spirit of applied mathematics", delivered on 17 August 1956 to the inaugural meeting of the Australian Mathematical Society. Among the many instances cited to justify his thesis are a number chosen from his own research with Jeffreys, giving an insightful account of this work. The paper is reproduced in full as Appendix 2. In the ensuing years, Bullen's view of pure mathematics, and the language he used to describe it, hardened noticeably. In an address to an audience of senior undergraduate students, he wrote in 1963:

> [The] applied mathematician has to respect the rules of deductive logic no less than the pure mathematician, even though there are occasions when his respect has to be tempered by other considerations. Also the more pure mathematics an applied mathematician knows, the more powerfully will he be equipped to face the tasks that confront him. But his work becomes sterile when, as sometimes happens, he becomes so affected by the beauty, or so tyrannised by the rules, of pure mathematics as to forget the importance of context.
>
> It is in fact a matter of fairly recent history that Applied Mathematics went through a period of decadence in many centres through too close association with Pure Mathematics. During the last thirty years or so, Applied Mathematics has been emerging from this decadence, at least in the more enlightened centres of the world, and an understanding of the distinct character of Applied Mathematics has been accompanied by a great surge of fertility.[9]

A long-time colleague of Bullen's in Sydney, Denis Winch, saw Bullen's views on mathematics as pivotal to the relationship with Room. He wrote: "The basis of their disagreement was Bullen's view that applied mathematics was a separate discipline to be studied for its own sake. Room held that pure and applied mathematics were inseparable, and should be taught together."[10] According to Room's biographers, the rift between the two departments "affected their joint activities and seriously weakened the voice of mathematics in university affairs."[11] Oliver Lancaster wrote similarly: "The effects were unfortunate in so far as divergent opinions on faculty and professorial board meetings tended to reduce the ability of either department to affect university policy."[12]

Knowledge of the dispute was widespread, to the detriment of the University. When Les Woods was leaving England at the end of 1953 to take up his senior lectureship in Bullen's department, he was told by John Greenlees Semple, a geometer and head of mathematics at King's College, Oxford, that he "was moving to a very unhappy mathematics department".[13]

Other professorial disputes in Australian mathematics did not have such ramifications, although in some cases they arose from similar assertions of authority. Tom Cherry and Maurice Belz were not the best of friends when, as an associate professor, the latter was given a separate

statistics department in 1948.[14] In the University of Queensland in 1966, actions by Fenton Pillow as professor of applied mathematics and acting head of department while the longstanding head Clive Davis was on leave led to lasting ill feeling between them. (But Pillow had seen first hand as a member of Bullen's staff what had happened in Sydney and was determined not to have the situation replicated in Brisbane.[15] That is not to suggest that Davis would have allowed it.) At the University of New South Wales in the late 1960s relations between two volatile applied mathematicians, John Blatt and Ted Buchwald, led in effect to two departments of applied mathematics. The relationship between Freddy Chong, professor of mathematics, and Don McNeil, professor of statistics, at Macquarie University in the late 1970s was also not always cordial.

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In 1952, before the Sydney University mathematics department was split, the university *Calendar* listed the staff as professors T. G. Room and K. E. Bullen; senior lecturers F. Chong, W. B. Smith-White, H. H. Thorne and K. C. Westfold; and lecturer H. Mulhall along with temporary lecturers M. N. Brearley and R. D. Munro and part-time lecturers E. B. Kraus, H. O. Lancaster, A. H. Low, T. Pearcey, S. A. Senior and J. L. Williams. The 1953 *Calendar* listed staff under three headings: pure mathematics, applied mathematics and statistics. Room, Chong, Smith-White and Williams moved to pure mathematics along with a new lecturer R. A. (Russell) Smith and new part-time lecturers B. A. Bolt and J. S. Sandiford; Bullen, Thorne (who died that year), Westfold and Mulhall went to applied mathematics; and Mulhall was listed also as being in statistics along with the part-time lecturers Lancaster and Pearcey.

The new senior lecturer in applied mathematics, Kevin Charles Westfold (or Westfold-Scott, according to his undergraduate enrolment), came to the University from a position as research officer in CSIRO's radiophysics division. His interests then were in the application of electromagnetic theory to astrophysics and geophysics and he was employed at the famous radio astronomy field station at Dover Heights in Sydney. Born in Melbourne on 24 August 1921, Westfold had gained his BA with honours in mathematics from the University of Melbourne in 1942, and then a BSc in 1943 and an MA in 1946. After a short period teaching and researching mathematics in Melbourne, he had travelled to Oxford University on a CSIRO studentship and gained a DPhil there in 1951 for his work on theoretical problems in radio astronomy. Westfold resigned from the University of Sydney in late 1960 to become foundation professor of mathematics at Monash University.

James Lewis (Jim) Williams was to become a mainstay of the Department of Pure Mathematics and of the Mathematical Association of New South Wales. He completed mathematics honours at Sydney University during 1936 (the same year as Clive Davis, professor of mathematics in the University of Queensland, and Pat Moran, first professor of statistics in the Institute of Advanced Studies, ANU), took up school teaching and did not receive a full time university appointment until 1959 when he was given a senior lectureship. Expanding class sizes led to his designation as Director of First and Second Year Courses in 1965. Williams died in 1993.

Bruce Alan Bolt, born at Largs, near Maitland, New South Wales, on 15 February 1930, had just completed his honours degree in the University of Sydney when he gained the part-time appointment just mentioned. He became one of Bullen's only two PhD students and in 1955 was appointed a full-time lecturer in applied mathematics. (Bullen's other doctoral student was Raymond Arthur William Haddon, university medallist in 1962. Haddon lectured in Bullen's department in the late 1960s and then pursued a successful career in seismology in Canada.) By 1963, Bolt was professor of seismology in the University of California, Berkeley. His distin-

guished career there included a term as president of the Seismological Society of America and among his numerous textbooks was a new edition of Bullen's original seismology text, written almost 40 years before.[16] He became an American citizen in 1972 (and that year took out a DSc from the University of Sydney), retired in 1993 as emeritus professor and died on 21 July 2005.

Bolt often related the story of his presence at a series of atomic tests at Maralinga, South Australia, in September 1956. "I ran outside the small concrete block building and saw, plump on the horizon, the tell-tale mushroom cloud," he wrote. Just three weeks before, Bullen had presented him with the opportunity to be there. Bullen had led him into his office "in a conspiratorial way" and said:

> Bruce, we have a chance to participate in an historical experiment using British tests of above-ground atomic explosive devices in Central Australia. The team will be under the direction of Professor J. C. Jaeger of the Department of Geophysics at the Australian National University. Will you go out with them and operate a seismograph? You will be able to estimate for the first time the structure of the Australian continent using very precise seismological measurements.[17]

The former Beverley Bentley, Bolt's wife, was born in 1932. She gained first-class honours and the university medal in mathematics at the University of Sydney in 1954 and was the winner of the Barker prize for mathematics. This had less standing, and considerably less monetary worth, than the Barker graduate scholarship that she would have expected to receive. Room had informed her "that 'they' had decided to give it to a man from the previous year because 'I would get married and for him time was running out'."[18] A PhD supervised by Room was awarded in 1960 and she was appointed lecturer in mathematics at Berkeley when her husband received the offer of a chair there.

Trevor Pearcey was another of the part-time lecturers from the early 1950s. He taught statistics for some years and is remembered as a pioneer of Australian computing, in particular as the designer of Australia's first computer, the CSIR Mark 1 Automatic Computer which first ran a program in 1949. As part of his Sydney University lectures from 1947 to 1952, Pearcey delivered the country's first course in numerical methods and computer programming. Born in Woolwich, London, in 1919 he had graduated from Imperial College with first-class honours in mathematics and physics. Much later, in 1972, he received a DSc from the University of Melbourne and began a lengthy career as dean of computing in the Caulfield Institute of Technology, later part of Monash University. Pearcey died in 1998.

Of the others mentioned above, Ross Donald Munro's address when he joined the Australian Mathematical Society as a foundation member in 1956 was given as "Operational Research Group, Army H.Q., Melbourne". He later joined the School of Traffic Engineering at the University of New South Wales. Eric Bradshaw Kraus was a CSIR meteorologist involved with early cloud-seeding experiments; he was subsequently professor of meteorology in the University of Miami, Florida. Angus Henry (Gus) Low, John St Alban Sandiford and Stanley Alan Senior pursued their mathematical careers at the New South Wales University of Technology, later the University of New South Wales (UNSW).

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Three notable but, as it turned out, short term appointments were made around 1954: those of Les Woods, Eric Barnes and Fenton Pillow.

Woods' career, including his two years as senior lecturer in applied mathematics at Sydney University, has been detailed in Chapter 5. He has written that he had been invited to take the foundation chair of mathematics at Monash University and, in declining, had recommended that

it be offered to Westfold. Woods was then Nuffield Research Professor of Mechanical Engineering at the Uuniversity of New South Wales and at the same time was also offered the chair of mechanical engineering at Sydney University and a fellowship at Balliol College, Oxford. In his words, his choice was to exchange his professorship "for a mere demonstrator's position in Oxford."[19]

Eric Barnes was also introduced in Chapter 5. He took up a readership in pure mathematics in 1954 having previously declined a senior lectureship because of the offer of a full lectureship in Cambridge. He had been awarded his PhD there, supervised by the eminent number theorist Louis Joel Mordell in 1952 and had also won the Smith's prize, shared with one other candidate. Back in Sydney, Barnes' first PhD student was Jane Pitman, daughter of Hobart's Edwin Pitman. In 1959, he was appointed Elder Professor of Pure Mathematics in the University of Adelaide.

Albert Fenton Pillow, to give his full name, was born in Kapule, in the Belgian Congo, on 27 March 1921 and came to Australia with his parents towards the end of 1924. He studied at Geelong College from 1930 to 1939 and then at the University of Melbourne, one of that group of distinguished students described in Chapter 4. His PhD at Trinity College, Cambridge, was supervised by George Batchelor and Hermann Bondi. He was to spend more than ten years at the Aeronautical Research Laboratories at Fishermans Bend, interrupted by the studies in Cambridge and culminating in the position of senior research officer in charge of the theoretical fluid dynamics group, before taking a senior lectureship in applied mathematics in the University of Sydney. Three years later he went to a similar post in the University of Melbourne and from there went for five years to the University of Toronto where he was professor of mathematics from mid-1962 to mid-1964. (Pillow candidly admits to catching up on a great deal of his mathematical education in Toronto—as a student in Melbourne he had never had a course in matrix theory, for example, "although I was expert in manipulating determinants ... and I finally taught myself some functional analysis."[20]) In July 1964 he took up an appointment as professor of applied mathematics in the University of Queensland.

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The late 1950s and early 1960s were, in contrast, notable for some lasting appointments. These included, in particular, those of Tim Wall and Max Kelly in pure mathematics, Peter Wilson in applied mathematics and Oliver Lancaster in mathematical statistics.

Lancaster's early career, including his wartime contribution and ending with travel to London in 1948, has been described in Chapter 5. After what was a personally difficult but academically enriching year abroad, he returned to Australia in August 1949 as a medical statistician in the School of Public Health and Tropical Medicine in the University of Sydney, where he had previously been employed, and in 1951 he enrolled for a PhD in the Faculty of Science. Room was appointed as his supervisor pending the return of Mulhall from Cambridge where he was doing his own PhD, at which time Mulhall was expected to become the official supervisor. Lancaster's degree, awarded in 1953 for a thesis entitled *The Distribution of X^2 in Discrete Distributions*, was the first doctoral degree to be conferred in Australia in the mathematical sciences. He would later receive an MD (1967) and a DSc (1971).

During the early 1950s, much of Lancaster's research was focused on the collection and statistical analysis of Australian mortality and other data. Two projects stand out. In the first "landmark paper" Lancaster in effect established a causal connection between rubella and congenital deafness through his examination of census and other records covering almost a century.[21] The second, published five years later in 1956, led to his conclusion that the death rate from melanoma was associated with the intensity of sunlight.[22] As Eugene Seneta wrote in an

obituary: "The danger of intense ultra-violet radiation has now passed into standard knowledge in Australia, with its discoverer forgotten." His work on rubella, on the other hand, remains well known in medical circles.[23]

In March 1959 while still in the School of Public Health and Tropical Medicine, Lancaster was promoted to associate professor. At the same time, encouraged by Bullen, he was applying for the chair of mathematical statistics in a new department in the Faculty of Science alongside the Departments of Pure and Applied Mathematics. He was hesitant about applying for the position, since he felt it was "too late to become a professional mathematician"[24] but, with support from Joseph O. Irwin and Maurice Kendall in England and Joseph Berkson in the US, he won the chair from the other main candidate, Geoffrey Watson. Jim Douglas, by then associate professor of mathematical statistics at UNSW, recalled that Lancaster was fond of holding "sandwich lunches" with special guests and he attended one of the first, in 1959, at which the mathematician-songwriter-satirist Tom Lehrer was also present.[25]

Lancaster's first fourth-year honours class, in 1960, included Chris Heyde, of whom there is much to write later; Murray Aitkin, now retired as professor of statistics at Newcastle-upon-Tyne; and M. A. (David) Hamdan who then became Lancaster's first PhD student. The second was Geoffrey Kennedy (Geoff) Eagleson. Born in Sydney in 1941, Eagleson graduated with first-class honours in pure mathematics and a university medal in 1963, and then moved to Lancaster's department. He held teaching positions in mathematical statistics in the University of Sydney and the University of Cambridge before joining CSIRO in 1980. Resigning from there as senior principal research scientist in 1988, Eagleson joined the Australian Graduate School of Management on the campus of UNSW and is now professor of management there.

On 25 September 1947, before he went overseas, Lancaster together with Helen Newton Turner of the CSIR and Stewart Rutherford held a meeting that led to the formation of the Statistical Society of New South Wales.

Robert Stewart Gregg Rutherford, to give his full name, had been appointed to a lectureship in economic statistics that year and joined Lancaster on the steering committee for the new society. Rutherford would go on to be professor of economic statistics from 1962 to 1980. Others elected to the steering committee included Harry Mulhall and the noted statistician and actuary, Alf Pollard, as well as David Beattie Duncan. Duncan had taught biometry in the University's Faculty of Agriculture since 1938 and had just returned as one of the first recipients of a PhD in statistics from Iowa State University. In 1961 he was appointed professor of statistics in the School of Hygiene and Public Health at Johns Hopkins University, Baltimore.[26]

For Lancaster, the 1947 meeting marked the beginning of a total commitment first to the new society and later to the Statistical Society of Australia. He was largely responsible for publication of the *Bulletin of the Statistical Society of New South Wales* from March 1949 when it first appeared, until September 1958. At that time it was replaced by the *Australian Journal of Statistics*, of which he was the founding editor. (In 1998, it became a joint publication: the *Australian and New Zealand Journal of Statistics*.) Lancaster was equally committed to the Australian Mathematical Society after its formation in 1956. He was president of the Statistical Society of New South Wales in 1953–1954 and of the Australian Mathematical Society in 1966–1968.[27]

Lancaster retired as emeritus professor in 1979, to be succeeded by Eugene Seneta. There was no pause in his rate of research. His *Bibliography of Statistical Bibliographies*[28] had appeared in 1968 and 21 supplementary lists were later published, the last in 1989. Around that time

he completed his long-term project on world mortality called *Expectations of Life*,[29] the fifth of his six books. This was a "book of amazing scholarship and commitment," wrote Seneta and Eagleson in an obituary: "its bibliography alone takes up pages 505–592, at two columns per page, and contains an estimated 2800 items [compiled] without the aid of electronic data bases."[30] Lancaster died on 2 December 2001. Seneta and Eagleson wrote:

> HOL was one of the small band of Australian statisticians who made Australia one of the powerhouses of the statistical world in the 1950s, 1960s and 1970s. They left a strong legacy.[31]

Sydney University's third professor of mathematical statistics was appointed in 1991 when John Robinson gained a promotion to a personal chair. Robinson, born in Brisbane on 12 February 1940, had largely through part-time study gained a BSc with honours from the University of Queensland in 1963 and a PhD from the University of Sydney in 1969. His first appointment there was as a lecturer in biometry in the Faculty of Agriculture in 1964. Two years later he transferred to a lectureship in the Department of Mathematical Statistics.

Meanwhile, in the recently created Department of Pure Mathematics, Gordon Elliott Wall had been appointed to a senior lectureship in 1956. Born in Adelaide on 11 March 1925, he was always known as Tim after a South Australian Test cricketer of the early 1930s who was a cousin of his father's (and who also was not Tim originally, but Thomas Welbourn Wall). Tim, the future mathematician, originally studied medicine at the University of Adelaide, following his parents who were both doctors, but switched to the science faculty after two years. After gaining his degree with honours, Wall headed for Trinity College, Cambridge, where he studied first under D. E. Littlewood and then J. A. Todd. He was there for only two years before taking an assistant lectureship at the University of Manchester and completing his Cambridge PhD in group theory under the supervision of Walter Ledermann. The next job, after travelling home and then back to England, was at the Newcastle-upon-Tyne branch of the University of Durham from 1952 until May 1956 when the appointment to the position in Sydney took place.[32]

Wall was promoted to reader in 1962 at the same time as Smith-White was promoted to associate professor, and Max Kelly, who had joined the department as a lecturer in 1957, was promoted to senior lecturer. John Michael Mack was there as a lecturer by that time. He was promoted to senior lecturer in 1972 and to associate professor in 1984. A respected number theorist, Mack was to have a wide involvement in university administration, including as chair of the academic board for five years in the 1990s, and in secondary school mathematics as holder of executive positions with the Mathematical Association of New South Wales and the Australian Association of Mathematics Teachers. In 1991–1992, he chaired an external review of VCE mathematics (Victoria's final school examination) on behalf of the Victorian Curriculum and Assessment Board. Mack retired in 1997 and was accorded the title of honorary associate professor.

Gregory Maxwell (Max) Kelly's reputation is in category theory. He was born on 5 June 1930 in Sydney and excelled in his school Leaving Certificate examination in 1946, having repeated the final year because he had started high school while just ten years of age. He began at the University of Sydney in the Faculty of Engineering, but moved to the Faculty of Science in his third year, graduating with first-class honours and the university medal in mathematics. It was Kelly's habit to win all available prizes and he continued it in Cambridge with the Adams Prize. He was there for more than five years, gaining a PhD under Shaun Wylie in algebraic topology, before returning to Sydney to the lectureship in pure mathematics. Twelve months leave to be taken at the Massachusetts Institute of Technology from September 1962 was aborted due to

the Cuban missile crisis but a few years later Kelly was able to work with Samuel Eilenberg and Saunders Mac Lane, among others, in instituting the study of category theory. He returned in mid-1965, began the Australian Category Seminar which still meets weekly, and took on Ross Street as a PhD student, his first and most successful.[33] Street was later professor of mathematics at Macquarie University and became the leading exponent of category theory in Australia.

In February 1967 Kelly took a chair of pure mathematics at UNSW, having declined similar offers from Flinders University and the University of Melbourne, and six years later accepted an invitation to a second chair in the Department of Pure Mathematics back at Sydney University. Wall had been promoted to professor of pure mathematics in 1965, not altogether welcoming the prospect because of the anticipated administrative load, which he was happy to leave for the time being to Room until the latter's retirement three years later.

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Room had served as dean of the Faculty of Science from 1952 to 1956 and again from 1960 to 1965 and he maintained a detailed interest in educational matters affecting science and mathematics, both in the university and in schools. He played a leading role in the construction of new school mathematics syllabuses when the Wyndham Report of 1957 led to the replacement of the Leaving Certificate, taken after five years of high school studies, by the Higher School Certificate, taken after six years, and he lectured broadly on the implications of the changes. One outcome was *The Sorting Process*,[34] written with John Mack and aiming to show a general audience the consequences of formal mathematical structures.

In 1955 Room had written his half-page note[35] on what he may subsequently be best remembered for: combinatorial designs now known as Room squares. Particularly during periods of

At T. G. Room's 80th birthday celebration, 1982. From left: Max Kelly, George Szekeres, Tim Wall, Mrs Jessica Room and T. G. Room. (University of Sydney Archives)

leave, he was able to continue his research into classical projective geometry with one research student, Philip Bruce Kirkpatrick, and later into finite geometries with another student, James William Peter Hirschfeld.[36] Kirkpatrick subsequently lectured for some years in Room's department. Hirschfeld, born in Sydney in 1940, joined the University of Sussex in England in 1966 and was appointed professor of mathematics there in 2000.

In the 15 years from 1953, when the Department of Mathematics was split, until Room's retirement at the end of 1968 the number of staff in pure mathematics trebled, largely due to the commonwealth government's increased financial support for universities following the report of the Murray Committee in 1957. The same report had allowed the creation of a Department of Mathematical Statistics. That period also saw the end of any individual's dominance of academic management at the departmental level. As he had anticipated, Wall became head of pure mathematics but three years later had relinquished the task. As was happening all around the country, the position would no longer necessarily remain the province of any particular professor.

When he retired, Room was presented with a scroll listing those closely associated with him in his department since his arrival in 1935, including all 190 honours (or equivalent) graduates and his departmental secretaries. The scroll sits in the mathematics library, now named the T. G. Room Library, in the Carslaw Building, a few doors away from where his office used to be. One of those secretaries, from 1947 to 1953, was Florence Muriel Kaldor, Alf Pollard's sister. She in fact had the delicate responsibility of being secretary to both Room and Bullen and was later secretary to Freddy Chong at Macquarie University.[37] Another mark of recognition that Room greatly appreciated was the inauguration by the Mathematical Association of New South Wales of the T. G. Room Award, given annually to the student who gains first place in the Higher School Certificate mathematics examination.

In retirement, Room continued his research. This included a book on miniquaternion geometry with Kirkpatrick[38] and did not abate when he began three years working with the Open University in England in 1971. Room returned to a quieter life in Sydney in 1974, and died suddenly on 2 April 1986.[39]

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In applied mathematics, Woods and Pillow had left during 1956 and Bolt had been given a full time lectureship. Peter Robert Wilson was first appointed to the department in 1959.

Wilson was born in Melbourne on 17 October 1929 and educated at Scotch College, Hawthorn. From the University of Melbourne, he obtained a BA with honours in 1951, a BSc in 1952 and an MSc in 1958, and he has a PhD from the University of Sydney, awarded in 1962. After receiving his BSc, Wilson taught at his former school, Scotch College, for two years before taking the lectureship in Sydney. He was promoted to senior lecturer in 1963, reader in 1966 and professor of applied mathematics when Bullen retired in 1971. Wilson's research covered many aspects of solar structure such as sunspots and both small and large scale surface magnetic fields. He moved to a half-time professorial position in 1995 and retired as emeritus professor in 1998.

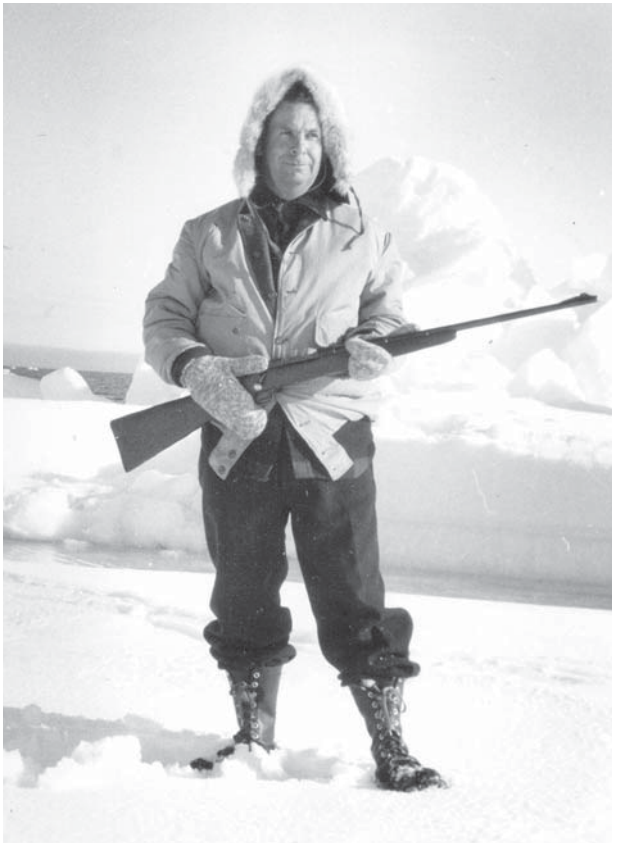
In 1961 Bullen appointed the Latvian Leonids Slaucitajs (1899–1971) to a senior lectureship in his department. Slaucitajs had worked in universities in Latvia and Germany, as well as the Carnegie Institute in Washington, before joining the geophysics department at the National University of La Plata, Argentina, in 1944. He remained in Argentina until his retirement in 1968, except for about three years in Sydney. In that time, he supervised the PhD of Denis

Edwin Winch, who described Slaucitajs as having a very broad knowledge of the earth sciences, particularly oceanography, geomagnetism, ionospheric physics and solar terrestrial relationships. "He took a number of Honours students on excursions to the CSIRO Division of Fisheries and Oceanography at Cronulla," Winch wrote, "and took me on a visit to the magnetic observatories in Port Moresby and Melbourne."[40] As part of his work in geophysics in Argentina, Slaucitajs led three expeditions to the Antarctic.

Winch was born in Sydney in 1937, was dux at Homebush Boys High School in 1953 and gained first-class honours in applied mathematics in the University of Sydney in 1961. His PhD, awarded in 1967, was for a thesis titled simply *Geomagnetism*. He was appointed to a lectureship in applied mathematics in 1963 and was associate professor from 1973 until his retirement to an honorary post in 1997.

Bullen also appointed Harley Wood, the New South Wales government astronomer from 1943 to 1974, to a part-time lectureship in 1960. Wood taught spherical astronomy to advanced undergraduate students and continued in that role for many years. Ted Buchwald was another notable appointment from the early 1960s. He joined Bullen's staff as a senior lecturer in 1961 and took the chair of applied mathematics at UNSW seven years later.

Bullen retired from the University of Sydney in 1971 and then taught at the International Institute of Seismology and Earthquake Engineering in Tokyo and the University of British Columbia, Canada. He died in Auckland on 23 September 1976.



Keith Bullen, 1906–1976, above in 1927 and right, near the North Pole on a seismological expedition in 1954. The rifle is to fend off polar bears. (University of Sydney Archives)

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Many of the 190 honours (or equivalent) students associated with Room's professorship would also have studied under Bullen, particularly during the seven years from the time Bullen joined the University until the department was split. The following are some of those 190 who have had distinguished careers in mathematics or a related field and, in most cases, are not otherwise documented elsewhere in this book.

The seven in Room's first honours class in 1935 included Alf Pollard and Ronald Gordon Giovanelli (1915–1984), who became chief of the Division of Applied Physics at CSIRO and was for many years an honorary associate in the Department of Applied Mathematics at Sydney University. In the latter capacity he supervised Peter Wilson's PhD studies. Again there were seven students in the following year. They included Maston Beard, a radar engineer who with Trevor Pearcey designed the circuitry for Australia's first computer, and William Ross Blunden, later professor of traffic engineering at UNSW, as well as Clive Davis, Pat Moran and Jim Williams.

The eminent physicist Edwin Ernest Salpeter, born in 1924, was in the class of 1944 having fled his native Austria in 1939. He gained his PhD from the University of Birmingham, England, in 1948 and since 1949 has been at Cornell University, Ithaca, New York. He is there still, now as the J. G. White Distinguished Professor of Physical Sciences, emeritus since 1997.

Herbert Aron David, a statistician who will be mentioned later in connection with the University of Melbourne, and John Joseph O'Dwyer studied honours mathematics in 1947. O'Dwyer went on to the chair of physics at Southern Illinois University, Carbondale, and then the State University of New York, Oswego.

Owen Martin Phillips, from the honours class of 1951, is now Decker Professor Emeritus and Research Professor in the Center for Environmental and Applied Fluid Mechanics at the Johns Hopkins University, Baltimore, where he was first appointed in 1957. His text, *Dynamics of the Upper Ocean*,[41] resulting from doctoral studies at Cambridge, is considered to be a classic in its field. Phillips was elected FRS in 1968. Bruce Bolt and Maurie Brearley were in the same honours year.

John Anthony Hartigan, honours 1958, is Eugene Higgins Professor of Statistics at Yale University, Connecticut. Hartigan was previously at Princeton University, where he gained his PhD in 1962.

Michael Anthony Arbib, born in England in 1940, studied pure mathematics honours at Sydney University in 1960 and received a PhD in mathematics from the Massachusetts Institute of Technology in 1963. After five years at Stanford, Arbib became chair of the Department of Computer and Information Science at the University of Massachusetts at Amherst in 1970 and remained there until 1986. He moved then to the University of Southern California, where he is Fletcher Jones Professor of Computer Science and, befitting his manifold interests, is also Professor of Biological Sciences, Biomedical Engineering, Electrical Engineering, Neuroscience and Psychology. He was given an honorary DSc by UWA in 2004.

Two shared the university medal for pure mathematics in 1961: Graeme Bryce Segal FRS and Brian David Outram Anderson FRS. They received their fellowships of the Royal Society in 1982 and 1989, respectively. Anderson followed his BSc with an undergraduate degree in electrical engineering and took out a PhD in that field from Stanford University in 1966. He has subsequently held chairs in the University of Newcastle and the Australian National University (ANU).

Segal was born in Sydney on 21 December 1941. He completed a DPhil under Sir Michael Atiyah FRS at Oxford University in 1968, working in the field of equivarient *K*-theory, which combines ideas from algebraic geometry, linear algebra and number theory. Segal held numerous positions at Oxford from 1964 and was professor of mathematics in 1989 but left there the following year when appointed to the Lowndean Chair of Astronomy and Geometry at Cambridge University. In 1999 he returned to Oxford as a senior research fellow at All Souls College.

The former *Australian* journalist Mungo Wentworth MacCallum completed honours in pure mathematics in 1962 and he ends this selection from Room's 190 honours graduates. But three other Sydney University mathematics honours graduates might be mentioned at this time.

The first is Paul Desmond Scully-Power, who may well be better known among non-mathematicians than any of those above. Born in 1944, he graduated BSc with honours in applied mathematics in 1966 and within six years was permanent head of the Royal Australian Navy's first oceanographic group. An involvement with the US Navy began in July 1972 and culminated in his eight-day space flight aboard *Challenger* in October 1984, making him the first Australian-born traveller in space. Scully-Power emigrated to the United States in 1977 but has worked in executive positions and on government boards back in Australia since 1996. He was at one time chancellor of Bond University, Queensland. (There have been two other Australian-born astronauts. Philip Kenyon Chapman was born in Melbourne in 1935 and graduated with a BSc in physics and mathematics from the University of Sydney in 1956. He has a DSc in instrumentation from the Massachusetts Institute of Technology and served as a mission scientist in the *Apollo* program, resigning in 1972. Andrew S. W. Thomas, known as Andy, was born in Adelaide in 1951 and has degrees in mechanical engineering from the University of Adelaide including a doctorate in 1978. In 1998 Thomas flew for 130 days aboard the Russian space station *Mir* and he was a member of the *Discovery* mission in 2005.)

From the same applied mathematics honours class as Scully-Power, John Robert Booker went on to become professor of engineering mechanics in the University of Sydney in 1985. He died in 1998, aged 55. Austin Keene, whom Booker had known when he was at high school in Wollongong, became his constant adviser in Sydney when the choice had to be made between civil engineering and mathematics.[42]

Paula Cohen may also be singled out since she is a graduate in both applied mathematics (first-class honours and a university medal, shared, in 1978) and pure mathematics (first-class honours in 1979). She gained a PhD from the University of Nottingham, England, in 1985 and since September 2002 has been professor of mathematics at Texas A&M University. Her research interests are in number theory and classical geometry.

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On 1 January 1991, almost forty years after the great split, the three mathematics departments at Sydney University were incorporated into a single School of Mathematics and Statistics. The outgoing heads of department were Peter Wilson in applied mathematics, Eugene Seneta in mathematical statistics and Terry Gagen in pure mathematics. The departments had existed as separate entities within the Faculty of Science when, at the vice-chancellor's request, Gus Lehrer took on the job of combining the three sets of staff and their responsibilities.[43] A professor of pure mathematics in the university since 1989 and with little previous administrative experience, Lehrer was head of the new school for three years.

Gustav Isaac Lehrer was born in Munich, Germany, on 18 January 1947 and came to Australia in November 1950. He has a BSc with first-class honours and the university medal in pure

mathematics, awarded in 1967 by the University of Sydney, and a PhD from the University of Warwick gained four years later. After two years as a lecturer in the University of Birmingham, England, he was appointed lecturer in pure mathematics at Sydney University in 1974. Lehrer's research centres on the representation of algebraic structures in a geometric context. After two years as professor and head of the Centre for Mathematical Analysis at ANU in the late 1990s, he returned full time to Sydney University as an Australian Research Council professorial fellow.

Terence Matthew (Terry) Gagen, the last head of the Department of Pure Mathematics, was born in Brisbane in 1941. He holds a BSc with first-class honours and a university medal from the University of Queensland (1964) and a PhD from ANU (1967), supervised by Zvonimir Janko. Gagen joined the University of Sydney in 1968 and was an associate professor in pure mathematics from 1983 until his retirement in 2003.

The School of Mathematics and Statistics, when it was first formed in 1991, included some 70 full-time equivalent teaching staff. Government strictures reduced that number to around 43 by mid-2005. The second volume of an authoritative history of the University of Sydney coincidentally concludes its study at around the time of the formation of the school and includes comprehensive accounts of the staffing and of the teaching and research profiles of the three former departments.[44]

The current professors in the school are John Joseph Cannon, Edward Norman (Norm) Dancer, Nalini Joshi, Gus Lehrer and John Robinson. Lehrer and Robinson have been mentioned above.

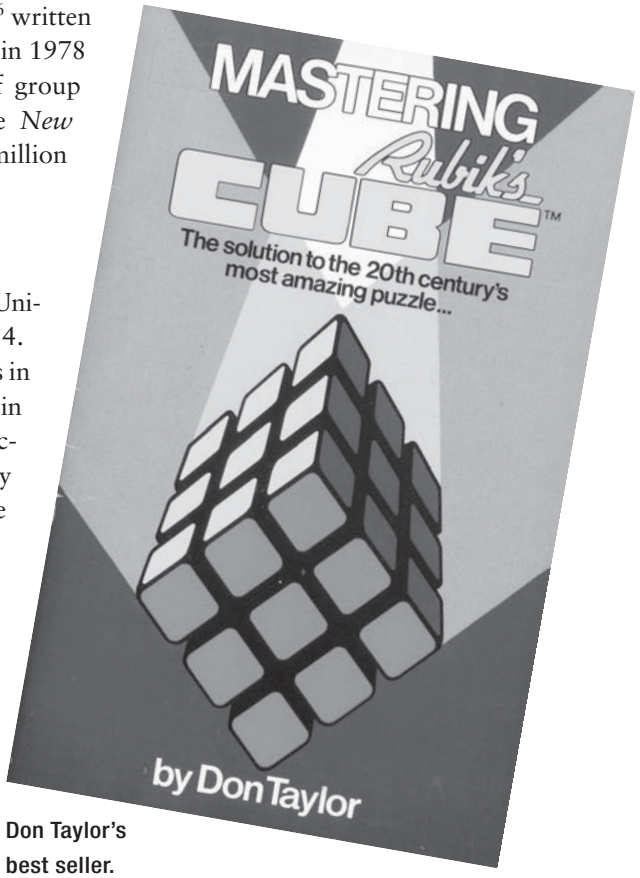
Dancer was appointed to the chair at Sydney University in 1993. With a BSc from ANU and a PhD from Cambridge, he was appointed lecturer in mathematics at the University of New England in 1973 and had a personal chair there by 1987. Dancer's interests are in nonlinear functional analysis and ordinary and partial differential equations.

Cannon was born on 1 August 1943 at Lake Cargelligo, almost in the centre of New South Wales, and his schooling was by correspondence until 1955. He graduated BSc (honours in pure mathematics, 1965), MSc (1967) and PhD (1971) from the University of Sydney and was appointed to a lectureship there in 1967. Promoted to professor in 2000, Cannon pioneered the use of computational algorithms in modern algebra and was instrumental in the development of the symbol manipulation programs *Cayley* (in 1974) and *Magma* (in 1987) for group theory and other algebraic structures.[45]

There have been fewer than ten women professors in mathematical sciences in Australia and Nalini Joshi is one of the most recent to be appointed. She gained first-class honours and the university medal in applied mathematics from the University of Sydney in 1982 and then an MA (1984) and a PhD (1987) from Princeton University, New Jersey, for her work in nonlinear differential and difference equations. After holding positions at UNSW and the University of Adelaide, Joshi was appointed to the chair in applied mathematics in 2002, four years after Peter Wilson had retired from the post.

After Lehrer, the head of school for five years was Christopher John (Chris) Durrant, whose PhD from Cambridge was in solar astrophysics. He came to Australia, to a lectureship in applied mathematics at the University of Sydney, in 1983 and retired as an associate professor in 2002. Dancer and Robinson had terms then as head of school before the position was taken by Donald Ewen (Don) Taylor at the beginning of 2004. Taylor is a graduate of Monash University (MSc, 1968) and then Oxford (DPhil, 1972, supervised by Graham Higman), and was at La Trobe University for three years before joining the University of Sydney in 1975. Now an

associate professor, his book on Rubik's cube,[46] written while on leave in Eindhoven, The Netherlands, in 1978 and conceived originally as an application of group theory, reached the number one spot on the *New York Times* best seller list and sold over one million copies.



Don Taylor's best seller.

The University of New England

The University's beginnings as the New England University College have been described in Chapter 4.

The Department of Mathematics and Physics in the college was split into separate departments in 1952. The Department of Physics, within the Faculty of Science, was very small: it consisted only of Jack Somerville as senior lecturer-in-charge and Reg Smith. The remainder from the old department all went to the new Department of Mathematics in the Faculty of Arts. Roy Smith was senior lecturer-in-charge and Wes Taylor, Alwyn Horadam and Mollie Horadam were lecturers. There was a new lecturer, Pietro (or Pedro or Peter) Majstrenko, who held an MA from Copenhagen, and a part time lecturer, Alexander Aitkin, who had been at the Canberra University College and the following year would be appointed special method (mathematics) lecturer for the Diploma of Education.

Two years later the college won autonomy as the University of New England (UNE) and John Boris Miller joined the staff of the mathematics department as lecturer for external studies. His subsequent career in Canberra and at Monash University will be described in coming chapters. Andy Guinand, who, like Roy Smith, had studied under Titchmarsh at Oxford, was appointed professor of mathematics in July 1955 from a large field of applicants that included Smith and, when Guinand departed just two years later, it was Smith who won the chair. Guinand took various posts in Canada until becoming the first head of mathematics at the newly founded Trent University in Peterborough, Ontario, in 1964. He died in Peterborough on 22 March 1987.

Smith quickly took the opportunity to restructure the department's courses in a manner distinct from those of Sydney University, which New England had previously been obliged to follow. In his words, he was so successful that "for the whole of the 1960s any student of reasonably high ability ended up by doing mathematics. This was very much resented by other departments."[47] Three students of that period stood out, taking honours in the same year: Peter Dodds, Alan McIntosh and Neil Trudinger. Dodds became professor of mathematics at Flinders University, Trudinger at ANU and McIntosh at Macquarie University and then ANU.

Edmund John Burr joined the department as lecturer in mathematics in 1957. Known generally as John Burr, he was born in Poona, India, in 1925, came to Australia aged 15 and studied at the University of Queensland, later gaining a PhD from UNE. Burr was promoted to senior

At a conference on nonlinear partial differential equations at the University of New England, December 2003. From left: Alan McIntosh, Robert Bartnik, Norm Dancer, Neil Trudinger.

lecturer in 1961 and subsequently became associate professor of mathematical statistics and then professor of computing science in 1973. He retired with an emeritus professorship in 1989.

A chair in pure mathematics was established in December 1965 and Smith's title then became Professor of Applied Mathematics. The new professor of pure mathematics was Grainger Rabone Morris. Born on 21 March 1922 in Hobart, he had been educated in Sydney. On a Barker graduate scholarship from Sydney University, he travelled to Cambridge and within five years had completed the mathematical tripos and a PhD in nonlinear oscillations with Dame Mary Cartwright as supervisor. In 1952 Morris took a lectureship at the University of Hull, arriving just after Bernhard Neumann had left for Manchester but while Hanna Neumann was still there as "guiding spirit".[48] At the beginning of 1957 he returned to Australia to a lectureship in the University of Queensland. He resigned from there as a reader in May 1966 to take the position in Armidale, where, in Roy Smith's view, he became a "genuine polymath". One of the jobs Morris took on, succeeding Austin Keane in the role, was as an examiner for the University of Papua New Guinea to vet the standards of its mathematics subjects. On his retirement at the end of 1985, Morris was made emeritus professor.

By the late 1980s Roy Smith, John Burr, Grainger Morris, Wes Taylor and Alwyn Horadam had all retired, so the department took on a new look. Norm Dancer, who had joined as a lecturer in 1973, and Sidney Allen (Sid) Morris were the two professors of mathematics at the end of the 1980s; and Joachim (Joe) Hempel and Eveline Bofinger (née Graham) were associate professors. Dancer held a personal chair from 1987 to 1993 when he left for a chair of pure mathematics at the University of Sydney. He was replaced by Robert Bartnik, whose career is described in Chapter 7.

Sid Morris, no relation to Grainger, was born in Brisbane on 24 November 1947. He graduated from the University of Queensland and a year later received a PhD from Flinders University.

On gaining his doctorate, Morris lectured in mathematics at the University of Adelaide during 1970 and then at UNSW until 1975. He was appointed to a readership in mathematics at La Trobe University and, while on extended leave from La Trobe, took the chair at UNE in 1988 and was also head of department there. After three years, Morris moved on to senior positions at the University of Wollongong and the University of South Australia before being appointed professor of informatics in the University of Ballarat in 2002. There he heads the School of Information Technology and Mathematical Sciences. Morris' research interests, originally in topological group theory, now also include informatics and mathematical finance. With Joan Cleary and David Yost, in 1987 he won the Lester R. Ford Award of the Mathematical Association of America as authors of an article of expository excellence in one of its publications.[49] (Peter Neumann, Desmond Fearnley-Sander and Andrew Coppel are other Australian winners of the same award.)

Joe Hempel, with interests in complex analysis, potential theory and differential equations, was appointed to a lectureship at New England in 1967; he retired in 1998. Eve Bofinger and her husband Victor John (Vic) Bofinger, both mathematics honours and PhD graduates of the University of Sydney and formerly both lecturing in statistics at the New South Wales University of Technology and then both at the University of Sydney, were statisticians in the department and were to dominate that area for many years from the early 1970s.

Ernest William (Ernie or Ern) Bowen was another who joined the department at UNE in the 1960s. He was born in Melbourne in 1926, took out a BA with honours in mathematics, a BSc in physics and an MA from the University of Melbourne and began as a lecturer in the Department of Mathematics at UWA in 1953. Larry Blakers and Harry Levey supervised his PhD there, gained in 1961. Bowen was active in the formation of the Mathematical Association of Western Australia in 1959, joined UNE as a senior lecturer in mathematics in 1966 and continued his work with school mathematics through the New England Mathematical Association. He retired in early 1989 and is still active in mathematical computing and in compiling a history of mathematics and statistics in Armidale, a source for much of the material hereabouts.

The original handwritten minutes of meetings of the New England Mathematical Association show that it was established at a meeting on 15 February 1958 attended by Roy Smith, John Burr, John Miller, Wes Taylor, Alwyn and Mollie Horadam and ten others from local schools and the CSIRO. Alec Aitkin sent his apologies. Alwyn Horadam was elected convener until a meeting a month later at which Smith was elected founding president. The minutes of the second annual general meeting, on 31 March 1960, record that: "The first award . . . of the Association's Mathematical Prize of £10 was shared between Mr. A. G. R. McIntosh (Richmond High School) and Mr. N. S. Trudinger (Armidale High School), each of whom obtained double first-class Honours in the previous Leaving Certificate."

With assistance from the University's Department of Mathematics, in 1987 the New England Mathematical Association began publishing the *Australian Senior Mathematics Journal* for the Australian Association of Mathematics Teachers, to which it is affiliated. John Pegg, now professor of mathematics education at UNE, was its editor for the first six years. Pegg has a BSc and an MMath from the University of Newcastle and a PhD from UNE. He was active in negotiation with the federal government for the creation in July 2004 of the National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia, known more conveniently as SiMERR. Based at UNE, the centre works with rural and regional communities to achieve improved educational outcomes for students.

Others who filled senior positions or were longstanding staff members in mathematics or statistics at UNE include Gwenda Lewis, who, as Gwenda Cane, began as a graduate assistant in 1963 and retired as a lecturer in statistics in 1994; Hylton Ian Davies, who gained a PhD from the University of North Carolina and was a lecturer from 1967 to 1998 and was also employed by CSIRO to collaborate in research; and Peter Eugene Lush (1928–2002), a lecturer and then senior lecturer from 1959 to 1985 and collaborator with Roy Smith.

By mid-2005 there were just twelve members of staff at the level of lecturer or above teaching in mathematics or statistics at UNE and no full professor. The head of the School of Mathematics, Statistics and Computer Science at that time was Christopher John (Chris) Radford, a mathematical physicist, appointed lecturer there in 1986 and promoted to associate professor in 2005.

The University of Melbourne, from 1953

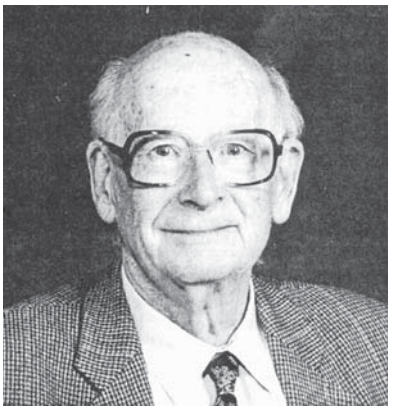
The standing of Thomas MacFarland Cherry as mathematician and administrator continued to grow in the 1950s. He won an ScD from the University of Cambridge in 1950 and was elected FRS in 1954. He played substantial roles in the formation of the Australian Mathematical Society (detailed in Chapter 10) and the Australian Academy of Science (Chapter 8). He was foundation president of the Society in 1956, president of ANZAAS Section A in 1958, foundation president of the Victorian Computer Society in 1961–1963 and president of the Academy of Science from 1961 to 1965. During 1963 he received honorary doctorates from both the Australian National University and the University of Western Australia.

Cherry retired and was made emeritus professor at the end of that year, but as Russell Love wrote, "the full life he had always lived continued unabated, and his worth was increasingly recognized."[50] He remained on staff as a research fellow. Towards the end of 1964, as president of the Academy, he led a delegation of scientists to Beijing at the invitation of the Academia Sinica, although this was not in accord with government attitudes of the time. (The situation was different in May 1980 when one of the first official Australian contacts with China following the

Thomas MacFarland Cherry, 1898–1966, receiving an honorary doctorate at the Australian National University, 1963.

end of the Cultural Revolution was a delegation consisting of the mathematicians Pat Moran, Alex Robertson, Alan Brace and Alf van der Poorten. Brace, a Welshman with a PhD in combinatorics from UWA and a useful knowledge of Mandarin, was teaching at the time at the Canberra College of Advanced Education. From 1981 to 1988 he was an intelligence analyst in the Office of National Assessments.)

On 1 January 1965 Tom Cherry was made a Knight Bachelor. He suffered a severe heart attack soon after but recovered and spent a further year teaching and writing at the University of Washington, Seattle. Struck down by another heart attack, he died on 21 November 1966.[51]



Eric Russell Love, 1912–2001.

The Australian Mathematics Teacher devoted a complete issue to memorial articles including a recounting of his role with the Mathematical Association of Victoria and of his varied research interests, in differential equations, transonic flow and computing. His student, professorial colleague and admirer, Russell Love, wrote in the *Journal of the Australian Mathematical Society*:

> It was only when one came to know him that one realized what great powers of leadership and force of character Cherry possessed. He had a mild manner, giving no impression of forcefulness; and he was never ruffled. His staff saw him as their adviser and, after a little while, friend; and junior staff came to regard him as the centre of their world.[52]

Love succeeded Cherry as head of the Department of Mathematics when the latter retired and he had earlier, on appointment as professor in 1952, taken on Cherry's responsibilities as chair of the Mathematics Standing Committee of the University's Schools Board. That led to a lasting involvement with school mathematics syllabuses and examination papers. He retired in 1977 and, as emeritus professor and honorary professorial fellow, was awarded an ScD from the University of Cambridge a year later. In 1991 the University of Melbourne accorded Love an honorary DSc. He wrote almost 50 papers in his retirement, mostly on inequalities and special functions, particularly Legendre functions, and he maintained his teaching interests by being a sessional tutor in the department. When Love died peacefully on 7 August 2001 he had completed some 60 years of service to the University.[53]

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Returning to the general picture, there were few lasting changes to staff profiles in mathematics and statistics in the University of Melbourne during the 1950s. Cherry was professor of applied mathematics and Love of pure mathematics; Felix Behrend, who had been appointed associate professor in August 1954, was acting professor of applied mathematics when Cherry took leave in 1955 and of pure mathematics when Love was on leave in 1957. John Colin Barton was appointed lecturer in 1956 and promoted to senior lecturer in 1962; he retired in 1982.

John Philip Ryan was appointed senior lecturer in place of Behrend in 1955. Born on 25 February 1921, he had studied a mixture of BSc and BA subjects from 1939 to 1942. "For unknown reasons, the BSc was not conferred until 1950 and the BA not until 1986," according to a communication from the University of Melbourne Archives.[54] Ryan was with the CSIRO Radiophysics Laboratory in Sydney until 1945 and then lectured in mathematics at Melbourne Technical College until his university appointment. He is remembered for his

development of courses in engineering mathematics, as the first secretary of the Australian Mathematical Society, and for a deep and lasting involvement with the Australian Labor Party on its "Catholic left".

The prominent statistician Herbert Aron David was appointed senior lecturer in statistics in 1955. Born in Berlin in 1925, David, having graduated from the University of Sydney (BSc with honours, 1947), had gone on to gain a PhD from University College, London, in 1953. He returned to Sydney to spend two years as a research officer with CSIRO and then gained the position in Melbourne. He left there in 1957 to become professor of statistics at Virginia Polytechnic Institute and is now Emeritus Distinguished Professor in Liberal Arts and Sciences at Iowa State University, where he has been since 1972.

Fenton Pillow was senior lecturer in applied mathematics from 1957 for three years. In that short time he supervised the MSc thesis of Adrian Edmund Gill, whom Cherry later counted among the five or six best students that he had encountered in over 30 years as head of mathematics. Gill was born on 22 February 1937 in Brighton, a suburb of Melbourne, and excelled at Essendon High School both academically and sportingly. He gained his BSc with first-class honours in 1958 and his MSc two years later and then headed for Cambridge for further studies in fluid mechanics under George Batchelor. The doctorate completed, Gill spent 1963–1964 at the Massachusetts Institute of Technology and returned to Cambridge to become senior assistant in research in dynamic oceanography in Batchelor's Department of Applied Mathematics and Theoretical Physics. He succeeded Owen Phillips in that position when Phillips went to Johns Hopkins University and when further funding became available in 1966 was joined by the experimentalist Stewart Turner and others. Herbert Huppert joined the team in 1970. The place was awash with Australians—George Batchelor, Adrian Gill, Herbert Huppert, Owen Phillips, Fenton Pillow, Phil Silberstein, Roger Thorne, Alan Townsend, Stewart Turner and Bill Wood (and Bruce Morton, originally from New Zealand but a long time professor of applied mathematics at Monash University), if not quite all at the same time.[55]

There was no permanency attached to the position in Cambridge and Gill applied twice for jobs back in Australia, first for the chair of meteorology at the University of Melbourne and, four years later, as chief of the CSIRO Division of Atmospheric Physics. By that time, 1982, he had published his acclaimed book, *Atmosphere–Ocean Dynamics*,[56] which was one of the first attempts to unify broad areas of geophysical fluid dynamics, but the offer from CSIRO was as chief research scientist and was rejected. Instead, Gill joined the Robert Hooke Institute for atmospheric research in Oxford, became ill with colon cancer two years later and died on 19 April 1986. He had been elected FRS just a month before.[57]

One of Melbourne University's best known graduates, a little younger than Adrian Gill, is Neil Sloane, famed for his work in combinatorics and on error-correcting codes and for his collecting of integer sequences. He was born in Beaumaris, Wales, on 10 October 1939, came to Melbourne in 1948 and took out degrees in electrical engineering and arts (with honours in mathematics) in the years 1956 to 1960. Sloane went then to Cornell University, graduating with an MS and a PhD in electrical engineering, taught there for two years and in 1969 joined Bell Telephone Laboratories, now AT&T Laboratories, where he has been ever since. Eric Barnes was one of Sloane's research collaborators in the early 1980s.

Another top student from that time was Ruth Frances Curtain, now professor of mathematics at the University of Groningen, the Netherlands. Curtain was born in Melbourne in 1941, studied there for a BSc with honours (1962), DipEd (1963) and MA (1965) and then moved to

the United States to study for a PhD in applied mathematics at Brown University, Providence, Rhode Island. She taught at Purdue University for two years and from 1971 to 1977, before moving to Groningen, was a research fellow and then lecturer at the University of Warwick, UK. Curtain's research interests lie in the area of infinite dimensional systems theory.

A key figure in operations research in the University of Melbourne, Bruce Desmond Craven, was appointed senior lecturer there in October 1962 after eight years as senior research physicist with Australian Paper Manufacturers, Melbourne. Born on 7 May 1931, Craven graduated from the University of Melbourne with a BSc in 1951, an MSc with honours (1953), a BA with honours (1959) and a DSc in 1973. He was promoted to reader in 1968, the position he held when he retired as an honorary principal fellow at the end of 1996. The current professor of operations research is Peter Gerrard Taylor. Born in Nottingham, UK, in 1958, Taylor's qualifications (BSc with first-class honours, 1979; PhD, 1987) are from the University of Adelaide and he was in the Department of Applied Mathematics there until moving to Melbourne in 2002.

Craven is a keen exponent of the history of operations research in Australia and of the Australian Society for Operations Research (ASOR), of which he was a foundation member. It was formed on 1 January 1972 by combining the Victorian Operations Research Society with the Operations Research Section of the Statistical Society of Australia (New South Wales Branch) and now has chapters in Canberra and all states except Tasmania.

Allen Maurice Russell joined the Department of Mathematics as a lecturer at around the same time as Craven. Born in Ulverstone, Tasmania, in 1938, Russell gained a BSc with honours in mathematics from the University of Tasmania in 1958, taught in schools for a few years and was invited then by Love to become a senior tutor. He subsequently took out a PhD with Love as supervisor in the area of real analysis. In 1994 Russell transferred from his position as reader at Melbourne University to become a professorial fellow in the Faculty of Business and Economics at Monash University. He was dean of the faculty when he retired in 2001.

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James Wilkinson Craggs succeeded Cherry as professor of applied mathematics. A graduate of the University of Manchester and the University of Cambridge (with PhDs from both), he stayed in Melbourne for only a few years, resigning in 1967 due in part to some difficulty with Love over Craggs' wish to update the mathematics syllabuses then in use. Maurice Belz, professor of statistics since 1955, retired shortly after Cherry did and was replaced by Evan James Williams. A few years before his retirement, Belz appointed Peter Derrick Finch and Johannes Stephanus (Stephan) Maritz as senior lecturers in statistics. Finch was later professor of mathematical statistics at Monash University and Maritz, reader in statistics at Melbourne University from 1967 to 1972, had chairs at both Monash and La Trobe Universities.

Williams was born in Hobart on 13 April 1917 and studied under Pitman there. He graduated with a Bachelor of Commerce and spent the years 1938–1939 on a CSIR studentship in the United Kingdom before returning to Melbourne to a wartime position in CSIRO's Division of Forest Products. He was a senior principal research scientist when he resigned in 1956 to become professor in the Institute of Statistics at North Carolina State College at Raleigh, having been awarded a DSc by the University of Melbourne in 1954. Williams returned to CSIRO, to the Division of Mathematical Statistics in Canberra, in 1960 and in 1964 took the chair in statistics at Melbourne University in preference to an offer of a personal chair at the University of Tasmania. Except for a further year's secondment to CSIRO in 1976, he remained there until his retirement as emeritus professor in 1982.[58]

Maurie Brearley's appointment to the University came a few years after Cherry's retirement and following eleven years as a lecturer and then senior lecturer in the University of Adelaide. Brearley succeeded Basil Rennie as professor of mathematics at the RAAF Academy, Point Cook. Rennie's appointment, and then Brearley's, had been as professors in the Faculty of Science whereas the Department of Mathematics had always been in the Faculty of Arts. At around the time of Brearley's appointment, the department was moved to the Faculty of Science.

Throughout 20 years as Professor of Mathematics Brearley's responsibilities remained the teaching of RAAF cadets but he was a frequent visitor to the main campus as a member of the professorial board and he gave occasional lecture courses there. Brearley retired in 1985, was appointed emeritus professor and for the following 20 years continued to combine his engineering and mathematical skills by conducting research on the application of mathematics to sport. That had been the theme of his PhD thesis. The same expertise had been applied earlier in what became almost a separate career in rehabilitation engineering within which his inventions included a stair-climbing wheelchair (specifically for a student of his at Point Cook who had become a paraplegic after a gliding accident) and a bespoke mattress for iron lung patients.[59]

The period of six years or so following Cragg's departure in 1967 was a lean time for mathematics at Melbourne University. The Department of Mathematics was unable to fill its professorial vacancies while not far away the newly established Monash University was in full swing with half a dozen chairs covering pure and applied mathematics and mathematical statistics. In the older university, the only professor in the department was Russell Love, professor of pure mathematics; Evan Williams was professor in the Department of Mathematical Statistics; and Brearley was at Point Cook. Bill Wood, introduced in Chapter 4, had been appointed reader in 1965 and was to serve a number of years through this period as acting professor of applied mathematics. At the same time, Bruce Craven was acting professor of pure mathematics. Use was also made of long term visiting professors: David Hugh Michael, a noted geophysicist who had completed a PhD with George Batchelor, was visiting professor of applied mathematics in 1969–1970 and the celebrated Hungarian mathematician Arthur Erdélyi was visiting professor of mathematics in 1970–1971.

Other senior staff members in the Department of Mathematics during the late 1960s and into the 1970s included the readers Fred Syer and Roger Grimshaw. Grimshaw was appointed senior lecturer in 1966 and promoted to reader in 1970. The senior lecturers around that time included John Ryan, John Barton, Ian Evans and Christopher John Finns Upton.

Syer's early duties at the University of Melbourne have been detailed in Chapter 5. He took leave to obtain a PhD from Imperial College, University of London, in 1960, was promoted to reader on his return to the University and, when he retired early in 1968, was in the School of Engineering with responsibilities for engineering mathematics. He died on 15 June 1993.

John Upton, as he was always called, was born on 21 October 1926. A graduate of Oxford University and one of the first to gain a PhD from the University of Melbourne, in 1959, he had first joined the University around 1949 as tutor with Syer at Mildura. He was promoted to senior lecturer in 1963, was chair of the School of Mathematical Sciences from 1978 to 1986 following Russell Love's retirement, and died on 31 January 1991. Upton was secretary of the Australian Mathematical Society from 1963 to 1967.

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The partial drought for mathematics at the University of Melbourne had ended by 1973 with the appointment of two applied mathematicians to chairs of mathematics: Simon Rosenblat and Colin John Thompson.

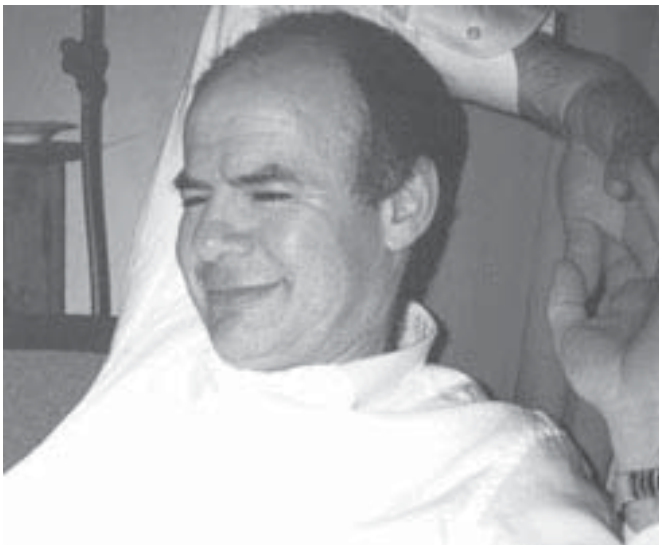
Rosenblat would later play a key role in the formation of the Australian Mathematical Society's Division of Applied Mathematics. Born in Poland on 23 June 1931, he had completed his education in the University of Sydney, where he was awarded a PhD in 1957 for work on aerodynamic forces on an aerofoil. Rosenblat held appointments at Imperial College, London, and the Technion (Israel Institute of Technology), Haifa, before taking the chair at Melbourne University in 1972. After eleven years, he moved to a position at the Illinois Institute of Technology. He died in San Francisco on 19 September 2002.[60] His chair in Melbourne was taken by Lee Raymond White, a graduate of the University of Queensland and with a PhD from ANU. White was appointed in 1984 but resigned in 1998 to take a chair in the Department of Chemical Engineering at Carnegie Mellon University in Pittsburgh, USA.

Thompson, with a BSc and a PhD from UNSW, held a chair of mathematics in the department for 30 years and now holds an honorary professorship. His research in statistical mechanics has led to modern applications such as modelling complex systems and financial risks. He has also collaborated in projects with environmental scientists on quantitative risk analysis of genetically modified crops using stochastic dynamical systems.

The academic career of Anthony John (Tony) Guttmann had begun at the University of Newcastle with his appointment as a lecturer in mathematics there in 1971. He was born in Melbourne on 8 April 1945 and took out a BSc (1965) and an MSc (1967), both in physics, from the University of Melbourne, and then a PhD (1969) in mathematics from UNSW, supervised by Barry Ninham and Colin Thompson. After three years as professor of mathematics at Newcastle, Guttmann resigned in order to accept the lesser position (in terms of salary, at least) of reader in the University of Melbourne, but two years later had won a personal chair there. His interests range over a number of areas within physics and mathematics and he is one of the originators in combining the fields of statistical mechanics and combinatorics. Guttmann's extensive activities on behalf of organised mathematics in Australia, with the Australian Mathematical Society and the Australian Mathematical Sciences Institute, are outlined elsewhere.

Two lasting appointments in pure mathematics from around that time were those of Jaromir Joseph (Jerry) Koliha and John Richard James Groves. Koliha, born in the Czech Republic, studied at the Charles University, Prague, and has a PhD from the University of Melbourne, where he was appointed to a lectureship in 1969. He is there still, now as an associate professor. Groves went to ANU with his Oxford BA to undertake a PhD under Laci Kovács, joined the University of Melbourne as a lecturer in 1972 and has been a reader since 1987. His interests are in infinite soluble groups. Derek Allan Holton began at Melbourne University as a lecturer a year or so before Groves. Holton was born at Chesham, Buckinghamshire, in 1941 and came to Melbourne with his family in 1957. He completed a BSc in 1961, a DipEd in 1962 and an MA in 1967, and went then to McGill University in Montreal where he received his PhD in 1970. The job in Melbourne followed. In 1985 Holton accepted the chair of pure mathematics at Otago University, Dunedin. His research in graph theory and combinatorics was later matched by a deep interest in mathematics education.

A second chair of pure mathematics came with the appointment of Charles Frederick (Chuck) Miller III in 1976. Miller was born in Springfield, Illinois, on 12 February 1941 and gained a BA from Lehigh University (in 1962), an MS from New York University (1964) and a PhD from the



Hyam Rubinstein.

University of Illinois at Urbana-Champaign (1969). He was an assistant professor at Princeton University when he gained the chair in Melbourne. Miller's interests are in combinatorial and geometric group theory and other aspects of group theory. For over twenty years he has also been a consultant to the Australian Football League and other sporting organisations on the scheduling of their matches; in this he worked with colleagues James Joseph (Jim) Cross and Christine Sue Mangelsdorf.

When Love retired in 1977, his chair of pure mathematics was taken by Leon Simon, whose career is described in Chapter 7 in connection with his move to ANU in 1981. Simon was followed in Melbourne by Joachim Hyam Rubinstein, known generally as Hyam. Rubinstein was born in Melbourne in 1948 and completed his first degree at Monash in 1969. From there he went to the University of California at Berkeley where he gained a PhD in three-dimensional manifolds. Appointed to Melbourne University as a lecturer in 1978, he was promoted to senior lecturer in 1981 and, encouraged by Simon, applied for and won the chair of pure mathematics in the following year. Rubinstein was president of the Australian Mathematical Society in 1990–1992.

The professors of mathematical statistics following the retirement of Evan Williams in 1982 were Christopher Charles Heyde, from 1983 to 1986; Peter John Brockwell in 1988–1989; Timothy Carlisle Brown from July 1992 to 2002; and currently Richard Huggins, formerly of La Trobe University.

Almost 50 years after they had been split, the two departments were recombined in 1997 into a Department of Mathematics and Statistics. Walter Neumann held a personal chair in mathematics in the new department until 1999. In July 2005 the staff consisted of five professors, twelve associate professors or readers, ten senior lecturers, seven lecturers and seven tutors. The professors then were Derek Yau Cheong Chan, with a PhD from ANU, appointed in 1995; Peter Forrester, a mathematical physicist also with a PhD from ANU; Tony Guttmann; Chuck Miller; and Hyam Rubinstein.

The University of Adelaide, from 1945

Harold Sanders had replaced John Wilton as Elder professor of mathematics and head of Adelaide's Department of Mathematics in 1944 and he remained in that position until his retirement at the end of 1958. Sanders had "outstanding knowledge and ability in mathematics" but his extremely large teaching commitment and his responsibilities to the Public Examination Board of South Australia meant that he had no opportunity to carry out original research. He died on 3 September 1983 in his 90th year.[61]

Sanders himself may not have been in a position to conduct research but his department was set to establish itself as a leader. Hans Schwerdtfeger had arrived in 1940 and was to stay for eight years, to be replaced by George Szekeres. George and Marta Sved, long time friends of Szekeres' from Hungary, had been in Adelaide since 1939 and with Felix Behrend were to be influential in bringing Szekeres and his wife Esther to the country. The Sveds both had very long involvements with the University of Adelaide. George (1910–1994) was an accomplished mathematician who served the Department of Civil Engineering from 1950 to 1975, including two years as dean of the Faculty of Engineering. Marta (formerly Márta Wachsberger) had beaten George into second place in a national mathematics competition in Hungary (so he married her, he used to say).[62] She was for many years employed as a tutor and then a senior tutor in mathematics, remaining as an honorary associate well into her retirement. At the age of 74, she obtained a PhD from Adelaide, supervised by Rey Casse. Born in Budapest on 16 December 1910, Marta Sved died in Adelaide on 30 September 2005.

György (George) Szekeres was born in Budapest on 29 May 1911. His high school teacher in mathematics and physics later became professor of theoretical physics in the University of Budapest and the teacher's research interests in relativity developed into one of the pupil Szekeres' enduring interests. He was entered by his school into the physics section of a nationwide competition and Klein Eszter, or Esther Klein, whom he would marry in 1937, was another entrant. "For Jewish students these competitions were of great importance as success ensured them one of the restricted university places," wrote John Giles and Jennifer Seberry Wallis, two of Szekeres' PhD students, in a tribute on the occasion of his retirement.[63]

Szekeres studied chemical engineering at the Technological University of Budapest to comply with the wishes of his father who ran a leather factory, so the only university mathematics course he ever attended was in first-year calculus. Klein, meanwhile, entered the Faculty of Science in the University of Budapest, helped in overcoming the *numerus clausus* (which restricted Jewish matriculants) by the professor of mathematics, Lipót Fejér.

With a group of equally enthusiastic mathematics students, all former problem-solving contributors to a longstanding and still highly regarded high school journal, they organised their own weekly seminars to pose problems and discuss solutions. Included in the group were Paul Erdős, two years younger than Szekeres, and Paul Turán, both of whom like Szekeres would become mathematicians of the highest order. The future Marta Sved was another member. By the late 1930s, while working in a leather factory, Szekeres had made notable contributions in combinatorial geometry, including a joint publication with Erdős in which they generalised a problem proposed by Klein—one of the first results in the celebrated Ramsey theory. But events in Europe obliged George and Esther, married by then although living apart through economic necessity, to flee Hungary in April 1939.

They went to Shanghai, since, with the help of his older brother's wife's uncle, Szekeres was able to organise employment as a leather chemist ahead of their arrival. For that reason,

although living in ghetto-like but harmonious and secure conditions in a Jewish community, they did not consider themselves to be refugees and throughout their time there Szekeres was able to maintain correspondence in mathematics with Erdős, Turán and others from his student days.[64] After the war, he found employment as a clerk in an American airforce base and during that time wrote his first papers in the area of group theory. George and Esther's son Peter, later to become a prominent mathematical physicist at the University of Adelaide, was born in Shanghai in 1940.

Ren Potts tells the story of the arrival of the Szekeres family in Adelaide in 1948 and of the University's embarrassment that George's only formal qualification was a diploma of chemical engineering:

> [After] much persuasion he was urged to submit for a PhD, although, as he pointed out, he would have to be his own supervisor and internal examiner. The University was further embarrassed when, on a close study of the regulations, it was found that the application for Szekeres to enrol for a PhD had to be turned down—because he could not be classified as being a graduate.[65]

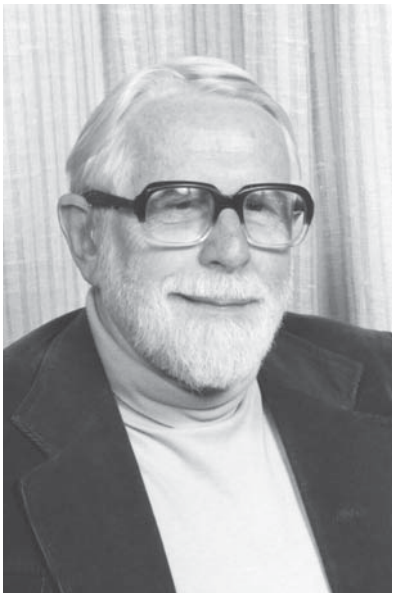
That did not stop the University from promoting Szekeres to senior lecturer in 1950 and reader in 1957.

He finally got his doctorate, an honorary DSc from UNSW, at the time of his retirement, having by then supervised "at least sixteen or seventeen" PhD students. Szekeres remembered with some fondness his first two graduate students, particularly since they died within five weeks of each other in 2001 just prior to his 90th birthday.[66] The first was Jim Michael, mentioned already in Chapter 5, who was appointed lecturer in mathematics in Adelaide in 1958 and promoted in turn to senior lecturer, reader and professor. Not enjoying the administrative obligations of that post, he resigned his chair and reverted to a readership in 1970. Michael's research in mathematical analysis and particularly in the field of partial differential equations was considered by Potts to have influenced the course of mathematics in Australia. He retired at the end of 1983, though still continuing his research, was made professor emeritus in 1989, and died on 17 April 2001, aged 81.[67] Szekeres' second graduate student, Irvine Noel Baker, was born in Adelaide on 10 August 1932 and went on to gain a doctorate from the University of Tübingen. Known always as Noel, he was appointed to a lectureship in mathematics at Imperial College, London, in 1959 and retired as professor of pure mathematics there in 1997. Baker died on 21 May 2001. He and Szekeres had become close friends, sharing also a love of chamber music, and Baker had dedicated his last paper to Szekeres in honour of his 90th birthday.[68]

While in Adelaide, Szekeres worked in an "astounding" variety of fields. In number theory, he wrote on partitions; in algebra, on ideals of a polynomial domain; and in general relativity, on singularities of Riemannian manifolds. His work on the mathematical theory underlying the study of black holes was fundamental. There were also publications on the iteration of functions, in combinatorics and in numerical analysis. As Giles and Seberry wrote, "In this period George was beginning to have a remarkable effect on the Australian mathematical community."[69] In 1963 he accepted the offer of the chair in pure mathematics at UNSW.

Esther Szekeres tutored mathematics at the University of Adelaide and also taught at schools, one of a number of migrants with similar backgrounds and similar new careers. Potts was effusive on this period of the immigrant mathematician in Adelaide:

> It was not only Schwerdtfeger and Szekeres but Sved, Sag and Greenfield who were responsible for reviving mathematics. Despite incredible hardship, misunderstanding, and language difficulties, they transmitted to their students an enthusiasm for mathematics. George Sved was



Herbert Sydney (Bert) Green, 1920–1999, in 1989. (Australian Academy of Science)

> to become mathematics' greatest ally in the Faculty of Engineering; Hanna Schwerdtfeger, Esther Szekeres, Marta Sved, Lily Sag, and Lia Greenfield were to be eminent as tutors in mathematics in the University and teachers of mathematics in schools.[70]

Lily Sag, whom Potts mentioned, was formerly Lily Szekeley. Like the Sveds and the Szekereses, she too was prominent in the mathematics and physics problem competitions in Hungary in the late 1920s; she died in 1996. With her husband, she had travelled to Australia on the same ship as the Sveds, settled in Melbourne and moved to Adelaide in 1953. Their son Thomas William (Tom) Sag studied mathematics at the University of Adelaide, completed an MSc under George Szekeres and then travelled to the University of Manchester for a PhD in numerical methods. He was appointed to a lectureship in mathematics at Flinders University and retired in 1997 after 30 years there.

Peter Szekeres, son of George and Esther, was educated in Adelaide and received a PhD from King's College, London, in 1964 in the area of relativity. He held research and teaching positions at Cornell University and King's College before taking a lectureship in mathematical physics at the University of Adelaide in 1971. Now retired, he still holds a visiting fellowship in the University and continues his research in general relativity and cosmology.

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The Department of Mathematical Physics that Peter Szekeres was to join was created in 1949, no doubt, wrote Bert Green, "with some hope of reviving the traditions set by Horace Lamb and William Bragg in the early days of the University, but explicitly to provide an impetus to research in the mathematical sciences, which was at a low ebb at the time."[71] It is very likely that the fillip that would be given by George Szekeres' arrival around the same time was not properly anticipated. The new department, consisting originally of just two members of staff, did not get underway until August 1951. Bert Green was the new professor, the first in Australia in the area of theoretical physics, and Harry Messel was appointed senior lecturer. Green's distinguished career before arriving in Australia has been mentioned already in Chapter 5. He remained in Adelaide for the rest of his life, retiring in 1985 but with no diminution in his research. From 1946 until his death on 16 February 1999 Green produced more than 150 articles and 13 books, nine of them as sole author, on topics as diverse as particle physics, environmental science and neurophysiology.[72]

Harry Messel's parents had migrated from the Ukraine to Canada in 1890 and he was born on 3 March 1922 in Manitoba. After secondary studies at the Royal Military College in Kingston, Ontario, winning the Governor-General's medal there "plus almost every other award," Messel served with distinction in the Canadian armed forces during World War 2 and then enrolled for two degrees simultaneously at Queen's University in Kingston in 1946. His results, including first-class honours in mathematics, brought a raft of offers: "I had one from

Princeton, I had another one from Brown, I had another one from MIT." But Messel chose to go to the University of St Andrews where he could work in modern algebra and group theory with H. W. Turnbull. From there, with "sufficient mathematics to be able to use it for some practical purpose," he went to the Institute for Advanced Studies at Dublin where he obtained his doctorate, met Bert Green and, with a young nurse whom he married and who wanted to come to Australia, accepted the post in Adelaide.[73] Angas Hurst takes up the story:

> Bert and Harry were an oddly assorted couple, Bert being reserved and not very interested in socialising while Harry was extremely extroverted and tended to dominate any social gathering. But they got on famously, with their abilities complementing each other's very well . . . Harry Messel only stayed nine months before leaving to take up the long-vacant chair of physics in Sydney, but in that time they produced thirteen papers on cosmic rays, not to mention other papers that Bert wrote on other parts of mathematical physics.[70]

Messel was followed as senior lecturer in mathematical physics by John Clive Ward (1924–2000), appointed in October 1953. He also held the post for just nine months, an experience which he considered to be a "disaster". Ward's undergraduate years had been at Oxford where he graduated with first-class honours in mathematics. Prior to going to Adelaide he had spent a year in Sydney as a mathematics tutor at St Andrews College with a "tenuous connection" to Sydney University, and there he had befriended Freddy Chong and Dick Makinson. Some years later, having been elected FRS, Ward won a chair in mathematics in Wellington, New Zealand, but was soon persuaded by Chong to move instead to the chair of theoretical physics at the newly opened Macquarie University. He remained there until 1984.[75]

The next appointment in mathematical physics at Adelaide lasted far longer than the nine months for each of Messel and Ward. The former Bailey Boy, Angas Hurst, stayed until his retirement 31 years later in 1988, and for many years after that he continued his research in the University as emeritus professor. Equally at home among mathematicians and physicists, Hurst was chair of the Australian Academy of Science's National Committee for Physics from 1979 to 1987.

For the first ten years or so within mathematical physics in Adelaide, there was little in the way of lecturing duties or committee work to hinder the development of research. Ren Potts had been appointed to the mathematics department in 1951 "to strengthen the teaching of Mathematical Physics in that area" and he and George Szekeres were seen as valuable allies for Green's small research team.[76] Hurst's appointment dated from 1957 and Ian Ellery McCarthy, the first PhD graduate of the department and later professor of physics at Flinders University, became its third staff member in 1960. It started around then to be a "regular university department" teaching honours and third-year courses.

McCarthy is one of many Adelaide graduates in mathematical physics to be mentioned at various parts of this book. Tom Michael Lampe Wigley was one whose distinguished career was forged overseas. He was an honours graduate in mathematical physics in 1960 and later returned to do a PhD on plasma dynamics, with application to cave breathing, graduating in 1967. At that time he joined the Department of Mechanical Engineering at the University of Waterloo in Ontario, Canada, teaching courses in applied mathematics, statistics, air pollution and meteorology. He was there until 1975. Since 1987 he has held a personal chair in climatology in the University of East Anglia in Norwich, UK, and now combines that with his position as senior scientist in the National Center for Atmospheric Research at Boulder, Colorado.

The graduates in mathematical physics across the country keep the discipline alive and

nominally distinct from theoretical physics. They were able to host the twelfth International Congress of Mathematical Physics at the University of Queensland from 13 to 19 July 1997. According to the website for the congress: "In summary, the 13 Plenary Talks, 35 Invited Talks, 106 Contributed Talks and 62 Posters add to 216 = 6^3 Contributions."[77]

Perhaps the last hurrah of mathematical physics in the University of Adelaide was the appointment of the celebrated physicist, cosmologist and communicator Paul Charles William Davies to a chair of mathematics and physics in 1990. His title was changed in 1993 to Professor of Natural Philosophy and in 1997 he moved to Macquarie University, again as professor of natural philosophy but in its Australian Centre for Astrobiology. Davies was born in London in 1946 and now has Australian citizenship. His PhD from University College, London, in 1970 was in physics but his first teaching position, from 1972 to 1980, was as a lecturer in mathematics at King's College in the University of London.

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In the mid-1950s, the full-time lecturing staff in mathematics, separate from mathematical physics, consisted of Harold Sanders as Elder Professor; William Statton, first appointed in 1927, as reader; Maurice Gray, George Szekeres and Basil Rennie as senior lecturers; and Potts as lecturer. Potts was promoted to senior lecturer in 1955, around the time that Maurie Brearley was appointed lecturer. Brearley remained in Adelaide for eleven years during which time he obtained a PhD for himself in 1958, supervised by Bert Green. He then succeeded Rennie as professor of mathematics in the University of Melbourne by taking his chair at the RAAF Academy, Point Cook.

Renfrey Burnard (Ren) Potts was born in Adelaide on 4 October 1925 and attended Prince Alfred College there. It was wartime when he completed school and, unable for medical reasons to join the armed forces, he was strongly encouraged to undertake an emergency three-year BSc (Engineering) course, which would give him entry into the army as an officer. He won one of twelve university entrance scholarships available in the state, although this entailed an extra year at high school leading to exemptions from certain first-year university courses. Potts acknowledged the influence of Hans Schwerdtfeger who taught him third-year mathematics and persuaded him to continue with mathematics when the end of the war led to the cancellation of his original enrolment and his transfer to a degree in science. It took two years to catch up and obtain his honours degree, in 1947, and then a Rhodes scholarship took him to Oxford a year later, after Sanders had given him two academic terms as a temporary lecturer. He travelled to Oxford with Les Woods, also a Rhodes scholar.[78]

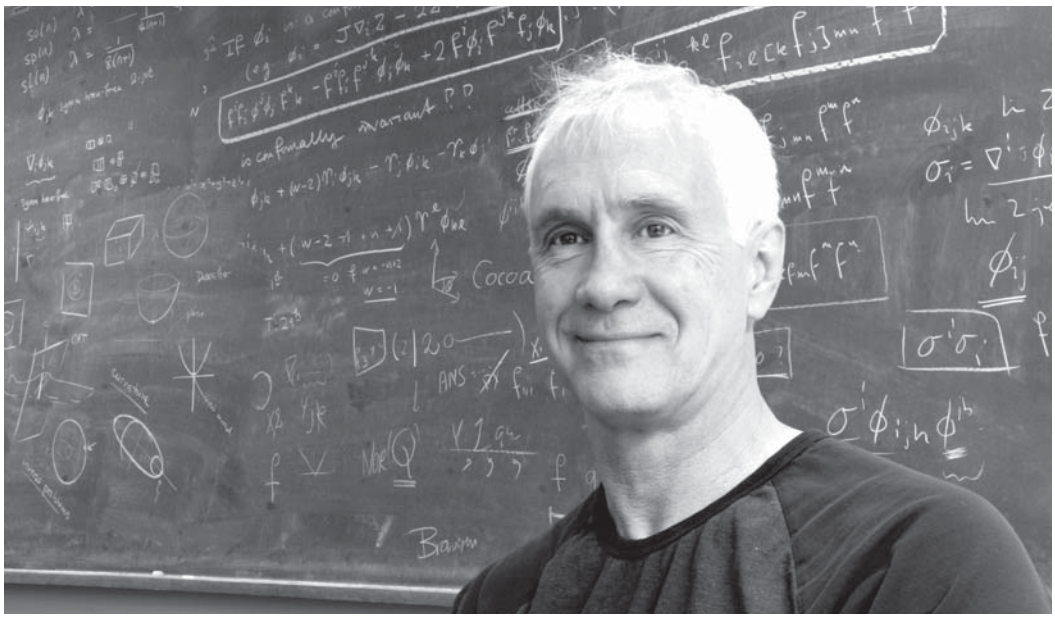
Eric Stephen Barnes, 1924–2000, in 1955. (Australian Academy of Science)

The Oxford experience, studying for a BA in applied mathematics, was not a pleasant one for Potts, until he switched successfully to research for a DPhil in mathematical physics. The "Potts model" that resulted from this work is still often cited.[79] Hearing of the new department being established in Adelaide, he applied for the position that was won by Harry Messel ("a pal of

Bert Green's") and was instead offered the lectureship in mathematics. He and Messel travelled together to Australia "and by the time [the ship] got to Australia I was a cosmic ray physicist." In the short time that Messel was in Adelaide he and Potts wrote "six or seven" papers together, besides the 13 papers that Messel wrote with Green.[80] Potts' later research would be largely in the areas of operations research, difference equations and robotics.

Following Sanders' retirement at the end of 1958, and after two years as an associate professor at the University of Toronto, Potts was appointed professor of applied mathematics in Adelaide. Just before that, Eric Barnes won the position of Elder Professor of Pure Mathematics there. They served alternate three-year terms as head of department, a novel arrangement at the time, until 1971 when they became heads of newly created departments of applied and pure mathematics. By then there were also separate departments of computing science and statistics and in 1973 these four, together with mathematical physics, became the constituent departments of a new Faculty of Mathematical Sciences, with Barnes as its first dean. For Green's mathematical physicists, it was not an easy decision to align their department so strongly with mathematicians since there remained a responsibility for the teaching of physics students. The main research interests of the group, allied even with the pure mathematicians in some instances, determined the issue.[81]

Barnes left the faculty in 1975, relinquishing the Elder Chair to Potts, and became deputy vice-chancellor of the University but returned as professor in the Department of Pure Mathematics in 1981. Although he took early retirement in May 1983, necessitated partly by health problems, he remained active in the department for a further ten years. He died on 16 October 2000. Eric Barnes is remembered also for his work in the wider mathematical community—for the Australian Mathematical Society, of which he was president in 1962–1964, and the Australian Academy of Science as well as in local school mathematics. He was chief examiner in mathematics and chair of the mathematics syllabus committee and was prominent in the



Mike Eastwood. (Photo by Ben Osborne, University of Adelaide)

establishment of the Mathematical Association of South Australia of which he was the foundation president from 1959 to 1961.[82]

In 1976 William Moran, a specialist in harmonic analysis with a BSc from the University of Birmingham and a PhD from the University of Sheffield, was appointed to succeed Barnes as professor of pure mathematics. Moran, born on 2 January 1944 in Rotherham, England, had attended school there before going on to Birmingham. He taught at the University of Liverpool from 1968 until taking the position at Adelaide but resigned that post in acrimonious circumstances[83] in September 1991 and moved to Flinders University. He was professor of mathematics there until 2001. Following Moran, chairs in pure mathematics in the University of Adelaide have been held by Alan Carey, Mike Eastwood and Michael Murray.

Carey was appointed in 1993, having joined the Department of Mathematical Physics in a research position in 1975 and the Department of Pure Mathematics as a lecturer ten years later. He was born in Sydney in 1949 and graduated BSc with first-class honours and the university medal in pure mathematics from the University of Sydney in 1971, subsequently obtaining an MSc from the University of Adelaide (1973) and a DPhil from Oxford (1975). His work in quantum field theory saw him aligned with the mathematical physicists in Adelaide as much as with the pure mathematicians. Carey resigned from the chair in 2001 to become dean of the Mathematical Sciences Institute at ANU. He was president of the Australian Mathematical Society in 2000–2002.

Michael George Eastwood was born in England in 1952. He holds a BA with first-class honours in mathematics from Oxford University (1973) and a PhD from Princeton University (1976). Eastwood has been at the University of Adelaide since 1985 and became professor of pure mathematics in 1996. He is currently an ARC Senior Research Fellow, as is his colleague Mathai Varghese. Both work in the field of differential geometry. Varghese, born in 1960 and with a PhD from the Massachusetts Institute of Technology, has been at the University of Adelaide since 1989 and has established himself as a distinguished researcher.

Michael Murray is also a differential geometer, with a DPhil from Oxford supervised by Sir Michael Atiyah. Four years earlier, in 1979, he gained a BSc with first-class honours from Monash University. Murray first joined the University of Adelaide as a lecturer in pure mathematics in 1992 and was appointed professor there in 2003.

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As mentioned above, Ren Potts came back to the University as professor of applied mathematics in 1958. From the earliest days he was at the forefront of computing in Australia, working in that area with David Elliott who was appointed senior lecturer in May 1958 while Potts was still in Toronto. Elliott had come from the New South Wales University of Technology where he had spent a year in the Department of Electrical Engineering with the university's original computer, the UTECOM, the same machine as the English Electric DEUCE that he had worked on in the mathematical division of the National Physical Laboratory in England. When Elliott left the UTECOM Laboratory, his place was taken by Barry Stephen Thornton, a first-class honours graduate in physics from the University of Sydney. Thornton briefly held a senior lectureship in the Department of Mathematics at the New South Wales University of Technology before going to UTECOM and was later to become the foundation head of the School of Mathematical Sciences at the New South Wales Institute of Technology. The senior programmer in the UTECOM Laboratory at the time, T. M. (Larry) Park, later became a senior lecturer in Thornton's school.

In the University of Technology Elliott had sought to undertake PhD studies with Les Woods, by then Nuffield Professor of Mechanical Engineering there (and supervisor of Thornton's PhD), but when that could not be fulfilled he looked elsewhere and was offered the senior lectureship in Adelaide. He was the first of Potts' 20 PhD students, graduating in 1961 with a thesis on the application of Chebyshev polynomials in numerical analysis. Elliott left Adelaide in May that year to take a senior lectureship in the Basser Computing Department of the University of Sydney, where he and John Bennett comprised the whole department and taught the recently introduced Diploma of Numerical Analysis and Automatic Computing. In 1964 Elliott was appointed to the chair of applied mathematics in the University of Tasmania.

Potts' role in organised computing in Australia began with the meeting he called on 24 October 1960 to found the Computer Society of South Australia. He was elected president and Reyn Keats, still at the Weapons Research Establishment at Salisbury, was elected to the committee. The inaugural meeting took place a month later with Elliott as guest speaker, on the topic *A Brief History of Computing*. Computer societies were subsequently formed in Victoria (in April 1961), Queensland (February 1962), New South Wales (August 1962) and Canberra (March 1965) and these five were the founding societies of the Australian Computer Society on 1 January 1966.[84]

Keats, whose early career has been outlined in Chapter 5, was brought to the University as senior lecturer in 1961. Two years later Rainer Radok and Jane Pitman were apponted.

Jens Rainer Maria Radok, born on 18 February 1920, had been schooled in Königsberg, East Prussia. After gaining qualifications in mechanical engineering from the technical high school in Münich, his distantly Jewish background forced immigration to England in July 1939 and he was interned there two months later.

Radok came to Australia aboard *Dunera* and was again interned until 1942. He was allowed then to serve in the military forces, at the same time studying part-time at the University of Melbourne, and in 1945 began as a research assistant with CSIR's Division of Aeronautics. With an MA from Melbourne University gained in 1949, Radok returned to Europe for further study at the Cranfield College of Aeronautics, England, and research positions in Amsterdam and Zürich. After another 18 months with the Division of Aeronautics (by then renamed the Aeronautical Research Laboratories), the eight years from August 1955 saw Radok in various positions in the United States, during which he was awarded an engineering doctorate from Münich, and included three years as professor of applied mechanics at the Brooklyn Polytechnic Institute, New York. He was with Interscience Publishers in Vienna furthering his interests in the translation of foreign texts when he gained a readership in Adelaide.

The position was upgraded to a personal chair in applied mathematics in 1964, perhaps as a result of a threatened move to the University of Sydney.[85] It was Radok's choice, encouraged by Potts, to begin a new research career in oceanography, which Radok saw as an area of growing relevance in Australia. From 1966 he was situated at the university's Bedford Park campus, where he soon established the Horace Lamb Centre for Oceanographical Research. When that campus was converted into the Flinders University of South Australia he remained there as foundation professor of applied mathematics. For a few months in 1971–1972 he was the University's professor of oceanography, the first in the country, but a dispute led to the rapid acceptance of his resignation. Radok then worked as a private environmental consultant in Adelaide until, in 1981, he took the chair in applied mathematics at the Asian Institute of Technology, Bangkok.

He remained in Thailand after retirement in 1985 constantly writing of his personal background and mathematical interests until his death there on 23 August 2004.[86]

Edith Jane Pitman, Edwin Pitman's daughter, was born on 6 December 1932 in Hobart. Her initial university studies for a BA were heavily directed towards languages but mathematics prevailed. After just six weeks as a research student in the University of Tasmania, she took a position with the Weapons Research Establishment in Salisbury, South Australia, but that too was only for a short time. In July 1954 she obtained a senior teaching fellowship at the University of Sydney and, at T. G. Room's suggestion, undertook a PhD to be supervised by Barnes. Two years in Cambridge studying under Louis Mordell and Harold Davenport then led to a lectureship in mathematics at the University of Tasmania, which Pitman chose over an offer from Room to return to Sydney. She was there for less than four years before taking a senior lectureship in the University of Adelaide, overlapping briefly with Szekeres there and contributing with Barnes to that university's reputation in number theory. She retired as a reader in early 1997. Her brother James is professor of statistics and mathematics at the University of California, Berkeley.[87]

There were other longlasting appointments in the 1960s, particularly in applied mathematics: Jag Mazumdar, Charles Pearce and Ernie Tuck.

Jagannath Mazumdar graduated BSc with first-class honours in applied mathematics from Patna University, India, in 1953 and gained an MSc two years later. He has a PhD from Moscow State University (1966) and an honorary PhD *ad eundem gradum* from the University of Adelaide (1968) where he arrived to take up a lectureship in 1966. Mazumdar carried out research both in solid mechanics and biomedical engineering and on his retirement in 2002 as associate professor was made adjunct professor in both the Department of Applied Mathematics and the Department of Electrical and Electronic Engineering. He is also adjunct professor in the School of Electrical and Information Engineering at the University of South Australia.[88]

Charles Edward Miller Pearce was a New Zealander, born in Wellington on 29 March 1940. He completed his secondary schooling as dux of Hutt Valley High School in 1957, and went on to gain a BSc from the University of New Zealand (1961), an MSc from the Victoria University of Wellington (1962) and a PhD from ANU (1966). His research interests in probabilistic and statistical modelling and analysis, stochastic processes, control theory and optimisation are reflected in the positions he has held: a junior lectureship in mathematics and mathematical physics in Wellington in 1962, lectureships in statistics at ANU (1966) and the University of Sheffield (1966–1968), and then a senior lectureship in mathematics in the University of Adelaide in 1968. He was promoted to reader in applied mathematics there in 1982 and professor of applied mathematics in 2003. Pearce has served three terms as national president of the Australian Society for Operations Research and has represented Australia on the International Federation of Operations Research Societies.

Ernest Oliver Tuck was born in Adelaide on 1 June 1939. He graduated BSc with first-class honours in mathematics from the University of Adelaide in 1960 and a PhD from Cambridge in 1964. In between, he held an assistant lectureship in mathematics at the University of Manchester. He was senior research fellow in engineering science at the California Institute of Technology when appointed reader in applied mathematics in Adelaide in 1968. Tuck was promoted to professor in 1974 and on Potts' retirement in 1990 became the Elder Professor. His publications cover ship hydrodynamics, aerodynamics, industrial fluid dynamics and the analysis of games of chance.

He and Potts tended to share the headship of the Department of Applied Mathematics, with Tuck in fact claiming to have been instrumental in the creation of that department. Dissatisfaction with what he saw as a dominating role played by pure mathematicians in the former Department of Mathematics led to his threatened departure:

> So I began negotiations with the Dean of Engineering to transfer myself to that Faculty, and to set up a new Department of Engineering Science, modelled on one I had been with in Caltech in 1966–7, with main responsibility for service teaching mathematics to engineering students. Ren heard about this and said to me—"wait, I have a better idea". His better idea was to split Mathematics into Pure and Applied.

Tuck retired in June 2002 with a promise "to keep having my morning coffee in the department, as I have most days for 34 years".[89]

With Tuck's retirement, Pearce took on the title of Elder Professor at the beginning of 2004. He was joined by a second professor of applied mathematics, Nigel Geoffrey Bean, in April that year. Although born in Cambridge in 1967, Bean completed all his school and university studies in Adelaide, apart from a return to Cambridge for his PhD from 1989 to 1993. His working career has been spent entirely in applied mathematics at the University of Adelaide, including a prolonged involvement with the Teletraffic Research Centre there. This centre, now known as TRC Mathematical Modelling, conducts research and development in telecommunications network analysis and resource optimisation in manufacturing. It was established in 1985 with funding from Telecom Australia and is now the only university-based research group that is directly funded at a significant level by Telstra.

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The Faculty of Mathematical Sciences with its five departments remained intact until 1987 when the mathematical physicists left it to amalgamate with the physicists in a new Department of Physics and Mathematical Physics in the School of Chemistry and Physics. The mathematical physics group has been reduced essentially to one person, Max Adolph Lohe, appointed there as an associate professor in 1996 after ten years with the Northern Territory University. There were other changes to the faculty in the late 1990s and early 2000s so that at one stage the statisticians also lost their identity, being merged into the Department of Applied Mathematics. Currently there is a School of Mathematical Sciences, comprising disciplines of applied mathematics, pure mathematics and statistics, as one of seven schools in the Faculty of Engineering, Computer and Mathematical Sciences.

Within the discipline of statistics, Edmund Alfred (Alf) Cornish was the first professor, appointed in 1960, and he was also the first chief of the Division of Mathematical Statistics (DMS) in CSIRO. His career is described in Chapter 8. Cornish was succeeded in the chair first by Alan Treleven James, who held the post from 1965 until his retirement as emeritus professor in late 1989, and then by Richard Gentry Jarrett.

James was born on 22 July 1924 in Berri, South Australia. He attended school in Adelaide and graduated with an honours BSc in physics from the University of Adelaide in 1944. Cornish was at that time chief of the precursor to DMS and he immediately appointed James to a position as assistant research officer. After five years there, in which time he completed a part-time MSc, James travelled on a CSIRO studentship to Princeton University to work towards a PhD supervised by Samuel Stanley Wilks, one of the founders of the study of mathematical statistics in the United States. He subsequently returned to Adelaide and CSIRO for some six years before resigning as a principal research officer to move to Yale, where he was appointed

a full professor in 1963. The post at the University of Adelaide followed two years later. James' research during the 1950s and 1960s built upon his deep knowledge of modern algebra and differential geometry, taught to him originally by Hans Schwerdtfeger, and he was to have a "profound impact" on multivariate analysis and the analysis of variance.[90]

His successor, Richard Jarrett, was born in Adelaide on 30 November 1947. He has a BSc with first-class honours in mathematical statistics from the University of Adelaide and a PhD in theoretical statistics from Imperial College, London, completed in 1973. He was with the DMS when he was appointed director of the Statistical Consulting Centre at the University of Melbourne and four years later he took the chair in statistics in the University of Adelaide. In 2000 Jarrett left to rejoin the DMS, by then revamped as CSIRO Mathematical and Information Sciences.

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Ren Potts, the dominant figure in this account of mathematics at the University of Adelaide since 1945 and a dominant figure in the history of applied mathematics in Australia, passed away on 9 August 2005, two months short of his eightieth birthday.[91]

The University of Tasmania, from 1948

When Mac Urquhart returned to active work as a lecturer in mathematics at the University of Tasmania in 1947, he continued with the dedication and versatility that he had shown in Melbourne. "In one year," wrote David Elliott,

> because of staffing difficulties, he gave all the lectures in Applied Mathematics. At one time or another during his lecturing career, he also gave lectures to first, second and third year classes in Pure Mathematics, as well as fourth year lectures in Geometry and Relativity. The only subject in which he was not prepared to lecture was Statistics.[92]

He was promoted to senior lecturer in 1952 and to reader in 1966. By then he was known to be suffering from inoperable cancer and he died on 23 February that year. Urquhart was a foundation member of the Australian Mathematical Society and he helped start the Mathematical Association of Tasmania, which is the local teachers' body, and was its first president. For reasons given in Chapter 4, Urquhart published none of his research; but one result of his investigations into special relativity survives and is known as Urquhart's Theorem. He considered it to be the "most elementary theorem" of Euclidean geometry and that epithet has also survived. It is elementary enough to be given here:

> Let $OAXC$ be a convex quadrilateral and let CX meet OA (produced) in B and AX meet OC (produced) in D. If $OA + AX = OC + CX$, then $OB + BX = OD + DX$.[93]

The lecturing staff by 1952 consisted of Edwin Pitman, professor there since 1926, the senior lecturers Urquhart and Henry Löwig, and the lecturer Peter Sprent. Löwig and Sprent left around 1955 but Carl (or Charles) Felix Moppert had been appointed to a lectureship the year before. Born in Basel, Switzerland, on 7 October 1920, Moppert had gained a doctorate from the University of Basel in 1949 for a thesis on Riemann surfaces, supervised by Alexander Ostrowski. He was a schoolteacher in his home town before gaining the Tasmanian position and left Hobart in 1958 for a senior lectureship at the University of Melbourne.[94]

A number of new appointments followed. Six years after John Jaeger had moved to Canberra, Laurence Stanley Goddard was appointed to the second chair of mathematics. Born on 25 April 1917 in Sydney, Goddard completed a BSc with honours in mathematics in the University of

At the opening of the E. J. G. Pitman Mathematics Collection, 2 November 1987. Front, left to right: B. Brown, B. H. Neumann, Pitman, E. J. Hannan. Back, left to right: D. R. McNeil, A. M. Hasofer, G. McPherson, E. J. Williams, R. Lidl, C. C. Heyde.

Sydney during 1937 and then travelled on a Barker graduate scholarship to Cambridge where he obtained a PhD in 1946. Before gaining the chair in Tasmania he had lectured in mathematics and statistics at two Scottish universities, the University of St Andrews and the University of Aberdeen. Other appointees a year later, in 1959, were the pure mathematicians Jane Pitman and German-born Werner Alex Julius Greve.

In May 1967, during a period of some disarray for mathematics in Hobart going back to Urquhart's time when he and Goddard disagreed over many things, such as the re-examination of an honours student,[95] Goddard resigned and took a chair of mathematics in the University of Salford, UK. In retirement he returned to Australia and died on 26 February 1996 at Springwood in the Blue Mountains, west of Sydney.

Edwin Pitman had retired in December 1962 and a new professor, David Elliott, had arrived in 1964. Pitman's "unique, original and influential contributions" to the theory of statistics and probability were acknowledged in 1978 when the Statistical Society of Australia established its Pitman Medal "for high distinction in Statistics", and made the first award to Pitman himself. For twelve years after his retirement he travelled extensively, including a year as visiting professor in the University of Adelaide and two years in the University of Melbourne. The University of Tasmania awarded him an emeritus professorship shortly after he retired and an honorary

DSc in 1977 and ten years after that, to mark his 90th birthday, named its library's mathematics collection in his honour. His role in the formation of the Australian Mathematical Society is told in Chapter 10. Edwin Pitman died on 21 July 1993.[96]

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His successor Elliott was born in Plymouth, England, in April 1931. He took an honours degree in mathematics at University College, London, graduating in 1951, and a coursework master's degree the following year. At Princeton University in 1954, in the aeronautical engineering department, Elliott carried out research in boundary layer theory and compressible flow leading to the degree of Master of Science in Engineering but a year later, back in England, began work in the National Physical Laboratory and was introduced to computing, the area that would dominate his future career. That led in the first place to the job in Sydney at the then New South Wales University of Technology working on UTECOM, as recounted above. In January 1964 he took up his appointment in Tasmania.

As the replacement for Jaeger, Goddard had originally been appointed professor of applied mathematics based on industrial work he had undertaken in England prior to obtaining his PhD, so when Pitman retired the University advertised for a professor of pure mathematics. Since that brought no useful response, Goddard argued that his inclinations were by then back towards pure mathematics so the University should advertise instead for a professor of applied mathematics. His title was accordingly changed when Elliott filled the chair there.[97]

A few months after Elliott's arrival, John Donaldson, whose first degree was from the University of Edinburgh, enrolled as Elliott's first PhD student and three years later was given a tenured lectureship. He was a senior lecturer when he retired in 2003, shortly before his trip to Scandinavia to see his daughter become Crown Princess Mary of Denmark. With research interests in oceanography and industrial mathematics, he currently holds visiting professorships at the Universities of Aarhus and Copenhagen in that country.

In retirement, Elliott continued the secretaryship of the Australian Mathematical Society that he had taken on in 1990 and held that position for eleven years. The University of Tasmania has, incidentally, been notable in the production of long term workers for the Australian Mathematical Society: both Walter Bloom and Barry Jones, secretary and treasurer, respectively, during much of the 1980s, completed their undergraduate degrees there. Elliott was professor for some 30 years and looks on himself proudly as the third of the triumvirate with McAulay and Pitman making an almost unbroken span of one hundred years of chairs of mathematics in the University of Tasmania.

The terms of the University's next two appointments as professors of mathematics were very short. Goddard was succeeded as professor of pure mathematics by the Berlin-trained Paul Joachim Rudolph Kochendörffer (1911–1980), until then a frequent visitor to Adelaide, but he held the chair only for a year from August 1968 and then for personal reasons returned to Germany to a position in the University of Dortmund. Four years later Howard Cook, born in 1933 and with a PhD from the University of Texas, was given a short term appointment as professor of pure mathematics; he was in Tasmania only for 18 months before taking a chair at the University of Houston.

When Rudolf, or Rudi, Lidl was appointed to a chair in 1976, aged only 27, it was hoped that the position would be stabilised. Lidl had been on a six-months visiting appointment at Monash University when the position in Tasmania was advertised. Born in Linz, Austria, he had received a doctorate from the University of Vienna in 1970 and, at the time of his appointment

to the chair in Tasmania, was associate professor at the University of Technology in Vienna. In 1991 Lidl became Executive Dean of Science and Technology and two years later was appointed deputy vice-chancellor. His research interests are in finite fields and polynomial algebras and his textbooks on finite fields, written with Harald Niederreiter in 1983 and 1986,[98] are still primary sources in this area.

Barry Edward Johnson and Richard Burt Melrose were two of many eminent mathematicians to come out of the University of Tasmania.

Johnson was born on 1 August 1937 in London. He came with his parents to Tasmania at age 14 but they moved back to Britain two years later leaving Barry to continue his studies at Hobart State High School. He entered the University of Tasmania when he was not yet 16 and at age 32, with a PhD from Cambridge was appointed professor of mathematics at the University of Newcastle-upon-Tyne. Johnson's work in harmonic analysis and Banach algebras was seminal; he was elected FRS in 1978 and was president of the London Mathematical Society in 1980–1982. He died on 5 May 2002.[99]

Melrose was born in Sydney on 8 April 1949 and was schooled across the country, in New South Wales and Western Australia, before taking his high school matriculation in Tasmania in 1965. His BSc from the University of Tasmania in 1969 was followed by a BSc honours degree in theoretical physics at ANU and then a PhD from Cambridge in 1974.

> At the University of Tasmania I played rugby and was a member of the Jazz club; I had intended to study Physics to Honours level, but found the atmosphere in the Physics Department decidedly unattractive. As far as Mathematics is concerned, I particularly remember the excellent tutoring of Diana Frost (Shelstad) and the chaotic, but instructive, lectures of Werner Greve—perhaps he has influenced my own lecturing style. All in all the undergraduate education then was really quite good, if a bit spotty. My escape from Tasmania was largely due to the kindness (and administrative skill) of Hans Buchdahl, who got me into the honours year, contrary to the rules, at ANU in his little department and hence eventually to Britain. At Cambridge I finally learnt a little Mathematics.[100]

Melrose joined the Massachusetts Institute of Technology in 1976 and within three years became a full professor there, renowned for his work in functional analysis. He was the first of three Australians who have won the prestigious Bôcher Memorial Prize and in 1990 was a plenary speaker at the meeting of the International Congress of Mathematicians in Kyoto, Japan.

Diana Shelstad, whom Melrose referred to, has held a Distinguished Chair in the Department of Mathematics and Computer Science at Rutgers University, Newark and New Brunswick, since the mid-1980s. She gained her PhD from Yale a year or so after Michael John Sharpe, another Tasmanian, who is professor emeritus in probability theory at the University of California, San Diego. He was first appointed as assistant professor of mathematics there in 1967, the year his PhD was awarded, and was promoted to full professor ten years later.

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The University of Tasmania brought the two small departments of mathematics and physics together in 2000 as a single school, incorporating also the Institute for Southern Ocean and Antarctic Studies, and Lawrence (Larry) Forbes was appointed professor of mathematics and head of the new school. He is an applied mathematician whose honours BSc and PhD, supervised by Len Schwartz and Ernie Tuck and awarded in 1981, are from the University of Adelaide; he was formerly a reader in mathematics at the University of Queensland where he was first appointed in 1985. Forbes' interests include fluid mechanics and numerical methods.

In 2005 the school's establishment in mathematics and statistics consisted of just 8.5 staff members including Forbes, down from 13 ten years earlier. Two of those, Peter Trotter and Barry Gardner, both algebraists and both now readers in the school, have been at the University of Tasmania since 1968.

The University of Queensland, from 1947

Clive Selwyn Davis was born on 15 April 1916, attended Sydney Technical High School, from where he excelled in the Leaving Certificate examinations, and then enrolled for an engineering degree at the University of Sydney. Two years later he transferred to science. His studies there and his distinguished wartime career, which included an exemplary flying record for the RAF and pioneering work in operations research in England and Australia, have been recounted in Chapter 5. At war's end he was the country's first beneficiary of the Gowrie Scholarship Trust Fund, a scheme instituted to assist Australians returning from war and maintained for their descendants today, and entered Trinity College, Cambridge. His PhD was supervised by Louis Mordell. Davis's interest in number theory led then to an appointment to the staff of the University of Bristol where Hans Arnold Heilbronn was professor and head of department. Seven years later, in January 1956, he won the chair at the University of Queensland, succeeding Eugene Simonds who had retired the previous July.[101]

Davis was selected after the original list of 15 candidates for the chair was reduced to a shortlist of six. One of those, Frederick Atkinson, withdrew when he obtained the newly created chair of mathematics at Canberra University College. Another, Laurence Goddard, gained the chair at the University of Tasmania two years later. James Patrick McCarthy was the local shortlisted candidate and he petitioned unsuccessfully for a senate inquiry into the appointment when he and the others were passed over in favour of Davis. He argued against the processes used since the senate's appointed selection committee included no mathematicians, not even Simonds who at that time had not yet retired. Instead, in McCarthy's view the real decision was made by a committee formed by the secretary of the Association of the Universities of the British Commonwealth in London based partly on interviews of four of the candidates who were then resident there. McCarthy was not interviewed by the local committee.[102]

The staff in the Department of Mathematics when Davis arrived consisted of McCarthy, who had been promoted to associate professor in January 1947 and was acting professor following Simonds' departure; two senior lecturers, Ian Andrews Evans and Henry Maurice Finucan; two lecturers, Patrick Blake McGovern and Harold Kerr Powell; and an assistant lecturer Michael Patrick O'Donnell. Ethel Harriet Raybould had left the University the year before.

Evans had graduated from the University of Queensland with first-class honours in mathematics after gaining a BSc in 1942 and then spending three years as assistant research officer in CSIRO's Division of Radiophysics. He was appointed as assistant lecturer in 1947 and in 1949 took leave without pay for two years to complete a BA at Cambridge. He was promoted to lecturer shortly after his return and then to senior lecturer just prior to Davis's arrival. Evans resigned in 1960 to take a senior lectureship in the University of Melbourne. When he died in 2000, aged 78, he willed his extensive library to the Department of Mathematics at La Trobe University, where his children had been educated.

McGovern was also appointed in 1947; he died in May 1966 while still a staff member. Powell joined the department in 1949, was promoted to senior lecturer in 1960 and retired

in 1966. O'Donnell was in the department for more than 26 years, until his death as a senior lecturer in 1976.

Henry Finucan's appointment as a permanent member of staff dated from February 1946 following his war service, as described in Chapter 5. He was promoted to senior lecturer in 1952 and to reader in 1959. Staff shortages and increasing numbers of students after the war meant that it was only around then that he was able to concentrate his teaching in the area of statistics, the job to which he had been appointed in the first place, and to spend some time on research. He was heavily involved in various professional societies including a term as president of the Australasian Region of the Biometrics Society. Finucan's health deteriorated from the early 1980s and he died on 28 February 1983.[103]

In terms of staff numbers, the department that Davis found in 1956 reminded him of Sydney University 20 years before, but he had far greater student numbers to contend with, and he was not satisfied with the course given to honours mathematics students particularly in comparison with that at Bristol University where he had just spent seven years. He soon introduced both a separate honours stream (inspiring other departments in the university to do the same[104]) and the novel notion at the time of tutorial classes for all students, and he was permitted to appoint extra staff to take up the extra load. The first new full-time appointee, arriving at the end of 1956, was Grainger Morris who came from the University of Hull and was to be with the Department of Mathematics in Queensland for almost ten years before taking the chair of pure mathematics in the University of New England. Most of the load, however, was taken up by casual staff with the next full-time staff appointment being that of Ernst Traugott Steller. He was appointed lecturer in January 1959 and retired as senior lecturer in December 1977. Almost in parallel was the appointment of Leo Esmond Howard as a lecturer in April 1960; he died in office as a senior lecturer in June 1978. Howard was renowned for knowing the names of his first-year engineering students before his first lecture to them—he would study photographs that were supplied with class lists at that time.[105]

There was a great influx of new staff in the 1960s. Davis was the first in the University to call for a departure from the one-professor standard for departments in the University of Queensland when he argued successfully for a second professor, in applied mathematics. The position was first advertised in May 1959 but when James McCarthy was the only applicant it was soon advertised again, attracting four further candidates including Rainer Radok and John Mahony. However, in May 1960 the chair was offered to another of the candidates, William Charles Hoffman, an American with a PhD from the University of California, Los Angeles, who had recently joined the Department of Physics in the University. He subsequently withdrew, due to ill health as the University records it but due to Hoffman's perception of anti-Americanism on the campus according to Davis, and that September the position was instead given to Mahony.[106]

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John Mahony has been mentioned in Chapter 4 as a product of Melbourne University. He obtained his PhD from the University of Manchester, supervised by Richard Meyer, returned to Melbourne to the Aeronautical Research Laboratories, where he worked with Fenton Pillow and Harry Levey among others, and in 1958 replaced Meyer as senior lecturer in aeronautical engineering at the University of Sydney. (Meyer's story is told in Chapter 8.) Mahony had accepted a readership in applied mathematics at UWA before the Queensland offer came through but took the chair instead and just three years later resigned to join Larry Blakers and Harry Levey as professors of mathematics in Perth.

Pillow by that time was professor of mathematics in the University of Toronto. He accepted the offer of the chair at Queensland which Mahony had vacated in January 1964 and arrived in Brisbane that July, in time to join the department in a move to the Priestley Building, which still houses mathematics and is named for the founding professor. Pillow remained professor of applied mathematics until his retirement as emeritus professor in July 1986.

Fenton Pillow, 1921–2006, in 1966.

Other lasting appointments from the mid-1960s (in alphabetical order) were those of Brian Lindsay Adkins, Ludvik Bass, John Alan Belward, Kenneth Capell, Vincent Gerald Michael Hart, Alan Stuart Jones, Keith Robert Matthews, Kenneth Graham Smith and Anthony McLean Watts.

Some of these appointments, namely those of Hart, Bass and Belward, arose as a result of a shortage of staff in the area of applied mathematics which occasioned a two-week visit by Davis to England and Ireland to seek temporary staff. He was advised to visit University College, Cork, and stayed three nights with Hart (both drinking whiskey until two or three o'clock each morning, as Hart recalled[107]). Davis prevailed upon Hart, who had an MSc and a PhD from the National University of Ireland, to take a twelve-month appointment from July 1964. When that was completed, Hart returned to Ireland but in July 1966 accepted a permanent appointment as reader, although also offered a full chair in Canada. He remained in Queensland until his retirement in July 1995. Hart's research interests were in elasticity and biomathematics and he is at the university still, as an honorary research consultant.

A second chair in applied mathematics was proposed during Hart's first year in Queensland. Bass, whom Davis had met in London, was a clear candidate but was appointed reader instead, in April 1965, with the promise of a quick review of his position. He was promoted to professor of mathematical physics and biomathematics in June 1967 and on retirement in March 1994 was made emeritus professor, with dynamic positron emission tomography as one of his continuing research interests. Bass was born on 9 March 1931 and educated in Prague and Vienna. After further study at the Dublin Institute for Advanced Studies he held a lectureship at Trinity College, Dublin, until 1961. At the time of his appointment to the post in Queensland, Bass was principal lecturer in mathematics at Lanchester College of Technology, now part of Coventry University.

John Belward, an applied mathematician with major interests in scientific computing, was born in Coventry in 1938 and studied at the University of Birmingham. Also interviewed by Davis in London, he was first appointed as a lecturer in the University of Queensland in July 1964, gained a PhD there in 1972 supervised by Pillow and Hart, and retired as reader in 2003. He is now an honorary reader in the University's Advanced Computational Modelling Centre and an adjunct professor in the Queensland University of Technology.

Now to the others mentioned above.

Brian Adkins, born in Brisbane on 10 July 1929, studied in Queensland (BSc, 1950) and in Melbourne where he gained an MA in 1959 and lectured in statistics until going briefly as senior lecturer to the University of New England. He was appointed senior lecturer in the University of Queensland in January 1964, was promoted to reader in 1971 and became the first non-professorial head of the Department of Mathematics in 1973. Adkins held that position for almost ten years, then became a pro-vice-chancellor of the University and retired due to ill health in October 1988. He died on 2 May 1990.

Alan Jones is probably the longest serving recent member of a mathematics department in any university in the country. Appointed as a lecturer on 2 January 1963, he retired as a senior lecturer on his 65th birthday, 7 July 2005, over 42 years later. Jones has a BSc with first-class honours in mathematics from the University of Adelaide, an MSc from the University of Melbourne and a PhD from the University of Queensland and, despite his retirement, remains the editor, and longest serving editor of all, of the *Bulletin of the Australian Mathematical Society.*

Keith Matthews was born in February 1939 and took out a BSc from the University of Queensland, winning the university medal in mathematics. He joined the department as a lecturer in August 1966 after a period in Cambridge with Harold Davenport that led to his MSc from the University of Queensland in 1967. The MSc constituted chapters on Waring's problem for a PhD that he had not been able to complete in Cambridge but Matthews did obtain a PhD from the University of Queensland in 1974. He retired in February 2001 but continues to maintain the internationally respected Number Theory Web, which first went online on 24 November 1995. Matthews also maintains a web page for the Department of Mathematics in the University of Queensland that lists all appointments to the department up to 1972.[108]

Finally from this group, Capell, Smith and Watts were all on staff for similar periods. Ken Capell in fact began with the Department of External Studies in the University in 1959 and spent a year and a half in the Queensland University College of Townsville before gaining his lectureship in Brisbane at the beginning of 1964. He was promoted to senior lecturer in 1973 and retired in March 1994. Ken Smith, a graduate originally of the University of Sydney, was there from May 1965 to January 1997, promoted to senior lecturer in 1974. Tony Watts was appointed directly to a senior lectureship in December 1964, and retired at the end of 1996. Watts and John Holt, at one time a reader in applied mathematics in the University, began OPCOM, a software and operations research company, in 1985; the company was acquired by the Swedish firm Carmen Systems in April 2005.

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Towards the end of the 1960s there was another surge in appointments, a number of them made by Pillow as acting head of department in 1966 when Davis was on leave. This was an initiative on Pillow's part that was not appreciated by Davis and it resulted in continued bad feeling between them. The more senior or longstanding of this second group of appointees were, alphabetically: Phillip Morris Diamond (appointed lecturer in July 1969, promoted to senior lecturer in January 1977, retired as a reader in 2006); James Meredith Fitz-Gerald (appointed lecturer in December 1969, promoted to senior lecturer in January 1974, resigned July 1984 when appointed general manager, operations research, with Repco Ltd); Stephen Lipton (see below); Sheila Macdonald (now Sheila Williams, see below); Janislaw Maria Skowronski (reader from March 1968 until his death almost exactly 24 years later); Anne Penfold Street (see below); and Rudolf Oldrich Výborný.

Výborný was born on 3 July 1928 and gained a doctorate from Charles University, Prague. After ten years in the Czechoslovak Academy of Sciences, he spent two years in the University of Adelaide as senior lecturer and then was appointed professor of analysis in Queensland, with interests in both real and complex analysis. He retired in July 1989 as emeritus professor.

Stephen Lipton came from UNSW as foundation professor of statistics in August 1967 and was head of department for five years following Adkins. A member of the interim council of Griffith University in 1971, he retired as professor emeritus in July 1991 and died on 21 February 1993.[109] One of the most eminent honours graduates in statistics during Lipton's long period as professor, though that was not his original interest, was Brisbane-born Peter Donnelly. A vacation scholarship to work with Ted Hannan at ANU before he began fourth-year studies engendered the interest in statistics and he was subsequently awarded a Rhodes scholarship to Oxford. Donnelly gained a DPhil in mathematics there in 1983, won a chair in mathematical statistics and operational research at Queen Mary and Westfield College, University of London, in 1988, aged 29, and was appointed professor in the Department of Statistics and Department of Ecology and Evolution in the University of Chicago in 1994. Two years later, Donnelly went to Oxford as professor of statistical science and head of its Department of Statistics.

Sheila Williams was known by many names. She was born Sheila Oates in Cornwall, England, won a scholarship to St Hugh's College, Oxford, and after gaining her honours degree went on to do a DPhil under the supervision of Graham Higman. She became first a lecturer and then a fellow at St Hilda's College, Oxford, and visited Australia in 1965 to attend the country's first international group theory conference, held by Bernhard Neumann in Canberra. There she met Ian Macdonald who had been a PhD student of Neumann's at Manchester and was professor of mathematics at the University of Newcastle, New South Wales. They were married in December of that year and the following August Sheila was able to gain a temporary senior lectureship in Newcastle. Both moved soon after to Queensland, Ian as reader and Sheila as senior lecturer. The marriage did not last: Ian resigned from the University of Queensland in December 1968 and returned to Britain, to a position at the University of Norwich. Promoted to a readership in 1969, Sheila married her colleague Neil Williams in 1979 and in her publications, in algebra and combinatorics, has signed herself both as Sheila Oates Macdonald and Sheila Oates-Williams ("the hyphen purely because of the unfortunate initials without it!"). Neil Williams was born in Adelaide and raised in Canberra, and at ANU also had Neumann as a PhD supervisor. He spent a year in South Africa, then some time at Monash University before joining the University of Queensland in 1973. He remained there as lecturer and then senior lecturer until taking early retirement at the beginning of 2001. Sheila had retired in February 1997 and remains an honorary research consultant.[110]

Anne Street was born on 11 October 1932 in Melbourne and studied chemistry for a BSc with first-class honours and then an MSc from the University of Melbourne. At the University of Illinois she obtained a PhD in mathematics in 1966. Her background is evident from her changing research interests: molecular orbital theory to crystallographic colour groups to binary arrays to block designs. Street taught for four years in Illinois and then was appointed to a lectureship in the University of Queensland at the beginning of 1967. She was promoted to senior lecturer in 1970 and reader in 1975 and won a personal chair in 1985, becoming the third female professor of mathematics in the country after Hanna Neumann and Cheryl Praeger. A founding fellow of the Institute of Combinatorics and its Applications in 1961, Street was

awarded an honorary doctorate in mathematics by the University of Waterloo in 1996 and that year began a six-year term as president of the institute.

One of her collaborators, in two books and a number of papers and chapters of books, is her daughter Deborah Jane Street. Debbie Street gained first-class honours and the university medal in statistics from the University of Queensland in 1979 and a PhD in experimental design from the University of Sydney, awarded in 1982. She held positions at the Waite Agricultural Research Institute in Adelaide and at UNSW before being appointed associate professor of statistics at the University of Technology, Sydney in 1995.

Anne Street retired in 2000 but remained for some years as director of the University's Centre for Discrete Mathematics and Computing that she was largely responsible for forming in early 1998. She is still with the University as a professorial research fellow and honorary professor of the centre. Its director now is Elizabeth Billington. Many other staff are or were involved in the centre and five of them (Street, Billington, Oates-Williams, Diane Margaret Donovan and Barry Denis Jones) had earlier combined to produce a successful text on discrete mathematics.[111]

Jones was appointed lecturer in the department in 1968 and retired in 2004; he was treasurer of the Australian Mathematical Society from 1983 to 1993. Elizabeth Billington, incidentally, is the current secretary of the Society, having succeeded David Elliott in 2001. She was born Elizabeth Jane Morgan in 1947 at Yelverton, Devon, England, and took an Oxford BA with honours in mathematics through St Hilda's College where Sheila Oates was her tutor. She began at the University of Queensland as a tutor in 1971, completed a PhD there with Anne Street as supervisor in 1978 and went through the ranks to be promoted to reader in 1992.

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Mathematics in the University of Queensland is currently described as a single discipline loosely divided into five programs: Algebra and Combinatorics, Applied Mathematics, Analysis, Scientific Computing, and Statistics. The discipline is part of the School of Physical Sciences in the Faculty of Engineering, Physical Sciences and Architecture. There are currently (in August 2005) almost 40 full-time staff members spread through the five programs and also in most cases aligned with either the Centre for Discrete Mathematics and Computing, the Centre for Statistics, the Centre for Mathematical Physics, the Advanced Computational Modelling Centre, the Financial Mathematics Research Group or, finally, the Centre for Applied Dynamical Systems, Mathematical Analysis and Probability.

The current professors are Anthony John (Tony) Bracken (mathematical physics and biomathematics); Kevin Burrage (computational mathematics); Annette Dobson (chairs in biostatistics and epidemiology); John Eccleston (experimental design); Mark Gould (with a PhD in mathematical physics from the University of Adelaide, 1979); Geoff McLachlan (a statistician with a BSc, PhD and DSc all from the University of Queensland); Bernard Pailthorpe (computational science); Phil Pollett (applied probability); and Hugh Possingham (chairs in zoology and mathematics). Dobson's career will be described later in connection with the University of Newcastle. It is noteworthy that this list does not include a pure mathematician.

Bracken, Gould, McLachlan and Pollett were appointed to personal chairs; Bracken is the current head of discipline. His BSc with first-class honours (1966) and PhD (1970) are from the Department of Mathematical Physics in the University of Adelaide. He first joined the University of Queensland as a lecturer in 1973, became senior lecturer in 1977, reader in 1983 and professor in 1991.

Burrage is an Australian Research Council Federation Fellow. He was born in 1952 in Carshalton, UK, and was in the Department of Mathematics at the University of Auckland from 1978 until taking the chair in Queensland in 1991. His research interests include scientific computation, stochastic models and simulation in environmental modelling, and finance.

Pollett was born in Adelaide in 1957 and studied applied mathematics there and at Cambridge University (PhD, 1983). He lectured at the University of Wales in Cardiff, the University of Adelaide and Murdoch University in Perth before being appointed senior lecturer in the University of Queensland in 1987. He was promoted to professor in January 2005.

Possingham was also born in Adelaide, in 1962, and studied there and at Oxford (DPhil, 1987). He was a lecturer, then senior lecturer, in applied mathematics in the University of Adelaide from 1991 and was appointed professor of environmental science there in 1995. He joined the University of Queensland as professor of mathematics and professor of zoology in 2000 and from 2003 has been an ARC Professorial Fellow.

The University of Western Australia, from 1951

When Charles Weatherburn retired in 1950 as foundation professor of mathematics in the University of Western Australia he was honoured with an emeritus professorship, by the naming of the Weatherburn Lecture Theatre in the Mathematics Building and by an honorary Doctor of Laws from Glasgow University. He remained in contact with the University, "always pleased to welcome for a cup of tea and a chat old students and friends who cared to drop in," until his death on 18 October 1974.[112]

Weatherburn had hoped to appoint Melbourne University's Russell Love to succeed him but that only hastened Love's appointment as professor of pure mathematics in Melbourne.[113] Instead, in August 1952 he was followed in the chair by Larry Blakers, whose early career has been detailed in Chapter 5. Soon after completing his studies for a PhD in topology from Princeton University in 1947, Blakers was offered a senior lectureship in the University of Melbourne but declined it in favour of further research at Princeton. In 1949 he took a position as assistant professor at Lehigh University, Pennsylvania, was promoted to associate professor in 1951 and was appointed from there to the chair in Perth.[114] He remained as chairman or head of department for almost all of the time until his retirement as emeritus professor and honorary fellow of the university at the end of 1982. Blakers died on 6 March 1995, beset by Alzheimer's disease. In 1992 he had been awarded an honorary Doctor of Laws degree by ANU.[115]

Albert Laurence (Larry) Blakers, 1917–1995.

Blakers is remembered as the great organiser and initiator, being responsible in large part for the founding of the Australian Mathematical Society in 1956, the Mathematical Association of Western Australia (MAWA) in 1958 and the Australian Association of Mathematics Teachers (AAMT) in 1966. He also founded the National Mathematics Summer School in 1969. Having set the wheels in motion he would encourage others to play leading parts in the administration of the separate organisations while he sometimes subsided into a lesser role. The story of the

Australian Mathematical Society and of Blakers' pioneering efforts in establishing it is told in Chapter 10; he was the Society's president in 1980–1982.

The formation of MAWA followed talks with Frank Gamblen, who had been on staff at UWA since 1938, and Ernie Bowen, a recent appointment with experience of the Mathematical Association of Victoria. The discussions led to a meeting called by Blakers on 6 August 1956 to which "All Persons Interested in the Teaching of Mathematics" were invited and at which a provisional committee for a West Australian branch of the Mathematical Association (of Great Britain) was installed. Gamblen was elected soon after as founding president, Bowen as treasurer and Hans Briner, another recent arrival in the department, as secretary. It was a wide-ranging committee with representatives also from private and public schools, the teachers' college and the technical college.[116] Details of the formation of AAMT are given in Chapter 8.

The Summer School that Blakers developed "is a program for the discovery and development of mathematically gifted and talented students from all over Australia."[117] Conducted annually by the AAMT and ANU, with commercial sponsorship since 1989, it consists of a two-week residential course held in Canberra and is attended by high school students who have normally completed Year 11, following a rigorous selection process. Blakers directed the first 24 Summer Schools, well into his retirement, and was succeeded in that job by Terry Gagen, now retired from the University of Sydney but continuing with this voluntary work. Almost 2,000 students have participated in one or more of the courses.

Before the summer school went national, Blakers had conducted a similar statewide event for some years. He had also conducted intensive study groups for schoolteachers. In these his assistants included Nathan (Norm) Hoffman who has now been involved in such mathematics enrichment programs for some 40 years. Hoffman was born in Perth on 25 December 1931, took out his BSc in mathematics from UWA in 1953 and embarked on a distinguished and varied career with the Western Australia Department of Education. During time off from 1970 to 1973 at the University of Montana he earned two master's degrees, one in teaching, the other in mathematics, and an education doctorate. "Retirement" in 1986 led to employment by Edith Cowan University where the Mathematics Problem Solving Program that he directs is now in its twelfth year of operation.

Blakers described his own interest in mathematics education as dating from his attendance at a conference held in Bombay in 1955 under the auspices of the International Mathematical Union. T. G. Room in Sydney was at that time chair of the Australian Subcommission of the International Commission on Mathematical Instruction and was happy to recommend Blakers as the country's representative at the conference, provided the necessary money could be found. The request for financial assistance, unusual at the time, went directly to the commonwealth's Minister for Territories, Paul Hasluck (later Sir Paul) who had been a reader in history at UWA, and was relayed to the Minister for External Affairs, Richard Casey (later Baron Casey). First class air travel was duly arranged.[118]

The staff when Blakers arrived in Western Australia as professor of mathematics consisted only of himself, the senior lecturers Frank Gamblen and Ray Storer, and the recently appointed graduate assistant Malcolm James Hood. Hood left in 1954 to work at the Weapons Research Establishment in South Australia and while on secondment to the Royal Aircraft Establishment at Farnborough in England completed an MSc at London University. He returned to Perth and was appointed lecturer at UWA in August 1960, was promoted to senior lecturer in 1972 and was one of the longest-serving staff members when he retired in 1996. There was a vacancy for

a lectureship that was filled within a few months of Blakers' arrival by Joe Gani and within a few years he had also appointed Ernest Bowen, Peter Wynter and Hans Briner to lectureships. In 1962, Ron List was given a senior tutorship and was to be the longest serving of all when he retired as senior lecturer in 2003.

Gani's career is yet to be described in detail but at UWA he was charged by Blakers with the development of statistics and in this he was assisted by N. U. (Uma) Prabhu, who had been his student at Manchester. Prabhu succeeded Gani as group leader in statistics in 1961 when the latter moved to Pat Moran's Department of Statistics at ANU. During the period 1956–1963, Moran, Gani and Prabhu contributed substantially to the burgeoning theory of continuous time storage models as an aspect of queuing theory. Prabhu was appointed to the Department of Industrial Engineering and Operations Research at Cornell University in 1965 and shortly after was promoted to a professorship there. He remained in that position until his retirement in 1994. An honours student from Prabhu's time at UWA, Marcus William (Marc) Feldman, went on to gain an MSc from Monash University and, in 1969, a PhD in theoretical population genetics from Stanford University, California. Feldman was promoted to full professor in the Department of Biological Sciences at Stanford in 1977; he has gained renown for his work in the mathematical theory of cultural evolution.

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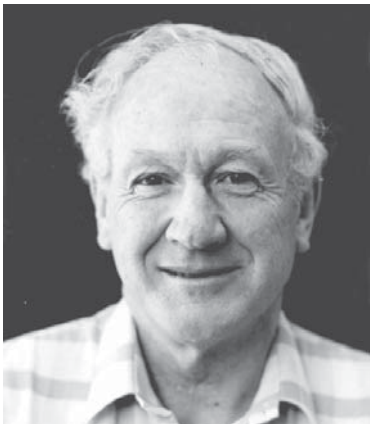
By the end of the 1950s Blakers was able to offer Harry Levey a readership and then to appoint him to the first chair of applied mathematics in the university. Harris Charles (Harry) Levey, born in Melbourne on 27 April 1923, had been educated at University High School in that city. At the University of Melbourne, studying part-time, he completed a BSc with first-class honours in physics in 1943, a BA with first-class honours in mathematics in 1946 and an MA with first-class honours in March 1949. His research on the hodograph method applied to transonic flows, supervised by Tom Cherry and supported by the Aeronautical Research Laboratories (ARL), was highly regarded and he was sent shortly after by the ARL to undertake a PhD at the University of Manchester. Supervision there was partly by Richard Meyer and the degree was awarded in December 1951. Levey returned to Australia and for seven years was with the ARL as senior scientific officer in charge of the theoretical fluid mechanics group. His appointment to the readership in Perth took place from August 1958 and promotion to professor in January 1961. But Harry Levey was just 43 when he died on 13 June 1966 as the result of a heart attack.[119]



John Joseph Mahony, 1929–1992.

In his eight years in Perth, Levey saw staff numbers increase from ten to 26 as the Department of Mathematics grew from what was essentially a servicing operation to a research centre in which, in particular, Levey and Blakers were able to develop applied mathematics as a discipline of its own. He was active in MAWA and in ANZAAS and with Blakers and Gani was pivotal in the establishment of the Summer Research Institute of the Australian Mathematical Society. In research, according to his friend John Mahony, "his greatest strength . . . lay in his tremendous skill as a classical analyst."

> He did not deign to turn this expertise to advantage in the publications race by solving pseudo-problems because he believed strongly that Applied Mathematics

should concern itself with scientific and engineering problems. He would use pseudo-problems to build his own armory of analytical techniques but he never bothered to keep the results of the investigations per se.[120]

Mahony had left the University of Queensland at the beginning of 1964 to take a second chair of applied mathematics at UWA, joining Levey and his other former post-war co-workers from the ARL, Phil Silberstein and David Hurley, who had been appointed to readerships in 1960 and 1961, respectively. Peter Wynter, whose appointment dated from August 1957, was another from the ARL days. As well, Fenton Pillow had returned from Toronto to take Mahony's chair in Queensland and Bill Wood was about to be appointed to a readership in the University of Melbourne so across Australia former ARL colleagues were collaborating in research in a range of areas from Mahony's singular perturbation theory to Silberstein's functional analysis.

Levey's death within a few years of Mahony's arrival in Perth, during which he had clearly experienced some difficulty coping with Mahony's expectations, was to be a psychological burden for Mahony for the rest of his life. He took a year's study leave at Harvard University where he shared an office with John Philip and returned to his responsibilities in Perth, including collaborative research with Hurley and Philip in particular, "with vigour". He was appointed founding editor of the *Journal of the Australian Mathematical Society (Series B)* in 1975 and was active in the establishment of the Mathematics-In-Industry Study Group ten years later, but then took early retirement in 1986. His major academic activity after that was in producing the text *An Introduction to Mathematical Modelling*[121] with Neville Fowkes, who had joined UWA as a senior lecturer in 1969 and is there still. The book appeared in April 1994 but Mahony had died of cancer on 30 June 1992, aged 62.[122]

In 1966 Silberstein was offered a chair of pure mathematics in the University of Queensland but was persuaded to remain in Perth and take Levey's chair instead. Silberstein's move towards pure mathematics and academia had begun with his introduction to integral equations by Russell Love when they were in the Aeronautics Division together. Pillow and Silberstein had both gone in 1947 to Cambridge to pursue their doctorates, Pillow in aerodynamics and Silberstein in integral equations, but in the event Silberstein's PhD was on linear operators, supervised by Frank Smithies. Both returned to the ARL but by the end of the 1950s the growing administrative load there and the foreseeable expansion of the university sector encouraged the move by Silberstein and his colleagues to senior university positions. Blakers was able to draw a large number of them to Perth.

Silberstein attracted other functional analysts to the department, such as Wendy Robertson (wife of Murdoch University's Alex Robertson), who was appointed senior lecturer in 1973, and Lyle Noakes, who joined the department in 1977 and now has a chair in pure mathematics in the School of Mathematics and Statistics there. Noakes is originally a New Zealander, with a DPhil from Oxford awarded in 1974. Silberstein retired in December 1985 and was made emeritus professor.

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The statistician Terry Speed joined the department in 1974 as associate professor and was promoted to become one of four professors there, with Blakers, Mahony and Silberstein, in 1976. Speed's next appointment, six years later, was as chief of CSIRO's Division of Mathematics and Statistics and that story is taken up in Chapter 8. Blakers retired the same year that Speed left and his chair was taken by Cheryl Praeger, only the second woman after Hanna Neumann at ANU to be appointed to a chair of mathematics in Australia.[123]

Cheryl Praeger with Bernhard Neumann.

Cheryl Elisabeth Praeger was born on 7 September 1948 in Toowoomba. Her first school was the Humpybong State School at Margate, on Moreton Bay just north of Brisbane, and for her final three years of high school she attended Brisbane Girls Grammar School. At the University of Queensland she gained a BSc with first-class honours in mathematics and a university medal in 1970 and then undertook an MSc, supervised by Sheila Oates Macdonald (now Williams). On Macdonald's advice, Praeger took advantage of a commonwealth scholarship for further study at Oxford. Her travelling companion was Kaye Christine Vale, now Kaye Stacey, who had graduated with a university medal in pure mathematics from UNSW. At Oxford, Vale took out a DPhil in pure mathematics and in 1992 became foundation professor of mathematics education at the University of Melbourne. Praeger joined St Anne's College at Oxford and gained an MSc in 1972 and a DPhil in the area of finite permutation groups in 1973, both supervised by Peter Neumann.

Praeger had met Neumann briefly in Australia and they have remained close friends since her days at Oxford—they have since collaborated in about a dozen research papers. The relationship with the Neumann family, particularly Peter and his parents Bernhard and Hanna (and then with Bernhard's second wife Dorothea) at ANU, goes back to the vacation scholarship that Praeger won in 1968 for study there. Thirty years later Bernhard Neumann interviewed Praeger on behalf of the Australian Academy of Science. Commenting himself on this relationship, at the end of the interview he said to her:

> After all, you have long been essentially a daughter, in that I introduced you to research in 1968–69, and a great-granddaughter through being the pupil of my son Peter, who 'mathematically' is my grandson because he learned his mathematics research from Gilbert Baumslag, who took his PhD with me![124]

After Oxford, Praeger spent three years at ANU and was then appointed to a two-year temporary lectureship at UWA. At ANU she had met and married John Henstridge, a statistician whose PhD was supervised by Ted Hannan. He gained a temporary tutorship in Perth and the

couple determined to settle there when Praeger won a permanent lectureship in 1977, choosing it over a similar offer from the University of Melbourne. In 1979 Henstridge moved to the School of Agriculture at UWA and four years later resigned to take a position with CSIRO's consultancy company Siromath. The experience led him in 1988 to establish Data Analysis Australia as a strategic information consultancy that has succeeded in furthering the profession of commercial mathematician and statistician.

Praeger was promoted to senior lecturer in 1982 and won the chair, in "any area of pure and applied mathematics", the following year from more than 80 applicants.[125] Her interests, always based in group theory, extended to the mathematics of weaving, combinatorial designs and computational algorithms. She was awarded a DSc from UWA in 1989, an honorary DSc from the Prince of Songkla University, in southern Thailand, in 1993 and another honorary doctorate from the Université Libre de Bruxelles in 2005.

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Mahony's and Silberstein's retirements happened within a year of each other. Alistair Mees was appointed to a chair of modern applied mathematics in 1984, having answered the same advertisement that led to Praeger's appointment, and Timothy Carlisle (Tim) Brown to the chair of statistics in 1987. Brown, born in East Melbourne in 1953, has a BSc with first-class honours from Monash University and a PhD from Cambridge University. He lectured at the University of Bath and Monash University before being appointed senior lecturer in statistics and foundation director of the Statistical Consulting Centre in the University of Melbourne in 1984. Brown returned to the University of Melbourne, to the chair there, in 1992 and was appointed Dean of Science at ANU in 2002.

Mees was born in Rosyth, Scotland, in 1947 and has a BSc with first-class honours in mathematical physics from the University of Edinburgh and a PhD from Cambridge, gained in 1973. He lectured in Cambridge for ten years before coming to the chair in Perth. Mees resigned the chair in 2002—and was made emeritus professor—in order to join the finance industry in the US and was replaced by Andrew Bassom in 2004. Bassom has a BA from the University of Oxford, obtained in 1984, and a PhD from the University of Exeter, 1988. Previously a reader in applied mathematics at Exeter, his interests concern stability problems in boundary layer flows and vortex dynamics.

The current professor of statistics at UWA is Adrian John Baddeley, born in Melbourne in 1955 and with a BA with first-class honours in pure mathematics and statistics from ANU (1966) and a PhD from Cambridge (1980). His previous position, until 1994, was as research group leader in the Centre for Mathematics and Computer Science in Amsterdam. Jiti Gao is a more recent arrival; he is a professorial fellow whose interests include statistics and quantitative finance.

Among longer-serving senior staff members are the following (in alphabetical order). Leslie Stephen Jennings was born in Adelaide in 1947 and has a PhD from ANU supervised by Mike Osborne; he joined the University in 1973 and is now an associate professor. Grant Keady, with a PhD from Cambridge, is a senior lecturer who was appointed to a lectureship in 1974. William Ellison (Bill) Longstaff studied in the University of Queensland before obtaining a PhD from the University of Toronto in 1972; he has been at UWA, now as associate professor, since 1976. Tsoy-Wo Ma, an analyst, was appointed lecturer in 1970 and is now a senior lecturer; his PhD is from the University of California, Santa Barbara. Robin Milne is a statistician with a PhD from ANU, appointed lecturer in 1974 and now a senior lecturer. Phillip Schultz is an algebraist

who trained and worked as a mining engineer before taking out a PhD in mathematics from the University of Washington, Seattle; he was appointed to a lectureship in 1970 and is now associate professor. Bob Sullivan was first associated with the University in 1970 and is now a senior lecturer; he has a PhD from Monash University and research interests in transformation semigroups. Kaipillil Vijayan is a statistician with a PhD from the Indian Statistical Institute; he joined as a senior lecturer in 1969 and is now an associate professor.

Anthony Geoffrey (Tony) Pakes was one of the early appointments at Monash University. He was born in Melbourne, studied at the University of Melbourne (BSc with first-class honours, 1968) and gained a PhD from Monash in 1971, the year he was appointed lecturer in mathematics there. Pakes went to UWA as associate professor in 1980 and has twice served as head of mathematics; his research interests are in probability theory and distribution theory.

The University of New South Wales

There were undergraduate courses being conducted in 1948 within the New South Wales Institute of Technology, the direct forerunner of the University of New South Wales, even before the institute was officially established. The post-war emphasis on technological growth saw the state government keen to open a technologically oriented tertiary institution as soon as possible and the new institute, with no specific academic or administrative staff of its own, no library facilities and no buildings, was to operate using the staff and facilities of the Sydney Technical College under the direction of the Department of Technical Education.

When legislation allowing the establishment of the new institution was proclaimed on 1 July 1949, it referred to the New South Wales University of Technology. (A separate New South Wales Institute of Technology began operations in 1965.) Its first director—the term "vice-chancellor" being disparaged as belonging to conventional universities—was Arthur Denning who shortly after was also to be the government's Director of Technical Education. Denning's administrative career began when he was head teacher of mathematics at Sydney Technical College in the mid-1930s; he had previously taught mathematics at Canterbury High School where his star pupil was Alf Pollard.

In a move aimed at reducing the influence of the Public Service Board, at the beginning of 1953 Denning was replaced by John Philip Baxter (later Sir Philip), the professor of chemical engineering in the University, and 18 months later the University became an entirely self-governing body. And in 1955 the director's title was changed to Vice-Chancellor. Following a recommendation by the commonwealth government's Murray Committee, the change of name to the University of New South Wales (UNSW) came about on 7 October 1958, by which time most departments had moved from the original site as part of the Sydney Technical College, close to the city, to its present position at Kensington in Sydney's eastern suburbs.

Geoffrey Bosson, the first head of mathematics in the new university, had been head of the mathematics department at Brighton Technical College in England when he was interviewed with regard to a position in the Sydney Technical College. He was told at that time of the plans for an expansion in technological education in New South Wales. Bosson was born on 8 October 1908 at Longton, Stoke-on-Trent, and gained an MSc at University College in the University of London. His job in Sydney began on 29 December 1947 and a few months later he was teaching courses in mathematics, as a service subject only, for the intended Institute of Technology. The staff he headed were not all as qualified as he was, although the following extract from a history of the University, might be an exaggeration:

> In the [technical] college it was assumed that only an engineer could teach engineering mathematics. The result was that three of the small maths staff had no general maths qualifications and things that needed to be taught they had never learned themselves. This problem could be solved only with the effluxion of time, and the employment of specific maths specialists, trained, for example, in statistics.[126]

The Sydney Technical College, which traces itself to the Sydney Mechanics' School of Arts established in 1833, and other technical colleges throughout the state, had for some time been conducting post-secondary diploma courses of high standard. The intention with the new institute was to convert some of these into degree courses and to introduce new degree courses to support post-war industrial expansion. In 1948 there was already a one year post-diploma course in statistics offered by J. H. (Hans) Weiler in Sydney and a year later Jim Douglas was teaching a similar course in the Newcastle Technical College.

James Bartram (Jim) Douglas was born on 14 April 1923 in Heidelberg, a suburb of Melbourne. After two years as a student teacher in rural Victoria and then one year at the Melbourne Teachers College in the grounds of the University of Melbourne, he transferred to that university in 1943 to undertake a BSc majoring in physics. In high school he had preferred to learn bookkeeping, shorthand and typing (except that as the only boy in the class he never had access to a typewriter), and had dropped all mathematics after his second year. The need for mathematics in order to study physics dawned while he was a student teacher and he taught himself the school syllabus during those years. He ended his undergraduate years with an honours BA in mathematics as well as the BSc in physics. Towards the end of 1947 Douglas replied to an advertisement for lecturers in the New South Wales Institute of Technology.

He found himself instead teaching diploma mathematics in Newcastle as a very young head of department. While he was there he developed his interest in statistics, leading to an invitation by Maurice Belz to undertake an MA back in Melbourne. His employers approved to the extent that they generously offered half pay to complement the scholarship that Belz had arranged. The area of research, to do with contagious distributions, became a lifelong study for Douglas. He retired from UNSW as associate professor of mathematical statistics in 1983 and was awarded an honorary DSc by the university in 2003 shortly after his 80th birthday.[127]

In 1952, after completing his course in Melbourne, Douglas was obliged to return to Sydney rather than to Newcastle and he found the new university well under way with Bosson in charge of mathematics. Bosson's administrative capabilities were recognised immediately. They curtailed his earlier research interests in elasticity but led to his rapid promotion, to associate professor at the beginning of 1951 and then professor of mathematics in November of the same year. Bosson retired at the end of 1968 as emeritus professor and he died on 21 March 1984.[128]

Charles M. Groden, Martin A. Eggar, James Langford (Jim) Griffith, John Sandiford and Colin Bruce Kirkpatrick were also among the dozen or so original staff in mathematics at the New South Wales University of Technology. Groden was from Poland and had an MSc from Zurich. Promoted to senior lecturer in 1959, he was with the University for well over 20 years. Eggar was there from 1950 to 1968; his qualifications included a DSc from the University of Berlin. Griffith was promoted to senior lecturer in 1953 and was an associate professor when he retired in the early 1970s. He was a prolific contributor to the *Journal and Proceedings of the Royal Society of New South Wales*. Bruce Kirkpatrick, as he was always known, was born in Boort, Victoria, in 1919, and was with the CSIR Radio Research Board when he joined the Sydney Technical College as a lecturer in 1947. The father of Sydney University's Philip

Kirkpatrick, he went to the new university as a senior lecturer in mathematics, and retired in 1979.

Among the next group of appointments, in 1954 Alex Reichel joined the school. With Vic Bofinger, he had been a student at New England University College and they were required to complete their honours studies in Sydney; that was in 1948. Reichel was promoted to senior lecturer in 1962 and soon after left to take a similar post in applied mathematics at the University of Sydney. He retired from there as associate professor in 1992. Two other longstanding appointments at that time were those of Gus Low, who was appointed in 1953, and Charles Dixon Cox, at the beginning of 1957. Both served the University for some 35 years, except that Low, who had gained a PhD in fluid mechanics supervised by Les Woods, lectured full-time at Sydney University from 1964 to 1967. Low was invited back to UNSW to become the school's first Director of First-Year Studies; he was an associate professor when he retired in 1989.

Simon Jacques Prokhovnik was appointed in 1955. He was born in Paris in 1920, arrived in Australia in 1931 and studied mathematics and chemistry at the University of Melbourne. Appreciated for his knowledge of relativity and cosmology, he retired as associate professor in 1981 but continued to be involved with the University for another ten years. He died in June 1994.

For some years all mathematics teaching conducted by the developing School of Mathematics in the Faculty of Applied Science was in the servicing of other areas. The first specialisation in the new school was due to Douglas when a course was offered in 1953 on the application of statistical methods to the design of experiments but it was not until 1959 that full mathematics courses in their own right were being offered. Douglas also supervised the first postgraduate degree in mathematical sciences in the University, an MSc for Hans Weiler in 1956. By that time the School of Mathematics had become part of a "fairly traditional" Faculty of Science.[129]

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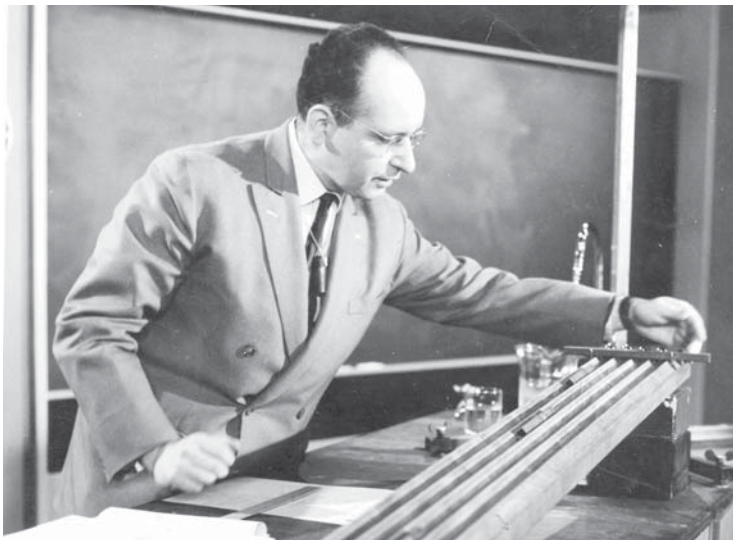
The expansion and consolidation of the 1950s culminated in the appointment of John Markus Blatt as foundation professor of applied mathematics. Born in Vienna, Austria, on 23 November 1921, Blatt was raised in a stimulating intellectual and cultural Jewish environment. It was destroyed when Hitler invaded in 1938 causing the family to flee to Paris and then Cincinnati in the United States. With an undergraduate degree from the University of Cincinnati, he carried out postgraduate study in theoretical physics at both Cornell University and Princeton University and was awarded PhDs from both in 1946. Blatt moved to the Massachusetts Institute of Technology and with Victor Frederick Weisskopf wrote a fundamental book on nuclear physics that was for many years the standard text on the subject throughout the world. It was the first of a number of books by Blatt to gain such a status.[130] In 1951 he moved to Urbana, Illinois, where he began his lifetime involvement with computing by working on ILLIAC, the most advanced computer of its time. He brought that knowledge with him to Sydney University when offered a readership in physics by Harry Messel two years later.[131]

In fact, as James Franklin wrote, his "enthusiasm for computing and connections with Illinois helped convince a major donor, Adolph Basser, to put the winnings of his horse's victory in the Melbourne Cup towards the building of the SILLIAC, the next generation of the ILLIAC machine."[132] Some rivalry ensued between workers on SILLIAC and UTECOM, two of the first three computers in Australia. UTECOM was brought to UNSW in August 1956, partly due to Bosson's initiative.[133] There is debate over which was the first to be operational but UTECOM was officially opened on 11 September, one day before SILLIAC's opening.



John Markus Blatt, 1921–1990, around 1965. (UNSW University Archives)

Blatt was appointed to the UNSW position in 1959, a transfer from Sydney University that was occasioned in part by his "strong personality"[134] and this was soon in evidence again in Kensington. Blatt became head of school in 1962 but quickly demonstrated both unwillingness and unsuitability for administration.[135] Within a few months, Baxter had replaced him as head with an executive committee comprising Bosson, Blatt and Douglas with Stan Senior, another of the early appointments in mathematics, as "Executive Officer and Coordinator". Senior's job must have required a considerable amount of tact: in the university *Calendar* of 1962 he is not listed as belonging to any department but rather is "Senior Lecturer (Liaison)".

The committee approach was also unsatisfactory and Bosson reverted to the headship in 1963 with Max McKay as executive assistant, an appointment necessitated in part by Bosson's growing partiality to alcohol.[136] McKay's wartime experiences with the RAAF and RAF have been recounted in Chapter 5. In 1948 he graduated with a BA in mathematics and Latin from the University of Sydney and then taught in schools for four years. A year after gaining a pass MA with a project supervised by T. G. Room he found himself appointed to a lectureship in mathematics in the University of Technology. That was February 1954. During 1955, McKay sat through the Sydney University fourth-year honours course, the culmination of his formal training in mathematics. In 1961 he was promoted to senior lecturer and in 1966 he gained a PhD from UNSW, supervised by Austin Keane who had joined the university as a lecturer around the same time as McKay.

In 1967 McKay was appointed foundation professor of mathematics in the University of Papua New Guinea, occasioning a change in his research interests from the atomic physics that he had worked on with Keane to computational linguistics, an area that was more relevant to the country's needs. One of the first students in the new university, completing three years of mathematics, was Mekere Morauta (later Sir Mekere), the seventh prime minister of the country. McKay returned to Australia in 1977 as foundation director of the Bendigo College of Advanced Education and retired at the end of 1988 having negotiated an agreement for the college to affiliate with La Trobe University. In retirement, there was a degree in theology from the Australian College of Theology in 1990 and the pursuit of an athletics career that began as

a student at Sydney University and has continued with numerous gold medals in international veterans' events.[137]

Though not an administrator, Blatt was recognised and appreciated for his vision for mathematics in the new university and in the staff he appointed towards that end. George Szekeres, his first professorial appointment, arrived from Adelaide as professor of pure mathematics in July 1963. Szekeres retired in 1976, aged 65, but was regularly seen in his office well beyond his 90th birthday. That birthday occasioned a celebration that brought to Australia the distinguished mathematicians John Coates, Vera Sós, Béla Bollobás and Ronald Graham who, along with Alf van der Poorten (also distinguished but resident in Australia), were the guest speakers. Szekeres' early fondness for problem solving never left him. In an attempt to emulate the vehicles for this that were so highly regarded in Hungary, he began the UNSW School Mathematics Competition, which still runs today in junior and senior divisions, and he launched the magazine *Parabola* for high school students. The Australian Mathematical Society recognised Szekeres' contribution to Australian mathematics by establishing the George Szekeres Medal in 2001.

In July 2004 George and Esther Szekeres moved back to Adelaide to be closer to their family. George, at age 94, died on 28 August 2005, at 6.30am, and less than an hour later Esther, aged 95 and aware that George had just passed on, also died. Esther had been appointed to a tutorship in mathematics at Macquarie University when it opened in 1967 and was later awarded an honorary DSc by that university, in recognition also of her voluntary work with talented students. In a brief announcement to members of the Australian Mathematical Society, Tony Guttmann wrote: "George was one of the heroes of Australian mathematics, and, in her own way, Esther was one of the heroines."[138]

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Max Kelly came from the University of Sydney as second professor of pure mathematics in 1967, remaining for six years and then returning to a chair at Sydney. The other professorial appointments in the late 1960s were more lasting: Ted Buchwald as professor of applied mathematics appointed in 1968 and Michael Hasofer as professor of statistics in 1969. Economic statistics was separately catered for with the appointment within the School of Economics of the foundation professor in that area, Nanak Kakwani, in 1970; he was to hold that position for over 30 years.

George and Esther Szekeres at a party for their 50th wedding anniversary,1987.

Buchwald's appointment, which took place just prior to Bosson's retirement, was with a view to his taking over as head of school, a position that Blatt was incapable of handling, in which Szekeres and Kelly had little interest, and which proved unmanageable for an executive committee. The result was a fiery relationship with Blatt that led to a revamping of the departments within the school. By 1974 there were departments of pure mathematics, applied mathematics and statistics, headed in effect by Szekeres, Blatt and Hasofer, but what had originally been Bosson's department, responsible for most of the servicing mathematics to other disciplines and known at one time as the Department of General and Engineering Mathematics, was renamed the Department of Theoretical and Applied Mechanics to provide a shelter for Buchwald. From 1980 until his retirement in 1988, Buchwald was dean of the Faculty of Science, which was also a source of irritation to Blatt (and not to him alone).

Buchwald is remembered as the prime mover in the foundation of the Australian Mathematical Society's Division of Applied Mathematics at a time when no one else was coming forward to take on the job. The details of that are in Chapter 10.

Villiam Teodore (Ted) Buchwald was born in Bratislava, Czechoslovakia, on 9 September 1929; he obtained a BSc with first-class honours in applied mathematics from the University of Manchester and a PhD from the University of London. Prompted by Bernhard Neumann in Manchester, who revealed that he was shortly to take up the foundation chair of mathematics at ANU, Buchwald accepted a senior lectureship at the University of Sydney in 1961 after ten years of teaching in English grammar schools and lecturing in the Manchester College of Science and Technology. Seven years after his retirement from UNSW as emeritus professor, he took the position of head of the Department of Mathematics and Computing Science in the University of the South Pacific, Fiji. Buchwald died on 6 April 1998.

It was not only Buchwald that Blatt did not get on with. A pointer to his volatility is the fact that he is one of the few to resign as a fellow of the Australian Academy of Science. He was elected to fellowship in 1966 and resigned early in 1982, perhaps because "he never felt quite happy with organisations of any kind".[139] Remembered also for pioneering the introduction of computing as an essential component of mathematics courses and for his later involvement in mathematical economics, Blatt retired from the University in 1984 and settled in Haifa, Israel. He died there on 16 March 1990.

Blatt's retirement allowed Buchwald to unite the two departments of applied mathematics. The original department had moved towards Blatt's initial calling of theoretical physics, teaching quantum mechanics, nuclear physics, special relativity and the like, though it was later obliged to take on areas such as optimisation and numerical analysis, while Buchwald's department concentrated on classical topics, fluid mechanics in particular with a later emphasis on geophysical fluid dynamics. The reunified department, with Ian Sloan as its first head, was thus exceptionally broad in its research interests.

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While Blatt concentrated on the quality of staff around him, Jim Douglas claims as his idea a unique scheme of cadetships to improve the quality of students. It was introduced around 1960 and lasted some five years.[140] Selected high school leavers were effectively offered seven-year scholarships, first to complete an honours degree in mathematics or statistics with an allowance of £530 a year, and then to undertake a PhD as a teaching fellow in the University, but with no suggestion of bonding successful candidates to further work for the University. Notable participants in the scheme included van der Poorten; Melbourne University's Colin Thompson,

whose PhD in 1964 was the first in mathematics to be awarded by UNSW; and Lynne Billard.

Billard received her PhD in 1969 and is currently University Professor in statistics at the University of Georgia, Atlanta, where she has held a chair since 1980. She was president of the American Statistical Association in 1996 and president of the International Biometric Society for the two years before that. From the American Statistical Association she has received both the Wilks Award (in 1999) for an outstanding career in research and the Founders Award (in 2003) in recognition of her service to the profession of statistics. Yet she nearly did not receive the offer of a UNSW cadetship—it had not been anticipated that there would be candidates from outside New South Wales, and Billard was from Queensland, and there were objections from some, not including Douglas, regarding women awardees.[141]

Neville Smythe, born in 1941, and John Hutchinson, born in 1946, were also accepted as cadets. They completed their honours studies at UNSW but chose to pursue their PhDs in the United States, Smythe at Princeton and Hutchinson at Stanford. That obliged Smythe to accept a teaching position at Kensington for three years. He then went back to the US for two years at the University of Virginia and then two years at Dartmouth College. In 1972 he accepted a senior lectureship at ANU and retired from there in January 2005. When Hutchinson completed his PhD in mathematical logic under the distinguished Harvey Friedman, a requirement to return to UNSW was waived as no jobs were available. Instead, he gained a lectureship at ANU and has been there ever since, promoted to professor in 1999.

Billard's training emphasises the fact that when Hasofer arrived in 1969 as the first professor of mathematical statistics he found a Department of Statistics that had already been active for some eight years, although its relationship with the other mathematicians was not always a happy one. In 1964 and again in 1966 recruitment and programming problems and disagreements over appropriate computing facilities had led to moves to separate from the School of Mathematics and transfer to another faculty, but these did not eventuate.[142]

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Douglas had been promoted to associate professor in 1959, before the formation of the department. Stephen Lipton was appointed in the same year, as senior lecturer, but had moved to the University of Queensland as professor of statistics in August 1967. From 1954 until his appointment to UNSW, Lipton had been senior scientific officer at the Rothamsted Experimental Station in Hertfordshire, north of London. He was born on 7 December 1928 in Liverpool, England, and had an MSc from the University of Liverpool, gained in 1955.

Abraham Michael Hasofer was born in Egypt in 1927 and educated at Faruk University, Egypt, and the University of Tasmania, where he took out the degrees of BSc (with honours in mathematics, in 1960), BEc (in 1964) and PhD (also in 1964). He was a lecturer in the Department of Mathematics in the University of Tasmania from 1961 to 1964 and his PhD there, supervised by Laurence Goddard, was the first to be awarded by that university in the mathematical sciences. When he retired, he was awarded an emeritus professorship and began three years of research at La Trobe University in Melbourne. Hasofer is still active as visiting professor in the Centre for Environmental Safety and Risk Engineering in the Victoria University of Technology. One of his former PhD students, Robert J. Adler, born in Newcastle in 1950, is now professor of statistics in the Israel Institute of Technology (the Technion) where he was first employed in 1980.

Clyde Arnold (Charles) McGilchrist was another of the University's early statisticians. He was one of its first research students, with an MSc in 1963 and a PhD in 1966. Appointed to a

lectureship in 1961, he was promoted to associate professor and then to professor of statistics in 1993, the year in which Hasofer retired. McGilchrist retired a few years after his promotion to professor but then took a position with the National Centre for Epidemiology and Population Health at ANU.

By that time, William Thomson Mulhinch Dunsmuir, appointed professor of mathematical statistics at UNSW in 1993, was head of department. He holds qualifications from RMIT University and La Trobe University and a PhD from ANU awarded in 1977 and was previously professor of statistics at Bond University, Queensland. Matthew Paul (Matt) Wand is the second professor of statistics in the department, appointed in 2003. Wand grew up in Wollongong, graduated from the University there with first-class honours and the university medal in statistics in 1986 and took out a PhD from ANU in 1989.

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Michael Cowling in 1994. (Australian Academy of Science)

Reverting to the story of pure mathematics at UNSW, shortly before Szekeres' retirement Gavin Brown was appointed to a chair there. Born on 27 February 1942 in Lundin Links on the east coast of Scotland, Brown had an MSc from the University of St Andrews (1963) and a PhD from the University of Newcastle-upon-Tyne (1966). He was senior lecturer in mathematics at the University of Liverpool when he won the chair at UNSW. Brown quickly asserted himself as an eminent researcher in the field of Fourier analysis and as an administrator of note. He followed Buchwald as dean of the Faculty of Science but resigned in 1992, was made emeritus professor, and took the post of Deputy Vice-Chancellor (Research) in the University of Adelaide. Two years later, he was vice-chancellor there and two years after that he moved to the University of Sydney as vice-chancellor, a position he holds still.

Brown was joined as professor of pure mathematics at UNSW by Michael George Cowling in November 1983. Cowling was born in Melbourne in 1949, gained a BSc with first-class honours in pure mathematics from ANU in 1971 and a PhD in harmonic analysis from Flinders University in 1974, supervised by Garth Gaudry. Before being appointed to the UNSW post, he had spent much of his time at the University of Genoa in Italy. Gaudry held a chair of mathematics at Flinders for 21 years but, following Brown's resignation, moved to UNSW as professor of pure mathematics alongside his former student, Cowling. He was there for ten years before officially retiring in July 2003 and joining the Australian Mathematical Sciences Institute as its director.

There are two current professors of pure mathematics, besides Cowling. Anthony Haynes (Tony) Dooley was born in Melbourne in 1951 and, like Cowling, has a BSc from ANU and also a PhD from there, awarded in 1977. He first joined UNSW as a lecturer in 1983 and has

held a chair there since 1999. Dooley's research covers Lie groups and ergodic theory and he has an extensive involvement in university administration. Colin Eric Sutherland, born near Christchurch, New Zealand in 1948, is the other. His chair at UNSW dates from 1996.

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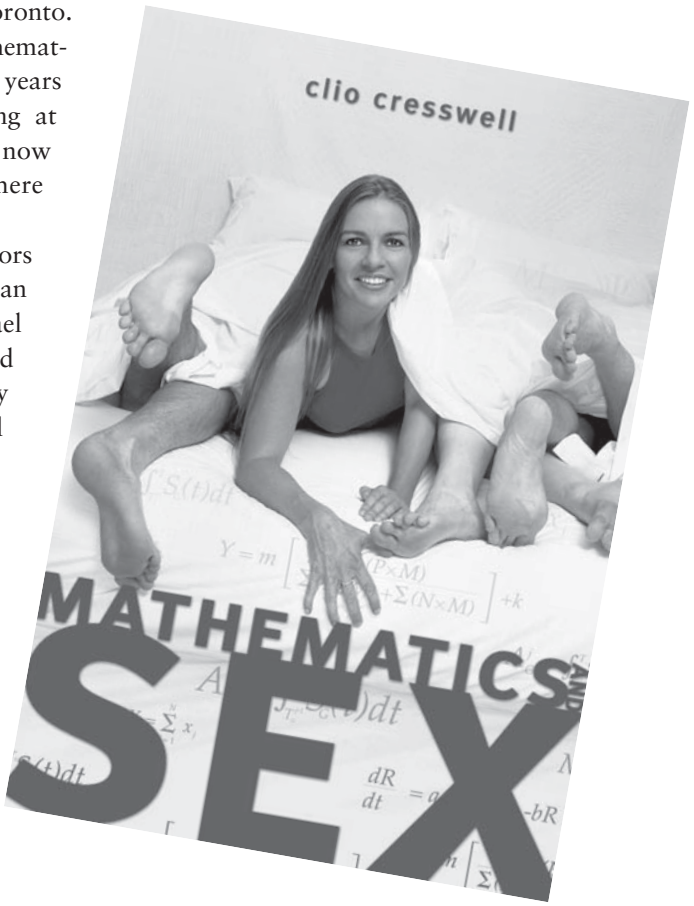
Among the applied mathematicians, William Eric (Will) Smith was one of the longest serving, being one of Blatt's first appointments as a senior lecturer in 1960. Born in Sydney in 1931, he had studied at the University of Sydney and at Oxford in theoretical physics, but he subsequently took out a PhD in applied mathematics, supervised by Blatt. Smith retired as associate professor in 1992 but remains an active associate of the University. Blatt's chair was taken in 1986 by Roger Hamilton James Grimshaw, born and educated in New Zealand and with a PhD from the University of Cambridge awarded in 1964. His interests were predictably close to Buchwald's: fluid mechanics and nonlinear wave theory. Grimshaw had previously been at the University of Melbourne, where he was appointed senior lecturer in 1965 and reader in 1970, and he returned to that city and a chair at Monash University in 1994. Since 2000, Grimshaw has been professor of mathematical sciences at Loughborough University in Leicestershire, UK.

Buchwald's chair went to Colin Rogers. Rogers was born in Great Britain on 1 December 1940. His first degree was from the University of Oxford and was followed by an MSc in 1965, a PhD in continuum mechanics, which remains his major interest, in 1969 and a DSc in 1991, all from the University of Nottingham. He also has an MEd from the University of Toronto. Before taking the chair in applied mathematics at UNSW in 1992, Rogers spent five years as professor of mathematical engineering at Loughborough University of Technology, now renamed Loughborough University, where Grimshaw has a chair.

Along with Rogers, the current professors of applied mathematics at UNSW are Ian Hugh Sloan and Jason Middleton. Michael Leslie Banner also held a chair in applied mathematics there, from 1999 to early 2005. Banner's degrees are in mechanical engineering from Sydney University followed by a PhD in earth and planetary



The cover of Clio Cresswell's *Mathematics and Sex*, Allen and Unwin, Australia (2003). Cresswell, born in England and raised in France, has a PhD from the University of New South Wales, where she was a visiting fellow for many years. She was appointed senior lecturer in mathematics at the University of Sydney in 2005.

sciences from the Johns Hopkins University, Baltimore, awarded in 1973. In that year he was appointed to a lectureship at UNSW and in research has been involved in fundamental investigations of air-sea interaction processes, especially related to breaking waves. In 2002 Banner was awarded the Sverdrup gold medal of the American Meteorological Society for advancing the understanding of wave dynamics and now, in retirement, he holds adjunct appointments in the University of Miami and Columbia University, New York. Middleton, with a PhD from Monash University, is also involved in meteorology and oceanography, with his research conducted through the School's Centre for Environmental Modelling and Prediction. Until his resignation in 2005, Lance Leslie was also a professor of applied mathematics and, like Middleton, had a PhD from Monash and was expert in meteorology.

There is much to be said in Chapter 10 of Ian Sloan, the Scientia Professor who first joined the University in 1965 as one of Blatt's "bright young men". He was born in Melbourne on 17 June 1938, had his secondary schooling at Ballarat College and studied at the University of Melbourne for a BSc with a major in physics in 1958 and a BA with first-class honours in pure and applied mathematics in 1960. (A preference for physics saw him drop applied mathematics early in his second year but Russell Love subsequently talked him into catching up and enrolling for honours in mathematics.[143]) He obtained an MSc under Bert Green at the University of Adelaide and a PhD under Sir Harrie Massey at University College, London, and after a brief period in industry was appointed to the lectureship at UNSW. Sloan gained a personal chair in mathematics there in 1985 and was selected as an inaugural Scientia Professor in 1999. His conversion from theoretical physicist to numerical analyst came about in the mid-1970s and he has since made lasting contributions in many areas within computational mathematics such as boundary integral equations and high-dimensional multiple integration. He was chair of ANZIAM (in 1989–1990) and president of the Australian Mathematical Society (in 1998–2000), sharing only with Bob Anderssen the distinction of having held both positions.

Financial mathematics

Mathematicians at UNSW were among the first in the country to further the development of financial mathematics as a new area of application of mathematics. While groundbreaking work in portfolio selection dates from the 1950s and in option pricing from the 1970s, it was not until the 1980s that a few mathematicians in Australia recognised the relevance and applicability of their training to the new field. John Blatt in particular was among the first of these. Blatt's specific interest was in mathematical economics, a field that is peripheral to finance, but his work was a stimulus to many as the opening of areas of application beyond the classical ones and those related to traditional science.

Marek Musiela, now the head of quantitative finance with the banking and financial group BNP Paribas in London, was a senior lecturer in the School of Mathematics at UNSW at the time. Born and educated in Poland, Musiela had a background in stochastic calculus and numerical analysis and had worked in Grenoble, France, before coming to Australia in 1987. Partly at the instigation of Alan Brace, who at the time was with a stockbroking firm in Sydney, Musiela instituted weekly seminars at UNSW in mathematical finance. They were attended regularly by Brace, Ben Goldys (now a senior lecturer at UNSW) and Rob Womersley (now an associate professor at UNSW), among others. Marek Rutkowski (also from Poland and now an associate professor of statistics at UNSW) joined the group a little later. A number of standard reference publications in finance resulted from their collaborations.[144] The seminars continued until around

1995 when Musiela and Brace left the country. Brace by then was working for Citibank Australia and was sent to the Isaac Newton Institute for Mathematical Sciences in Cambridge; he is now a consultant on interest rate movements for the National Australia Bank.

In a largely separate development at the same time, Jack David Gray was then a senior lecturer at UNSW and had his interest in finance aroused as part of his work for the Mathematics-in-Industry Study Group, described in Chapter 8. This led to the establishment of a consulting group in the school and some years later to a combined degree in mathematics and finance run jointly with the Faculty of Commerce. Gray spent some years in Boston with the global investment firm GMO before returning to Sydney as chief investment officer with Sunsuper; he is now with GMO's Sydney office. His early training was in applied mathematics, although at UNSW he was attached to the Department of Pure Mathematics through which he had obtained a PhD in 1968.

Most universities around the country now run degree courses that combine the two areas of mathematics and finance, but the first was the course for a Bachelor of Mathematics and Finance conducted by the School of Mathematical Sciences at the University of Technology, Sydney (UTS) in conjunction with the School of Finance and Economics there. It took in its first students in 1991. The course came about largely through the efforts of Carl Chiarella, who in 1971 joined the New South Wales Institute of Technology, which was reborn as a major component of UTS in 1987, as a lecturer in mathematics.

Chiarella was born in Sydney in 1944. He has a BSc with honours in applied mathematics from the University of Sydney, an MSc from there and a PhD in nuclear reactor theory from UNSW, supervised by Austin Keane while Chiarella was a tutor at Wollongong University College. He took out a Master of Commerce degree from UNSW in 1977 and then moved to that university, to the School of Banking and Finance, as a senior lecturer in 1986. Within a few years he had a second PhD from the same university, this time for a thesis in economic dynamics. He returned to UTS in 1989 as professor of finance. Chiarella retired in 2004 and was made emeritus professor, but he returned to UTS as professor of quantitative finance a year later.

Others who are involved in mathematical finance at UTS, within the Department of Mathematical Sciences, include Alex Novikov and Eckhard Platen. Novikov, born in 1945, has an MSc from the Moscow State University, Physical Technical Institute, and both a PhD and a DSc from the Steklov Mathematical Institute where he spent 26 years before coming to Australia as senior lecturer in mathematics at the University of Newcastle; he was appointed professor of probability at UTS in 1999. Platen was born in 1949. With doctorates from Dresden and Berlin and experience in the field of stochastic numerical methods, he came to Australia in 1991, to a senior fellowship at ANU, and in 1994 established the Centre for Financial Mathematics in the Institute of Advanced Studies there. His chair in quantitative finance at UTS, to which he was appointed in 1997, is a joint position with the School of Finance and Economics.

Ross Maller and Jiti Gao moved towards finance from a background in statistics. After 20 years with the CSIRO Division of Mathematics and Statistics, reaching the position of principal research scientist, Maller joined the Department of Mathematics and Statistics at UWA in 1988, transferred to the Department of Accounting and Finance as professor of quantitative finance in 1999 and is currently a long term visitor as professor of mathematical finance in the School of Finance and Applied Statistics at ANU, where in effect he took the position vacated by Platen.

Gao followed Maller to UWA. He has a DSc in statistics from the University of Science and Technology of China and a PhD in economics from Monash University. His research covers

applications in both finance and economics, specifically dealing with statistical inference for stochastic processes and time series econometrics.

Others around the country at professorial level who have worked in mathematical finance include ANU's Peter Hall and Chris Heyde (it was Heyde who brought Platen to Canberra), Sydney University's Eugene Seneta, Monash University's Fima Klebaner, Ballarat University's Sid Morris and Queensland University's Kevin Burrage. All have backgrounds in mathematical statistics except for Morris in topology and Burrage in computational mathematics.

In July 1990 the Institute of Quantitative Research in Finance, known popularly as the Q Group, was founded with 35 members. With chapters in Sydney, Melbourne and Adelaide, there are now some 150 members, including those of the Sydney Financial Mathematics Workshop (SFMW) which became a special interest branch of the Q Group in 2000. The monthly meetings held by SFMW as "a major disseminator of mathematical financial research"[145] are considered to be a direct continuation of those conducted by Musiela up to the mid-1990s. Peter Walter Buchen, senior lecturer in applied mathematics in the University of Sydney, also attended many of Musiela's seminars and is one of the leading lights in SFMW.

Buchen was born in Norway in 1946, came to Australia in 1950 and studied at the University of Sydney where he gained a BSc with first-class honours and the university medal in applied mathematics in 1967. He went then to Cambridge University where he was awarded a PhD for a thesis in theoretical seismology in 1971. After three years as a research fellow at Emmanuel College he returned to Australia to a lectureship at Sydney University and was promoted to senior lecturer in 1980. His current relevant research interests are mainly in the area of exotic option pricing.

Buchen was the first to introduce an option pricing subject in a mathematics department in Australia when Mathematical Theory of Option Pricing was offered as a fourth-year applied mathematics honours subject at Sydney University in 1988. Before that, in 1985, John van der Hoek in the University of Adelaide had been using material from mathematical finance in a course he developed on stochastic differential equations and at about the same time Chiarella incorporated finance subjects into a coursework MSc in operations research at the New South Wales Institute of Technology.

Chapter 7

Mathematics in Canberra's Colleges and Universities

There was disagreement in the first decade of the 20th century, following the federation of the colonies on 1 January 1901, as to where the seat of the federal government should be located, but by 1908 the Canberra–Yass area of New South Wales had been selected. The Australian Capital Territory was declared on 1 January 1911 and in 1923 the government agreed that the parliament would be moved from Melbourne to the new capital after the federal election of 1926.

Within a year of that occurring there were calls for the "provision of University facilities for residents of Canberra, with particular reference to the needs of officers of the Federal Public Service and their families."[1] Well before there was a university presence in Canberra, the military had already established an academic foothold there.

Australia's military, naval and air force colleges, and ADFA

Lord Kitchener in 1910 recommended that a college for the training of officers for Australia's permanent military forces be established and it was not too long after, on 27 June 1911, that the Royal Military College of Australia (RMC) was opened in Duntroon. Colonel (later Major-General) William Throsby Bridges was its first commandant and he, like many of the first intake of 42 staff cadets, was soon involved in war. Bridges himself, in command of the First Australian Division, was mortally wounded at Gallipoli.

The Royal Australian Naval College (RANC) had by then been set up at Geelong and within two years was transferred to Jervis Bay. The headmaster of the college from 1920 to 1930 was the mathematician and physicist Frederick William Wheatley. He was born at Kapunda, north of Adelaide, in 1871 and was one of the first mathematics honours graduates of the University of Adelaide, under William Bragg, in 1904. After obtaining a BSc from the University of Oxford, Wheatley, who was fluent in German, returned to Australia and spent the war years as a cryptographer and teacher at RANC. He died in 1955.[2]

Naval cadets entered the college at age 13, so for many years all teaching was at secondary level only. The headmaster and teacher in charge of mathematics there from 1935 to 1949 was Quentin de Quentin Robin, who held qualifications from the University of Melbourne. He was followed by Gerald (Gerry) Gleeson, who has a BA from the University of Melbourne and a BSc and MEd from the University of Sydney. Gleeson became a senior New South Wales public servant and was prominent in the formation of the Australian Catholic University. Later teach-

The Barnard family at their home, Duntroon, around 1913. Mildred, later Mildred Prentice, and her father are on the left.

ers of mathematics included Kenneth E. Armstrong, with a BA from the University of Sydney; Donald G. Thompson, with MSc degrees from both the University of New England and the University of New South Wales; and Peter Joseph O'Halloran, who was head teacher in mathematics from 1965 to 1969. There will be much more to write of Peter O'Halloran towards the end of this chapter.

Tertiary level subjects in mathematics, following syllabuses of UNSW, were introduced during O'Halloran's term. The last of the mathematicians at RANC, John Ernest (Jack) Casey, taught there until 1988. Casey was born in Sydney in 1930, gained a BA and a BSc from the University of Sydney and an MSc from Macquarie University, and was mathematics master at Sydney Boys High School when he took the position at RANC in 1970. While there, he undertook a second MSc from the University of Wollongong, specialising in operations research, and was the first to graduate with that degree after the former college of UNSW gained its autonomy. Casey subsequently taught at the Australian Defence Force Academy and retired from there as a senior lecturer at the end of 1990.[3]

The Royal Australian Air Force College, at Point Cook in Victoria, was not founded until 1947 although the site had been associated with military aviation since 1913. The RAAF College was affiliated with the University of Melbourne in 1961 and developed into the RAAF Academy. Stories of the two professors of mathematics there, Basil Rennie and Maurie Brearley, have been told elsewhere in this book.

Donald Ross Watson was senior lecturer in mathematics under Rennie from 1961 and then under Brearley for ten years until 1975. Born in Sydney in 1928 and with a BSc and a DipEd from the University of Sydney, Watson had in fact joined the RAAF College as a teacher in 1955 and, uniquely, throughout his period of employment in the Academy he remained a member of the

Victorian public service rather than become an employee of the University of Melbourne. After gaining an MA in fluid dynamics in 1959 and then a PhD in mathematical economics in 1975, both from the University of Melbourne, Watson that year was appointed warden, or academic principal, at the Academy. He left there when it was incorporated into the Australian Defence Force Academy, effectively in 1985, and soon after joined the Victoria University of Technology. He retired in 1993, aged 65, but remains active still with part-time work there. Michael John Christopher Baker was lecturer in mathematics and then senior lecturer at the RAAF Academy for almost the whole time that it was associated with the University of Melbourne.

The naval and military colleges were affiliated with the University of New South Wales in 1967, although there had been a tradition of advanced mathematics teaching at Duntroon from its beginnings. Appendix 1 includes a brief description of the level of mathematics at both institutions around 1914 and much of the story of Robert Barnard, professor of mathematics at RMC at that time, has been told previously. He had been chosen as professor from 20 applicants, "of whom only three were considered to have the necessary qualifications."[4] The *RMC Reports* covering the years 1910 to 1923 give a useful account of activities in those times, such as Barnard's responsibilities also for the teaching of astronomy and the slowdown in studies in 1915 "on account of the general disturbance and excitement produced by the war."[5] There is a short street, Calculus Lane, near the Barnard family home in Duntroon that is said to have been named in his honour.[6]

Barnard was succeeded in 1923 by Archibald Daniel Gilchrist. He had first been appointed to the civil instructional staff at RMC in January 1912, chosen by Barnard and H. S. Carslaw from 16 applicants.[7] Born in Kew, Victoria, on 14 April 1877, Gilchrist had previously been

Archibald Gilchrist in charge of a mathematics lecture at the "Duntroon Military Training College", date unknown. (Australian War Memorial)

an instructor in the engineering department of the Working Men's College, Melbourne, and had been head of the Department of Engineering and Surveying at the Ballarat School of Mines from 1908.[8] He held an MA and a degree in civil engineering from the University of Melbourne. Gilchrist saw the college through its lean times following World War 1 and during the Depression years. In 1931, as a cost-saving measure, there was a controversial move from Duntroon to Victoria Barracks in Sydney. Gilchrist moved with the college, one of only two civilian staff to do so, while his assistant, Traill Alexander Sutherland, appointed in 1926, sought alternative employment in Melbourne. The college returned to Duntroon in 1937 and Sutherland was invited to resume his lectureship. The following year, he became professor of mathematics on Gilchrist's retirement and the lectureship was taken by the Sydney-trained Arthur Eric Shepherd.[9]

Born in Daylesford, Victoria, on 9 February 1902, Sutherland had been educated at the University of Melbourne where he gained his BSc, MA and DipEd. Apart from a period of war service as a scientific observer with RAAF radar, he remained professor of mathematics at RMC until 1961, at which time he became the College's director of academic studies. Those war years also saw Shepherd's departure, necessitating Gilchrist's recall from retirement to teach mathematics—a measure that was not considered to be too successful.[10]

Sutherland was succeeded as professor of mathematics by Alister McMullen, born in 1921 and with an MA from the University of Sydney gained in 1953. He had previously been at the Sydney Teachers College. With the University of Sydney's Jim Williams, he wrote a string of successful school texts, the *On Course Mathematics* series, during the 1960s and early 1970s.

Sutherland's appointment as director of academic studies reflected the army's wish, not without opponents, to raise the college's academic standards. It was a view that could be dated back to the years following World War 2 and led in the 1950s to RMC cadets gaining credits towards degrees in science, arts or engineering from universities in Sydney, Melbourne and Canberra. External examiners were introduced by Sutherland for RMC's diploma courses but the need for a closer university affiliation became dominant in government thinking. ANU, nearby in Canberra, was unwilling to form an association with the RMC, but some two years of negotiations with UNSW finally led to the establishment of its Faculty of Military Studies within the College.

The association of RANC with UNSW was different. It was only for the conduct of certain first-year subjects, including mathematics, and its students were to travel to Sydney for their later studies.

Courses began at the new faculty in RMC in 1968 with five academic chairs, including John Carlyle Burns as professor of mathematics. McMullen became his assistant as associate professor, a position he held until his retirement in 1983.

Burns was born in Auckland, New Zealand, on 12 February 1926 and took a BSc followed by an MSc with first-class honours in mathematics at Auckland University College in 1945. After two years as a junior lecturer in mathematics in Auckland, he travelled to England and obtained a BA in the mathematical tripos at Cambridge in 1949, again with first-class honours, and then a PhD under Sir James Lighthill at the University of Manchester. There, Burns met Ted Buchwald who was then an undergraduate but later, as dean of science at UNSW, would be instrumental in appointing him to the post in the Faculty of Military Studies. In 1953 Burns left Manchester for a senior lectureship in applied mathematics in the Victoria University of Wellington, New Zealand, and nine years later, at the suggestion of James Ewen Drummond, a friend from schooldays, applied for and won a senior lectureship in applied mathematics at

ANU. He was appointed from there to RMC and retired in 1987 as an emeritus professor of UNSW.[11]

The existing RMC staff members in mathematics were taken into the new faculty. These included Neville de Mestre who became RMC's first civilian to have a degree conferred during one of its graduation parades when he received his PhD in 1974. There is much more to say of de Mestre later.

By the mid-1970s, there had been government approval in principle for the establishment of a single defence force academy at Duntroon, adjacent to the existing site of the RMC, to provide academic and military studies to officer cadets from all three armed services. But it was not until 7 May 1981 that an agreement was signed to establish the Australian Defence Force Academy (ADFA) and within it a college of UNSW. The University's Faculty of Military Studies ceased operations with its conferring of degrees on 9 December 1986 and ADFA's opening ceremony was held two days later. The RMC continues in its role of providing military training to the graduates of the university college.

The first professor of mathematics in the college, which today likes to style itself as UNSW@ ADFA, was Colin Pask. In effect, he succeeded John Burns. Born in England in 1943, Pask had come to UNSW in 1965 to work with John Blatt. He obtained a PhD from there in 1968 and was a senior fellow in the Research School of Physical Sciences at ANU when appointed to ADFA. Pask retired in 2003 and was followed as professor of mathematics in what became the School of Physical, Environmental and Mathematical Sciences by Rowland Sammut. Sammut has a BSc in applied mathematics with first-class honours and a university medal from UNSW (1973) and a PhD from ANU (1976). With research interests in optics and photonics, he first joined ADFA in 1986.

Canberra University College

The University Association of Canberra was formed in January 1929 for the purpose of providing classes "forthwith" for local students and by the end of the year the Canberra University College had received government approval to commence operation, "pending the establishment of a teaching University in Canberra." An arrangement was reached with the University of Melbourne to adopt its syllabuses and teach towards its examinations, and lectures began on 31 March 1930.[12]

A. D. Gilchrist, from the nearby RMC, taught the first classes in pure mathematics on a part-time basis. There was provision also for the teaching of statistics in the early years and the first mathematician appointed to the Canberra University College was in this field. That was Frances Elizabeth (Betty) Allan. Born in Melbourne on 11 July 1905, she had graduated from the University of Melbourne in 1926 with a BA followed by a DipEd and an MA in 1928 under J. H. Michell's supervision. While appreciating her "uncommon mathematical courage and perseverance", he is reported to have said also that she was "very exceptionally free from the instability commonly attributed to her sex."[13]

Betty Allan lectured at Melbourne University for part of 1928 during a period of illness of Maurice Belz and then went to England funded by a CSIR studentship won from a strong field of candidates. That was for the express purpose of studying the techniques of R. A. Fisher in the application of statistical methods to agriculture. She returned to commence ten years working as a biometrician at the CSIR in Canberra, offering statistical and mathematical advice across the gamut of CSIR's interests.

Her teaching of statistics in the Canberra University College in 1932 and of pure mathematics from 1935 to 1937 was part-time only. For some years, the only mathematical subjects offered in Canberra were Pure Mathematics I and Theory of Statistics, but the college calendars listed the full range of Melbourne University subjects.

The Depression years, and then the War, hampered the growth of the College and in mathematics there were many years with no one on staff and no lectures delivered. By 1947, teaching in mathematics was still the province of a single part-timer, Alexander George Aitkin, who since 1944 had been the mathematics master at Canberra High School. A year later, he was joined by Donald Vivian Youngman who taught the class in Statistical Methods. When the Aitkin family moved to Armidale in 1950, he was replaced by Arthur Shepherd who, before the war, had taught at RMC.

Alex Aitkin was the father of Donald Alexander (Don) Aitkin, who was a vice-chancellor of the University of Canberra, and of the statistician Murray Aitkin. He was born in Broken Hill in 1905 and studied at the University of Sydney, obtaining a BSc with first-class honours in mathematics and then an MSc in special relativity. He was head of mathematics at Armidale Teachers College from 1950 until he took the corresponding post at Sydney Teachers College in 1959. In Sydney, Aitkin was largely responsible for the introduction of Cuisenaire rods in the teaching of primary school mathematics, based on his study of their use in Britain and the United States during a period of study leave in 1957. (Clements, Grimison and Ellerton attribute the popularity of Cuisenaire rods in Australia to the visit of a British mathematics educator, Caleb Gattegno, in the late 1950s, but "by the early 1970s it was apparent that under the Cuisenaire system many children were learning a lot about coloured rods but relatively little about mathematics."[14]) Calendars of the University of Sydney in the early 1960s list Aitkin as a part-time lecturer in both the Department of Pure Mathematics and the Department of Applied Mathematics, an unusual distinction. He died in Sydney in 1993.[15]

Canberra University College's first professors were appointed in 1948 commencing a period of expansion that anticipated and culminated in an association with the Australian National University in 1961, but for mathematics the expansion did not begin until the mid-1950s. Henry Greenhalgh, an MA from the University of Queensland and lecturer in mathematics there from 1962 to 1972, and Samuel Stuart McBurney from Melbourne were then the part-time lecturers in mathematics and statistics. They were about to be joined by Frederick Valentine Atkinson as the College's first professor of mathematics. It was only around that time that students were first admitted to the College on a full-time basis.

In April 1955 a committee that included Melbourne's Russell Love, Sydney's T. G. Room and ANU's John Jaeger met to consider applications for the chair of mathematics at the Canberra University College. They would have been greatly impressed by the number and quality of the candidates. There were 16 applicants, at least twelve of whom went on to occupy chairs in mathematics or related disciplines in universities around the world. The unanimous decision of the committee was for Atkinson; the runner-up was Bill Smith-White of the University of Sydney.[16]

Derick Atkinson, as he was known, was born in Pinner, Middlesex, England, on 26 January 1916. He took out a BA with first-class honours in mathematics and Russian from Oxford in 1937 and a DPhil in 1939, saw war service in India with the intelligence corps of the British Army, obtaining the rank of major, and from 1946 to 1948 lectured at Christ Church and Balliol College in Oxford. For the ensuing seven years, before taking the appointment in Canberra, he

was professor of mathematics at University College, Ibadan, Nigeria. His later research interests were in ordinary differential equations and functional analysis, though his early work, under the guidance of his doctoral supervisor E. C. Titchmarsh, was on the Riemann zeta-function. Atkinson left the Canberra University College in October 1960 following a dispute over staffing matters and because he felt he should have been offered the chair in the new university that was offered to Bernard Neumann.[17] He took the chair of mathematics in the University of Toronto where he remained until his retirement in 1981. He died on 13 November 2002.[18]

While Atkinson was still in England preparing to come to Australia, he notified his approval of the appointment of Roger Thorne to a lectureship in his new department. In the event, Thorne withdrew, preferring a position in Sydney if possible. He had at least two further offers, from Newcastle University College[19] and the University of Sydney, and chose the latter with the tragic consequences reported in Chapter 4. With Thorne unavailable, William Anthony O'Neill (Bill) Waugh was appointed lecturer. Also an Oxford graduate, he had previously lectured at the Royal Military College of Science in Shrivenham, England, where he had befriended Andy Guinand, shortly to be appointed to the chair of mathematics at UNE. Waugh was appointed in August 1956; he resigned in September 1958 to take a position in the University of Western Ontario.

There were only three other full-time mathematicians at the Canberra University College: John Boris Miller, appointed lecturer in 1957 and later to become professor of pure mathematics at Monash University; the New Zealander James Ewen Drummond, appointed senior lecturer in 1958; and Claude Elias Billigheimer, appointed lecturer in 1959 from a position at RMC. Billigheimer held a BSc and an MA from the University of Melbourne and in 1966 was Atkinson's first PhD student at the University of Toronto. He became professor of mathematics at McMaster University in Hamilton, Ontario.

In addition, Edward James (Ted) Hannan was appointed professor of statistics and head of a new Department of Statistics in 1959. He was easily the most suitable applicant from a field of eight.[20] Hannan was assisted by Conrad Emanuel Leser, with a DPhil from Zurich and an MSc in economics from London, who had in fact been appointed senior lecturer in statistics in 1955, but within the Department of Economics.

Apart from Atkinson's, all of these positions were carried over to ANU in 1960 when the college became the University's School of General Studies. It was the responsibility of the Canberra University College to seek a replacement for Atkinson following his resignation, but the newly appointed professor was not to have any involvement in the College—by the time of his appointment the association with ANU had begun.

Contrary to the situation five years earlier, there was a dearth of applicants for the chair. By 1960, most of those who had applied on the previous occasion had obtained chairs elsewhere. Initially, only two applications were received, one from Archibald Brown, a reader in applied mathematics at Melbourne University, and the other from Carl Moppert, a senior lecturer there. Brown was favoured, but the selection committee, which included John Jaeger, Ted Hannan, Tom Cherry and Derick Atkinson until he left Canberra, determined to seek further expressions of interest. Frank Smithies, a fellow of St John's College, Cambridge, was subsequently approached, but declined to apply.

In the meantime, Douglas Barker Sears, who had been professor of mathematics at the University of Cape Town, South Africa, for the preceding ten years, showed interest in coming to Canberra. Sears was then 41 years of age and held the degrees of BSc and DSc from the University of Witwatersrand and DPhil from Oxford. Like Atkinson's, his Oxford doctorate had

been supervised by Titchmarsh. He was offered the chair but within a few weeks wrote back to express his reservations about the impending association with ANU. He feared that a post in "the general studies division" of a university would be "inevitably of lower status" and in consequence the committee was obliged to recommend Brown for the job.[21] Sears later took a position at Flinders University; he was professor of mathematics there from 1967 to 1972.

The announcement of the new chair in mathematics was in fact made by ANU in October 1960 and the appointment, dating from 1 February 1961, was in that university.

Archibald (Archie) Brown was born on 8 November 1917 at Greenock in Renfrewshire, Scotland. He obtained an MA with first-class honours in mathematics and astronomy from the University of Glasgow in 1939 and a PhD from Cambridge, supervised by Sir Arthur Eddington, in 1946. In between, he spent the war years with the United Kingdom ministry of supply in their research section on statistical methods. After three years lecturing in astronomy at Cambridge and three years as a research fellow in the Yerkes Observatory at the University of Chicago, working on the dynamics of stellar systems and magnetohydrodynamics, in 1950 Brown was appointed senior lecturer in mathematics at the University of Melbourne. He was acting professor of applied mathematics there during 1959 while Cherry was on sabbatical leave.[22]

Brown retired from his chair at ANU at the end of 1982 and was appointed to a visiting fellowship in the Department of Theoretical Physics there. He died on 20 August 2002.

The Australian National University

With a recently acquired DSc from the University of Sydney, Pat Moran left his lectureship at Trinity College, Oxford, in late 1951 to take up the foundation chair in statistics within the Research School of Social Sciences at ANU.

The University at that time had been functioning for less than two years. It had been established by an act of federal parliament on 1 August 1946 specifically "to drive Australia's social, cultural and economic prosperity through research of the highest quality."[23] A university focused on research alone had not been an easy option. The concept was in the minds of those who in 1929 had formed the University Association of Canberra, which was responsible for the establishment of the Canberra University College, but the implementation of the grander scheme had to wait until Herbert Cole (Nugget) Coombs, as director-general of post-war reconstruction and with the support of Prime Minister Ben Chifley, ran with it in 1945.

The University began with four research schools: the John Curtin School of Medical Research, the Research School of Physical Sciences, the Research School of Pacific Studies, and the Research School of Social Sciences to which Moran was invited. There was at that time no other explicit mathematical presence although John Conrad Jaeger was appointed to his foundation chair in geophysics on the same day as Moran was appointed to his in statistics. It was essential to the concept that the university draw people of such talent and distinction, and of even greater benefit if, like Moran, these were expatriates attracted home. In the four research schools, holders of tenured positions were to be described as professors, readers or professorial fellows, senior fellows and fellows, while limited-term appointments were as senior research fellows, and research fellows.

Discussions in 1946 regarding the School of Physical Sciences had involved Harrie Massey, then at the University of London, and Mark Oliphant who had been professor of physics at the University of Birmingham, England, since 1937. Oliphant was appointed director of the school and saw its most important task narrowly as "research in fundamental nuclear physics and in

the related branch of chemistry—the chemistry of radioactive substances".[24] He broadened that view within a few years with the appointment of Jaeger to the fourth chair in his school. Oliphant himself was professor of particle physics and Ernest William Titterton was appointed professor of nuclear physics in September 1950. There was also an obligatory relationship with the Mount Stromlo Observatory, and Richard van der Riet Woolley, who had been director of the observatory since 1939, was appointed professor of astronomy in July 1950.

While Oliphant had played a primary role as an adviser to the new university council, the original adviser in the area of social sciences was unable at that time to agree with the vice-chancellor, the economist Douglas Copland, on the direction the school should take. Consequently, it was Copland who determined the staffing in social sciences through what he deemed to be a "federation of departments".[25] There were five original departments besides Moran's in statistics: they were in the areas of economics, law, demography, history and political science.

Within the Department of Economics, in July 1950 Horace Plessay (Horrie) Brown had been appointed to a readership in statistics which he held until his death in 1971. He had previously been the director of research in the Commonwealth Bureau of Census and Statistics and with D. V. Youngman, who was one of those who had taught statistics part time at the Canberra University College, had developed sampling techniques for the bureau's business surveys. Brown was also closely connected with the development and introduction of a uniform tax system in Australia in 1942.[26]

Patrick Alfred Pierce Moran

Moran was chosen as one who could provide advice across the disciplines and within the John Curtin School of Medical Research as well.

> He arrived with clear ideas about what he wanted to do. On the teaching side, he expected to give lectures to economists and other social scientists about statistical methods, such as the theory of sampling and sampling surveys. There should also be courses with a different emphasis for biologists and medical scientists. On the research side, he hoped to stimulate fundamental work in the theory of statistics. Within a short time, he [was] working on the prediction of sunspots, a general probability theory of dams and storage systems, trend and seasonal variations in the value of sales in Sydney clothing and drapery stores, and a remarkable range of other problems to which statistical methods might be applied.[27]

Pat Moran, Ted Hannan, Geof Watson and Geoffrey Watterson at University House, ANU, in 1957.

Moran was born in Sydney on 14 July 1917, the son of a surgeon with broad general interests in science. After a school education interrupted by his father's extensive travelling, he entered the University of Sydney in 1934, gained first-class honours in mathematics and travelled to Cambridge in September 1937 for further studies in mathematics. This was despite a letter to his father from H. S. Carslaw advising that he "should choose some other career as he would not succeed as a mathematician".[28] With Freddy Chong, whom he had known at Sydney University, he entered St John's College, and both were wranglers in the mathematical tripos, part 2, in 1938. Moran's wartime career has been recounted in Chapter 5.

His department at ANU was never large—at no time did it contain more than seven academic staff—but "it played a unique role in the training and development of several generations of Australian statisticians," to the extent that in 1988, when Moran passed away, nine of the 15 current professors of statistics in Australian universities had worked with him there either as staff or as research students.[29]

For over 18 months, Moran worked alone. In October 1953, he was joined by Ted Hannan as a research fellow pursuing his doctorate; in January 1954 by Joseph Gani as a PhD student; and in March 1955 by Geof Watson as a senior fellow. Watson was one of that distinguished band of Melbourne University honours mathematics graduates of the 1930s and 1940s.

Hannan was working in the Commonwealth Bank, having only a pass degree in commerce from the University of Melbourne but with a reputation already for his extensive knowledge of econometrics. Coombs by then was the governor of the Commonwealth Bank and in 1953 chose Hannan to undertake a year's further study at ANU. Hannan's interest in mathematics and statistics had been aroused by a few undergraduate subjects taught by Hans Schwerdtfeger and Maurice Belz and his talent in these areas was soon recognised by Moran, who arranged his transfer to his own department. Hannan obtained a PhD in the area of stochastic processes in 1956 and by 1959 had won the chair of statistics at the Canberra University College.

Joe Gani, probably in the early 1960s.

Hannan's major contributions were in time series analysis. His monograph *Time Series Analysis* was published in 1960, and later translated into Russian and Japanese, and his "profound" masterpiece *Multiple Time Series*[30] appeared ten years later. He retired in 1986 but continued working until the day of his death from a sudden heart attack, 7 January 1994. His close friend and colleague Joe Gani was to write:

> He and E. J. G. Pitman were the two self-trained Australian statisticians who achieved international eminence in their field while working in Australia. If Australia is considered today as a statistics-friendly country, it is in good measure because of Ted's 40 years at the ANU.[31]

Joseph Mark Gani was born in Cairo, Egypt, on 15 December 1924. As a schoolboy, he learnt Italian and French in Egypt and English in Japan before moving to London where he attended

Imperial College and gained a BSc with first-class honours in mathematics. After undertaking one year's postgraduate study in statistics and for a short while being a demonstrator in applied mathematics there, Gani immigrated to Australia in 1948 and obtained a lectureship in applied mathematics at the University of Melbourne. A falling out with Russell Love saw his return to London for a brief period and then two years as a labourer among other jobs around the country before Larry Blakers appointed him to a lectureship in mathematical statistics in the University of Western Australia in 1953.

At the end of that year, Gani began three years leave of absence which took him to ANU on a commonwealth postgraduate scholarship, leading to his PhD under Moran two years later, and then to the University of Manchester on a Nuffield Fellowship. He returned to the University of Western Australia where he became a senior lecturer and then reader, and in 1961 resigned from there to begin four years as senior fellow with Moran, back in Canberra. There followed ten years during which Gani was professor of statistics at Michigan State University and then at the University of Sheffield, England, where for much of the time he was also head of the Manchester-Sheffield School of Probability and Statistics.

All this teaching and administrative experience saw Gani well-suited for his next appointment as chief of the CSIRO Division of Mathematical Statistics in 1974, though he needed a great amount of coaxing to take the position. That will be pursued in a later chapter.

In 1963, Hannan and Gani, together with Norma Ruth McArthur who at that time was a senior fellow in the Demography Department, founded the Applied Probability Trust (APT) to foster research in mathematics and probability theory. They personally raised sufficient finance to encourage the London Mathematical Society to support the venture by nominating the mathematician Sir Edward Collingwood FRS as a fourth trustee and by publishing the *Journal of Applied Probability*, launched in 1964, and later *Advances in Applied Probability*. Hannan remained a trustee throughout the developmental years of the APT,[32] and Gani is still a trustee today. He is also editor of another APT publication, *The Mathematical Scientist*, a journal of general mathematics whose origins are described in Chapter 10. Besides Gani, the current trustees are Christopher Heyde and Daryl John Daley from ANU, and Sir John Kingman FRS, director of the Isaac Newton Institute for Mathematical Sciences at the University of Cambridge, representing the London Mathematical Society.

Moran did not initially support the formation of the APT and relations with Gani were "strained" when Gani left in 1964 for the position in Michigan.[33]

This was the time also of the formation of the Statistical Society of Australia. It was created in October 1962 by an amalgamation of the Statistical Society of New South Wales, founded in 1947, and the Statistical Society of Canberra, founded in 1961, which then became branches of the national body. Moran was its first president and during his term of office saw further branches formed in Victoria and Western Australia. A South Australian branch followed within a few years and, somewhat later in 1981, a Queensland branch. Moran was also president of the Australian Mathematical Society in 1976–1978, and was succeeded in that position by Gani who was by then at CSIRO.

After Geof Watson had left Moran's department, in 1958 Moran was able to prevail upon Jo Moyal to leave Manchester and take up a readership with him. Moyal had visited Australia four years before, for a visiting readership in theoretical physics in Harry Messel's School of Physics at the University of Sydney, and in the meantime had also held visiting professorships at Columbia University, New York, and the University of California, Berkeley.

Moyal joined the University of Manchester in 1948 and gained a reputation there that would lead Sir Harold Jeffreys at Cambridge to describe him as "one of the two most brilliant statisticians in England".[34] He was born José Enrique Moyal in Jerusalem on 1 October 1910 and attended high school in Tel Aviv. He studied mathematics at Cambridge, electrical engineering at the Institut d'Electrotechnique in Grenoble and the Ecole Supérieure d'Electricité in Paris, theoretical physics at the Institut Poincaré, and mathematical statistics at the Institut de Statistique of the University of Paris. Until the collapse of France, Moyal remained in Paris where, from 1940, he researched turbulence and diffusion of gases for the Ministère de l'Air. He fled to England as the Germans entered the city.

In 1964 Moyal was appointed senior scientist at the Argonne National Laboratory in the US Atomic Energy Commission near Chicago, but he returned to Australia eight years later to join Freddy Chong as the two professors of mathematics at Macquarie University in Sydney. He retired from there in December 1977 and moved to Canberra where he was awarded an honorary DSc by ANU in 1997. He died on 22 May 1998.

Joe Gani described the variety of Moyal's achievements:

> Moyal's scientific work can be divided into three parts: research in (a) engineering, (b) mathematical physics including quantum theory, and (c) stochastic processes. As an engineer, he investigated the properties of rubber and rubber-like materials, as his early papers up to 1946 testify. His interest in mathematical physics is evident from his famous paper[35] of 1949 read to the Royal Statistical Society, and in several other papers ... He is the originator of the 'Moyal bracket' in quantum mechanics. But his main interest was the theory of stochastic processes and its application to physical problems such as neutron diffusion and multiplication, and cascades.[36]

Others whom Moran recruited into his department in the 1960s included Peter Derrick Finch in 1962; David Vere-Jones, following Moyal's departure in 1964; and Michael Hasofer in 1965. They later held chairs of statistics at Monash University, the Victoria University of Wellington in New Zealand, and UNSW, respectively.

Finch had previously been at the University of Melbourne and there had supervised the MA studies of Daryl Daley. Daley went then to Cambridge where his PhD thesis, *Some Aspects of Markov Chains in Queueing Theory and Epidemiology*, written first under the supervision of John Kingman and later David George Kendall, marked his future interests in a blend of mathematics and applied probability. He returned to Australia in 1970 to join Moran's Department of Statistics as a senior fellow and, having been celebrated in a festschrift on the occasion of his 65th birthday on 4 April 2004, in the following year won a promotion to professor in ANU's Mathematical Sciences Institute.

In 1972, Richard Lewis Tweedie joined the Statistics Department as a post-doctoral fellow after completing his PhD that year at Cambridge University working under David Kendall. Tweedie was born in Leeton, New South Wales, on 22 August 1947, gained a first-class honours degree in statistics from ANU in 1969, and completed a research MA there in six months before travelling to Cambridge. Joe Gani took him into CSIRO in 1974 and he became managing director of Siromath, a private mathematical and statistical consulting company part-owned by CSIRO, from 1981 to 1987. He left that year to become one of four foundation deans at Bond University, Queensland. Four years later, he headed to the United States to positions in Colorado and then Minnesota before succumbing to a heart attack, aged 53, on 7 June 2001. Tweedie's achievements in the ergodic theory of Markov chains were recognised by the award

of a DSc from ANU in 1986.[37] The prestigious Institute of Mathematical Statistics honoured his memory with the Tweedie New Researcher Award.

Ted Hannan returned to Moran's department as its second professor in 1971 and succeeded Moran as head of the department on the latter's retirement in 1982. That did not stop Moran's research output, but he suffered a stroke in July 1987 and died from a heart attack on 19 September 1988.

To those who knew him, Moran was "unaffected, quiet, friendly and courteous", notably conservative and deeply religious.[38] In the mid-1950s, he led a group that was dedicated to opposing anti-Catholicism and in particular worked successfully at denying a position at ANU to an eminent English chemist who was seen as a communist sympathiser.[39] It would have been with considerable understatement that Gani wrote "one could not always agree with his conservative views" but with obvious sincerity, admiration and gratitude that he added "one was always able to recognise his intellectual power, his flair for important scientific and statistical problems, and his honesty."[40]

The relationship between Moran's and Hannan's statistics departments, when the latter was in the Canberra University College and later when it was part of the School of General Studies at ANU, was always close and mutually beneficial with a considerable amount of interplay between the two sets of staff. Gani has written: "in a very real sense, the two Departments functioned as a single extended group."[41]

One of the earliest appointments to Hannan's department, in February 1961, was that of Warren John Ewens. Born in 1937 in Canberra, Ewens had attended high school in Adelaide and graduated from the University of Melbourne with a BA with first-class honours in mathematical statistics in 1958 and an MA two years later. He was a senior tutor in Belz's statistics department in Melbourne in 1959 and then, concurrently with his job with Hannan, he studied in Moran's department and obtained his PhD from there in 1963. Highly regarded for his work in stochastic and deterministic population genetics, Ewens was appointed to the foundation chair of mathematics at La Trobe University, Melbourne, in 1967, to a chair in biology at the University of Pennsylvania in 1972 and to a chair in mathematics at Monash University in 1977. The chair in Pennsylvania was maintained on a fractional basis once he was appointed to Monash[42] and when he retired from Monash in 1996 Ewens returned full time to Pennsylvania and is now the Christopher H. Browne Distinguished Professor of Biology there. He was elected FRS in 2000.

Christopher Robin (Chip) Heathcote, a graduate of the University of Western Australia and the University of Melbourne and with a PhD from Moran's department gained in 1961, joined Hannan's department as a senior lecturer in September of the following year. He was promoted to reader in 1966 and succeeded Hannan as professor of statistics and head of department when Hannan moved back to Moran's department in July 1971. Heathcote retired in 1996.

Also in 1971, Richard Deane Terrell was appointed professor of econometrics in the same department. Originally from Adelaide, he had been appointed lecturer under Hannan in 1964 and in 1969 was the first to receive a PhD in statistics from the School of General Studies rather than from Moran's research-oriented department. From 1994 to 2000, Terrell was vice-chancellor of the university.

Other appointments to Hannan's department in the 1960s included Eugene Seneta at the beginning of 1966 and Christopher Charles (Chris) Heyde to a readership in September 1968. Born in the Ukraine, Seneta had come to Adelaide with his family in March 1949, aged eight.

He obtained a BSc from the University of Adelaide with first-class honours in pure and statistical mathematics in 1964 and a PhD from ANU in 1968. He was promoted to reader there in 1974 and in 1979 took the position of professor of mathematical statistics in the University of Sydney, succeeding Oliver Lancaster.

Heyde, born in Sydney on 20 April 1939, was one of Lancaster's first students, gaining his BSc with first-class honours in mathematical statistics and the university medal in 1961. With his PhD under Moran in 1965, he worked in the United States and the United Kingdom before taking the readership in the School of General Studies. From 1975 to 1983, Heyde was chief research scientist in the Division of Mathematics and Statistics in CSIRO and was then appointed professor and head of the Department of Statistics in the University of Melbourne. In May 1986, he succeeded Hannan in Moran's original chair.

Bernhard Hermann Neumann

The 1946 act that established the Australian National University provided for the possible incorporation of the Canberra University College. Such a move was keenly anticipated by the College, especially since it had never had a lasting arrangement with the University of Melbourne, and was at the same time keenly resisted by ANU as a potential dilution of its research-oriented goals. Both institutions were growing and each fulfilled an essential role. It was Prime Minister Robert Menzies' determination that Canberra could not afford two universities and representatives of the two bodies were to decide upon a form of association in which neither was to be seen as dominant.

The old university with its four original research schools became the Institute of Advanced Studies (IAS) and the college became the School of General Studies (SGS), split into Faculties of Arts, Economics, Law and Science. The new university came into being on 1 October 1960, with a new vice-chancellor, Leonard Huxley, taking up duty the day before. Huxley had previously been Elder Professor of Physics at the University of Adelaide and "satisfied Oliphant's essential criterion of *not* being an economist".[43]

A year before, possibly at the suggestion of Larry Blakers in Perth as part of his vision for a national approach to mathematics,[44] Pat Moran had called together the senior professors of mathematics from around the country to discuss the desirability of forming a Department of Mathematics within the Research School of Physical Sciences in the proposed IAS. Only T. G. Room opposed the plan, fearing that it would drain the talent from other universities, and Oliphant was happy to proceed with it.

Jo Moyal had known Bernhard Neumann, reader in mathematics in the University of Manchester, from his own days there and in May 1960 wrote to ask if he were interested in heading the new department. A polite refusal nonetheless encouraged Oliphant to pursue the matter when he visited London later that year and by October Neumann had accepted the position. There was a condition attached: that a separate offer be made to his wife Hanna (since they were "a housekeeper-gardener couple" in his words), as long as it was seen to be justifiable on an independent assessment of her credentials. Hanna Neumann was offered a readership in the same department.[45]

Bernhard Hermann Neumann was born on 15 October 1909 in Berlin. He taught himself differential calculus at age twelve and in July 1932 had his DrPhil from the University of Berlin conferred, one of the youngest ever to receive a doctorate in mathematics from a German university. As a Jew, Neumann received no offer of employment in Germany and in August 1933

enrolled at Cambridge University for a second doctorate, a common practice among the German émigré mathematicians. Having submitted his thesis, Neumann was obliged to undertake an oral examination:

> The examiners were Philip Hall . . . and M. H. A. Newman and I was their first PhD student. I was asked two questions. One was whether I preferred beer or wine for lunch, and I answered, 'Wine'. Afterwards I was asked would I take my coffee black or white. I said, 'Black'. These two questions clearly satisfied the examiners, and I passed.[46]

In late 1937, Neumann was appointed temporary assistant lecturer at University College, Cardiff, and a year later married Hanna von Caemmerer whom he had met in January 1933 during her first semester of study in the University of Berlin. He already had his first doctorate at that time and was working there as an unpaid assistant in the experimental physics laboratory. They would meet over coffee with a group of friends, many of whom would later excel as mathematicians. One such was Rudolf Kochendörffer who in 1968 was professor of pure mathematics in the University of Tasmania.

Born on 12 February 1914 in Berlin, Hanna had been educated there under difficult financial circumstances following her father's death early in World War 1. She completed her undergraduate studies in mathematics, physics and philosophy and in the summer of 1937 was accepted as a research student at Göttingen. After three semesters there, with war imminent and having been outspokenly critical of Nazism, she departed for Britain.[47]

Bernhard and Hanna had become engaged during Easter 1934 when Hanna visited Bernhard in London, but the times were such that this future "mixed" marriage had to be kept secret. They were parted again soon after the wedding when Neumann, although initially deemed a "friendly alien", was interned.

In October 1944 he was allowed to volunteer for the British army and he served successively and with distinction in the Pioneer Corps, Royal Artillery and Intelligence Corps, reaching the rank of company sergeant-major. The couple, by then expecting their second child, had moved from Cardiff to Oxford in 1940 and Hanna soon determined that she would complete her work towards a doctorate there.

Departing temporarily from an earlier interest in finite plane geometries, she chose a problem in combinatorial group theory for her DPhil thesis, supervised by Olga Taussky-Todd for whom, coincidentally, Bernhard had done some work in Cambridge. The thesis was written "in a caravan by candlelight" and then typed on "a card-table by a haystack when the weather permitted", due to the need to move from the original Oxford premises.[48] The degree was awarded in mid-1944, by which time she had given birth to their third child. Bernhard was still in the army but was rarely further than a long cycle ride away from Hanna.

After demobilisation at the beginning of 1946, Neumann resumed his academic career with a lectureship at University College, Hull, and two years later moved to Manchester, where, a few years before the time of Oliphant's visit, he had been awarded a DSc. Hanna also had obtained a position in Hull and maintained it for twelve years, rising to senior lecturer, before finally being able to join Bernhard in Manchester with a lectureship there. That was in 1958 and in the meantime Bernhard would return to Hull during vacation times and most weekends. Hanna had continued her research in earnest, often jointly with Bernhard, and in 1955 was herself awarded a DSc from Oxford. One of their joint papers,[49] with a third co-author, Graham Higman who was then at Manchester, is still often quoted: it introduced what are now called HNN-groups, for Higman-Neumann-Neumann.

Bernhard Neumann's interests from the days of his Berlin doctorate were in group theory, a field that he was to influence in many ways. His Cambridge thesis, for example, initiated the study of group varieties and in 1952 he won Cambridge University's prestigious Adams Prize for an essay on free products of groups. (The renowned Australian applied mathematician George Batchelor had won the Adams Prize the previous year, Sydney University's Max Kelly won it a few years later and Alistair Mees, professor of applied mathematics at UWA from 1984 to 2002, won it in 1981.) In 1959 he gained his FRS and it was shortly afterwards that he first visited Australia, on sabbatical leave from Manchester.

He had come at the urging of his school friend Felix Behrend and, over a three-month period, visited and lectured at most universities in the country, including ANU. He found Australia to be "absolutely amazing"[50] and was sufficiently impressed with the state of universities and mathematics in the country to join the Australian Mathematical Society that had been formed less than three years before. There had also been a much earlier Australian connection: Neumann had applied for the lectureship at the University of Melbourne that Russell Love filled in 1940.[51] So the approach by Moyal and then Oliphant was understandably well received.

Neumann's appointment as professor and head of the Mathematics Department in the Research School of Physical Sciences began officially on 1 January 1962. There had been a brief, second visit to Australia the previous September but he did not arrive permanently in the country until 2 October 1962. He and Hanna had spent the previous year as visitors at the Courant Institute of Mathematical Sciences, New York, and in that time Neumann had already begun recruiting for his new department.

In fact, many of Neumann's early appointees took office before his own official commencement date. The first to take up duties was the functional analyst Robert Edmund Edwards who was appointed reader on 19 September 1961 and held a personal chair in the department from 1970 to 1986. Edwards, born on 15 March 1926 in Wimbledon, Surrey, had graduated with first-class honours in mathematics from the University of Manchester, and taken his first academic post at Birkbeck College in the University of London. His PhD from there was awarded in 1951. He brought to Australia an intimate knowledge of French functional analysis and abstract harmonic analysis and founded a successful school of research in Australia in these areas. Since his time at Birkbeck College, Edwards had suffered from agoraphobia and his research and student supervision in Canberra were carried out almost entirely in his home. Further ill health plagued him in his later years, and he died on 5 August 2000.[52]

Another very early appointment was that of John Wilder Miles, professor of applied mathematics from 28 December 1961. He remained in Canberra only until January 1965 but was considered by Neumann to be one of the most accomplished mathematicians ever to work in Australia.[53] Born in December 1920 in Cincinnati, Ohio, Miles had studied at the California Institute of Technology. He left ANU to become professor of applied mechanics and geophysics at the University of California, San Diego, and took a research chair in the same department on his retirement in 1983.

Miles considers the "most important event" of his time in Canberra to be that Herbert Eric Huppert began his graduate work with him there.[54] Huppert, born in Sydney on 26 November 1943, went with Miles to finish his graduate work in San Diego and became one of Australia's most eminent academic exports. Hubbert had completed a BSc with first-class honours and the university medal in applied mathematics at the University of Sydney in 1964. With an MSc from ANU and his PhD from the University of California, he headed for Cambridge and an

outstanding career in general fluid mechanics applied to the earth sciences. He was elected FRS in 1987 and since 1989 has been professor of theoretical geophysics at Cambridge. From 1991 to 1996, Huppert also served as professor of mathematics at UNSW.

The analyst William Andrew Coppel, whose primary field was the theory and application of differential equations, was appointed to a fellowship in Neumann's department just a few days after Miles. A graduate of the University of Melbourne, he transferred to the Department of Theoretical Physics in 1989 and remained there until his retirement as emeritus professor in 1995. A group theorist, László György (Laci) Kovács, came a little later, in October 1963 as a fellow and became a senior fellow in July 1967. He retired at the end of 2001. Neumann had known Edwards and Kovács in Manchester.

Bernhard and Hanna Neumann on the occasion of Bernhard's election as a fellow of the Australian Academy of Science. (*The Canberra Times*, 1 May 1964)

Hanna Neumann was also of course an early appointment in her husband's department, although obligations to her research students in Manchester meant that she could not come to Australia at the same time as Bernhard.[55] Her readership dated only from 18 July 1963 and was not to last long: on 1 April 1964 she was appointed professor of pure mathematics in the SGS. Archie Brown's department, brought over from the Canberra University College, had been split into two following consultation with Hanna ("I now incline towards separation into Departments of Applied Mathematics and of Pure Mathematics," she wrote[56]) and Brown became professor of applied mathematics. Hanna was the first woman to be appointed to a chair at ANU, occasioning a considerable amount of newspaper publicity, and she was the first woman to have a chair in mathematics in any Australian university.

Another of Bernhard Neumann's early coups was the bringing to Australia of the preeminent number theorist Kurt Mahler. Mahler had been at Manchester since 1937 and was one of Neumann's first visitors to his new department. He surprised Neumann as much as anyone else when he accepted the offer of a chair.[57]

Kurt Mahler was born on 26 July 1903 at Krefeld am Rhein in Germany. He contracted tuberculosis at the age of five, severely affecting his right knee and greatly hindering his schooling. Much of his mathematics was self taught and in 1921, after some of his work had been forwarded to Carl Ludwig Siegel, then at Göttingen, he was encouraged to prepare himself for university entrance examinations. In 1923, success in these examinations saw him enter the University of Frankfurt am Main, where Siegel had just been appointed professor, but less than two years later he was able to move to Göttingen which was still the world's leading centre for mathematics. He remained there until 1933 although his doctoral dissertation, on the zeros

of the incomplete gamma function, was submitted to the University of Frankfurt. Mahler's reputation was established during these years at Göttingen. While there, among other achievements, he invented a new transcendence method, he discovered his celebrated classification of transcendental numbers and he pioneered diophantine approximation in p-adic fields.[58]

Mahler's first visit to Manchester was during 1933–1934, when Hitler had come to power in Germany. After spending two years at Groningen in the Netherlands, and suffering through the effects of an accident with a bicycle and another bout of tuberculosis that left him with a permanent limp, he returned to Manchester and was to remain there for almost 25 years. He was elected FRS in 1948 and in 1952 the first personal chair in the history of the University of Manchester was created for him

In Australia, Mahler was not content just to undertake research in the IAS. He also initiated and taught courses in number theory within Hanna Neumann's department in the SGS and he was instrumental in setting Alf van der Poorten and John Coates off on their careers in number theory.[59]

John Henry Coates was born on 26 January 1945 at Possum Brush, south of Taree in New South Wales, and took out his BSc from ANU. He travelled first to the Ecole Normale Supérieure in Paris for further study, then to Trinity College, Cambridge, for research leading to his doctorate, and held positions in Harvard University and Stanford University in the US before returning to England to a lectureship at Cambridge in 1975. For a short while following Bernhard Neumann's retirement, Coates held a chair of mathematics in the IAS. He then took professorial positions in France, at the University of Paris XI at Orsay and the Ecole Normale Supérieure, before returning to Cambridge in 1986 on his appointment to the Sadleirian Chair. He had been elected an FRS in the previous year. During the 1970s, Coates worked on aspects of elliptic curve theory that would later contribute to the success of his PhD student Andrew John Wiles in settling a 350 year old conjecture—the famous Fermat's Last Theorem.

In 1968, Kurt Mahler reached what was then the statutory retiring age for professors and was obliged to retire from ANU. He accepted a chair at the Ohio State University in Columbus, Ohio, but in 1972 returned to Canberra for his "final retirement". His mathematical activity did not abate, as is shown by the publication of some 40 papers from 1972 until his death in Canberra on 26 February 1988.[60] He left almost $48,000 to the Australian Mathematical Society which used it to establish a lectureship in his memory and, fittingly, in 1991 John Coates was the first of the Society's Mahler Lecturers. (Mahler was generous in his bequests to mathematics. The Society's share was one of five equal parts of the residue of his estate, the others going to the Australian Academy of Science and three Israeli universities.[61])

Neumann's visitors sometimes made front page news in the national press. On page 1 of the very first issue of *The Australian*, 15 July 1964, was a small paragraph headed "Maths expert visits ANU":

> Professor Alexander G. Kurosh of Moscow State University arrived in Canberra yesterday for a month's visit to the Australian National University. The professor, known for his work in abstract and general algebra, will work with Professor B. H. Neumann at the ANU.

Meanwhile, in the SGS before Hanna Neumann joined it as professor of pure mathematics, Archie Brown had assumed office as the professor of mathematics in the Faculty of Arts.

René François Edouard Van der Borght, born in 1921, had a doctorate from Louvain, Belgium, and was at the time working at the University of Natal in Durban, South Africa. He was to join Brown as an associate professor but only after very protracted negotiations. The position had

been advertised during Atkinson's time with the Canberra University College but, following his departure, Van der Borght was instead offered a senior lectureship pending the appointment of a new professor. He was at ANU at the time with a visiting fellowship in astronomy but returned to Durban to take a newly created second chair in mathematics.[62] Once Brown was appointed, the ANU offer was changed back to an associate professorship and finally in August 1961 Van der Borght joined Ewen Drummond, John Miller and Claude Billigheimer in the Department of Mathematics within SGS. He was not there long: by September 1965 Miller and Van der Borght had taken chairs in pure mathematics and applied mathematics at Monash.

The early appointments to Brown's department included the new lecturers Michael Frederick (Mike) Newman, who went subsequently to Hanna Neumann's Department of Pure Mathematics, and Stephen Michael Anselm Meggitt. They were appointed in June 1961 and January 1962, respectively, and the next to be appointed was John Carlyle Burns, later to be professor of applied mathematics at RMC, in January 1963. When Brown's department was split in April 1964, his new Department of Applied Mathematics consisted of himself, Drummond, Meggitt, Burns and, for a short time, Van der Borght.

Mike Newman became a mainstay of mathematics at ANU, keenly aware of all aspects, having experienced life under Archie Brown, Hanna Neumann and, from 1970, Bernhard Neumann and his successors. Born in Heidelberg, Germany, on 28 October 1934 he had come to Sydney with his parents in 1939. His father's first cousin was Bernhard Neumann who had resisted the temptation to follow other family members and change his name to Newman. Furthermore, having family in Australia had had no influence on Neumann's decision to migrate. In fact, Mike Newman knew little of his cousin until he asked his advice before heading overseas in 1957 with his Sydney University MSc. Consequently, Newman went to the University of Manchester and having gained his PhD sought a position back in Australia. Guarded as always against any suggestion of nepotism but unable to deny reality, Neumann would not have Newman in his department until 1970 when in any case his cousin was working for his wife. By that time, Newman had been a reader in Hanna's department for three years. A distinguished algebraist, Newman retired from ANU as professor of mathematics in 1999 and is now a visiting fellow there.

Other longstanding ANU mathematicians, appointed to Hanna's department in the 1960s, include the algebraists Robert Aitken Bryce and Peter John Cossey, both from Queensland; Martin Ward, who was one of her first doctoral students at ANU; and Allen Algernon Tung Lun (Algy) Howe. Howe, born in 1942, studied originally at the University of New England, graduating from there in 1966, and has a PhD from ANU in the area of differential equations. John Cossey was later the Australian Mathematical Publishing Association's public officer, succeeding Newman in that position, and Howe has been treasurer of the Australian Mathematical Society since 1993. All are now retired.

Hanna Neumann's keenly felt responsibilities to her department and her students, whether PhD students or undergraduates studying mathematics for only one year, drastically reduced the time she had available for her own research. She was able to help Bernhard organise a successful international conference on the theory of groups in Canberra in 1965, the first such conference on any mathematical topic to be held in Australia, and she contributed one of the major survey talks on varieties of groups. She also managed, towards the end of 1966, to complete her monograph[63] in that area, begun some ten years before.

She had for some years taken a keen interest in secondary education and the work of the Canberra Mathematical Association which Bernhard had helped to found in 1963. He was its

first president, from 1963 to 1965, and Hanna was president in 1967–1968. Hanna travelled widely through New South Wales leading discussions with teacher and parent groups on new syllabuses being introduced for school mathematics and, with Bernhard and Larry Blakers, was instrumental in the formation of the Australian Association of Mathematics Teachers (AAMT) on 29 January 1966.[64]

Bernhard was its first president too, from 1966 to 1968. This was the occasion for the New South Wales branch of the Mathematical Association (of Great Britain) to become the Mathematical Association of New South Wales and for its journal, *The Australian Mathematics Teacher*, first published in 1945, to be transferred to AAMT. Other state branches around the country similarly proclaimed their independence from Britain and AAMT was formed as a federation of these affiliated associations.

Research for Hanna Neumann climaxed with the work in group theory that she was able to carry out with Ian Dey while on a twelve-month sabbatical with Bernhard in 1969–1970. Ian Malcolm Steel Dey had been one of her first PhD students in Manchester, appointed to her department in Canberra as a lecturer in 1967.

Hanna had been back in Australia only a short while before she was invited to make a lecture tour of Canada, commencing in October 1971. A month later, in Ottawa, she felt ill, admitted herself to hospital and quickly went into a coma. She died on 14 November without regaining consciousness.[65]

The second professor of pure mathematics in ANU's School of General Studies, succeeding Hanna Neumann and destined also for Bernhard Neumann's mantle, was Neil Sidney Trudinger. Born in Ballarat on 20 June 1942, Trudinger graduated from the University of New England with a BSc and then travelled to Stanford University in Palo Alto, California, where he took out an MSc in 1965 and a PhD a year later. He was a lecturer and senior lecturer at Macquarie University from 1967 to 1970 and was then appointed reader at the University of Queensland. He was given a personal chair there in February 1973, but it was less than a year later that he moved to Canberra. Trudinger's field of expertise concerns nonlinear partial differential equations and their applications. He was elected FRS in 1997.

There were no further lasting staff changes within Bernhard Neumann's department during his final few official years there. He married again in 1973 and retired at the end of 1974, at which time he was made professor emeritus and an honorary fellow of the University. But there was little pause in his activities. Bernhard Neumann is considered to be responsible, more than any other individual, for bringing to Australian mathematics maturity, respectability and international recognition. In large part, he did this through his attendance as a delegate to meetings of the International Mathematical Union, held every four years in conjunction with an International Congress of Mathematicians. He attended 13 of these congresses.

At the 1970 meeting in Nice, France, Neumann was appointed to improve communication among mathematicians and as a result he instituted the *IMU Canberra Circular*, which he edited and produced, almost single-handed, from 1972 to 1999. It was issued quarterly and distributed free to over 1100 mathematicians worldwide before electronic communication lessened its need. The *Circular* included information on conferences, details of honours received by mathematicians, and notifications of the deaths of mathematicians.

Neumann was a member-at-large of the International Commission on Mathematical Instruction from 1975 to 1982, and an executive member from 1979 to 1982, and through this association was able to facilitate Australia's hosting of the Fifth International Congress

on Mathematical Education in Adelaide in August 1984. The organisation and conduct of the congress were largely the responsibility of the AAMT; John Mack from the University of Sydney was chair of the organising committee. Four years later, during Australia's bicentennial year, the International Mathematical Olympiad was held in Canberra, again facilitated in part by Neumann's international connections.

Bernhard Neumann died suddenly in Canberra on 21 October 2002. He had received many honorary awards: doctorates from the University of Newcastle, Monash University, the University of Western Australia, the University of Hull, the Australian National University, Waterloo University and the Humboldt University of Berlin, and in 1994 he was made a Companion of the Order of Australia.

He was well known also for his interests outside mathematics. On his first visit to Australia he played in many chess clubs and at the time of his death was the oldest rated chess player in the country. He was known to the broader Canberra public, particularly its taxi drivers, as a familiar figure cycling on its roads. And he was an active musician, playing both cello and recorder. On the day before he died, he was helping to judge an annual chamber music competition.[66]

Selected works of both Bernhard and Hanna were published in six volumes in 1988.[67] Bernhard wrote essays on their life together to introduce the various chapters. Of their five children, Peter, the second oldest, and Walter, the second youngest, became noted mathematicians.

Peter, or sometimes πeter as he is known to sign himself, spent an academic term in 1966 teaching at Monash University in Melbourne and was that year elected fellow and praelector in mathematics at Queen's College, Oxford. A year later, he was appointed lecturer in mathematics at Oxford. He has supervised well over 35 doctorates, including that of Cheryl Praeger of UWA. For his wide-ranging contribution to British mathematics and particularly his research into diverse branches of group theory, in 2003 Peter Neumann was awarded the Senior Whitehead Prize of the London Mathematical Society. The award is made every two years; in 1997 it was won by John Coates.

Walter David Neumann pursued a good part of his career in Australia. Accompanying his parents to New York in 1961, he was admitted, aged 16, to New York University but completed his undergraduate studies with a BA from the University of Adelaide. His interests were originally in group theory but, according to his father,[68] he was talked out of this by older brother Peter ("There are too many Neumanns in group theory.") and instead went to Bonn, in Germany, to study algebraic topology. With his PhD from there, he obtained a position in Princeton University and then a chair at the University of Maryland. He moved to Ohio State University in 1984 and later accepted a readership in the University of Melbourne, with interests now "somewhere on the interface" between group theory and topology. Walter Neumann was appointed to a personal chair in mathematics and statistics there in 1997 and since 1999 has been professor of mathematics at Barnard College, affiliated with Columbia University, New York.

Other departments

A further development in 1970 was the establishment of the Department of Applied Mathematics within the Institute of Advanced Studies, separate from Bernhard Neumann's department but built upon six tenured positions taken from it. Its first professor, Barry Ninham, recalled[69] that this was probably the initiative of Ernest Titterton, who had succeeded Mark Oliphant as director of the Research School of Physical Sciences. John Miles had quit Neumann's department, leaving finite group theory dominant there, so Titterton saw a need for some broadening

of interests, solid state physics being another department that he introduced at the same time. Ninham gained the chair over "a large field of distinguished older guys" who had applied for the "plum job" in Canberra. John Crawford, the vice-chancellor after Huxley, had also tried to persuade George Batchelor, by then entrenched at Cambridge but well known to Crawford, to take the position.

Barry William Ninham was born in Croydon, a western suburb of Adelaide, on 9 April 1936. He gained a BSc from UWA in 1957 and an MSc in theoretical physics there a year later. His PhD, from the University of Maryland in 1962, was in the area of mathematical physics. Attracted by John Blatt to UNSW, he was lecturer, senior lecturer and then associate professor there until 1968 when he returned to Maryland as visiting scientist in the National Institutes for Health. Ninham has held an emeritus position at ANU from the time when he officially retired in 2002 but continues his prodigious work effort in various European centres which he visits for six months at a time, as well as at ANU. If fashion allowed it, Ninham would describe his field as natural philosophy: his interests range from colloid and surface chemistry to statistical mechanics to applications of number theory in physics to asymptotic analysis, with well over 300 publications covering these and other areas.

The Department of Applied Mathematics which he founded in Canberra reflects all of these interests, being an international, research-only group at the intersection of physics, chemistry and biology.[70] A number of professors in the department were or became fellows of the Royal Society. These include Jacob Nissim Israelachvili and Allan Whitenack Snyder. Israelachvili held a joint position in Ninham's department and in the Neurobiology Department at ANU from 1974 to 1986. Elected FRS in 1988, he is now professor in the Department of Chemical Engineering at the University of California at Santa Barbara, where he conducts research in the general area of intermolecular and surface forces and interactions. Snyder, born in 1940, was in applied mathematics at ANU from 1971 to 1983 and was head of the department from 1980. He currently directs the Centre for the Mind, a joint venture of ANU and the University of Sydney. Snyder was elected FRS in 1990 and was named by *Bulletin/Newsweek* magazine in 1998 as one of Australia's ten most creative minds.

Stjepan Marcelja and Stephen Timothy Hyde are current professors in the Department of Applied Mathematics. Marcelja joined it as a senior research fellow in 1975 and is now also the director of the highly regarded Rudjer Boskovic Institute in Zagreb, Croatia. Hyde, whose background is in physics with a PhD from Monash in 1986, was recently elected to fellowship of the Australian Academy of Science for work that included the application of non-Euclidean geometry to two-dimensional problems of membranes and crystal development. He was Ninham's successor as head of department from 2000 to 2002.

One of the first research fellows in the department, there until 1975, was John Perram. Perram was born in Sydney in 1945 and educated at the University of Sydney (BSc with first-class honours, 1966) and the University of Manchester (PhD, 1969). Now retired, he was professor of applied mathematics in the University of Southern Denmark from the time he left ANU. Michael Newton Barber was a Queen Elizabeth II Fellow[71] in the department from September 1972. He attended UNSW as an undergraduate and in 1972 obtained a PhD in theoretical physics from Cornell University. Barber was in the School of Mathematics at UNSW from 1974 to 1984 and in that year succeeded Archie Brown as professor of applied mathematics in the SGS. After ten years at ANU, he took a senior administrative position at UWA and in 2002 became Executive Director, Science Planning, in CSIRO.

Barber joined Mark Diesendorf, Colin Pask and Peter Richmond in Ninham's department as the four Queen Elizabeth II Fellows there at the time. Diesendorf, who was foundation director of the Institute for Sustainable Futures at UTS from 1996 to 2001, and Pask, later professor of mathematics at ADFA, had previously completed PhDs in applied mathematics at UNSW.

Perram and Barber also exchanged ideas with Rodney James Baxter in ANU's Department of Theoretical Physics. Kenneth James Le Couteur was the foundation head of that department, appointed in 1956 and there as head until 1985. Most of its members regarded themselves as mathematicians as well as physicists and for a brief period Le Couteur was the PhD supervisor of Martin John Dunwoody in Bernhard Neumann's Department of Mathematics when it first became operational in 1961. Dunwoody's was the first PhD to be given at ANU in mathematics. He was with the University of Sussex from 1964 to 1992 and was then appointed professor of mathematics in the University of Southampton; he retired from there as emeritus professor in 2003.

Baxter was also a PhD student of Le Couteur's at that time. He became interested in statistical mechanics and was appointed to a fellowship in the Department of Theoretical Physics in 1970. He went on to solve a number of two-dimensional lattice models of magnets and gases using what are now referred to as the Yang-Baxter relations. As well as being problems in combinatorics, the mathematics showed unexpected connections with other fields such as the Rogers-Ramanujan identities and the braid relations of knot theory.[72]

The resulting field of exactly solvable models in statistical mechanics blossomed in Australia, continuing the tradition set by Bert Green and Angas Hurst in Adelaide. Two of the better known models are named after Ren Potts' early work during his doctoral studies. In 1971 Baxter and Colin Thompson, by then at the University of Melbourne, initiated an annual Statistical Mechanics Meeting held alternately at ANU and in Melbourne. Others who worked in the Theoretical Physics Department with Baxter, either as colleagues or students, included Ian Enting, Paul Pearce, Peter Forrester and Aleks Owczarek, all now associated with Tony Guttmann and MASCOS at the University of Melbourne (MASCOS is described in Chapter 8), and Reinout Quispel, professor of applied mathematics at La Trobe University.

There were other mathematical interests pursued in the Department of Theoretical Physics, for example Robert Dewar's work on coordinate systems in plasma physics. Dewar was appointed professor in what is now the Research School of Physical Sciences and Engineering at ANU in 1992. Statistical mechanics continues to be a focus of research there with Murray Batchelor and Peter Bouwknegt, among others. They hold joint chairs in ANU's Mathematical Sciences Institute.

Batchelor has a BSc with first-class honours in theoretical physics and a university medal from UNSW (1983) and a PhD from ANU (1987), supervised by Barber. Pier Gerard (Peter) Bouwknegt was born in the Netherlands in 1961 and was educated there; he is noted for his work in conformal field theory. From mid-1995 until the end of 2004, Bouwknegt was with the Department of Physics and Theoretical Physics at the University of Adelaide. Baxter was professor in the Department of Theoretical Physics at ANU from 1981 until his retirement in 2002 when, as an emeritus professor, he moved into the Mathematical Sciences Institute. His work in statistical mechanics was recognised by his election as an FRS in 1982. Born in London in 1940, Baxter studied at Cambridge (BA in 1961, ScD in 1984) before gaining his PhD from ANU in 1964.[73]

Some members of ANU's Department of Physics in the Faculty of Science are also assoc-

iated with mathematicians around the country through the Australasian Society for General Relativity and Gravitation, which was formed at a meeting of mathematicians and physicists in Canberra in September 1994. The first Australasian Conference on General Relativity and Gravitation was held 18 months later and further conferences have been held every two or three years since then.

Mathematics spread in other directions in the University as well. The Computer Centre, established largely on Pat Moran's advice to further the development of computational statistics and operations research,[74] was to take in a number of eminent mathematicians, including its foundation head Michael Robert (Mike) Osborne. He was born on 26 December 1934 and educated at the University of Melbourne (BA, 1957) and the University of London (PhD, 1961). After positions that included a lectureship in mathematics at Imperial College, London, Osborne came to the Computer Centre at ANU in 1966. When the centre was disbanded in 1978, he was appointed professorial fellow in statistics in the Research School of Social Sciences and, in 1992, professor in the statistics research section of the Centre for Mathematical Analysis. He retired as emeritus professor in 2000.

Others in the computing area at ANU have included Robert Scott Anderssen, Richard Peirce Brent and Brendan Damian McKay.

Bob Anderssen was born in Brisbane on 13 January 1939. His studies at the University of Queensland (BSc, 1960; MSc, 1965) were followed by a PhD from the University of Adelaide, supervised by Rainer Radok and Rudolf Výborný. The degree was awarded in 1968, although he had completed the work for it in 1966 and had already been teaching for a year at Monash University. The position as a research fellow in Osborne's Computer Centre at ANU followed and he was to remain there until 1979 when he was talked into joining Joe Gani's Division of Mathematics and Statistics at CSIRO.

Richard Brent was born in Melbourne in 1946 and is able to trace a direct line of descent from Sir Isaac Newton's mother. With a BSc with first-class honours in mathematics from Monash and a PhD in computer science from Stanford, in 1972 he took a research fellowship with Mike Osborne in the ANU Computer Centre and was appointed foundation professor of computer science, within SGS, in 1978. Acknowledged as the leading exponent of computing science in Australia, Brent's interests extend to computational number theory (an area in which he is entirely self-taught), computer architecture and numerical analysis. He had a chair in the IAS, in a department called the Computer Sciences Laboratory, when he left in 1998 to become professor of computing science at Oxford.[75] In 2004 he was awarded a Federation Fellowship allowing his return to ANU where he now leads the computational mathematics program of the Mathematical Sciences Institute.

Brent tells some interesting stories of his days at Monash. The following concerns Zvonimir Janko, professor of pure mathematics there from 1965 to 1968:

> While at Monash I helped some of Janko's students compute character tables etc. for finite simple groups, but Janko did not believe in computers so the output of the program had to be written out in longhand before showing it to him. (I took a course from Janko in group theory and he gave me an oral exam—after running out of knowledge I challenged him to a game of chess, and managed to make it last until it was time for him to see the next student!)[76]

Brendan McKay, born in 1951 in Coburg, Victoria, is a current professor of computer science at ANU, having first been appointed to the Computer Sciences Laboratory as a lecturer in 1983. His interests extend beyond computing science, notably to combinatorics and graph

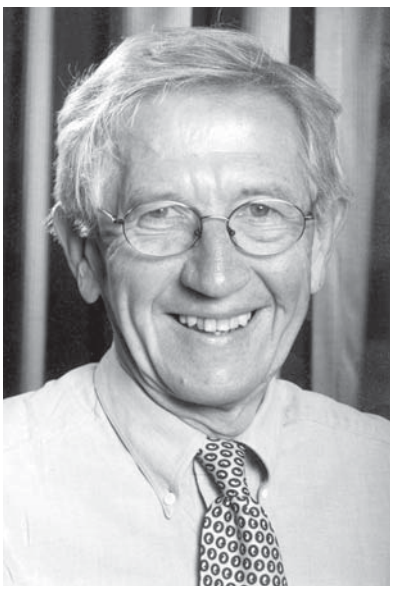
theory, and, along with others such as Michael Hasofer, he is known for his authoritative rubbishing of the bible codes—"miraculous patterns" that can be discerned in the bible and other holy writings.

Others who were at the Computer Centre for shorter periods include Robert Oliver Watts, David Ryan and Denis James Evans. Bob Watts was there from 1972 to 1978 working with Osborne on large scale Monte Carlo calculations. From September 2001 until his retirement in December 2003, he was chief scientist with BHP Billiton Ltd and since then he has headed the Industry Advisory Board of the Australian Mathematical Sciences Institute. Ryan joined the centre in 1968 as a PhD student and is now professor of operations research in the Department of Engineering Science at the University of Auckland. Evans also obtained his PhD in the Computer Centre, in the area of statistical mechanics, and is now a professor of chemistry at ANU. For some years, he was director of the ANU Supercomputer Facility.

Later developments

By the late 1970s, mathematical sciences at ANU comprised the Department of Mathematics in the Research School of Physical Sciences and the Department of Statistics in the Research School of Social Sciences; the Department of Pure Mathematics, the Department of Applied Mathematics and the Department of Statistics within the School of General Studies, which would shortly be renamed simply as the Faculties; and the Department of Applied Mathematics begun by Barry Ninham and existing separately in the Research School of Physical Sciences. In addition, Richard Brent was in the Computer Science Department in the School of General Studies.

In 1982, the two mathematics departments in the Faculties came together again as a single department within its Faculty of Science. The department was home to the Centre for Mathematical Analysis (CMA) which began operations that year as one of ten centres of excellence established by the commonwealth government. Neil Trudinger, the successor to Hanna Neumann as professor of pure mathematics, was the director of the new centre, with its advisory group extending beyond ANU to Alan McIntosh, then at Macquarie University, and Bob Anderssen and Frank de Hoog in CSIRO. Brent was also a member of the advisory group and, additionally, was seconded to the centre from 1983 to 1985. Archie Brown retired around the same time and Michael Barber was appointed professor of applied mathematics.



Derek Robinson

In the Research School of Physical Sciences, Bernhard Neumann was succeeded as head of the Department of Mathematics by John Coates until Coates left for Paris in 1979. Robert Edwards remained as professor of mathematics through this transitional period and two new professors were appointed in the early 1980s to join him: Derek Robinson, who took over as head until the end of 1988, and Leon Simon.

Robinson was born on 25 June 1935 in Bournemouth, England. He attended the University of Oxford and obtained a BA in mathematics with first-class honours in 1957 and a DPhil in theoretical physics in

1960. After eleven years as professor of theoretical physics in the Université d'Aix-Marseille and five years as professor of mathematics at UNSW, Robinson took the post at ANU in 1982 and retired with an emeritus appointment in 2000. He was president of the Australian Mathematical Society in 1994–1996.

Simon, born in 1945, is a graduate of the University of Adelaide where he obtained his PhD in pure mathematics in 1975, supervised by Jim Michael. He was professor of mathematics in the University of Melbourne from 1978 to 1981 before taking the ANU post and he left there in 1990 for a chair at Stanford. At ANU Simon built up an active and influential group in geometric measure theory, attracting to it a number of European mathematicians including Gerhard Huisken and Klaus Ecker. Huisken had a postdoctoral fellowship with Simon in 1983–1984 and a lectureship from 1986 to 1992. He is at present director of the Max Planck Institute for Gravitational Physics in Potsdam and in 2003 won Germany's prestigious Leibniz Prize as one of the world's top researchers in theoretical physics. Ecker came to ANU at the same time as Huisken and went on to a chair of mathematics at Monash University and then a chair at the Free University, Berlin, where he continues the research begun with Simon. In 1994 Simon won the American Mathematical Society's prestigious Bôcher Memorial Prize for research in analysis, awarded only 20 times since 1923, and in 2003 he was elected an FRS.

One of Coates' appointments in 1978 would later be a professor in the Department of Mathematics, but tragically only for a short while. Roger Wolcott Richardson came to ANU as a professorial fellow from a chair at Durham University in the UK. Born in Baton Rouge, Louisiana, on 30 May 1930 and with a PhD from Harvard completed in 1958, Richardson had left the US in 1970 in protest at the country's foreign policy. A highly regarded topologist and algebraist, his position in Canberra was upgraded to a chair in 1992 but he died on 15 June the following year. Richardson was one of the founders of the annual Australian Lie Group Conference, the first meeting of which took place in 1989, and much of his later work was done in collaboration with M. J. (Mike) Field, who was then at the University of Sydney and since 1992 has been professor of mathematics at the University of Houston.[77]

Meanwhile, from 1986 Chris Heyde had remained head of the Department of Statistics in the IAS. Peter Gavin Hall was given a personal chair in the department in 1988, having joined the

Peter Hall, left, and Alan Carey in 2001.

statistics department in the Faculties as a lecturer in 1978 and having held a joint appointment in both statistics departments as reader from 1986. In 1991, his chair reverted to a full-time appointment within the Faculties. Hall is now supported by an ARC Australian Professorial Fellowship paid to ANU but 50 per cent of which is seconded to the University of Melbourne.

Peter Hall was born on 20 November 1951 and graduated BSc from the University of Sydney in 1974 with first-class honours in mathematical statistics and the university medal. By 1976 he had obtained an MSc from ANU and a DPhil from Oxford for his work in limit theory and within ten years he had established himself as a statistician of great distinction. Trudinger, for example, considers Hall to be the most successful mathematical scientist to come out of Australia[78]—high praise from one who would also be a contender for that title. In 1986, Hall was awarded the Australian Mathematical Society Medal. He is a fellow of the Institute of Mathematical Statistics (1984), a fellow of the Australian Academy of Science (1987), an honorary fellow of the Royal Statistical Society (1989), a fellow of the American Statistical Association (1996), a fellow of the Royal Society of London (2000), and a corresponding fellow of the Royal Society of Edinburgh (2002). In 2002 Hall received the American Statistical Association award for the most outstanding paper on statistical applications that year.

Through the 1970s and 1980s, Chip Heathcote and Deane Terrell remained as professors of statistics in the Faculties. Desmond Francis (Des) Nicholls joined the department as a lecturer in 1971 after gaining a PhD from there in the same year. He had studied first at UNE and had been a lecturer in the University of Queensland from 1965 to 1971.

Iain Murray Johnstone was one of the top students from that time. Born in Melbourne in 1956, he completed a BSc in pure mathematics and statistics with first-class honours in 1977 and an MSc the following year, already achieving noteworthy results with his supervisor Chris Heyde. He then proceeded to Cornell University for a PhD, awarded in 1981. Johnstone joined Stanford University soon after and in 1992 was promoted to the position of Professor of Statistics and Professor of Health Research and Policy (Biostatistics). He was president of the Institute of Mathematical Statistics in 2001–2002 and in 2005 was elected to the US National Academy of Sciences.

In 1995 the Department of Statistics in the Faculties was renamed the Department of Statistics and Econometrics and in 2001 it merged with the Department of Finance to form the School of Finance and Applied Statistics, within the Faculty of Economics and Commerce. Des Nicholls gained a chair of statistics there in 1995. The head of the school and also a professor of statistics is a graduate of Adelaide and Stanford universities, Terry O'Neill.

By then, major changes had also taken place for mathematics and statistics in the IAS. According to the authors of *Fire in the Belly*,[79] which documented the first 50 years of the Research School of Physical Sciences and its successor school, the mathematics department that had been founded by Bernhard Neumann, though comprising a "strong and productive group", had no overlaps of research interests with the wider school and was never really a part of it. Moreover, Moran's statistics department in the Research School of Social Sciences had a similar reputation, "so that amalgamation was anticipated as a natural development for many years before the School of Mathematical Sciences began in 1989." In fact, the two departments had been housed together in the Mathematical Sciences Building since 1963 and remained nearby when they moved in the mid-1970s to the northern end of the campus, originally to a building named in memory of Hanna Neumann. Ninham's Department of Applied Mathematics, on the other hand, occupied and still occupies cottages in the south of the campus.

The recombined Department of Mathematics in the Faculties, with its CMA, was also incorporated into the ambit of the School of Mathematical Sciences in 1989. Chris Heyde was the first dean of the new school, succeeded by Neil Trudinger in 1992. The school contained two divisions, one being the Department of Mathematics and the other the original two departments from the IAS, constituting the Mathematics Research Section and the Statistics Research Section of the school. Both divisions had responsibility for research and postgraduate education, while the Department of Mathematics also conducted undergraduate and honours teaching.

In 1991, when the initial funding ran out, the centre was reconstituted and expanded as the Centre for Mathematics and its Applications and in 2002 the school was renamed the Mathematical Sciences Institute (MSI). In alphabetical order, the following are the more recent appointments as professor in the MSI that are not mentioned elsewhere.

Michael Barnsley was trained in Oxford and Wisconsin; an expert in fractals, he is the co-founder and former head of Iterated Systems Inc. John Blatt's stepson, Amnon Neeman, born in Jerusalem in 1957, studied at the University of Sydney (BSc with first-class honours in pure mathematics and the university medal in 1979 and MSc, also in 1979) and Harvard (PhD in 1983); his interests are in the field of algebraic geometry. John Norton has a PhD in electrical engineering from Imperial College, London, gained in 1967; his research interests include the identification of dynamical systems and state estimation. Alan Welsh holds a BSc from the University of Sydney (1982) and a PhD from ANU (1985); he is a statistician who has been at ANU since 1987 and for four years before that was at the University of Chicago. Dayal T. Wickramasinghe has a Cambridge PhD; his primary interests are in astronomy. And Susan Ruth Wilson, born in Sydney in 1948, was appointed professor of statistical science in the CMA in 1994 and holds a joint appointment in ANU's Centre for Bioinformation Science.

The University of Canberra and the Australian Mathematics Trust

The Canberra College of Advanced Education (CCAE) was founded in 1967 and accredited as the University of Canberra in 1990. The College, and then the University, was the original home of the Australian Mathematics Competition, which has developed to be Australia's largest mass-participation event.[80] Conducted now by the Australian Mathematics Trust, the competition in its local form was the brainchild of one of the first staff members at the college, Peter O'Halloran, who was later to take a primary role in spreading the concept and related ideas through much of the world.

When O'Halloran joined the College, the head of mathematics was Ivor Francis Vivian, who had been appointed principal lecturer there in 1969 and was to remain head of mathematics when university status was accorded and until his retirement in 1994. He then became a priest in the Liberal Catholic Church, headed the chaplaincy at CCAE until the end of 2003 and is now vicar-general of the Church's Australian province. Vivian was born in Torquay, Devon, in 1932, took out an honours degree in mathematics from the University of London in 1953, worked in guided weapons research in England and taught for some years in Ghana, then called the Gold Coast, in Africa, before taking a position at the Newcastle University College in 1960. He saw it become the University of Newcastle in 1965 and while on a period of leave in Bath, England, obtained an MSc in numerical analysis.

The head of statistics for much of the time until the establishment of the University was Hugh C. Mahon, also a principal lecturer. One of his staff in the early days was Ronald McKay, later vice-chancellor of the Northern Territory University.

Graham Hilford Pollard was another early appointment at CCAE when he was made lecturer in statistics in 1971. He was the first head of the Mathematics and Statistics Program when the disciplines were brought together in the new university. Born in June 1945, Pollard was also the Australian Capital Territory's open squash champion on several occasions during the 1970s. A son of Macquarie University's Alf Pollard and with a BSc from the University of Sydney and a PhD from ANU awarded in 1986, Pollard went on to become professor of applied statistics and pro-vice-chancellor at the University of Canberra. He retired in 2003 as emeritus professor. Pollard and O'Halloran are the only Australian winners of the David Hilbert International Award, described below.

The other chairs in the School of Mathematics and Statistics over its lifetime were held by Robert Brien Mitchell, Robert Andrzej Bartnik, Peter Joseph O'Halloran and Peter James Taylor, and it is likely that there will be no more following the recent virtual elimination of quantitative sciences, including engineering, from the university's course profile.

Bob Mitchell's qualifications were in industrial engineering from the New South Wales University of Technology and UNSW, over the period 1957 to 1963. He taught at Macquarie University in the Faculty of Finance and Economics with Alf Pollard for six years from the time of the University's opening, and then moved to Canberra where he was appointed in the area of operations research as a college fellow, CCAE's equivalent of a professor at the time. The more usual title was conferred when university status was achieved. He spent many of his later years there in administration, for part of the time as assistant vice-chancellor in charge of finance, and retired in early 1997, also as emeritus professor.

Robert Bartnik was born in February 1956 in Melbourne and studied at the University of Melbourne (BSc with first-class honours, 1977, and MSc, 1980) and Princeton University (PhD, 1983). He held positions at ANU, UNSW and UNE, where he was professor of mathematics

At the first Australian IMO training camp, Newcastle, 1982. From left: Jim Williams, Bernhard Neumann, Alan Blair, Ken Ross, Paul Erdős, David Chalmers, Dirk Vertigan, George Szekeres.

Peter McNamara, left, with Terry Tao in Washington, 2001. McNamara, from Perth, is the only Australian to win two IMO gold medals (in Korea in 2000 and the USA in 2001).

from 1993 to 1997, before taking the chair at the University of Canberra. Bartnik's interests are in geometric analysis and general relativity. In 2005 he moved to a chair of mathematics at Monash.

The story of the remaining two professors at the University of Canberra, Taylor and O'Halloran, interweaves that of the Australian Mathematics Trust.

O'Halloran was born in Sydney on 27 April 1931, attended the Marist Brothers School in Kogarah and, with a BSc and DipEd from the University of Sydney, taught in a number of schools in New South Wales before being appointed head of mathematics at RANC in 1965. While there, he obtained an MSc from the University of Sydney, specialising in oceanography. In 1970 O'Halloran moved to CCAE and during 1972, on leave at the University of Waterloo, Canada, was encouraged by what he saw of broadly based mathematics competitions for high school students.

During his term as president of the Canberra Mathematical Association in 1976, he was able to implement a Canberra-wide mathematics competition with so much success that within two years it was being conducted on a nationwide basis as the Australian Mathematics Competition (AMC), sponsored by the Bank of New South Wales (now Westpac). In that first national competition, over 60,000 students took part.[81] In recent years this has grown to around half a million students from about 40 countries, mostly in the Asia-Pacific region.

While the AMC was open to all, O'Halloran also sought to cater for the elite amongst high school students by establishing in May 1980 the Australian Mathematical Olympiad Committee with the main aim of organising Australia's participation in the International Mathematical Olympiad (IMO). This is an annual event, first held in 1959 in Romania with just seven countries participating, all from eastern Europe. By 1981 when Australia entered there were 27 countries involved. Australia came 23rd in its initial effort, with its best subsequent result being ninth out of 82 in 1997.

The level of Australia's involvement, reflecting the hard work of O'Halloran and a number of colleagues, was such that by 1988 the country was able to host its own IMO, held that July

in Canberra with a then record number of 49 teams participating. Among the many Australian academics involved, Ren Potts was chair of the jury, assisted by Derek Robinson, Hans Lausch, John Mack and David Hunt. Hunt chaired the problem selection committee, the other members being Gavin Brown, John Loxton, John Mack and George and Esther Szekeres.[82]

Australia's IMO contestants necessarily show great talent at high school and many have gone on to distinguished careers in academia or business. The story of Terence Tao is one among many that demands mention. He was born in Adelaide on 17 July 1975, attended Blackwood High School in Adelaide and took part in the 1986 IMO, aged just eleven, then in the 1987 and 1988 IMOs as well. From 1989 to 1992, he studied at Flinders University, gaining a BSc with first-class honours in pure mathematics and an MSc. On his website, he explains: "No, I didn't really complete two degrees in four years; I attended Flinders part-time before my formal enrolment, and they decided to count those courses toward my degree."[83] Tao then completed a PhD at Princeton University in 1996 and not long afterwards was appointed to the Mathematics Department of the University of California, Los Angeles, where he is now a full professor. His interests range over harmonic analysis, partial differential equations, combinatorics and analytic number theory and he is already the recipient of numerous awards, prizes and fellowships, including the Bôcher Memorial Prize in 2002. Tao was visiting professor of mathematics at UNSW for six months in 2000 and at ANU for six months in 2001. In August 2006 he became the first Australian to be awarded a Fields Medal, the mathematical equivalent of a Nobel prize.

A few days before his 13th birthday, Tao won a gold medal at the 1988 IMO and remains the youngest student from any country to achieve that honour. At Australia's first IMO in Washington in 1981, Richard Wilson from the King's School in Parramatta, New South Wales, won a bronze medal and in 1983 in Paris Dirk Vertigan from the Elizabeth Matriculation College in Tasmania won the country's first silver medal. Vertigan went on to obtain a BSc with first-class honours in mathematics from the University of Tasmania, an MSc nine months

Peter O'Halloran receiving his David Hilbert Award from Don Aitkin, chairman of the AMT Board and vice-chancellor of the University of Canberra, at O'Halloran's home on 31 August 1994. Bernhard Neumann looks on.

later and a DPhil from Oxford in 1991; he is now an associate professor of mathematics at Louisiana State University, USA. Australia's first gold medal was won by Andrew Hassell from Christ Church Grammar School, Western Australia, in 1985 in Helsinki. Hassell gained a BSc with first-class honours in mathematics and the university medal from ANU and then a PhD from the Massachusetts Institute of Technology, under Richard Melrose. He now teaches in the MSI at ANU and carries out research in the fields of partial differential equations and pseudo-differential operators, among others.

Terry Tao's younger brothers Nigel and Trevor have also represented Australia in IMOs, Nigel in 1994 and both Nigel and Trevor in 1995, and on each occasion they won bronze medals. Trevor became one of the ten top-rated chess players in the country. Their father Billy Tao spoke of the backgrounds and accomplishments of his children[84] at a meeting on *Geniuses, Prodigies and Savants* conducted by Allan Snyder's Centre for the Mind in 1999.

Peter O'Halloran had numerous other accomplishments in areas promoting young achievement in mathematics. In 1984 he founded the World Federation of National Mathematics Competitions (WFNMC) whose initial activity was the publication of the journal *Mathematics Competitions* and which now also conducts an international conference at which the David Hilbert International Award and the Paul Erdős National Award are made to recognise mathematicians prominent in enriching mathematics education. The WFNMC now operates as an affiliated study group of the International Commission on Mathematical Instruction.

In 1989 O'Halloran established the Asia Pacific Mathematical Olympiad to cater for the Pacific rim area; in 1990 he introduced a range of challenge and enrichment activities now organised by the Australian Mathematical Olympiad Committee and known as the Mathematics Challenge for Young Australians; and in 1991 he was pivotal in establishing the Australian Mathematics Trust (AMT) as an umbrella body to administer all the activities with which he had been associated.

In 1991, O'Halloran received an honorary DSc from Deakin University. On 31 August 1994 he was himself presented with the Hilbert Award by the WFNMC for his "significant contribution to the enrichment of mathematics learning at an international level" and on 19 September he was awarded the World Cultural Council's José Vasconcelos World Award for Education which is an award "granted to a renowned educator . . . who has a significant influence on the advancement in the scope of culture for mankind." The award was made at a ceremony in Chambery, France, but O'Halloran could not be present. By August that year, he knew that he was terminally ill with cancer and he died on 25 September. After he had retired due to ill health, the council of the University of Canberra "agreed unanimously that Professor O'Halloran should be recognised in his own University by being appointed as Professor of Mathematics Education".[85]

His work was continued at an executive level by Peter Taylor who had joined O'Halloran at CCAE in 1972 as an assistant lecturer in mathematics.

Born in North Adelaide in 1947, Taylor had arrived in Canberra with a BSc (1967) and a PhD in applied mathematics (1972) from the University of Adelaide. By 1996 he had become professor of mathematics and education in the University of Canberra, but as a new arrival he was soon enmeshed with other colleagues in the day-to-day running of the AMC. He is now executive director of the AMT and chair of the Education Advisory Committee of the Australian Mathematical Sciences Institute, and he was president of the WFNMC for four years until July 2004. He is also vice-president of the International Mathematics Tournament of Towns,

which is a separate city-based schools mathematics competition first conducted in the former USSR in the late 1970s. For all this and more, Taylor received an honorary doctorate from the University of Rousse, Bulgaria, in August 2003.

The organisation within Australia of all of these competitions and programs is a complex matter. The original AMC was administered by a committee of staff members from CCAE, from the computing area as well as mathematics, and the committee was incorporated as a company, the Australian Mathematical Foundation Limited (AMF), in the 1980s. It maintains close co-operation with the Westpac Banking Corporation, which has now sponsored the competition for over 25 years. There are two separate and independent problems committees, one for the secondary schools version of the competition and the other for the primary schools version, begun in 2003, and both are chaired by Warren James Atkins, now retired from the Faculty of Education in the University of Canberra.

Atkins was one of the original mathematicians involved with O'Halloran in the development of the AMC and was honoured for his efforts by an Erdős Award from the WFNMC in 2004. Taylor had won the award in 1994. Graham Pollard also maintained a long association with the organisation of the competition, as did another stalwart member of the School of Mathematics and Statistics, its current head Peter Brown. Brown, who obtained a PhD from UNSW in geophysical fluid dynamics under Ted Buchwald's supervision, lectured for three years at the University of Papua New Guinea before moving to Canberra and the college in 1974.

More than 70 mathematicians from schools and universities around the country have been honoured by the AMT with a B. H. Neumann Award for their contributions to the enrichment of mathematics learning. The first was presented in 1992. A recipient in 1997, David Frederick Paget (1943–1997), is to be commemorated by the naming of a street in the Canberra suburb of Bruce. Paget, born in Twickenham, near London, was a lecturer and then senior lecturer in the University of Tasmania for 30 years. He was Australia's team leader for the IMOs from 1991 to 1995.

The Australian Mathematical Olympiad Committee (AMOC) was chaired initially by Bernhard Neumann, with O'Halloran as executive director, and was adopted by the Australian Academy of Science as a subcommittee. Jim Williams and Geoff Ball from the University of Sydney were then the team leader and deputy leader, and John Burns from RMC was the first secretary/treasurer. The AMF was funded by competition entry fees as well as sponsorship moneys and the AMOC made use of the extensive office infrastructure developed by the AMF, although it separately received generous sponsorship from IBM Limited. By the end of the 1980s, having successfully hosted an IMO in Canberra, the AMOC was also able to attract government funding for the first time.

The AMT was established as a non-profit organisation to bring together the two separate entities, the AMF and the AMOC. Bob Mitchell and Don Aitkin, the vice-chancellor of the University of Canberra at the time, led the negotiations between the parties and Aitkin became chairman of the board when the Trust was formed in 1992. The University of Canberra is the sole trustee and the board includes representatives of the Australian Academy of Science, the Australian Mathematical Society and AAMT. The AMF and the AMOC are now designated as sub-trusts of the AMT.

A more recent activity of the Trust includes the partnership with the School of Mathematics at UNSW in publishing the school journal *Parabola*. This will incorporate the similar-minded journal *Function* which has now merged with *Parabola* after almost 30 years of publication by

the Department of Mathematics at Monash University. There is also the establishment of an Australian Informatics Olympiad Committee to choose teams for the International Olympiad in Informatics. First conducted in 1989, this is the second largest of what are known now as the International Science Olympiads. The others are in physics, chemistry and biology. The IMO is by far the largest of the five.

The greatest compliment that can be paid to the AMT, and the greatest tribute to the work of Peter Taylor and his many co-workers and particularly to the memory of Peter O'Halloran, is that the world's largest mathematics competition is based on the AMC and run each year in Europe. It is known as "Le Kangourou des Mathématiques".