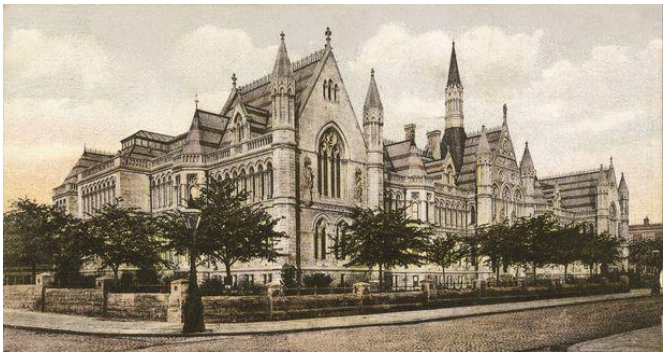
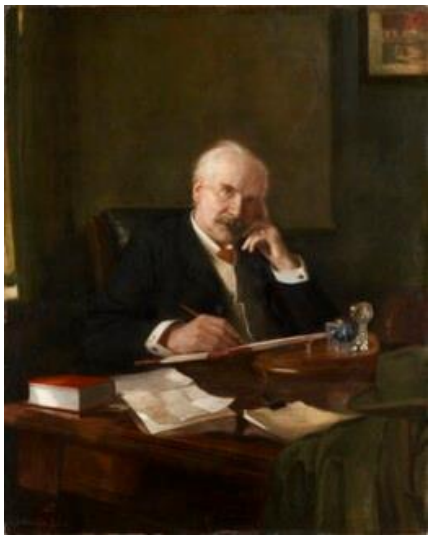
Centenary of the Sir Jesse Boot Chair in Organic Chemistry at the University of Nottingham

Origins of the School of Chemistry



Arkwright Building, University College Nottingham, 1881

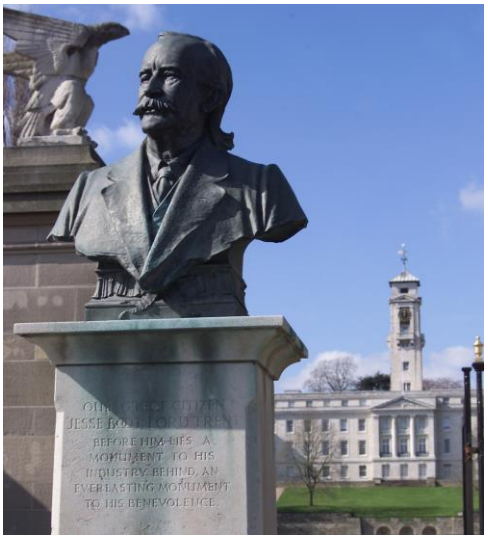
As the 1st World War ended in November 1918, large numbers of servicemen returned to Nottingham, with between 40 and 50 wanting to be trained for new careers in Chemistry at University College Nottingham. At that time, the University College was based in Nottingham City centre within the recently completed Arkwright building on Shakespeare Street, sandwiched between the City Library and City Museum, where it had been established in 1881 with Frank Clowes as one of the four founding Professors. The immediate space pressures caused by this influx of students were overcome by clearing out one of the large rooms of the museum of its stuffed animals (the surviving part of the collection now forms the Natural History collection at Wollaton Hall) and converting it into an elementary laboratory with 70 bench spaces for both full and part time students. However, it was realised by the Aldermen of the city that the University College would need to expand and in late 1919 they approached Sir Jesse Boot to see if he would be able to help fund this. He was very ill at the time with arthritis and did not respond until 2nd March 1920 at which time he indicated that he was unsure if he would be able to help. Around that time, Boots Pure Drug Company Ltd who employed 14,000 people in over 600 stores and factories across the UK was approached by Louis K. Liggett of the United Drug Company (a cooperative retail franchise that traded under the Rexall name and originated in Boston, USA) and it was agreed to sale the company to him for £2.25M (£66M in 2020). This suddenly left Sir Jesse Boot with a substantial amount of free cash and so on the 15th July 1920 he wrote to the Aldermen again, sending them a cheque for £50,000, of which £30,000 was for the University College building fund and £20,000 (£600K in 2020) for the foundation and endowment of a Chair of Chemistry to promote chemical research.



Sir Jesse Boot in 1909 by Noel Denholm Davis

This generous donation was quickly followed in 1921 by the donation of the Highfield estate for what was to become University Park and further donations covering the Great Hall which formed part of the Trent Building, the conversion of Lenton Hall into male student accommodation and the building of Florence Boot Hall for female students. In total Sir Jesse Boot contributed over £440,000 (£13M in 2020) plus the land for the new University College site during the 1920s. The Trent Building and University Park campus opened in 1928 with Frederic Stanley Kipping FRS having been installed as the first Sir Jesse Boot Professor of Chemistry in 1921. At that point, the Chemistry had eight staff members, which were split between the Shakespeare Street and Highfield estate sites.

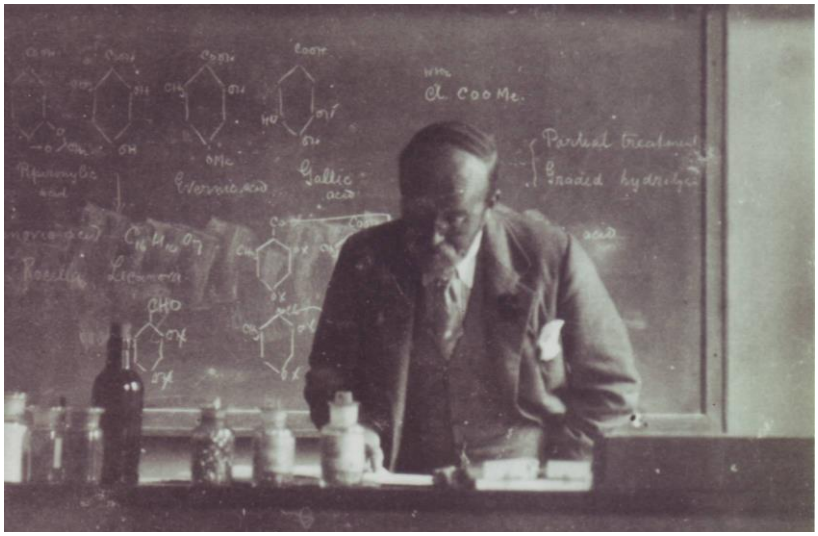
When the Great Depression occurred in the late 1920s, Louis Liggett was forced to sell his share in Boots and the company was eventually bought back into British ownership in 1933 by a consortium of businessmen led by John Campbell Boot, Jesse and Florence Boot's son who had become the Chairman of the Boots Pure Drug company in 1926 and led its move to the Beeston site in 1927. Sir Jesse Boot was made Baron Trent in 1929 and died in 1931. His family's association with University College continued, with John Boot, 2nd Baron Trent becoming its President in 1944 and then being installed as its first Chancellor, when the University received its Royal Charter in 1949. He continued in this role until retiring in 1954 at which time The Boots Pure Drug Co. endowed two further chairs, The Lord Trent Chair of Pharmaceutical Chemistry and The Lady Trent Chair of Chemical Engineering in his honour.



The Trent building and Jesse Boot bust, Highfields

Through the holders of the Sir Jesse Boot Chair of Organic Chemistry, the University of Nottingham gained an international reputation in Organic and especially Natural Products Chemistry. What is perhaps less appreciated is their contributions to the area of sustainable chemistry that has more recently resulted in the creation of the part GlaxoSmithKline (GSK)-funded Carbon Neutral Laboratory and the Centre for Green and Sustainable Chemistry. This research includes the exploration of the use of alginic acids to prepare weather resistant fibres conducted by John Masson Gulland that led to the formation of the Scottish Seaweed Research Association, Frederick King's later work with British Petroleum (BP) that brought Toprina, a yeast protein product made by a *Candida lipolytica* strain grown on oil derived long chain *n*-alkanes, Alan W. Johnson's work on insect pheromones as natural methods for pest control, and Leslie Crombie's studies on the use of pyrethins as natural insecticides and rotenone in agriculture and more recently in horticulture as a 'green' insecticide for clearing waters used in fish farming, prior to restocking.

Frederic S. Kipping FRS (1863-1949*)*: Frederic Kipping came to Nottingham in 1897 taking over the Chair of Chemistry from Frank Clowes. Just before this time, in the same year, he was elected as a Fellow of the Royal Society at the young age of 34, i.e. several years before his celebrated studies of silicon compounds. Kipping had undertaken his PhD in organic chemistry in Adolf von Baeyer's Institute at the University of Munich (1886-87) under the supervision of William Perkin Jnr (son of William Perkin of mauve dye fame. Following his PhD Kipping began his academic career as Demonstrator under Perkin at the Herriot Watt College in Edinburgh, and in 1890 he was appointed Chief Demonstrator at Central Technical College, London (later subsumed into Imperial College). It was during this time, in 1894, that with Perkin (Jnr), Kipping wrote the book "Organic Chemistry", which was the first textbook on organic chemistry in English to be published. This book became a standard teaching text up to the 1950s by which time his son F. Barry Kipping, then a lecturer at Cambridge, was editing it. Throughout the 1890s, Kipping studied the chemistry of monoterpenes, and particularly camphor and its derivatives. It was during these chemical studies that his interests in chirality ("pseudoracemisation" and "enantiomorphism") within carbon compounds and quaternary ammonium salts were aroused. The archives in the School of Chemistry in Nottingham hold a splendid glass cabinet containing several terpene samples made by Kipping during this period.



Frederic Kipping FRS teaching in the 1930s

Kipping's first studies on the organic chemistry of silicon were published in 1901, and from that time his research shifted almost entirely from carbon-based compounds to the chemistry of silicon and silicon oxides. His initial focus was on the preparation of left and right handed (chiral) silicon centres in organosilicon compounds and also the preparation of 'silicone', the silicon equivalent of acetone, a compound that had been proposed by Friedrich Wöhler, the father of organic chemistry. Kipping was at the forefront of the use of new synthetic organic reagents, with his group using alkylmagnesium halides in the synthesis of organosilicon compounds within a year of them being reported by Victor Grignard in 1900 (recognised with the Nobel prize for Chemistry in 1912). In 1908 Kipping became the first person to prepare a compound containing an asymmetric silicone centre. However, his attempts to isolate 'silicone' proved unsuccessful. Subsequently, it was established that this compound is very unstable and immediately oligomerises and polymerises to give the polysiloxanes that we are now all familiar with as silicon lubricants and rubbers. Kipping took up the Sir Jesse Boot Chair of Chemistry in 1921 and

delivered the first of the Sir Jesse Boot Foundation Lectures, titled 'Evolution in Chemical Industry – The Chemistry of Vitriol' in 1922. He went on to give another six of these Lectures, the last being 'The Chemistry of Vitamins' in 1934. More recent contributors to this public lecture series have included Nobel Laureates Sir Howard Florey (Penicillin, 1946), Linus Pauling (Molecular Architecture and the Processes of Life, 1948), Sir Harry Kroto (1998) and Sir J. Fraser Stoddart (2018)

Kipping went on to publish 57 papers on silicon chemistry before retiring in 1936 at the age of 73. His new and novel chemistry was used as the basis for the formation of the Dow Corning company in Midland, Michigan in 1943 by the Dow Chemical company (producers of magnesium) and the Corning Glass Inc. It has since become the largest producer of silicone products in the world with over 7,000 different adhesives, lubricants, rubbers and solvents, including those used in some medical implants. The earliest impact of silicones, in the 1940s, was in the water repellent boot jacks for the spark plugs in aircraft which allowed larger military aircraft to be flown between North America and the UK, rather than shipped by sea across the Atlantic.

Dow Corning recognised Kipping's contribution, with Dr Shailer Bass presenting him with a 3-volume set of his collected research papers on silicon research, bound in silicone impregnated glass fibre boards in 1945. During the visit, Dr Bass said: "you know, it was you and Mr Churchill that won WW2", Kipping's sharp response was "why bring Churchill into it?" demonstrating his acerbic wit.

Outside of the lab, Kipping was a keen sportsman, enjoying tennis, golf and snooker. He was married to one of three "Holland" sisters who all married significant organic chemists (Lapworth, Kipping and Perkin Jnr). A semi-fictionalised account of their lives has been written by another silicone chemistry pioneer, Prof. Eugene G. Rochow, aided by Eduard Krahé and Brian Kipping (his grandson). In 1960, Dow established the *American Chemical Society Kipping Award* for distinguished contributions in the field of silicon chemistry during the 10 years preceding nomination, to commemorate Kipping's contributions. Kipping was inducted into the International Rubber Hall of Fame, at the Goodyear Polymer Center at the University of Akron in 2004.

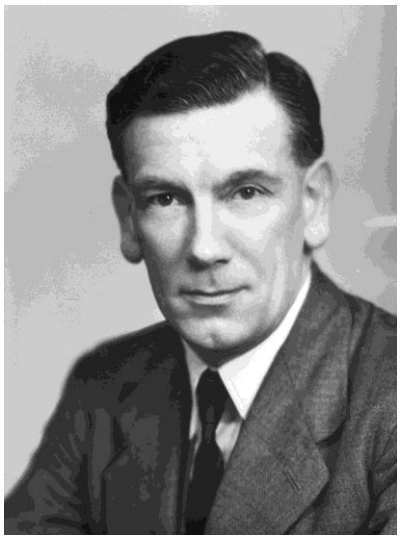
John Masson Gulland FRS (1898-1947): When Kipping retired in 1936, University College Nottingham appointed John Masson Gulland as his replacement. Gulland came from an academic family with his father later becoming Professor of Medicine at Edinburgh University. After gaining a BSc from Edinburgh in 1921 and a PhD from St Andrews under the supervision of Prof. (later Sir) Robert Robinson FRS, PRS, Nobel Laurate in 1925, he worked at the University of Manchester, and then the University of Oxford also with Robinson. He became a lecturer and Fellow at Balliol College in 1926 and was elected a Fellow of the Royal Society of Edinburgh in 1927. During this period, Gulland also worked briefly with William Perkin Jnr (Kipping's lab supervisor in Germany and Robinson's PhD supervisor) on strychnine and brucine, resulting in one paper. Gulland's research then changed direction and involved the use of both synthetic and physical chemistry methods to investigate biological systems. He moved to a Readership in Biochemistry at University College, London in 1931 and also an association with the Lister Institute. Having previously focused on the synthesis and structure of morphine alkaloids when working with Robert Robinson, Gulland's research shifted to focus on topics including the active constituents of yew and pellitory root, as well as reducing substances found in pigeon blood. Work at the Lister Institute included an examination of the spermicidal activities of aromatic aldehydes, quinols and quinones and eventually led to work on nucleic acids. Gulland became the Senior gas advisor to the North Midland Region of the Minister of Home Security in 1939 and was then appointed as Assistant Director of Chemical Research and Development working on a variety of projects in areas that would be considered sustainable chemistry today, such as the development of weather resistant fibres from the alginic acids extracted from seaweed. In 1944, Gulland reinvestigated the presence of *d*-ribose in yeast nucleic acid extracts and developed partial syntheses of several nucleotides. At this point in the 1940s, Phoebus Levene had already identified nucleic acids as the basic building blocks of DNA and RNA and had proposed the 'tetranucleotide hypothesis'. This hypothesis proposed that rings formed from one of each of the four deoxynucleotides could act as scaffolds for proteins that were thought of as the elements of heredity.

John Masson Gulland FRS at the Cold Spring Harbour Laboratory Conference on Nucleic Acids and Nucleoproteins in 1947 (courtesy CSHL)

However, measurements on the diffusion coefficients of yeast nucleic acids made by Gulland, Fletcher and Jordan published in 1944, lent strong evidence to the tetranucleotide hypothesis being incorrect. Gulland was elected as a Fellow of the Royal Society in 1945 in recognition of his nucleoprotein work. He also took an interest in the local industries in Nottingham, helping form the Lace Research Association in the same year. Later studies on calf thymus DNA using electrometric titration methods, led Gulland, Jordan and Creeth to propose that the DNA was an oligomeric structure with hydrogen bonds between the strands. These proposals were published in three papers during 1947, and in October of that year Gulland resigned the Jesse Boot Chair to take up the Directorship of Research at the Institute of Brewing in Edinburgh.

Unfortunately Gulland was one of 28 people killed on 26th October 1947 when the Flying Scotsman express train derailed near Goswick, Northumberland and so he did not get to see the major breakthroughs that Crick, Franklin, Watson and Wilkins made in determining the double helix structure of the DNA duplex, and the key role played by H-bonding, published in 1953. Interestingly, Linus Pauling gave the Sir Jesse Boot Foundation lecture in Nottingham in May 1948 when Dennis O. Jordan, Gulland's co-worker was still working there, but Pauling could not recall in a letter he sent to Harold Booth in 1990 if he had discussed H-bonding in DNA, "I do not remember whether or not I knew about the work of Gulland, Jordan and Taylor. If I had known about it, perhaps I would not have continued with the triple (DNA) helix study" which involved burying the phosphate groups in the interior of the triple helix as published in *Nature* in early 1953.

Frederick E. King FRS (1905-1999): 'Freddie' King gained his BSc (Hons) degree from East London College (later Queen Mary College) in 1924 and remained there to undertake a PhD in Physical and Inorganic Chemistry with Prof. J.R. Partington. He stayed at the College for a further three years, becoming a junior lecturer, teaching mainly organic chemistry. After being awarded a Ramsay Memorial Fellowship, King moved to Oriel College, Oxford where he worked with Robert Robinson as a Demonstrator in the Dyson Perrins lab. He gained a DPhil in 1933 and MA in 1934 at which time he was appointed as a University Lecturer and then held posts of Lecturer in Organic Chemistry at Magdalen and then Balliol Colleges. He replaced John Masson Gulland in the latter position. Whilst at Oxford, King's research was focused on the natural product physostigmine which was part of a plant extract with insecticide activity; the pure compound is now known to be an inhibitor of acetylcholine esterase. Work on this compound led to an interest in the synthesis and chemistry of saturated nitrogen heterocycles and culminated in work with Robinson on β-lactams in the preparation of new penicillin analogues (building on the pioneering work of Abrahams, Florey and Chain). King obtained his DSc in 1946 and gave the RSC's Tilden Lectureship on the chemistry of 3- and 4-membered ring heterocycles in 1948. In the same year, he accepted the Sir Jesse Boot Chair of Organic Chemistry at Nottingham, an appointment that was strongly supported by Sir Jack Drummond, the then Chairman of Boots, because of King's interest in bioactive compounds.



Frederick E. King FRS

At Nottingham, much of Freddie's research was conducted with another new arrival from Oxford, Trevor J. King. Trevor, who later became Professor of Chemistry and a Pro-Vice-Chancellor in Nottingham. Together, the Kings developed the phthaloyl protecting group allowing the preparation of polyglutamates and analogues of the tripeptide glutathione. Investigations of saturated nitrogen heterocycles continued, and the two King's research branched out to include examining the extracts of hardwoods that were particularly resistant to fungal decay in order to identify new chemical defence compounds. These researches resulted in the identification and characterisation of lignin, isoflavanone and catechin natural products. During these times, characterisations were primarily by crystallisation, with supporting evidence from UV/vis. and IR spectroscopy. Low field NMR was only available in the very last stages of King's work at Nottingham. Freddie was commended by Sir Robert Robinson PRS for the high level of productivity that he achieved with his research students, remarking that he himself had not achieved such levels of engagement at Oxford. This may have been because of 'King's Regulations' in which he set out minimum daily working hours, maximum holiday allowances and required his researchers to have clean lab coats and conduct weekly bench cleaning which he inspected on Saturday morning. King's research was recognised with Fellowship of the Royal Society in 1954. Freddie was very ambitious for

The Chemistry Building, University Park Nottingham, 15th May 1960

the School of Chemistry at Nottingham and continually pushed for both increases in staff numbers and for additional research and teaching accommodation, beyond that which was available in the Trent Building. He was heavily involved in the plans for the new Chemistry building as designed by Sir Basil Spence, but departed the University in 1955, five years before these designs were realised. He left to take up the position of Scientific Advisor at British Celanese where his research focused on acetylcellulose and various other synthetic fibres between 1955-59. He later moved on to British Petroleum's London Refineries and Technical Department and then became a director of the Energy Conversion Ltd subsidiary that was involved in metal-air battery and fuel cell research. The last part of his career was focused on BP's protein from oil research, with the aim of making animal and possibly human feedstocks from the biomass of bacteria that was generated when the bacteria were used to remove or reduce the sulfur content of crude oil. Significant progress was made in this project up to Freddie's retirement in 1970, and Toprina, the BP protein product was produced at Grangemouth from 1971. Unfortunately, the oil crisis in 1973 which resulting in quadrupling the prices of crude oil meant that the process was no longer economically viable.

Alan W. Johnson FRS (1917-1982): Originally from South Shields near Newcastle upon Tyne, Alan Johnson obtained both an Exhibition and then a Royal Scholarship to undertake his degree at Imperial College, London in 1936 and he obtained a 1st Class degree in 1938. He immediately embarked on a PhD with W.E. Jones and later Sir Ewart R.H.Jones FRS at Imperial. Prior to submitting his PhD thesis in 1940, Alan was recruited by ICI Ltd, but remained in London to work on a vitamin A synthesis with Sir Ian Heilbron FRS. He finally moved to the Dyestuffs Division of ICI in Blackley, Manchester in 1942 working with J.D. Rose FRS, and being advised by ICI consultants Sir Robert Robinson and A.R.(later Lord) Todd. In 1946 I.C.I. established University Fellowships and Alan was a first recipient of one of these, allowing him to study insect pigments at the University of Cambridge in Todd's lab. He was later appointed Assistant Director of Research in 1948 and then a University Lecturer. During his early years at Cambridge, Alan focused on the chemistry of acetylenic compounds and their potential as precursors for the synthesis of polyene-containing compounds such as vitamin A, writing comprehensive guides to acetylenic alcohols and then acetylenic acids in 1946 and 1950. These guides became seminal reference works in these areas over the following decade. In parallel, Alan worked on a number of metabolites from *Penicillium* species including stipitatic acid and other tropolones, expanding these studies to azepine rings. By 1950, the structures of all the vitamins had been determined except vitamin B_{12}, the deficiency of which caused pernicious anaemia. It is the only known cobalt containing natural product. Work carried out by E. Lester Smith FRS and his colleagues at the Glaxo labs on the isolation of the compound produced dark red crystals and led to a collaboration with Todd's group at Cambridge to elucidate the structure of, this, the most complex of all the vitamins. In parallel a group at Merck laboratories under Karl Folkers, was also trying to achieve the same objective. They identified the 5,6-dimethyl-1-α-D-ribofuranosyl benzimidazole fragment and the Cambridge group isolated and identified the phosphorylated version of this compound, allowing them to propose a partial structure of the compound, but lacking the exact structure of the corrinoid polyamide that binds the cobalt metal. Further degradation work at Cambridge helped define the corrin ring structure and the vitamin B_{12} structure was finally delineated through X-ray crystallography conducted by Dorothy Crowfoot Hodgkin FRS (later Dame) in 1955. Alan was heavily involved in this structural work, undertaking much of the day to day

Alan W. Johnson FRS

direction of Todd's lab in the period 1948-1955. The Nobel prizes awarded to Lord Todd (1957) and to Dorothy Crowfoot Hodgkin FRS in 1964, were both based partially on their work on the structural elucidation of vitamin B_{12}.

Alan Johnson was appointed as Jesse Boot Chair and Head of Department at Nottingham in 1955, and in this role one of his first challenges was to design the interior laboratory spaces of the planned new Chemistry Building that had been initiated by Freddie King. This he did with the help of Professor Dan D. Eley (later FRS) and Dr Cliff Addison (later Professor and FRS). Alan's research during this period, 1955 to 1968, at Nottingham involved a number of advances in corrin and porphyrin chemistry including studies on the preparation of methylcobalamin with his PhD student David Dolphin (later Prof. of Chemistry at Univ. British Columbia and FRS who went on to develop and commercialise some pioneering photodynamic therapeutics). Work on a variety of polypyrroles with Ronald Grigg (later Prof. of Organic Chemistry at Queens, Belfast and then Leeds, and FRS), developing methods to identify the peptides found in actinomycins and other antibiotics and working with Barrie W. Bycroft (later Prof. in the Pharmacy Department at Nottingham) on viomycin, an antibiotic from *Streptomyces* species that possessed anti-tubercular activity. Johnson was elected as a Fellow of the Royal Society in 1965.

In 1967, Alan was approached by the Agriculture Research Council to become involved in the establishment of an A.R.C. funded unit on Invertebrate Chemistry and Biochemistry at the University of Sussex. In the spring of 1968 he therefore resigned the Jesse Boot chair at Nottingham and moved to the Chair in Organic Chemistry at Sussex that was vacated by A.I. Scott FRS. Research in Sussex included that on insect pheromones such as those of the beetle *Scolytus scolytus*, the main vector for Dutch Elm disease, that decimated the stocks of this tree in the UK in the 1970's. He maintained an interest in vitamin B_{12} dependent reactions, with his final papers before retirement in 1982 being on the mechanism of ethanolamine ammonia-lyase. Sadly, just a few weeks after his retirement Alan passed away.

Leslie Crombie FRS (1923-1999): Leslie was born in York, but after the family moved to Portsmouth he was educated at Portsmouth Northern Grammar School and then took evening classes at Portsmouth Municipal College for an Intermediate BSc (London). He then became a laboratory assistant in the Admiralty Chemical Department, based in Portsmouth dockyard, where he met his future wife Mary. During this period, one project he worked on was the 'sulphide process' for camouflaging submarines whilst they were operating on the surface. By covering the exposed hull with seawater containing sodium sulphide, it made the upper hull black and ideal for night time operations or those close to shore, whilst treatment of the sodium sulphide coat with hydrogen peroxide, changed the colour to white, better for reducing the visual presence in daytime operations or when silhouetted against the horizon. During evenings and weekends he studied further and gained a 1st Class degree in Special Chemistry from the University of London in 1946. Leslie then moved to King's College, London where he studied for a PhD with Dr Stanley H. Harper, who had earlier worked in Rhodesia (now Zimbabwe), and had observed the use of extracts of pyrethrum from *Chrysanthemum cinerariafolium* as an insecticide. With other PhD students in Harper's group, Leslie established the structures and carried out the synthesis of the pyrethrin insecticides for his PhD, and he continued to research and publish in this area up to and beyond his retirement. Leslie received his PhD in 1948 before moving to an assistant lectureship at Imperial College in 1950. At Imperial he continued to work on the pyrethrin insecticides, whilst also looking at the synthesis of a range of other natural products including insecticidal lipid amides and fatty acids. Leslie moved back to King's as Reader in Chemistry in 1958 and there he started structural and biosynthesis investigations of the fish poison rotenone isolated from *Derris*. Donald Whiting was one of his first PhD students at King's to study the rotenoid insecticides, and after moving to Cardiff and then to Nottingham with Crombie, he became a lifetime collaborator and co-author of many of Crombie's publications. It was during his time at King's that Crombie established the structure of the tricyclic "citrylidine malonic acid" produced some eighty years earlier when citral was condensed with malonic acid in the presence of pyridine. He soon recognised that this structure had features in common with other more complicated natural products, *eg* bruceol, which led to him establishing "chromenylations" as a general stratagem in the synthesis of a range of interesting natural products

Leslie Crombie FRS

(cannabicyclol). In 1963, the invitation to take up the foundation chair in Organic Chemistry at The University of Wales in Cardiff came and Leslie and his family moved West (Donald Whiting had earlier been appointed lecturer in Cardiff in 1962). In Cardiff Leslie built up an impressive array of modern analytical and spectroscopic equipment, including X-ray, chiroptical equipment and radioactivity counters which allowed him to broaden and consolidate his research, and develop new research, eg. on the structures of the coumarin constituents of the "mamey" tree traditionally used to combat pests and parasites in the West indies and Central America.

Leslie took a sabbatical year in 1967 at UC Berkeley with the toxicologist John Casida (ForMemRS) and on his return he applied for and later took up the Sir Jesse Boot Chair of Organic Chemistry in 1969. He took with him Donald Whiting, and in 1972 he reappointed Gerry Pattenden to a lectureship who he had appointed earlier to a similar position in Cardiff in 1966.

Crombie was one of the foremost natural product chemists of his generation. He was elected as a Fellow of The Royal Society in 1973. When he moved to Nottingham, he once again built up an enviable portfolio of up-to-date analytical and spectroscopic equipment and he continued to make further major contributions in several areas of natural products. Paramount amongst these achievements were the determination of structures of the nicandrenoids found in the Peruvian "shoo-fly " plant that had been reported to have insecticidal properties, with his wife Mary, the avenacins (used by oat roots to defend them against attack, i.e "take all disease"), phorbol the co-carcinogen of croton oil, and cathedulin E4, from the euphoriant drug "Khat".

However, Leslie was not just a natural product chemist. He spent several years studying xanthophanic and glaucophanic acids (first produced by Claisen in 1897) when heating ethoxymethylene acetoacetate and sodio-acetoacetate) and also Peckman dyes. He also studied some chemistry of carbon suboxide, allenecyclopropanes, allene hydrogenations and transamidation reactions.

Leslie retired from the Sir Jesse Boot Chair in 1988 but continued to do research (with his wife Mary) and write-up nearly 80 publications in his retirement. Leslie was Dean of Science in Nottingham and held a number of leadership roles in several Societies including The Royal Society, The Royal Society of Chemistry, The Phytochemical Society of Europe and the European Society of Bioorganic Chemistry. Following retirement, Leslie was awarded the prestigious American Chemical Society International Award for Research in Agrochemicals in 1997.

Gerald Pattenden FRS (1940-): "Gerry" Pattenden was educated at Queen Elizabeth's Grammar School, Faversham, Kent and then gained a BSc from Brunel College of Advanced Technology (now Brunel University) in 1963, before undertaking a PhD at Queen Mary College, Univ. of London studying carotenoids with Basil Weedon, FRS (later Vice-Chancellor at Nottingham, 1976-1988). Following his PhD, Gerry was appointed by Professor Leslie Crombie to a lectureship at Cardiff, University College and moved to Nottingham in 1972. He was promoted to full Professor in Nottingham in 1980 and became Sir Jesse Boot Professor of Organic Chemistry in 1988. Gerry was Head of School during 1988-96, and then Pro-Vice- Chancellor for Research at the University (1997-2003). During this period Gerry established new posts in Biological Chemistry in the School (including the author) and made substantial contributions to developing new research facilities at Nottingham, including expanding the Chemistry Department through the construction of the Biological Chemistry North Wing in 1999 and the development and construction of the Centre for Biological Sciences which opened in 2003 (recently expanded to more than 800 researchers and renamed The Biodiscovery Institute). This was the first such disciplinary research building of its type at a University in the UK.

Centre for Biomolecular Sciences, 2008

Gerry has an international reputation in natural product chemistry and especially in the design and development of new strategies and transformations for the total synthesis of natural products, often inspired by Nature. His early research established the structures of the novel poly-cis carotenoid prolycopene and its congeners in Tangella tomato fruits. This led to extensive synthesis studies of other polyenes and colouring matters in plants and fungi, which allowed Gerry to interrelate the biosynthetic origins of many of these metabolites.

Gerry Pattenden FRS

Whilst in Cardiff, at the suggestion of Leslie Crombie, he studied the biosynthesis of the unusual vinylcyclopropane-based chrysanthemic acid found in pyrethrum, and in a collaboration with Crombie he synthesised the vinylcyclopropane-based terpenes presqualene and casbene which are intermediates in the biosynthesis of steroids, taxanes and phomactins. In Cardiff Gerry also developed a photochemical route to chrysanthemic acid which was the beginning of his lifetime interest in developing the scope for several other radical pathways to the synthesis of natural products. He used intramolecular photochemical, electrochemical and tin hydride-mediated cyclisations to synthesise a wide variety of polycyclic terpenes, and then developed cobalt-mediated radical reactions using vitamin B_{12} and its analogues to synthesise β-lactam antibiotics (thienamycin) and hypotensive agents (forskolin). At the same time Gerry played a leading role in developing tandem radical-mediated macrocyclization-transannular reactions and radical-mediated cascade cyclisations from polyene precursors in synthesis, particularly towards taxanes, polycyclic terpenioids, and steroids, eg oestrone, phomactin A. His synthesis of a linear heptacycle using *seven* consecutive ring forming reactions from a polyene radical precursor remains a world record for cascade reactions. Gerry was elected a Fellow of the Royal Society in 1991.

In the early 1990s, Gerry was attracted to several new families of natural products having structures based on the presence of multiple contiguous oxazole and other azole rings. He had the notion that some of these compounds might be involved in metal chelation and transport *in vivo* (cf. Vitamin B_{12}). He synthesised a wide range of azole based cyclic peptides, showed that they bound to metals, and then demonstrated that some could be assembled by cyclooligomerisations of mixtures of azole-based amino acids. Gerry's synthesis of the novel tris-oxazole-based macrocycle ulapualide A, found in nudibranchs was a significant achievement, and his synthesis of the oxazole/oxane macrocycle phorboxazole A provided more milligrams (2.3 mg!) than any other synthesis of this extraordinary cytotoxic sponge metabolite. Contemporaneously, Gerry was the first to demonstrate the scope for the intramolecular Pd (0)-catalysed coupling (Stille) reaction in the total synthesis of a range of complex polyolefin-based macrolide and macrolactam natural products, including rhizoxin D, pateamine, and amphidolide A.

Gerry stepped down as Sir Jesse Boot Professor in 2005 but continued his research, investigating biogenetic interrelationships in novel polycyclic structures found in corals (intricarene, plumarellide, ramswaralide, ineleganolide) largely through biomimetic synthesis, and studying the structure and biosynthetic significance of sobralene, a pheromone produced by the sand fly *Lutzomyia longipalpis* which is the main carrier of a parasite that causes the fatal human disease American visceral leishmaniasis (VAL). Having recently celebrated his 80th birthday, he has remained a regular attendee of research symposia in Nottingham, still asking penetrating and perceptive questions. His research ethos is upheld in the School by his former PhD students Chris Hayes and Hon Wai Lam (now Professors) and Anna Bertram (now Director of Laboratory Teaching and Associate Professor). In 2015 Gerry was awarded the degree of Doctor of Laws, *honoris causa* from Nottingham.

Christopher J. Moody (1951-): Chris Moody is a Mancunian and like F. S. Kipping was educated at Manchester Grammar School. He then gained a first class degree from King's College, London, before carrying out his PhD research at the University of Liverpool under the supervision of Charles Rees investigating the synthesis and reactions of nitrogen-sulfur ylides, particularly as precursors to nitrene reactive intermediates. He then spent a postdoctoral year at the ETH in Zürich working with Albert Eschenmoser, who along with Robert B. Woodward, had recently completed the first synthesis of vitamin B_{12}. In Zürich, Chris worked on the stereochemistry of 1,4-elimination reactions before taking up a post in industry at Roche, where he was involved in the early days of molecular modelling in the design of ACE inhibitors, his work laying the foundations for the subsequent discovery and marketing of the antihypertensive Cilazapril in 1990.

In 1979 Chris was appointed to a lectureship at Imperial College, London, renewing his collaboration with Charles Rees whilst establishing an independent research programme, and was promoted to a Readership in 1989. In 1990 he moved to the chair of organic chemistry at Loughborough University, and in 1996 he became Professor of Organic Chemistry at the University of Exeter. He was appointed Sir Jesse Boot Professor of Organic Chemistry in Nottingham in August 2005. Chris's early independent research career focused on the use of nitrene intermediates in the synthesis of a wide range of natural products, including the alkaloids indolactam V, phosphodiesterase inhibitors PDE-I and -II, the topoisomerase inhibitor BE10988, the isoindolobenzazepine alkaloid lennoxamine, and the staurosporine aglycone, a potent inhibitor of protein kinase C. Subsequently, he pioneered the study and applications of insertion reactions of metallocarbenes into O–H and N–H bonds.

Chris Moody

In Nottingham, Chris has continued the tradition of natural product synthesis, in particular thiopeptide antibiotics, and, in common with Gerry Pattenden, a strong interest in the polyazole natural products. This resulted in the syntheses of siphonzole, plantazolicin, goadsporin, wewakazole, and the G-quadruplex binding agent telomestatin. He also developed an interest in naturally occurring quinones. Although such compounds are highly coloured, their contribution to natural colour is insignificant. Instead, quinones are inextricably linked with natural oxidative processes in cells and were probably present in very early unicellular organisms about 2 billion years ago. Chris's work in Nottingham included syntheses of a range of quinone natural products such as lanciaquinone, crassiflorone, balsaminone, mevashuntin, and thiaplidiaquinone. These studies were carried out in parallel with extensive research on *unnatural* quinones in a medicinal chemistry programme. Thus, a series of indolequinones was developed as inhibitors of the human reductase enzymes QR1 and QR2, and of thioredoxin reductase; such inhibitors displaying potential as chemotherapeutic compounds. In addition, synthetic analogues of the benzoquinone ansamycins were synthesised and evaluated as inhibitors of the molecular chaperone Hsp90 and have potential applications in cancer and neurodegeneration. In collaboration with Nottingham colleague Professor Rob Stockman, Chris also participated in the European Lead Factory, part of the EU-funded Innovative Medicines Initiative, to develop novel scaffolds for drug discovery.

More recently, in common with some of his predecessors as Sir Jesse Boot Professor, Chris has worked on problems in sustainability including transition-metal free amination reactions, and solar photochemical oxidation of alcohols and C-H bond activation. He served as the inaugural Director of the EPSRC Centre for Doctoral Training (CDT) in Sustainable Chemistry (2014-2019) and oversaw the setting up of this successful initiative housed in the GSK Carbon Neutral Laboratory on the Jubilee campus in Nottingham. The CDT is now well established, and, under the directorship of Professor Peter Licence, is in its second funding period (2019-2027).

The Future

The century covered by the Sir Jesse Boot Chair in Organic Chemistry has seen an enormous expansion in the School of Chemistry at Nottingham, going from 8 academic staff and around 40 full and part-time students in 1920, to 50 academic staff and more than 800 fulltime undergraduate and postgraduate students and postdoctoral researchers in 2020. From a small laboratory in the Arkwright building in Nottingham city centre, chemical research is now carried out in three buildings including the State of the Art Carbon Neutral laboratory on the Jubilee Campus (previously the site of the Raleigh Bicycle works) and at the Biodiscovery Institute on University

The GSK Carbon Neutral Laboratory, Jubilee Campus, Nottingham, 2017

Park. Teaching chemistry has expanded internationally in the last 5 years to include a BSc in Chemistry jointly taught at the University of Nottingham, Ningbo, China campus and an apprenticeship scheme with participants from chemical companies across the UK. Over the past few decades, the contributions the chemists trained in Nottingham have later made in the Chemicals and Pharmaceutical sectors have been recognized by generous donations from Pfizer Drug Discovery, GSK, Astra Zeneca, Merck, ICI (all divisions), BP, Syngenta, and most recently from Sir Gordon Hobday and his family (an alumnus of the University who directed the research on Ibuprofen before becoming chairman of Boots & Co in 1970). The current Sir Jesse Boot Professor, Chris Moody is stepping down in September 2020 and a search for the next occupant of this important and prestigious chair in Organic Chemistry and its interface with Biology and Medicine will begin.

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