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Foreword

Dedication to Desmond Joseph Brown

Wilfred L. F. Armarego

Visiting Fellow, Department of Gene Biology, The John Curtin School of Medical Research, ANU College of Medicine, Biology and Environment, Canberra, ACT 0200, Australia. Email: wilf.armarego@anu.edu.au

This issue of *Aust. J. Chem.* is dedicated to Desmond Joseph Brown, formerly of the John Curtin School of Medical Research, ANU, whom we always referred to as 'Des'. An honorary member of the RACI and an eminent organic chemist who influenced the careers of many chemists, Des was a graduate of the University of Sydney and was awarded Ph.D. and D.Sc. degrees by the University of London. His detailed obituary has been published in *Chemistry in Australia*, July 2014, pp. 28–29.

Des's career (1942–1985) in academic organic chemical research was almost entirely in the field of heterocyclic chemistry, with emphasis in medicinal chemistry. His interest in these fields began during a year of study in Professor Adrien Albert's Chemotherapy Unit[1] at the University of Sydney. He then went to Imperial College, University of London, where he carried out research on heterocyclic analgesics[2] for his Ph.D. degree under the supervision of Dr A. H. Cook and Professor Ian Heilbron. This was followed by a year at University College, University of London, working on pyrimidine[3,4] and pteridine research. He was then appointed to the Department of Medical Chemistry in the John Curtin School of Medical Research (JCSMR) at the newly established Australian National University (ANU), where Adrien Albert had the foundation Chair. He assisted Professor Albert in the design of the building in Canberra, which was completed in 1956, and in establishing the department. Des was Professor Albert's right-hand man until Professor Albert's retirement in 1972, and later was appointed head of the Medical Chemistry Group in the JCSMR until his retirement at the end of 1985. He then became a Visiting Fellow in the Research School of Chemistry (RSC, ANU) where he was provided with an office and facilities for writing books (1986 to 2012).

The Department of Medical Chemistry consisted of a four-storey wing of the JCSMR building in which a very large space that spanned three storeys was designated 'The High Laboratory'. Des was in charge of this area which was used for very large scale syntheses and when the purification of large quantities of chemicals was required. This laboratory was converted to provide more laboratory space to accommodate new areas of research after 1972.

Des's research was mainly in the areas of pyrimidine, purine, and pteridine chemistry, substances that have central biological importance. He published most of his work in several series of papers, but only the first and the last parts of the series are referenced here. These include *Improved Syntheses in the Pyrimidine Series* (six parts),[3,5] *Simple Pyrimidines* (17 parts),[6,7] *Pyrimidine Reactions* (27 parts),[8,9] *The Dimroth Rearrangement* (18 parts),[10,11] *Isomerizations Akin to the Dimroth Rearrangement* (five parts),[12,13] *Purine Studies* (19 parts),[14,15] *Pteridine Studies* (12 parts),[16,17] *Aza-analogues of Pteridines* (eight parts),[18,19] *Triazolopteridines* (three parts),[20,21] and *Naphthimidazoles* (three parts).[22,23] Other papers that he wrote did not belong to any series and stood alone. These included papers on tri- and tetrazolopurinones,[24] a new route to pyrazolo[2,4-*b*] pyrazine,[25] triazolopyrimidines,[26] and triazolopurines,[27] among several others.

An important aspect of Des's research was the study of the physico-chemical properties of many of the compounds that he, his students, and co-workers prepared. The studies specifically included the ionisation constants of the substances as well as the electronic spectra of the neutral and ionic species,[28,29] photoelectron spectra of pteridines,[30] and ^{13}C NMR of tautomerism in *N*-heterocycles.[31] Together with Adrien Albert[32] and their co-workers, the department had amassed a tremendous amount of physico-chemical data[32] which is now indispensible in the field of medicinal chemistry.[33–35] The amount of data collected and published now makes it possible to predict with some degree of accuracy the dissociation constants of ionisable drugs,[36]

*Wilfred ('Wilf') Armarego was a British Subject born in Alexandria, Egypt. In June 1953, he was awarded the University of London External B.Sc. Special Honours degree in Chemistry. He then left Egypt for London and began research training in stereochemistry at Bedford College (University of London) in November 1953 under the tutelage of Professor E. E.Turner FRS, and subsequently submitted a Ph.D. thesis in 1955. He moved to Melbourne, Australia, in September 1956 and was appointed Research Officer at the new ICIANZ Central Research Laboratories where he worked on plant growth substances for 2 years. He joined the Department of Medical Chemistry, John Curtin School of Medical Research (JCSMR), ANU, in January 1960, where he worked until his retirement in 1996. Wilf was awarded a D.Sc. at the early age of 36 years by the University of London for his work in heterocyclic chemistry, and in 1972 he changed his research field to studies of pteridine requiring enzymes associated with a variety of inborn errors of metabolism in children. This involved work on enzyme purification, cloning, mutation, expression, kinetics, and mechanisms. Since retirement, Wilf has been a Visiting Fellow in the JCSMR. He has written four books (*Fused Pyrimidines, Part 1 – Quinazolines, Stereochemistry of Heterocyclic Compounds, Parts 1 and 2*, and* Purification of Laboratory Chemicals*) in addition to having over 140 publications in his name. His awards include FRSC (FRIC 1963), C. Chem, FRACI (1972), the A. D. Olle Prize (1968), and Worldwide WHO's WHO 2014 Professional of the Year, Representing Medical Research.*

a physical property which is important in cellular transport and mechanism of action of drugs. When Des took over the Medical Chemistry Group in 1972, chemists in particular were under very heavy pressure by the JCSMR powers that be to direct their research into areas that were more relevant to medicine. The Howard Florey era of doing very basic research in the School which might later be of use to medicine had ended. Des re-directed his research towards the amplification, by a variety of heterocyclic compounds, of the antibiotic activity of Phleomycin and, to a lesser extent, Bleomycin as antitumour agents.[37] He wrote three series of papers on the amplification of antibiotic and antitumour activities of purines and purine analogues (six parts),[37,38] unfused heterobicycles (eight parts),[39,40] and generally heterocyclic amplifiers (seven parts).[41,42] He wrote a review on this interesting amplification by a variety of heterocycles.[43]

Des Brown was a hard worker, but a gentle task master. He had more that 200 publications to his name, which included 12 books[44] in the renowned series *The Chemistry of Heterocyclic Compounds* published by John Wiley & Sons/Interscience. Four of these books were on pyrimidines. It is no wonder that in some circles he was called Mr Pyrimidine. When he was at RSC, he usually typed his own books on an electric typewriter. It was when hard copies of journals were no longer available, because they could be accessed online, that he started using PCs in order to access periodicals. In his last few years his eyesight started to fail, but that did not deter him. He even used large lenses and screens to read. On several occasions, I offered to proofread his books for him, but he used to say that he could manage slowly. He was not one for getting others to do his dirty work, and it was very rare for him to get his name on other people's work.

On a personal level, Des was a mentor, adviser, esteemed colleague, and dear friend to me. I met him in January 1960 when I flew from Melbourne to Canberra for an interview for the appointment of Research Fellow in the Department of Medical Chemistry. The aeroplane had arrived at 8.00 a.m. at Canberra airport, the terminal of which was nothing more than a wooden shack. Des collected me and introduced himself to me. He had to bend down to shake my hand. He was about twice my height, and Adrien Albert later described us as being 'at the extremes of normal human heights'. I still do not know how he managed to get into his little Ford Prefect! Des showed me around the department and introduced me to its members. I later met Professor Albert when he arrived at his usual time of 10.30 a.m. in time for morning tea. I must add that Adrien Albert always worked until midnight almost every night, when he then used to make himself a cup of tea before going to his flat at University House. I was well aware then that Des was a renowned heterocyclic chemist and he had just completed writing his first massive volume on *The Pyrimidines*. It did not take me long to see that he was a quiet, helpful, kind, and unassuming person. I was in daily contact with him during the period 1960 until 1972 when Adrien Albert retired, and later from 1973 until 1985 when Des was head of the Medical Chemistry Group. Our conversations were always on scientific matters. After 1973, he encouraged me in my new ventures of investigating ubiquitous reduced pteridine cofactors of three aromatic acid hydroxylases and the relevant reductase,[45,46] as well as ether-lipid monooxygenase.[47,48] Deficiency in these enzymes results in birth defects in children. This work required enzyme purification, enzyme kinetics, and later, DNA cloning in order to express enzymes with mutations found in affected children.[48] This was alien to him, but he supported me in my work both scientifically and financially.[49] The first thing he did was to buy a state-of-the-art spectropolarimeter for my use, as he knew I was working with optically active substrates.

When I was collecting literature data from the RSC library, I used to visit Des at his office there on a regular basis. That was when we used to discuss all sorts of subjects other than chemistry, and I got to know him well at the personal level. Des kept his private life very 'close to his chest', and it was then that I found out that he was a devoted family man with deep religious beliefs. I learnt a lot about his early days in Sydney and Sydney University, and in London at Imperial College, and his friends and colleagues during that period of time. His stories fascinated me as they brought back fond memories of my London days. He was a good mentor and friend to me, a man of great sensitivity and humility, a man whose true loves were his family and chemistry.

For a tall man, Des was very active, agile, and walked quickly. As a young man, he used to cycle daily from his home in Strathfield to Sydney University. He started to cycle when he realised that people kept away from him on buses because his clothes had a distinct laboratory odour – something that many young chemistry students must have experienced. He did not think twice about cycling from his home to Kirribilli, where Jan (later Mrs Brown) lived, and back again in one day through all the traffic bustle – a little more than 16 km each way.

The advice which Des repeatedly gave me was 'never volunteer to do anything, because you will find that you will be carrying the can for everyone'. Unfortunately, it is not in my nature to heed this advice, and that is how I came to accept the invitation for this tribute. One could not help liking Des, and it came through clearly from the messages that I received when I was inviting people to submit scientific contributions for this dedication to him. They all had very nice and touching words to say about him, each in their own way but expressing very similar sentiments. I sent out 24 invitations to his former students, co-workers, colleagues, and friends, and all of them replied. Fourteen were able to accept the invitation. The small number who accepted is not surprising, considering that Des lived to a ripe old age of 92 years. Some had retired and did not have new material worth publishing, some had gone into non-research employment, while others did not survive him.

The Medical Chemistry department in the JCSMR attracted no fewer than 17 Japanese scholars, post-doctorate researchers and Visiting Fellows over a 30-year period, so the proportion of Japanese contributors to this issue is not surprising. Des had a 'soft spot' for the Japanese, so much so that in 2010, after the Tsunami disaster, he and Jan donated a tidy sum of money for a scholarship to a deserving high-school student. Professor and Mrs Taguchi organised the donation of this money via Mr Toyohiko Yoshida, the Principal of Fukushima Prefectural Iwaki High School. They named it the 'Dr Brown Scholarship', which was awarded to three students, who went on to study environmental science or pharmaceutical chemistry, and whose homes were washed away by the earthquake disaster.

Contributions to this dedication issue comprise 11 original research papers and a short review, with 15 senior authors, as well as two short Focus articles by Heinz Duewell[50] and Gordon Barlin.[51]

Tomohisa Nagamatsu (Tomo) and collaborators have submitted a paper on the synthesis of 6-azapurines by transforming the antibiotics toxoflavin, reumycin, and fervenulin and their derivatives, and evaluating their antitumour activities. This involved contraction of six-membered to five-membered rings.

Tomo was a former Ph.D. student of Des Brown, and is now head of the Department of Medical Technology at Kumamoto Health Science University.[52]

Kazuo Sinozuka, also a former Ph.D. student of Des Brown and now Dean of the Graduate School of Science and Technology, Gunma University, and co-workers describe the improved fluorescent properties of a pyrene derivative, obtained by inserting the electron-withdrawing cyano group. They modified the side chain of the fluorophore and successfully incorporated it into oligo-DNA.[53]

A senior co-author of the two previous papers is the famous Japanese pharmaceutical and medicinal chemist Fumio Yoneda. He was formerly Professor of Pharmaceutical Sciences at Kumamoto University, then Professor, Councillor, and Dean of the Faculty of Pharmaceutical Sciences at Kyoto University. He is now a consultant to Fujimoto Pharmaceutical Co., Osaka. Dr Yoneda was an invited Visiting Fellow in Medical Chemistry in the early 1960s and collaborated with Des Brown and other members of the department, and he has kept in contact until the present day. He was a mentor to many outstanding students from Japan who are now in senior appointments.[52,53]

Kazuharu Ienaga (Kazu), a former Ph.D. student of Des Brown, is now a consultant to Nippon-Zoki Pharmaceutical Co. Ltd, Osaka. He worked for many years in this company on the use of renal metabolites as markers of the various stages of renal impairment, and has always been in close correspondence. His paper describes a simple two-step preparation of creatol, a critical renal metabolite of creatinine, via creatinine *N*-chloroamine.[54]

Hiroyasu Taguchi (Hiro) was a former Ph.D. student of Adrien Albert, and a close family friend of Des and Jan Brown. He has been their contact person for all the friends and students in Japan. Hiro was a regular Visiting Fellow in Medical Chemistry, having worked with myself on at least five occasions for periods of three months to one year over a span of 12 years. He was Emeritus Professor at Kyoto Women's University, and is now Research Professor in the Molecular Neuroscience Research Centre, Shiga University of Medical Science, Ohtsu. His paper with Ikuo Tooyama (Head of the Centre) and collaborators details the syntheses and physical properties of several fluorinated derivatives of curcumin. They had shown that the enol tautomers of curcumin bind to β-amyloid aggregate proteins in the Alzheimer brain. Their study of the ^{19}F-NMR spectra revealed the effects of substituents on the keto-enol tautomerism, and should be useful for studying their binding to the Alzheimer brain by ^{19}F-MRI.[55]

Branko Stanovnik, a most distinguished heterocyclic chemist and former vice-Dean of the Faculty of Chemistry and Chemical Technology, University of Ljubljana, has been associated with the Medical Chemistry department since 1978, when he was an invited Visiting Fellow in the JCSMR and had published a paper with Des Brown. He is also a very good friend of several of Des's former colleagues. He was the first to submit a paper for this issue, describing two general syntheses of 2,4,6-trisubstituted pyridines using microwave technology. The first starts with methyl ketones and *N*,*N*-dimethylacetamide dimethyl acetal (DMADMA) to provide 2-dimethylamino-6-methyl-4-substituted pyridines; the second starts with substituted amides and DMADMA to yield 2,4-bis(*N*,*N*-dimethylamino)-6-(substituted) pyridines.[56]

Lucjan Strekowski was a former Research Fellow who worked with Des (1981–1983) and published four papers with him. He is now Emeritus Professor of Organic Chemistry at Georgia State University, Atlanta. He kept in contact with Des and Jan until the end. With his co-workers at Georgia State University, Lucjan prepared 9-perfluoroalkylacridines by reacting 2-perfluoroalkylanilines with phenylmagnesium bromides which had at least one methyl group in the position *ortho* to the MgBr group. The reactions were peculiar in that the benzylic carbon atom of the anilines became C-9 of the acridines formed, one *o*-methyl group of the Grignard reagent was lost (as MeOH) and the perfluoroalkyl group except the benzylic CF_2 carbon atom of the anilines became a 9-perfluoroalkyl substituent.[57]

Wolfgang Pfleiderer, a renowned and distinguished heterocyclic chemist, has been a friend, collaborator, and mentor to a large number of students and staff members of the Department of Medical Chemistry. He was an invited Visiting Fellow in the early 1960s and again later when Des was head of the Medical Chemistry Group. He has always kept in contact with Des and Jan and friends in the JCSMR. He had much influence on the research of Adrien Albert, Des Brown, and junior members of the department with whom he also collaborated. With his student Q. Yao, they unravelled the protection and de-protection of functional groups of natural (6*R*)-5,6,7,8-tetrahydro-L-biopterin without interfering with the stereochemistry at the chiral centres. This is a ubiquitous cofactor for several aromatic amino acid and glyceryl-ether mono-oxygenases which make it indispensible for the growth and neurological development of neonates. Their work makes it possible to use the partially protected reduced biopterins in biochemical research.[58]

Thomas J. Delia, from Central Michigan University, USA, was a Visiting Fellow with me (1982–1983) when Des was head of the Medical Chemistry Group. He submitted a paper with Robin J. Hood on a new and mild procedure for brominating C5 of the pyrimidine ring when electron-releasing substituents were present at other positions in the ring. This is the only paper in this issue dealing with pyrimidines, a molecule which was dear to Des's heart.[59]

Maria Ngu-Schwemlein, a former Ph.D. student of Gordon Barlin (1986–1989), is currently Professor of Bioorganic Chemistry at Winston-Salem State University, USA. Her paper reports structure–activity studies, revealing the characteristic amino acid sequences in cationic amphipathic cyclooctapeptides which, in conjunction with common antibiotics, act synergistically to various extents on *Escherichia coli* and *Staphylococcus aureus*. This is a timely report considering the current increase in antibiotic resistance.[60]

A joint paper by Professor Mick S. Sherburn, who was a senior staff member in the Research School of Chemistry, ANU, when Des was a Visiting Fellow, and Michael N. Paddon-Row, a former Ph.D. student of Des and distinguished theoretical and practical chemist who is now Emeritus Professor of Chemistry, UNSW, and their co-workers describe intramolecular Diels-Alder reactions of 6-oxanona-1,3,8-trienes. Elegant synthetic work and cyclisation reactions lead to mixtures of *cis*- and *trans*-fused hexahydroisobenzofurans. The thermodynamic parameters were evaluated from kinetic studies. The ^{2}H kinetic isotope effects at the carbon atoms were determined for one example. Detailed theoretical studies of these reactions shed much light on the mechanism, and predict a concerted but synchronous path for the labelled triene cycloaddition in conformity with experiments. This paper is exemplary in demonstrating how the blending of synthesis, thermodynamics, and theory can enrich the discipline of organic chemistry.[61]

Martin G. Banwell was Director of the Research School of Chemistry, ANU, for a period while Des Brown was a Visiting

Fellow. With his co-workers, he unravelled a 14-step synthesis of the Amaryllidaceae alkaloid (+) narseronine, starting with the enzymically prepared pure enantiomer of 3-bromo-*cis*-1,2-dihydro-1,2-dihydroxybenzene. The planning and execution of this long synthesis, which involved stereochemical control, and optimised yields, should be rated among the classic syntheses in organic chemistry.[62]

Paul Waring and Christina L. L. Chai review and update briefly the chemistry and biology of the fungal metabolite gliotoxin and related epipolythiodioxopiperazine metabolites. The paper does, however, concentrate more on the extensive effects that these compounds have on the biology of the cell, research which occupied the interest of Paul Waring for some 30 years. He was an M.Sc. and Ph.D. student of Des Brown, and he held a post-doctoral fellowship followed by a research fellowship with me before taking up appointments in other departments in the JCSMR, and elsewhere at the ANU. Christina Chai, who knew Des, was a Reader in the Department of Chemistry, The Faculties, ANU, before taking up appointments at A*STAR and the National University of Singapore.[63]

References

[1] A. Albert, D. J. Brown, H. Duewell, *J. Chem. Soc.* **1948**, 1284. doi:10.1039/JR9480001284

[2] See pages S 106, 111, 113 in D. J. Brown, A. H. Cook, I. Heilbron, *J. Chem. Soc.* **1949**.

[3] D. J. Brown, *J. Soc. Chem. Ind.* **1950**, *69*, 353. doi:10.1002/JCTB.5000691201

[4] D. J. Brown, *Nature* **1950**, *165*, 100.

[5] D. J. Brown, *J. Appl. Chem.* **1959**, *9*, 203. doi:10.1002/JCTB.5010090402

[6] D. J. Brown, L. N. Short, *J. Chem. Soc.* **1953**, 331. doi:10.1039/JR9530000331

[7] D. J. Brown, P. Waring, *Aust. J. Chem.* **1978**, *31*, 649. doi:10.1071/CH9780649

[8] D. J. Brown, *J. Chem. Soc.* **1956**, 2312. doi:10.1039/JR9560002312

[9] D. J. Brown, P. Waring, *Aust. J. Chem.* **1978**, *31*, 1391. doi:10.1071/CH9781391

[10] D. J. Brown, J. S. Harper, *J. Chem. Soc.* **1963**, 1276. doi:10.1039/JR9630001276

[11] D. J. Brown, K. Ienaga, *J. Chem. Soc., Perkin Trans. 1* **1975**, 2182. doi:10.1039/P19750002182

[12] D. J. Brown, M. N. Paddon-Row, *J. Chem. Soc. C* **1967**, 1928. doi:10.1039/J39670001928

[13] D. J. Brown, T. Nagamatsu, *Aust. J. Chem.* **1979**, *32*, 1585. doi:10.1071/CH9791585

[14] A. Albert, D. J. Brown, *J. Chem. Soc.* **1954**, 2060. doi:10.1039/JR9540002060

[15] D. J. Brown, L. G. Stephanson, *Aust. J. Chem.* **1976**, *29*, 1031. doi:10.1071/CH9761031

[16] A. Albert, D. J. Brown, G. Cheeseman, *J. Chem. Soc.* **1951**, 474. doi:10.1039/JR9510000474

[17] D. J. Brown, N. W. Jacobsen, *J. Chem. Soc.* **1965**, 1175. doi:10.1039/JR9650001175

[18] M. E. C. Biffin, D. J. Brown, T. Sugimoto, *J. Chem. Soc. C* **1970**, 139. doi:10.1039/J39700000139

[19] D. J. Brown, R. K. Lynn, *Aust. J. Chem.* **1974**, *27*, 1781. doi:10.1071/CH9741781

[20] D. J. Brown, K. Shinozuka, *Aust. J. Chem.* **1981**, *34*, 189. doi:10.1071/CH9810189

[21] D. J. Brown, K. Shinozuka, in *Pteridines and Folic Acid Derivatives* (Ed. J. A. Blair) **1983**, pp. 63–67 (deGruyter: Berlin).

[22] D. J. Brown, *J. Chem. Soc.* **1958**, 1974. doi:10.1039/JR9580001974

[23] D. J. Brown, R. J. Harrison, *J. Chem. Soc.* **1960**, 1837. doi:10.1039/JR9600001837

[24] T. Nagamatsu, M. Ukai, F. Yoneda, D. J. Brown, *Chem. Pharm. Bull. (Tokyo)* **1985**, *33*, 3113. doi:10.1248/CPB.33.3113

[25] M. E. C. Biffin, D. J. Brown, Q. N. Porter, *Tetrahedron Lett.* **1967**, *8*, 2029. doi:10.1016/S0040-4039(00)90779-2

[26] D. J. Brown, K. Shinozuka, *Aust. J. Chem.* **1980**, *33*, 1147. doi:10.1071/CH9801147

[27] D. J. Brown, K. Shinozuka, *Aust. J. Chem.* **1982**, *35*, 1263. doi:10.1071/CH9821263

[28] D. J. Brown, P. B. Gosh, *J. Chem. Soc. B* **1969**, 270. doi:10.1039/J29690000270

[29] D. J. Brown, B. T. England, J. M. Lyall, *J. Chem. Soc. C* **1966**, 226 and in the majority of his other publications. doi:10.1039/J39660000226

[30] J. Spanget-Larsen, R. Gleiter, W. Pfleiderer, D. J. Brown, *Chem. Ber.* **1986**, *119*, 1275. doi:10.1002/CBER.19861190416

[31] G. B. Barlin, D. J. Brown, M. D. Fenn, *Aust. J. Chem.* **1984**, *37*, 2391. doi:10.1071/CH9842391

[32] A. Albert, E. P. Serjeant, *The Determination of Ionization Constants*, 3rd edn **1984** (Chapman and Hall: London).

[33] D. D. Perrin, *Dissociation Constants of Organic Bases in Aqueous Solution* **1965**, and Supplement **1972** (Butterworths: London).

[34] E. P. Serjent, B. Dempsey, *Ionisation Constants of Organic Acids in Aqueous Solution* **1979** (Pergamon Press: Oxford).

[35] D. D. Perrin, *Ionisation Constants of Inorganic Acids and Bases in Aqueous Solution*, 2nd edn **1982** (Pergamon Press: Oxford).

[36] D. D. Perrin, B. Dempsey, E. P. Serjeant, *pKa Prediction for Organic Acids and Bases* **1981** (Chapman and Hall: London).

[37] D. J. Brown, W. C. Dunlap, G. W. Grigg, L. Danckwerts, T. Nagamatsu, *Aust. J. Chem.* **1978**, *31*, 397. doi:10.1071/CH9780397

[38] D. J. Brown, Y. Iwai, *Aust. J. Chem.* **1979**, *32*, 2727. doi:10.1071/CH9792727

[39] D. J. Brown, W. B. Cowden, G. W. Rigg, D. Kavulak, *Aust. J. Chem.* **1980**, *33*, 2291. doi:10.1071/CH9802291

[40] W. B. Cowden, S. J. Sullivan, D. J. Brown, *Aust. J. Chem.* **1985**, *38*, 1257. doi:10.1071/CH9851257

[41] D. J. Brown, W. B. Cowden, S.-B. Lan, K. Mori, *Aust. J. Chem.* **1984**, *37*, 155. doi:10.1071/CH9840155

[42] D. J. Brown, B. J. Cronin, S.-B. Lan, G. Nardo, *Aust. J. Chem.* **1985**, *38*, 825. doi:10.1071/CH9850825

[43] D. J. Brown, G. W. Grigg, *Med. Res. Rev.* **1982**, *2*, 193. doi:10.1002/MED.2610020205

[44] *The Pyrimidines* (with an essay by S. F. Mason), Vol. 16, 774 pp, 1962; *The Pyrimidines, Supplement I* (with a chapter by R. F. Evans and an essay by T. J. Batterham), Vol. 16.1, 896 pp, 1970; *The Pyrimidines, Supplement II* (with a chapter by R. F. Evans and essays by W. B. Cowden and M. D. Fenn), Vol. 16.2, 916 pp, 1985; *Fused Pyrimidines Part 3, Pteridines*, Vol. 24, 730 pp, 1988; *The Pyrimidines*, Second Edition, Vol. 52, 1509 pp, 1994; *The Quinazolines, Supplement I*, Vol. 55, 736 pp, 1996; *The Pyridazines, Supplement I*, Vol. 57, 687 pp, 2000; *The Pyrazines, Supplement I*, Vol. 58, 557 pp, 2002; *The Quinoxalines, Supplement II*, Vol. 61, 510 pp, 2004; *Cinnolines and Phthalazines, Supplement II*, Vol. 64, 481 pp, 2005; *The Naphthyridines*, Vol. 63, 423 pp, 2008; *Cumulative Index of Heterocyclic Systems* (Volumes 1–64: 1950–2008) Vol. 65, 399 pp, 2008.

[45] W. L. F. Armarego, *Pteridines* **1998**, *9*, 55. doi:10.1515/PTERIDINES.1998.9.2.55

[46] W. L. F. Armarego, D. Randles, P. Waring, *Med. Res. Rev.* **1984**, *4*, 267. doi:10.1002/MED.2610040302

[47] H. Taguchi, W. L. F. Armarego, *Med. Res. Rev.* **1998**, *18*, 43. doi:10.1002/(SICI)1098-1128(199801)18:1<43::AID-MED3>3.0.CO;2-S

[48] H. Taguchi, B. Paal, W. L. F. Armarego, *J. Chem. Soc., Perkin Trans. 1* **1997**, 303. doi:10.1039/A603533G

[49] See pages 88 and 123 in H.-P. Zhang, N. Yang, W.L.F. Armarego, *Pteridines* **1996**, *7*, doi:10.1515/PTERIDINES.1996.7.4.123

[50] H. Duewell, *Aust. J. Chem.* **2015**, *68*, 261. doi:10.1071/CH14587

[51] G. B. Barlin, *Aust. J. Chem.* **2015**, *68*, 260. doi:10.1071/CH14584

[52] J. Ma, F. Yoneda, T. Nagamatsu, *Aust. J. Chem.* **2015**, *68*, 203. doi:10.1071/CH14425

[53] T. Moriguchi, S. Hida, F. Yoneda, K. Shinozuka, *Aust. J. Chem.* **2015**, *68*, 256. doi:10.1071/CH14477

[54] K. Ienaga, Y. Toya, K. Nakajima, M. Tachikawa, *Aust. J. Chem.* **2015**, *68*, 248. doi:10.1071/CH14476

[55] H. Taguchi, D. Yanagisawa, S. Morikawa, K. Hirao, N. Shirai, I. Tooyama, *Aust. J. Chem.* **2015**, *68*, 224. doi:10.1071/CH14464
[56] B. Prek, U. Grošelj, M. Kasunič, S. Zupančič, J. Svete, B. Stanovnik, *Aust. J. Chem.* **2015**, *68*, 184. doi:10.1071/CH14349
[57] L. Strekowski, J. Zhang, J. Sączewski, E. Wolińska, *Aust. J. Chem.* **2015**, *68*, 196. doi:10.1071/CH14401
[58] Q. Yao, W. Pfleiderer, *Aust. J. Chem.* **2015**, *68*, 211. doi:10.1071/CH14421
[59] T. J. Delia, R. J. Hood, *Aust. J. Chem.* **2015**, *68*, 254. doi:10.1071/CH14416
[60] M. Ngu-Schwemlein, J. Dumond, L. Rudd, J.-H. Rigaud, *Aust. J. Chem.* **2015**, *68*, 218. doi:10.1071/CH14427
[61] W. J. Lording, A. D. Payne, T. N. Cayzer, M. S. Sherburn, M. N. Paddon-Row, *Aust. J. Chem.* **2015**, *68*, 230. doi:10.1071/CH14430
[62] S. Yang, M. G. Banwell, A. C. Willis, J. S. Ward, *Aust. J. Chem.* **2015**, *68*, 241. doi:10.1071/CH14520
[63] P. Waring, C. L. L. Chai, *Aust. J. Chem.* **2015**, *68*, 178. doi:10.1071/CH14482