BIOGRAPHICAL MEMOIRS

Frederick Ernest King. 2 May 1905 – 14 August 1999

Donald Whiting

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D. E. King

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2 May 1905 — 14 August 1999

Elected FRS 1954

BY DONALD WHITING

School of Chemistry, University of Nottingham, Nottingham NG7 2RD, UK

Frederick Ernest King (Freddie) was born in East London in 1905, studied chemistry in London and Oxford, achieved Fellowship of The Royal Society at the age of 49, and held the Jesse Boot Chair of Organic Chemistry at Nottingham from 1948 to 1955. He moved on to senior positions in industry as a scientific advisor, first to British Celanese and then to British Petroleum, retiring in 1970.

EARLY YEARS, 1905–29

The King family had for several generations been successful cabinet-makers in London. His father, Frederick King, left the business to join the London County Council education service, becoming a head teacher of evening institutes. Frederick senior and his wife, Elizabeth, had three children, of whom Freddie was the eldest. All the children had distinguished careers. His sister was Deputy Director of Education for Richmond; his younger brother became a consultant pathologist in the Folkestone hospital group.

In 1912 the King family moved from their home near London Fields to Higham Park, a rural village near Epping Forest. In due course the young Freddie entered Bancroft's school at Woodford Wells as a day boy and passed the General School Examination in 1921, matriculating as a student of the University of London. At the age of 16 he was accepted to read for the BSc (Hons) degree at the East London College, which later became Queen Mary College, London. Freddie recorded that he regretted the decision to enter university so young. Among the lectures he attended were those given by B.D. Shaw in the short period that Shaw was an assistant lecturer there. Shaw's popular style of lecturing was based around lively practical demonstrations (from which his famous 'Explosives' lecture developed), and when F.S. Kipping FRS offered him a 50% increase in salary he moved to Nottingham, where Freddie would meet him again.

Freddie learned to row, and coxed the college eight to victory in the London University Intercollegiate boat race. He graduated in 1924 with a class 2(i) degree, and was offered the opportunity to study for a PhD with the Head of Department, J.R. Partington, working in physical and inorganic chemistry. After gaining his doctorate in 1927, Freddie stayed on at East London College for three years more, first as a postdoctoral fellow, then as a junior lecturer. He was disappointed to find that he was expected to teach organic chemistry but to continue research in physical chemistry. However, Alexander Robertson (FRS 1941) joined the staff as senior lecturer in organic chemistry at this time, and encouraged Freddie's interests in this field.

Freddie's work with Partington gave rise to five publications, on diverse topics. In one paper (1)* the vapour pressures of chlorine dioxide over a range of temperatures were reported, two (2, 3) dealt with the common ion effect, measuring the solubilities of inorganic salts in ethanol, and another (4) examined sound velocities in different gases over a temperature range.

These studies required considerable experimental skills and accurate measurements, for example the production of anhydrous organic solvents, the use of inert atmospheres and the handling of chlorine dioxide, a red solid at -88 °C, variously reported as being unpredictably and violently explosive. Freddie also performed some collaborative work with Robertson on flavonoid chemistry. In one study (6) they established the structure of the benzpyrone **1**†, obtained synthetically but ambiguously from a natural deoxybenzoin. Deciding that he wished to develop his interest in organic chemistry, Freddie, with Robertson's support, applied for and was awarded a Ramsay Memorial Fellowship. Thus, in 1930 Freddie and his wife Rose were able to move to Oxford. Freddie had married his first wife, Rose Ellen Holyoak, in 1928, at Higham Parish Church, where Freddie sang in the choir and was for a time a lay reader.

Oxford, 1930–48

King took up his Ramsay Fellowship at Oriel College. Robert (later Sir Robert) Robinson FRS (PRS 1945–50) had recently arrived in Oxford as Wayneflete Professor and had gathered together a large research group. In 1931 King became a demonstrator at the Dyson Perrins Laboratory, and undertook research with Robinson. He wrote a second thesis in 1933, for his DPhil, obtained his MA in 1934 and was appointed University Lecturer and Demonstrator. He held the post of Lecturer in Organic Chemistry at Magdalen College from 1936 to 1943 and at Balliol College from 1937 to 1945.

By all accounts Freddie's years in Oxford, excluding the wartime, were in the main happy and stimulating. He and Rose had two daughters (born 1931 and 1933) and two sons (1936 and 1940). One of his students at Oxford during this period, Dr Brian Langdon, recalls that tutorials with Dr King were both a pleasure and an inspiration, and that he appeared as a most likeable and kind man, with a good sense of humour. His tutees took tea from time to time at his house in Norham Road. They met his wife and children, and Dr Langdon remembers these occasions as very happy ones, enjoyed and valued by his students.

Freddie had good health that continued throughout his long life and he was a very keen hill

* Numbers in this form refer to the bibliography at the end of the text.

† The chemical formulae in this memoir are drawn using modern conventions, but only the details of stereochemistry known at the time of publication have been included.

walker, tennis player, gardener and pianist (he had reached grade VI while at school), enthusiastic in everything he tackled. His son-in-law, Mr Ken Ferguson, a good tennis player himself, remembers that matches with Freddie (then twice his age) were evenly divided, and describes him as an urbane and civilized man.

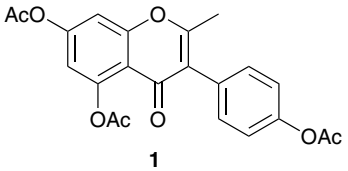
During the war, King's family was offered hospitality by the Warden of St Andrew's School, Delaware, USA. Freddie remained in the Dyson Perrins Laboratory in Oxford, pursuing some of his own work, but was also involved in Defence Research with the Ministry of Supply. One paper (18), on potential vesicants, was later published from the non-confidential aspects of this work. He and his family were reunited in 1944.

King's research work at Oxford was productive and he was awarded the DSc in 1946 and the Royal Society of Chemistry's Tilden Lectureship (20) in 1948. King hoped to make a permanent career in Oxford and was shortlisted for Fellowships of Balliol and Queens College in the late 1940s. However, he was not appointed to either post, and he believed that he was not strongly supported by Robinson. He therefore looked around for other opportunities. In 1948 the Jesse Boot Chair of Organic Chemistry at the University of Nottingham became vacant, after the departure of J.M. Gulland FRS (who had, coincidentally, preceded King as demonstrator at the Dyson Perrins in 1931). The appointments committee at Nottingham was advised by Sir Jack Drummond, Chairman of Boots, who was impressed by Freddie's research ideas in the area of bioactive compounds; and he was appointed to the chair.

Research at Oxford

King's research work with Robert Robinson focused on a natural product referred to as physostigmine (**2**) in Robinson's papers but as eserine in those of his Japanese competitors. Crude plant material containing this compound was used as an insecticide, and the pure material is now known as an inhibitor of acetylcholinesterase, to which it binds covalently. Robinson's group was engaged in the task of laboratory synthesis of physostigmine, and King published seven papers (8) with him in this area. His experience with Robinson exerted a profound effect on his future research. Physostigmine was a product from higher plants; it had important biological activity in animals; it contained saturated nitrogen-containing rings (heterocycles); and one of the tasks in synthesis (5) required the production of the phthalyl-protected amino-acid relative **3**. All these different topics were followed up in King's subsequent independent work.

The formation of saturated heterocycles was followed in a study (9) of the hydrogenation of papaverinol to form hydroxylaudanosines (**4**), alkaloids of the opium poppy group. Stereoisomers were formed, which the methodology of the day could not assign, and King realized that little was known about the geometry of heterocyclic systems. Pioneering investigations (11, 16) of the preparation of bicyclic heterocycles such as **5** and **6** in known *cis* or *trans* form were begun. A small contribution (10) with M.J.S. Dewar (FRS 1960) was to the chemistry of the aphrodisiac alkaloid yohimbine (**7**). A series of publications entitled 'Potential therapeutic agents' was started, based on the synthesis of relatives of various heterocyclic effect chemicals. These included quinoxalines (12) such as **8**, analogues (13) of the antimalarial mepacrine **9**, riboflavin (14) congeners **10** as antibacterials, products (17) simulating the antibiotic paludrine **11**, and benziminazoles (21) of type **12** structurally related to folic acid. Other investigations comprised those of artificial colorants, including the coeroxonones (7) such as **13**, a maroon dye; aminoalcohol derivatives such as **14** (15) resembling acetylcholine, and organoselenium heterocycles (19) of type **15**. From 1944 to 1949 King partici-



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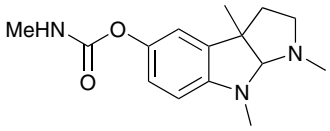

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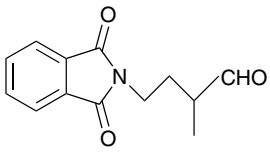

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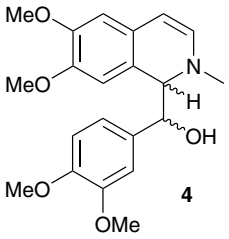

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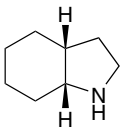

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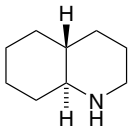

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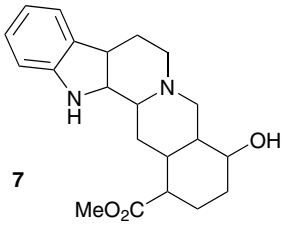

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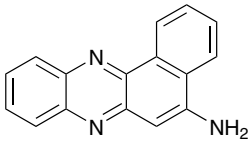

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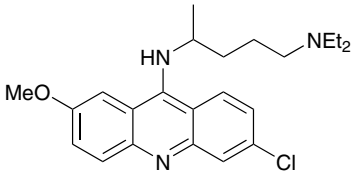

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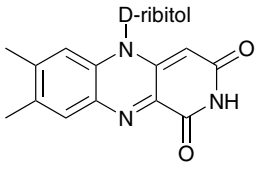
pated in research work on penicillin analogues organized by the Medical Research Council Committee for penicillin research.* This work engendered an interest in small nitrogen-containing rings shown in King's 1948 Tilden Lecture, which reviewed current knowledge of three- and four-membered heterocycles. In several papers he and his co-workers showed that several such compounds had been misassigned; thus substance **16**, supposedly with one four- and two six-membered rings, was actually **17**, with three six-membered rings (24).

* Collaborative publications from this period including F.E. King are listed in the bibliography of the Royal Society Biographical Memoir of Sir Ernst Chain by Sir Edward Abraham (*Biogr. Mems Fell. R. Soc. Lond.* **29**, 13–91 (1983)).



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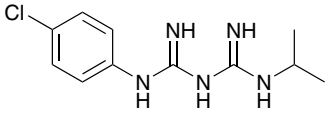

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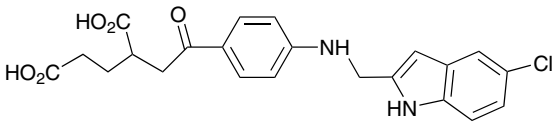

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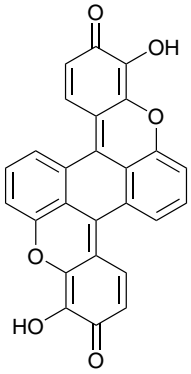

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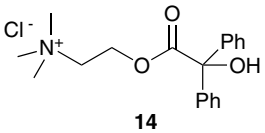

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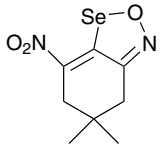

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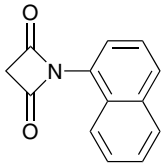

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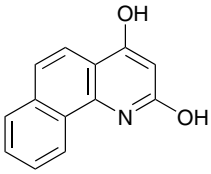

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Nottingham, 1948–55

In 1948 King moved to Nottingham as Sir Jesse Boot Professor of Chemistry. The department had a strong interest in organic chemistry but was seen to need diversification and strengthening. The newly appointed professor was determined to advance the research reputation of the department in all branches of chemistry, to increase the number of staff, and to expand the space and facilities available to chemistry to meet its commitments in teaching and research. King won respect for his leadership of the Department of Chemistry in these formative years of the new university. The number of staff rose to 16 by 1955. Three Readerships were created during these years, in inorganic, physical and pharmaceutical chemistry. Interestingly, three pharmaceutical chemists were based within chemistry.

The resignation in 1954 of the Reader in Physical Chemistry left the way clear for the appointment of D.D. Eley (FRS 1964), then Reader in Biophysical Chemistry in the University of Bristol, to the first Chair of Physical Chemistry at Nottingham. King persuaded the university to provide additional space to give him research facilities, albeit in temporary buildings.

The need for a new building to accommodate the Department of Chemistry had been recognized for some years. The cramped conditions of the existing buildings limited the number of departmental students and placed a major constraint upon the development of new areas of research. King had frequently drawn the Vice Chancellor's attention to the need to give priority to chemistry when planning for the expansion of sciences at Nottingham. Chemistry was popular both as a main honours subject and as a subsidiary subject. Before King left the university he had the satisfaction of knowing that plans for a new building to house the Department of Chemistry were well advanced, and that Basil Spence had been approached to design the building.

During the early 1950s most external support for research in the Department of Chemistry came from the Department of Scientific and Industrial Research, the Agricultural Research Council and other government bodies. Under King's leadership, all the various research groups within the department became active in pursuing industrial sponsorship for their work. His contacts with industrial firms resulted in collaborative research, for example with ICI, and with British Celanese Ltd whose staff contributed to the lecture programme in the Department of Chemistry.

King's ambitions for Nottingham and for his own research made him a hard taskmaster. Adopting a stiff public manner, he demanded a great deal from those with whom he worked, particularly his research students and junior lecturers. He was outspoken and direct in character, with a tendency to be forthright and brusque when criticizing his co-workers. All researchers were presented with a document, referred to as the 'King's Regulations', which covered a multitude of practices within the department. These included minimum acceptable working hours, maximum holidays, weekly bench cleaning, and smart laboratory coats. Tutorials could not be conducted during the hours normally reserved for teaching and laboratory work. Young staff found that they had to arrange to meet students in the evenings in the halls of residence, prior arrangement being insisted upon by wardens of women's halls lest the chaperone rules be broken. If King found a student in breach of these regulations, for example by not being at the bench when expected, or the bench not being properly polished at the regular Saturday morning inspection, he left a copy open on the bench with the appropriate regulation underlined. Living in a house adjacent to the campus, King was often in his office on Sunday mornings. A postgraduate of this period commented that Freddie was, although rather reserved and formal and not much given to small talk, quite pleasant and easy to get on with, and very helpful and supportive for those who worked diligently. The same man remarked that he never worked harder than in his three years with Freddie but that it was an immensely exhilarating and formative experience. Not surprisingly, Robert Robinson congratulated Freddie on the high level of productivity of his students, remarking that at Oxford he was unable to get so much work out of a student.

King's stiff exterior belied an inner kindness. At this period, the early 1950s, King occasionally invited his group to his home when he was most welcoming. One of his group got on well with Freddie until he married and took to leaving the laboratory around 5 p.m. Freddie complained about his absences, and relations soured from this time, once giving him a terrific

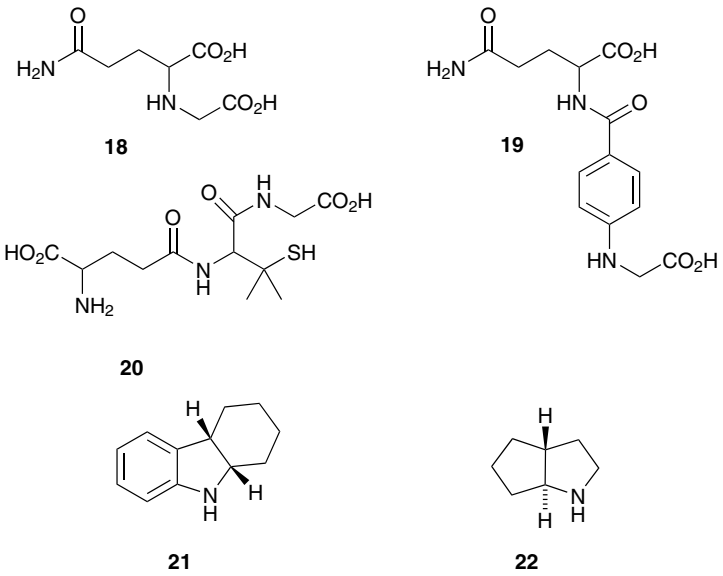
dressing down in the middle of the laboratory when he had not proofread a paper as quickly as required. The student resigned his demonstratorship, but when he found that he would then immediately be called up for National Service, Freddie not only told him he could withdraw his resignation but also made arrangements for an extension of his demonstratorship when the post formally ended.

King's ambitions for the expansion of the Chemistry Department at Nottingham brought him into conflict with the Registrar, with whom he had frequent rows. In one incident King instructed the chemistry workshop technicians to remove the door in the Trent Building labelled 'Chemistry' and hide it in the workshop. The next time the Registrar went to see him the discussion became a loud altercation, which could be heard throughout the area. When the Registrar stormed out of Freddie's office, with the latter still arguing, he suddenly found that he was standing in a departmental doorway bereft of a door. The resulting explosion caused the door to be rehung within the hour.

In 1955 King decided to leave Nottingham and academic chemistry, and take up the post of Scientific Advisor at British Celanese. His reasons for this decision can only be conjectured. Possible factors might perhaps include impatience with the delays over the new departmental building or the fact that advances in instrumentation meant that major new funding would be needed for new equipment, such as nuclear magnetic resonance and mass spectrometers. He also seems to have believed that his family would welcome a change of scene. It seems most likely that he felt the need for a new challenge, and when the opportunity arose with a company that he had good relations with, he took it.

Research at Nottingham

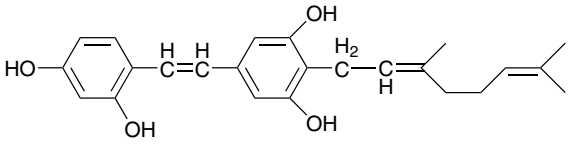
Once established at Nottingham, King continued to develop research that he had begun at Oxford. His fruitful partnership with Trevor J. King, who joined the staff from Oxford, was most significant in the establishment and running of a large research group. The seed of the early paper (5) on phthalyl protected aminoaldehydes for example **3**, grew into a fruitful exploration of the use of the phthalyl protecting group for amino acids, and the first reported application of this methodology (22) appeared in 1949 with the synthesis of glutamyl peptides such as **18**. This was followed by work on glutamyl tripeptides, for example **19**, related to folic acid, and **20**, an analogue of glutathione. The series on 'Reduced cyclic bases' continued with increasing stereochemical assurance, developing into studies of stereoselective synthesis, such as those of **21** and **22**, and of the geometry of elimination reactions. However, these endeavours were overshadowed by a major new line of work, namely the examination of natural products extracted from hardwoods, particularly those with notable resistance to fungal decay and to insect attack. It was believed that chemical defence compounds contributed to these important properties and that if such substances could be isolated they would offer valuable leads for development into marketable products. Freddie acknowledged that his family background in the craft uses of exotic timbers had aroused his interest in the area. This work was supported by the Forest Products Research Laboratory and by the Colonial Products Research Council. The constitution of the first of such extractives appeared (23) in 1950, and was that of chlorophorin (**23**) obtained from the durable timber iroko. Investigations of a wide range of timbers ensued, including English yew, Nigerian satinwood, muninga, opepe, acacia, ayan, wallaba, eucalyptus, rengas and lignum vitae. A wide range of constituents were isolated by the methods of the times. Chromatography was used, but without the aid of modern methods of fraction monitoring. The emphasis was heavily on crystalline compounds, because crystal-



lization was the only method of obtaining samples sufficiently pure for elemental analysis. Structure determination employed classical methods: characterization by chemical reactions, degradation, and unambiguous synthesis of fragments as final proof. Visible and ultraviolet spectra were reported in King's papers from the late 1940s on, but infrared measurements were not described in his work until the mid-1950s and were performed at Oxford, not at Nottingham. Proton magnetic resonance spectra and low-resolution mass spectra appeared in one or two of the late publications.

Many new compounds were discovered, belonging to most of the major classes of plant natural products. Examples, in chronological order, are the lignan isotaxiresinol **24** (25), the isoflavanone ferreirin **25** (26), the novel coumarinochromone distemonanthin **26** (27), the furoditerpene vouacapenic acid **27** (28), the catechin (−)-epiafzelin **28** (29), the leucoanthocyanidin melacacidin **29** (30), the chromenoxanthone jacareubin **30** (31), the diterpene ferruginol **31** (32) (the total synthesis of **31** was effected to demonstrate its constitution, which violated the isoprene rule for terpene structure), the triterpene cycloeucalenol **32** (33), the norlignan eusiderin **33** (34) (whose structure was not fully proven), the triterpene katonic acid **34** (35), the unusual alkaloid adifoline **35** (36) (for which only a partial structure could be elucidated), and the rare hydroxycoumaranone maesopsin **36** (37) (work performed at British Celanese). These products were of considerable academic interest, helping to establish the range and type of organic molecule formed in higher plants and enabling investigations of the pathways of plant secondary metabolism. Thus, the discovery of the flavan-3,4-diols proved to be the key to the understanding of the constitution and biosynthesis of the condensed tannins. However, none of these products exhibited biological activity of sufficient potency to merit development for agrochemical purposes.

Between 1948 and 1955 King published some 70 papers, several of which were written in collaboration with T.J. King. In recognition of these significant contributions to the field of natural products chemistry, King was elected to the Fellowship of The Royal Society in 1954. In 1955 he became an Honorary Fellow of Queen Mary College, London.



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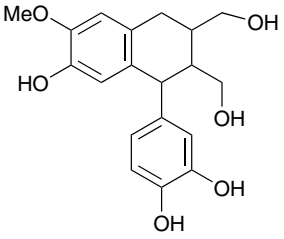

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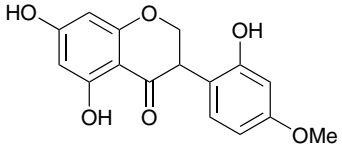

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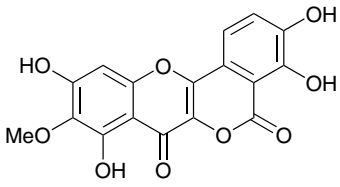

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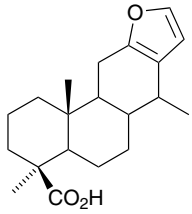

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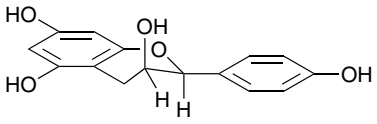

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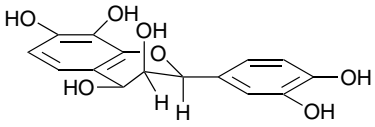

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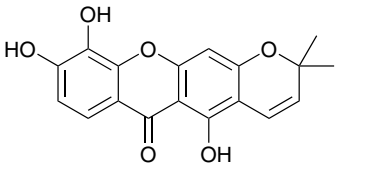
King's academic publications continued until 1965, by which time he and his co-workers had produced 146 papers, mostly in the *Journal of the Chemical Society*, *Nature* and *Chemistry and Industry.*

British Celanese, 1955–59

In 1955 King took up an appointment in industry as Research Director of British Celanese Ltd. In the early 1950s British Celanese was the leading UK manufacturer of acetate yarn and fibre. The company produced its own essential reagents, such as acetone and acetic anhydride, having set up an oil-cracking plant to produce propylene as a starting material. Celanese also had a new triacetate yarn, Tricel, and a nylon-6, Celon, in development. Furthermore, the company had ensured markets for their products through substantial investment in textile production and finishing, and in garment manufacture with a well-known underwear brand, Celanese. The group thus had a firm and sensible structure and must have seemed to have a sound future in 1955.

King led the Research Laboratory at Putteridge Bury near Luton, which was run as a com-



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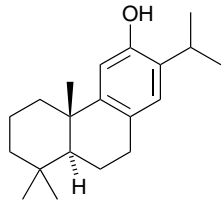

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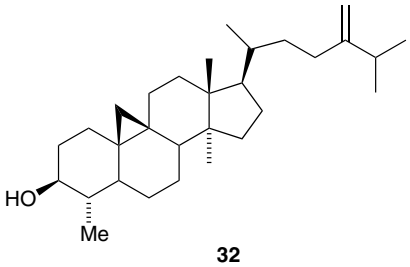

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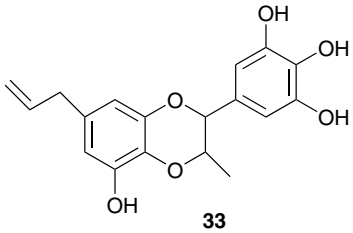

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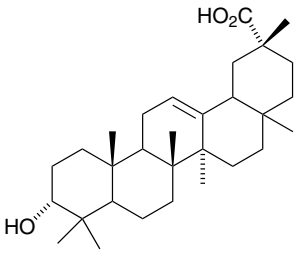

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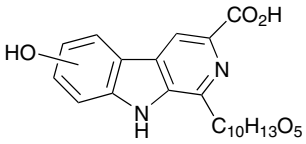

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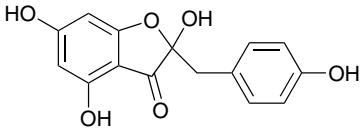

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plement to their production-oriented research at Spondon. He was in charge of research on problems of dyeing, processing and utilizing acetylcellulose fibres. Fibre development also extended to the melt-spinning of nylon-6, the production of cast and extruded film from secondary acetate and the provision of the necessary intermediates from petroleum thermal cracking products. Several patents, dealing with plasticizers and monomers, were filed during this period. As part of the job he toured Canada, the USA and Mexico gathering information on textile fibre processing.

In addition to the main company interests, he was able to set up a small group led by Dr J.W.W. Morgan to continue his work on hardwood extractives, and his collection of timbers was transferred to Putteridge Bury. Some students were able to register for PhDs during this work, although King's supervision became more distant, being performed by means of reports and occasional visits.

In the later part of the 1950s the synthetic fibre industry ran into worldwide difficulties. Through overproduction the profits from viscose rayon declined in the USA and Europe, and companies such as DuPont closed production. This recession began to hit the large Courtaulds Group hard, because viscose rayon was their major source of income. At the time Courtaulds was reliant on bought-in raw chemicals and had not extended its business either horizontally or vertically. The group then set about a major expansion, taking over or merging with many other companies in the UK and abroad. By 1964, 22 other businesses had been absorbed, including all the significant UK synthetic fibre manufacturers as well as operations in paint, steel cord, wood pulp, garments and plastics.

The merger with British Celanese in 1957–58 was one of the first of such operations. Courtaulds gave employment to only about 40% of British Celanese 'staff' (as opposed to 'operatives'), and the Putteridge Bury Laboratory was closed. Courtaulds' Research Director at that time was an ex-Cambridge mathematical physicist, Sir Alan Wilson FRS. Wilson's presence on the Board had ruffled feathers, and the Personnel Department had noted that the promotion of scientists to senior management positions was causing concern and resentment among other groups of specialists. Wilson himself made it clear that he did not want a Deputy Research Director. Under these circumstances it is perhaps not surprising that no satisfactory post was found for King within the Courtaulds Group, and he moved on to a new challenge with British Petroleum.

British Petroleum, 1959–70

In 1959 King joined BP's Refineries and Technical Department in London as Scientific Adviser; in 1960 this department was reorganized and King became a member of the Research and Technical Development Department; within this, he held a position on a special Research Policy Committee. He was chairman of the group covering Fundamental Research and Protein Projects and a member of the Technical Committee.

As Scientific Adviser, King carried the major scientific responsibility for the direction and co-ordination of work on the BP process for producing protein concentrate from petroleum fractions. He had special responsibilities in the areas of fundamental research projects in relation to university chemistry departments, including the awarding of research studentships and grants. Later he became closely concerned with various technical problems relating to sulphur recovery and new sources of power, and was made a director of Energy Conversion Ltd, a joint subsidiary company formed in 1961 concerned with fuel cells and metal–air batteries. He was part of teams visiting BP interests in Australia, Nigeria and Alaska.

BP's 'Protein from oil' programme had its origins in 1957 when its French Associate Company, Société Française des Pétroles BP (SFPBP) began microbiological research to try to solve the problem of removing sulphur from some types of crude oil. French researchers found that certain micro-organisms could feed on the waxes (long-chain paraffins) in crude oils, and because the wax in such oils was itself a problem, research on microbial dewaxing was pursued. Although a practical procedure, it was declared uneconomic unless a use could be found for the protein-rich biomass that was a by-product. The idea that this process could be used to produce protein as food from oil is generally credited to Alfred Champagnat, research director at SFPBP. Great enthusiasm for this project, which many believed might alleviate world malnutrition, swept through BP, and a pilot plant was set up at Lavera in France.

In 1963 BP's Board approved a new Research and Technical Development Group, including King, to set up a unit to work at Grangemouth. The team at Grangemouth worked on a somewhat different process from the Lavera one, and because of some difficulties in the Lavera plant it was decided to set up a new section, again including King, to coordinate the protein projects. BP's London management was cautious about the notion of using BP proteins for human consumption and, unlike the SFPBP's directors, preferred to concentrate on animal feedstuff. By 1965, several research laboratories had been set up and two process plants (Lavera and Grangemouth) were under development.

However, serious reservations about the viability of the protein projects were now being expressed within the company. The general manager of the Research and Technical Development Department doubted whether it would be economically viable to produce protein by the process. Freddie King, as Scientific Advisor, was of like mind on the economics, and also was dubious that farm animals, apart from broiler chicks, would thrive for their normal lifespan on diets fortified with yeast. After reading reports from the feeding trials in the Netherlands and from Lavera and Grangemouth, Freddie wrote that 'one cannot but feel serious anxiety for the future of the Protein Project'. However, with other companies around the world entering the field, BP decided to push on to produce the first commercial protein plant, and the Board approved plans to set up major outputs in both Grangemouth and Lavera in 1967–68. Eventually commercial sales of BP Protein marketed as Toprina began in the UK in 1971, and in France in 1972. BP then joined with the Italian state-owned business ANIC to form the Italproteine Company, to construct a plant in Sardinia capable of producing 100 000 tons of protein per year.

Freddie King retired in April 1970, when it seemed that Toprina production would come onstream in a major way. He would surely have followed the subsequent history of BP protein with interest. In brief it turned out that his economic doubts were justified. Capital costs were underestimated and members of the Organization of the Petroleum Exporting Countries (OPEC) almost quadrupled crude oil prices in 1973. Nevertheless, in view of other rising commodity costs, BP decided to pursue the Italproteine venture. By this time a rival Italian company, Liquichimica, had been set up to produce protein under licence from a Japanese group. However, both projects ran into severe problems, both environmental and political. Operation of the BP plant stopped in 1977, halted by concerns over microbiological pollution, and a year later BP protein operations were finally wound up.

In 1963 Freddie and Rose separated, and in 1969 Freddie married Dorothea Haines. He bought the 70-acre Glyde's Farm near Battle in 1966. After formal retirement in 1970 he worked as a consultant to BP for a year, and settled in East Sussex in 1971.

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The frontispiece photograph, taken by Elliott and Fry in 1954, is reproduced by courtesy of the National Portrait Gallery, London.

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