CHAPTER 12

THE ESTABLISHMENT OF CHEMISTRY WITHIN AUSTRALIAN SCIENCE—CONTRIBUTIONS FROM NEW SOUTH WALES

R. J. W. Le Fèvre,

"The utility of Pure Science cannot be tested in advance."

Science Reaches Australia

Beginnings and Backgrounds

A tablet fixed to a rock on Botany Bay bears an inscription which starts: "A.D. MDCCLXX. Under the auspices of British science, these shores were discovered by James Cook and Joseph Banks, the Columbus and Maecenas of their time. This spot once saw them ardent in the pursuit of knowledge. . . ." Thus is commemorated the moment at which modern Australian history began.

Great Britain gained Australia as a by-product of astronomical research. The Royal Society (of London) had been anxious to send an expedition to study the transit of Venus from the Pacific Ocean and had successfully interested the Admiralty in the project. The *Endeavour,* a bark of 370 tons, was provided, and Lieutenant James Cook appointed to command it. Cook's previous experience had been appropriate: he had conducted marine surveys around north-American coasts and had published in the *Phil. Trans.* an account of a solar eclipse observed from one of the Burgeo Islands near Cape Ray in Newfoundland; his skills as a navigator, and his qualities as a man, were highly assessed by his naval superiors.

Among those who sailed with Cook was Joseph Banks. The origins of the two men had been very different. Cook, born in 1728, was the son of a Yorkshire agricultural labourer; Banks, born in 1743, was the son of a wealthy landowner. Cook's formal schooling ceased when he was thirteen; Banks was educated successively at Harrow, Eton and Oxford, and on his twenty-first birthday found himself with ample means. At Eton, Banks had acquired a liking for botany, an interest he maintained through the Oxford years. Early in his majority, he visited Labrador and Newfoundland, bringing back a collection of plants and insects; in 1766 he was elected a Fellow of the Royal Society. Hearing of Cook's proposed expedition, he used influence to obtain governmental permission to join it.

So, on August 6, 1768, the *Endeavour,* with 85 persons on board, set out on a classic voyage which lasted, through perils and hardships, until July 13, 1771. Tahiti was reached on April 13, 1769, an observatory erected, and the necessary astronomical work performed. This done, Cook sailed in search of the great continent supposed to exist in the South Pacific. He cruised around the coasts of New Zealand for six months, and then proceeded on a course which brought him, on April 20, 1770, within sight of eastern Australia; eight days later, a landing was made at Botany Bay.

Cook first named the bay "Stingray Harbour", because of "the great quantity of this sort of fish found in this place . . ."; later, the relevant entry in his *Journal* was amended to "The great quantity of New Plants, etc., Mr. Banks and Dr. Solander collected in this place occasioned my giving it the name of *Botany Bay*". (Many of Banks' specimens are today back in Sydney, in the National Herbarium, to which they were presented in 1904 by the Trustees of the British Museum.) The *Endeavour* then continued up the east coast, rounded Cape York, and crossed Torres Strait to New Guinea. Repairs necessitated putting in to Batavia. A year later, Cook was back in Britain.

His reports stimulated curiosity and caused renewed speculation concerning undiscovered lands in southern latitudes; he was quickly appointed to lead a second expedition. In the *Resolution* he left Plymouth on July 13, 1772, and was away until July 30, 1775, again cruising mostly in the Pacific. No new continent was encountered. A third voyage, yet again to these regions, but with different objectives, started from the Nore on June 25, 1776; during this, on February 14, 1779, Cook was killed by natives on the shores of Hawaii.

His contributions to human welfare were not only through geography. The Royal Society elected Cook a Fellow in 1775, and in the following year awarded him the Copley Medal, citing his paper on "The Method taken for preserving the Health of the Crew of His Majesty's Ship, the *Resolution*", and noting that by using this method ". . . under the Divine Favour Captain Cook with a company of 118 men performed a voyage of three years and eighteen days, throughout all the climates from 52° North to 71° South, with the loss of only one man by a disease". Thereafter, the Admiralty ordered a supply of lemons in all ships of the British Navy, and scurvy disappeared.

The significance of Cook's explorations has been assessed by Trevelyan[1] in these words: "The fact that Cook claimed for the British Crown the coasts that he discovered in New Zealand and Australia, was not really as important as the fact that he brought them to the notice

[1] G. M. Trevelyan, "British History in the Nineteenth Century and After", Longmans, Green and Co., London, 1937, p. 55.

and knowledge of our navigators and statesmen. The French discoverers were hard on the same track, and the prize was still for the country that should send the first or the most effective settlers. The issue was decided by a grotesque event. Lord Sydney, the Home Secretary, persuaded Pitt that the felons whom it had so long been the custom to transport to the American colonies now lost, could be suitably disposed of at Botany Bay, about which Captain Cook had set people talking. There is no evidence that either Pitt or Sydney designed to build a new Britain in the Antipodes. If they had, they would scarcely have wished to lay the foundations in crime . . . Pitt helped to found Australia in a fit of absence of mind."

So, on May 13, 1787, Captain Arthur Phillip, in command of eleven vessels carrying 717 convicts and about 400 marines, sailors and officers, left Portsmouth. By January 18, 1788, this fleet reached Botany Bay, the shallowness and flat shores of which seemed unsuitable for the proposed settlement. A week later, Phillip moved his ships into Port Jackson—an inlet named but not explored by Cook eighteen years before. Dr. John White, Surgeon-General to the First Settlement, described[2] the new location as "without exception, the finest and most extensive harbour in the universe, and at the same time the most secure; being safe from all the winds that blow. It is divided into a great number of coves, to which his excellency has given different names. That on which the town is to be built, is called Sydney Cove".

In a short while, Dr. White ran out of oil of peppermint, which was much prized in those days as a specific for "gouty and cholicky pains and disorders arising from wind". White found an efficient substitute in the oil distilled from the leaves of a tree growing on the nearby shores; indeed, he considered it more efficaceous than the English oil, through being less pungent and more aromatic. The tree was, of course, a species of *Eucalyptus, E. piperita*; the oil was the first of many Australian essential oils, the investigation of which a century later would become one of the outstanding organo-chemical contributions to be made in Australia.

Apart from the distillation of potable spirits—not legalized until 1820—no other semi-chemical processes are mentioned in the early records. This is not surprising. The infant community was preoccupied with privation and internal disagreement. It was largely uneducated. In the thirty years after 1788, 15,794 male and female convicts had been transported to New South Wales;[3] they made poor farmers and

[2] J. White, "Journal of a Voyage to New South Wales, with Sixty-five Plates of Non descript Animals, Birds, Lizards, Serpents, Curious Cones of Trees and other Natural Productions", London, 1790.

[3] M. H. Ellis, "Lachlan Macquarie, His Life, Adventures, and Times", Angus and Robertson, Sydney and London, 2nd Edn., 1952.

artisans. Gradually, during Macquarie's Governorship, New South Wales "ceased to be a settlement and began to become a country". A few men with some technical abilities emerged. In 1815, James Dickson set up a steam engine to grind wheat, pulverize tanning bark, and saw timber at a mill in the Liverpool-George Street area. Twelve years later, in partnership with John Mackie, he added a "Steam Engine Brewery" and produced "potent ale" selling at one shilling and sixpence sterling per gallon. Francis Howard Greenway—a three-shillings-a-day convict—was designing public buildings and churches "which in the twentieth century enchant the modern architect". Matthew Hughes opened a school at Kissing Point in 1812; by 1817 Macquarie was able to review "two hundred and sixty boys and girls from the military and free schools". A native-born white race was rising.[4] Coal was being mined at Newcastle. Wool was well on the way to being the chief source of Australia's wealth.

Contemporary European Chemistry

As a science, the subject was only embryonic during Australia's first half-century. In Europe, the bare basic rules of chemical combination—despite the efforts of Richter, Proust, Berthollet, Wenzel, and Gay-Lussac, superposed on those of their predecessors Boyle, Black, Cavendish, Scheele, Priestly, and Lavoisier—did not become clear until Dalton's "New System of Chemical Philosophy" appeared in 1808 and stated one of the first great generalizations of science: the atomic theory.

Knowledge was growing. In 1789, Lavoisier listed 33 "elements" among which he included "Lumière", "Calorique", three radicals, "chaux", and four oxides; by 1826, Berzelius was able to list 50 true elements, each against the symbol used today. Improved methods of analysis, the discovery of benzene and many other important compounds of carbon, and the realization that chemistry could be useful to agriculture, medicine and industry, induced the multiplication of chemical facts faster than the then current theories could be modified to classify them. In retrospect therefore the period, especially where organic chemistry is concerned, appears very confused: a seeming continual flux of ideas and invention of terminologies.

Just after the mid-century, when complexity had reached a high degree, the introduction of the concept of valency caused a dramatic simplification. Although Frankland, Odling, Williamson, Couper, Gerhardt and others contributed to this development, it was Kekulé who in 1858 gave the clearest and most convincing account of the

[4] M. H. Ellis, "Lachlan Macquarie, His Life, Adventures, and Times", Angus and Robertson, Sydney and London, 2nd Edn., 1952.

matter; from him, too, in 1865-1866, came the proposal that benzene should be formulated as a ring of six carbon-hydrogen units.

Kekulé, who started as a *studiosus architecturae* at the University of Giessen but was influenced by the lectures and personality of Liebig so strongly that he quickly turned to chemistry, is justly honoured today for laying the foundations upon which modern knowledge of molecular architecture has grown. His creative ideas allowed many previously unmarshalled facts to fall into their proper places; they were consistent with demonstrations that molecules must be three-dimensional in character. No generalizations in chemistry have had more fruitful consequences than those relating to molecular structure.

Equipped for the first time in its history with an adequate basic theory, chemistry entered its "classical" period and expanded, through investigation and application, at an exponential rate unparalleled by any other subject. Kekulé made chemistry a science.

Colonial Science before 1850

The stirring of science in Europe had weak repercussions in Australia. "Upwards of thirty years have now elapsed, since the colony of New South Wales was established in one of the most interesting parts of the world—interesting as well from the novel and endless variety of its animal and vegetable productions, as from the wide and extending range for observation and experiment, which its soil and climate offer to the agriculturalist. Yet little has been done to awaken a spirit of research or excite a thirst for information amongst the colonists. . . . Be that as it may, however, this country affords an opportunity to an enlightened people, of putting into practice, with all the advantages of salubrity of climate and fertility of soil, the knowledge which has been obtained, by the experience of many ages, in every branch of agriculture, commerce and the useful arts; but in order to render that stock of information effective, we should be well acquainted with the present physical state of the country, its capabilities and resources; and here we are compelled to admit we are lamentably deficient. Yet we are of opinion that our ignorance arises in a great measure from the want of some nucleus, which might gather round it the many valuable facts that are floating about, and which, if collected and embodied in a proper shape, might be offered with advantage to the public. Existing circumstances call loudly for such a point of attraction: the spirit of enterprize is increasing and the tide of emigration is flowing rapidly towards this colony. To direct this spirit and assist this tide, would, we conceive, be performing a public service, which cannot be effected by individual exertion. It is therefore proposed to form a Society, for the purpose of collecting information with respect to the natural state, capabilities, productions, and resources of Australasia and the adjacent regions, and for the purpose of publishing, from time to time, such information as may be likely to benefit the world at large." With these words, on June 27 and July 4, 1821, Messrs. Bowman, Douglass, Field, Goulburn, Irvine, Oxley and Wollstonecraft became the original members of the Philosophical Society of Australasia.[5] A few months later, Major-General Sir Thomas Brisbane, K.C.B., arrived as Governor and accepted the office of President of the Society.

None of the founders was formally a scientist. Bowman and Douglass were medical men, Field was a judge in the supreme court of New South Wales, Goulburn and Irvine were army officers, Oxley a lieutenant, R.N., and Wollstonecraft a businessman. Many became landowners (e.g., Wollstonecraft obtained[6] a "grant of 524 acres, exclusive of rocks and sand, on the north shore of Port Jackson, and erected a small cottage called the Crows Nest from its commanding situation"). Sir Thomas Brisbane was an astronomer, anxious to establish an observatory in the new colony: this he did at his own expense near Parramatta,[7] engaging two assistants, Charles Rumker and James Dunlop. "The former had already attained a position as a good astronomer and mathematician; and the latter, though untrained, was young and enthusiastic, with great natural ability for mechanics." Among the first papers read before the Society was one by Rumker, "On the Astronomy of the Southern Hemisphere" (March 13, 1822); others dealt with ethnology, geology and geography; nothing that could be called "chemical" is mentioned in the records.

The "infant Society soon expired in the baneful atmosphere of distracted politics", according to the remarks of Judge Field. Precisely what happened is not clear.[8] The members were obviously wealthy (for failure to produce a paper the penalty was a fine of ten pounds, for non-attendance at a meeting, five shillings; no refreshment could be introduced, except tea and coffee, under penalty of five pounds—so stated Regulations I, V, and VII); they were not fully representative of all scientific activities then in the colony (e.g., Allan Cunningham, a botanist sent to Australia by Sir Joseph Banks, and who joined Oxley and King in various explorations, was not among them); perhaps their deliberations seemed insufficiently related to the practical needs of the country. At any rate, between 1823 and 1850 the Society was replaced by a succession of others, all explicitly formed to improve agriculture

[5] *J. Proc. Roy. Soc. N.S.W.*, 1921, 55, appendix.
[6] *J. Proc. Roy. Soc. N.S.W.*, 1921, 55, appendix.
[7] *J. Proc. Roy. Soc. N.S.W.*, 1921, 55, appendix.
[8] J. H. Maiden, "A Contribution to a History of the Royal Society of New South Wales", *J. Proc. Roy. Soc. N.S.W.*, 1918, 52, 215.

or horticulture. Under Vice-Regal Patrons or Presidents, these achieved reasonably large memberships. In 1850 the old Society was resuscitated as the Australian Philosophical Society; it was reconstituted in 1855 as the Philosophical Society of New South Wales, and finally, on December 12, 1866, became the Royal Society of New South Wales, following receipt of the Queen's assent to the use of the title on the previous November 15.

Looking back over the minutes of these Societies reveals no paper or discussion on any matter directly or indirectly chemical, until well into the mid-century. Yet it is difficult to believe that among the colonists there were not some who had had contact with European chemical discovery and progress during the early eighteen hundreds. The census of 1836 showed 77,096 people to be living along the east coast from Wilson's Promontory to Cape York; it also recorded over 3,000,000 sheep in the same area. Evidently major efforts were pastoral.

Among the few manufacturing processes started was one to refine sugar " in the village of Canterbury, within five miles and a half from Sydney". In 1842 the Australasian Sugar Company announced[9] that it intended "to carry on the Trade or Business of purchasing and refining raw sugar, the sale of sugar, the sale of Molasses, of the distillation of such molasses into spirits, the manufacture of Animal Charcoal, Ivory Black, Soda, Sal ammoniac, Black Ink and such other business connected with the general objects of the company as the Directors shall think fit". Production of sugar began in September, 1842. A year later, Edward Knox became the manager; he remained with the firm through its transformation on January 1, 1855, into the Colonial Sugar Refining Company, which today is Australia's oldest large-scale manufacturing company.

Initially, methods were empirical. Knox described himself as "only a theorist in sugar boiling"; he knew that "There was no book on sugar analysis in the English language", and that success in his new ventures would require mastery by trial and error of the technicalities of milling and the mysteries of agriculture. Not until 1879 did the Company add a chemist to its staff; nevertheless by doing so it became one of the first cane sugar manufacturers in the world to apply the science of chemistry to factory processes.[10]

The production, by simple methods, of other common requirements, also began in the 40's. In 1843 it had been suggested that surplus stock should be boiled down for tallow. Records show that, by 1848, there were in N.S.W. 223 flour mills, 2 distilleries, 51

[9] "South Pacific Enterprise", ed. A. G. Lowndes, Angus and Robertson, Sydney, 1956.

[10] "South Pacific Enterprise", ed. A. G. Lowndes, Angus and Robertson, Sydney, 1956.

breweries, 30 soap and candle works, 62 tanneries, 27 foundries, 8 potteries, 2 sugar refineries, 7 rope factories, 5 salt works, and 4 hat manufacturers. The gold discoveries of the 1850's caused a migration of labour to the diggings, thus temporarily depleting the force available for the undertakings just mentioned. However, through gold, Australia entered a period of economic expansion and accelerated immigration (more than 601,000 persons arriving during the decade 1850-1860, and of these some 138,000 settling in New South Wales). By 1860 the population of the whole country had passed 1·14 million.

The earliest "heavy chemical" industry seems to have been the making of sulphuric and nitric acids by the Elliott brothers, in Sydney, in 1862; this grew roughly in parallel with the growth of agriculture. The first municipal gasworks in New South Wales was established at Bega around 1885, but no serious attempts to utilize coal-tar as a raw material were made for many years (in fact, not until the 1930's, when Timbrols of Sydney initiated such work).

Chemistry Recognized in Australia

Foundation of the University of Sydney

In our colonial history, no band of men has displayed more foresight and confidence in the future than the group which worked to establish the University of Sydney. On September 6, 1849, Mr. W. C. Wentworth moved in the Legislative Council "That a Select Committee be appointed to enquire into . . . and report upon the best means of instituting an University for the promotion of literature and science, to be endowed at the public expense". The motion was approved. The Committee consisted of W. C. Wentworth, E. Deas-Thomson (Colonial Secretary), J. H. Plunkett (Attorney-General), C. Cowper, R. Lowe (afterwards Lord Sherbrooke), C. Nicholson (Speaker), R. Nichols and J. Macarthur. It presented its report on the twenty-first of the same month.

"Considering the rapid progress which the Australian Colonies have made of late years and still continue to make in population, wealth, and revenue, and that upwards of sixty-one years have now elapsed since the first of these Colonies was planted, your Committee feel persuaded that there cannot exist any diversity of opinion as to the policy of founding without any further delay upon a liberal and comprehensive basis, a University which shall be accessible to all classes, and to all collegiate or academical institutions which shall seek its affiliation." The report suggested that five Professors should be appointed initially. These were to be:[11] (1) A Professor of Classics

[11] H. E. Barff, "A Short Historical Account of the University of Sydney", Angus and Robertson Sydney, 1902.

and Mathematics, who would also be Principal of the University, at a salary of £800 per annum, (2) a Professor of Chemistry at £400 per annum, (3) a Professor of Natural History, including the Animal, Vegetable and Mineral Kingdom, at £400 per annum, and (5) a Professor of Anatomy, Physiology and Medicine, at £300 per annum; the salaries proposed were to be supplemented by the whole of the class fees of the students attending the lectures. Subsequent Chairs in Modern History, Political Economy and Modern Languages were also envisaged.

On October 2, 1849, a "Bill to incorporate and endow the University of Sydney" was introduced into the Legislative Council and read for the first time; the following day Wentworth successfully moved the second reading.

However, when the Bill was considered in Committee, a difficulty arose over a clause containing the names of members of the first Senate. In particular, objection was taken to the inclusion of Dr. William Bland who, having killed a naval officer in a duel, was in Australia as a permanent exile; the Bill as it stood would admit of the appointment of convicts to the Senate. Further criticisms concerned religious matters and Wentworth's proposal to exclude clergymen from all share in the management of the institution.

A revised Bill was approved during August and September, 1850; it received the assent of the Governor, Sir Charles Fitz-Roy, on October 1, 1850. A Senate, including persons in holy orders, was appointed by proclamation three months later. Charles Nicholson, Speaker of the Legislative Council, was elected as Vice-Provost. Barff comments:[12] "While Wentworth is recognized as the University's founder, it was the untiring energy of Nicholson which placed it upon its firm base."

Selection of Foundation Professors

The 1849 plans were reduced, and only Professors of Classics, Mathematics and Chemistry and Experimental Physics were sought first. Letters were accordingly despatched during June, 1851, to the following advisers in England: G. B. Airy, Astronomer Royal, Sir J. F. W. Herschell, Professor Malden, of University College, London, and Henry Denison, Fellow of All Souls College, Oxford.

Nicholson, in an eloquent address delivered on the occasion of the Inauguration Ceremony of the University, October 11, 1852, gave many details of the early steps. After mentioning the formation of a Senate with sixteen Fellows, he said: "No sooner had the Fellows

[12] H. E. Barff, "A Short Historical Account of the University of Sydney", Angus and Robertson, Sydney, 1902.

become invested with the important and responsible functions entrusted to them, than they proceeded to the establishment of Chairs in those several branches of literature and science, which are considered of fundamental importance in every system of academic training. . . . To secure the services of able and accomplished teachers was an object of earnest solicitude on the part of the Senate. After much and careful reflection, they resolved to entrust the selection of their first Professors to a committee of gentlemen in England. . . . The trust and duty imposed upon distinguished individuals were undertaken, and have been discharged, with a zeal and cordiality that demand our most grateful acknowledgement."

Among the sixty-odd candidates who came forward, thirteen were for the Chair of Chemistry and Experimental Physics. The Minutes of Marischal College, Aberdeen, Scotland,[13] record that in November, 1851, "the Senatus Academicus of Marischal College and University find that John Smith, A.M. and M.D. of this University, greatly distinguished himself when a student in the Faculty of Arts, gaining various prizes, among others the highest in Natural History, Mathematics and Natural Philosophy; that he distinguished himself similarly in the Faculty of Medicine and that he had been much devoted to the science of Chemistry and analytical researches therein; also that he has taught here the classes of Chemistry and Experimental Chemistry for upwards of four years, as substitute for Dr. Clark, whose state of health has prevented him from discharging the duties in person; that he has conducted these classes with the highest approbation of the Members of the Senatus and of the public; that he has discharged the duties of the Fordyce Lectureship in Agriculture with like success; and that, as a public teacher, he maintained proper order in large classes without apparent effort and communicates knowledge with uncommon ease and clearness. The Senatus therefore unanimously resolve to recommend him as being in their opinion qualified for the Professorship of Chemistry and Experimental Philosophy about to be established in Australia, and order an extract of this Minute to be given to him."

Smith was ultimately appointed. He arrived in Sydney during September, 1852, a few months after his colleagues Woolley and Pell, the Professors of Classics and Mathematics respectively.

John Smith, First Professor of Chemistry in Australia

Birth and Training

John Smith, the son of Roderick Smith, blacksmith, of the parish of Peterculter, Aberdeenshire, was born on December 12, 1821. His

[13] A. Findlay, "The Teaching of Chemistry in the Universities of Aberdeen", Aberdeen Univ. Press, 1935.

subsequent career testifies to the educational system and opportunities then available in Scotland. He entered Marischal College as a student in 1839, undertook courses in Arts and Medicine simultaneously, graduated as Master of Arts (with "Honourable Distinction") in 1843, and as Doctor of Medicine in 1844. During 1847 he appears to have visited Australia while serving as a surgeon on a merchant vessel—a voyage undertaken for the sake of his health. On returning to Scotland, he was appointed Assistant to Professor Thomas Clark (the deviser of the standard method for measuring the hardness of water by the soap test, the patenter of a process for removing temporary hardness by the addition of slaked lime to hard waters, and evidently a recognized British expert on water purification[14]); Smith, in fact, conducted Clark's chemical classes single-handed for nearly five years.

When Smith reached Sydney, a quantity of "philosophical equipment" selected by him had already been received;[15] he immediately began work in basement rooms of what is now the Sydney Grammar School, alongside Hyde Park.

The infant University formally started on October 11, 1852, with 24 matriculated students. It offered only two degrees, B.A., and M.A. For the former, seven subjects were to be taken: Greek, Latin, Mathematics, Natural Philosophy, Chemistry, Experimental Physics, and Logic. On October 18, the *Sydney Morning Herald* notified its readers as follows: "University of Sydney. Morning classes of CHEMISTRY. The Lectures on Chemistry will be given every morning (except Saturday) from 8.30 to 9.30 a.m., and will commence on Wednesday, the 20th instant. No evening classes of chemistry will be formed at present. W. Louis Hutton, Registrar."

Smith's Courses

As to the contents in detail of Smith's initial courses, there is no direct information extant. The letter addressed to the English Selection Committee had said that "in Chemistry the course of the University of Edinburgh or of King's College, or University College, London, was to be copied", and in Experimental Philosophy that "adopted by the Plumian Professor at Cambridge" was to serve as a model, but the lectures were also to include "those subjects which belong exclusively to other Chairs, such as the Jacksonian at Cambridge".

Some evidence on the courses actually given is provided by early examination papers. The University Calendar for 1857 is notable

[14] A. Findlay, "The Teaching of Chemistry in the Universities of Aberdeen", Aberdeen Univ. Press, 1935.

[15] H. E. Barff, "A Short Historical Account of the University of Sydney", Angus and Robertson, Sydney, 1902.

because as well as recording the awarding of the first seven degrees, it also prints the 1856 B.A. Degree questions in Chemistry. These were:

1. What distinction may be drawn between the solution of a substance in water, and the combination of a substance with water?
2. What classification may be made, for practical purposes, of the solid matters usually found dissolved in natural waters?
3. How may sulphuric acid be detected in soluble and insoluble compounds?
4. State the leading characters of chlorine gas?
5. When, where, and by whom, was gas-lighting first applied on a large scale?
6. What objection is there to the terms "combustible" and "supporter of combustion"? Cite an experiment to show that the distinction implied in those terms is not essential.
7. Give a diagram, with atomic weights, to illustrate the preparation of hydrochloric acid from common salt and sulphuric acid?
8. Write the formula of crystallized Epsom salts. How may Epsom salts be readily distinguished from oxalic acid, the external appearance being alike?
9. How may corrosive sublimate be detected in an organic mixture?
10. State some objections to the common theory of the constitution of salts and acids.
11. When isomorphous salts are dissolved together, in what manner do they crystallize?
12. What is the only constant and essential constituent of organic compounds?
13. Write the formula of cyanogen; and state how it is best prepared.
14. How may urea be formed artificially?
15. How is the vinous fermentation induced in sugar?
16. What acids are produced in the saponification of butter?
17. Describe the preparation of caffeine from raw coffee berries. What is supposed to be the chief physiological action of caffeine?
18. Describe the origin and properties of India Rubber and Gutta Percha.

Such a paper provokes what, after all, is a reasonable supposition: that Smith's courses were based upon those he had previously given for Clark in Aberdeen. Findlay[16] says of Clark that he "had essentially a practical turn of mind and was more interested in facts and in the practical applications of facts than in scientific theory or the systematising of facts. . . . Instead of commencing with the generalities of the atomic theory, he described in detail a few of the leading elements—as oxygen, hydrogen, carbon, sulphur, stating, as matter of fact the proportions of each in the several compounds, water, carbonic acid, etc., without making any references to the theory of combination. He next took up the atomic theory, and expounded it minutely, showing how far it was hypothetical, and how far an expression of experimental truth. Then followed the usual detail of the elements and their compounds, interspersed with discussions of leading points, as the constitution of the salts and acids, the theory of muriatic acid, the theory of the prussiates, etc. He devoted occasional lectures to leading processes in the arts, as the manufacture of coal-gas. . . . There was what many parties considered a want of order in his course. . . . He rather selected important and typical bodies, making them the representative of general classes and doctrines. This was especially his way with Organic Chemistry, under which he merely adverted to a few important substances. Neither was he systematic in dealing with the chemistry of drugs: a few substances that he had thoroughly mastered being all that he took notice of . . . he disliked the empty vagueness often disguised under a systematic array, and preferred the minute and thorough investigation of single and isolated facts. . .".

The early calendars show time-tables requiring Smith to lecture to undergraduates on a daily basis. He appears to have found time also to serve the general public outside the University. *The Sydney Morning Herald* of May 17, 1853, announced that "Dr. Smith intends to give a short course of lectures (say nine or ten) with a view to explaining some of the leading principles of chemical science. The chemical substances described will be chiefly those found in air and water. The lectures will be given on Mondays, Wednesdays and Fridays at 4 o'clock in the afternoon . . . and they will be open to ladies as well as gentlemen".

Smith's inaugural teaching was evidently not only theoretical. The old Sydney College formally became the Grammar School of today by an Act of the Legislature of New South Wales dated December 2, 1854, but the School did not open until 1857, and even then did not have full

[16] A. Findlay, "The Teaching of Chemistry in the Universities of Aberdeen", Aberdeen Univ. Press, 1935.

possession of the Hyde Park premises "as two of the four downstairs rooms were still cluttered up with chemical apparatus belonging to the University".

Intended Relationship of Grammar School and University

Smith and his two fellow Professors were among the first Trustees of the new School[17]—a School "begotten to be a kind of younger sister of the University" and imagined in Parkes' petition of October, 1854, as "a nursery provided for our University, a model afforded to other Schools and a new stimulus given to our progress in all that constitutes intellectual, moral and national greatness".

The preamble to the Act of 1854 setting up the School used words[18] parallel to those which, in 1850, had explained the reasons for a University: ". . . it is deemed expedient for the better advancement of religion and morality and the promotion of useful knowledge to establish in Sydney a public school for conferring on all classes and denominations of Her Majesty's subjects resident in the Colony of New South Wales without any distinction whatsoever the advantages of a regular and liberal course of education . . .". Smith, a product of Scottish education, would not have regarded his trusteeship as a sinecure. In 1853, he had joined the Board of National Education, upon which he remained, until its dissolution in 1866, as[19] a "zealous promoter of public elementary education". After the Public Schools Act of 1866 he was appointed to the Council of Education (which replaced the Board) and was, for a number of years, its President.

Foresightedness of Contemporary Educational Developments

In retrospect, all those who promoted these mid-century movements deserve our profound admiration. "The University was established somewhat in advance of a practical need of it" said Merewether,[20] the third Chancellor, who was convinced "that the attention of the Senate should be directed, not to present requirements, but to preparations for a great future". The word "somewhat" has the quality of understatement! If one remembers that the University of Sydney was founded at a time when the population of the area it was to serve was not more than 187,000, when some five years had still to elapse before the first Australian railway was opened, when the final abolition of transportation was occurring, or when payable gold was being dis-

[17] "The Sydneian", Centenary Number, Sydney Grammar School, 1957.
[18] "The Sydneian", Centenary Number, Sydney Grammar School, 1957.
[19] J. H. Heaton, "Australian Dictionary of Dates and Men of the Time", George Robertson, Sydney, 1879, 186.
[20] H. E. Barff, "A Short Historical Account of the University of Sydney", Angus and Robertson, Sydney, 1902.

covered near Bathurst, one can see that in no way was the move for a University a *response* to the type of industrial or commercial necessity which might have been felt 20 or 30 years later. Nor could it have been to provide a "University apex" to a well-organized system of general education, which cannot be said to have come into existence much before 1880, the date of Parkes' Public Instruction Act. Actually, the illiteracy around 1850 must have been considerable. In 1844, about one half of the children of school age in the State received no schooling; even a decade later, in 1854, a special Commission, after visiting the 202 schools in operation in the colony, reported[21] that few were worthy of the name.

It was against such a background that Dr. Woolley, during the University Inauguration Ceremony,[22] held on October 11, 1852, in the large hall of the Sydney College, invited those present to "meditate the erection, not of a frail and perishable theatre for the amusement of the multitude, but of a monument to endure throughout all generations".

University Acquires Permanent Site and Buildings

Fortunately, Merewether was Vice-Chancellor from 1854 to 1862 when the questions of a permanent site and buildings for the University came up for discussion. How he applied his doctrine "Magnis magna para" to both the Colonial Secretary and to the "prospectively inadequate" first plans is quoted *verbatim* by Barff,[23] pp. 69-70.

As a result, the Government allotted 128 acres of land adjoining the Victoria Park and sanctioned a grant of fifty thousand pounds "for the erection of a suitable building, on the condition that not more than ten thousand pounds should be expended in any one year". Edmund Blacket, well known for St. Andrew's Cathedral, St. John's Church in Glebe, St. Paul's College, and much else in the colony, became the architect. The style selected was "Tudor perpendicular Gothic", and the materials were to have been brick with stone facings. However, it was found that Sydney clay would not make bricks of a suitable colour, so[24] "after due consideration, the choice fell upon the stone of the Pyrmont quarries, which has provided Sydney with so many of its handsome edifices".

[21] "An Outline of the History of Public Education in New South Wales", issued by the Department of Education, Sydney, April, 1948.
[22] H. E. Barff, "A Short Historical Account of the University of Sydney", Angus and Robertson, Sydney, 1902.
[23] H. E. Barff, "A Short Historical Account of the University of Sydney", Angus and Robertson, Sydney, 1902.
[24] H. E. Barff, "A Short Historical Account of the University of Sydney", Angus and Robertson, Sydney, 1902.

Work began in 1855. By 1860 the first section of the main building was complete, and ground-floor space at the southern end had been fitted out by Smith as a laboratory and classroom. Virtually the whole of Smith's subsequent teaching in the University was conducted in this accommodation.

Smith as a Photographer

Part of the "philosophical equipment" brought out by Smith must have been apparatus for photography. His knowledge of the then new art was most probably acquired from Andrew Fyfe, who had been responsible for chemistry in King's College, Aberdeen, the sister establishment to Marischal College, during Smith's membership of the last-named. Fyfe "although of no great eminence as a chemist" took an interest in photographic processes and had *inter alia* devised a process whereby paper coated with silver phosphate could yield positive or negative prints.[25] Around 1850, the techniques of photography were improving rapidly, and a great step forward was the introduction, by Archer and Fry, of collodion as a medium by which light-sensitive silver salts could be attached to glass plates prior to exposure, while still moist, in the camera. Smith evidently used this "wet-plate" method, and was a skilled operator of it. Several hundred high quality negatives produced by him are now in the University archives. They cover a wide range of subjects — scenes on the goldfields, family groups, harbour views, portraits, etc.—and include a series dealing with the construction of the university buildings. As Macmillan says:[26] they "must rate as the most important collection of early photographic material so far discovered in this country, and one of the few collections of such material extant anywhere in the world. . . . From them an amazingly realistic and detailed picture of colonial life in the 1850's can be pieced together . . . of life in a bustling and formative decade". To this life, Smith was an active recruit.

Smith's Overseas Leaves

Smith's training and an important part of his adult life had been in a period when Chemistry was a mass of factual knowledge scarcely connected by any rational theories whatsoever. He took up his Professorship just before the subject began rapid development consequent upon the logical and simplifying generalizations made possible by new

[25] A. Findlay, "The Teaching of Chemistry in the Universities of Aberdeen", Aberdeen Univ. Press, 1935.

[26] D. S. Macmillan, "Professor John Smith, and the Beginnings of Photography in Australia", *Proc. Roy. Austr. Chem. Inst.*, 1959, 26, 343, cf. also K. Burke, "Early Photographic Processes and the John Smith Collection", *loc. cit.*, p. 354.

ideas of valency and molecular structure. Courses appropriate to the field as it was in 1852 would be out-of-date a decade later. Smith himself realized this.

At their meetings during September, 1860, the University Senate discussed two letters from Professor Smith in which application was made for leave of absence. According to the minutes, the first of these, after adverting to considerations of health and other private reasons for his desire to revisit England, pointed out that the progress in the "Art of Chemistry can be learned from books to only a trifling extent", that he "feels himself getting behind", and that he is "very desirous of visiting again the principal laboratories of Europe, and of enjoying some personal intercourse with their eminent conductors". He mentioned also that the Chemical Department of the University is in want of apparatus, to procure which £300 might be saved out of his emoluments during his absence, and that he could with great advantage make the selection himself in London and Paris. On these grounds he considered that his temporary absence would be the means of increasing his own future usefulness, and be of advantage in other respects to the University. Further, he alluded to the fact that under the established arrangements, none but chemical lectures were to be delivered in 1861, so that selection of a substitute for him would be thereby facilitated.

In the second letter, Professor Smith nominated a Mr. Charles Watt as a substitute, pronouncing him to be a gentleman of undoubted ability and zeal as respects the discharge of the duties proposed to be entrusted to him, and referred to the Rev. Chas. Kemp's testimonial on Mr. Watt's habits and character . . . Mr. Watt, he said, would undertake the duties for the year for a sum of £350.

After long and careful deliberation on the proposals contained in these letters, the Senate came to the conclusion that under the circumstances and on the terms specified, Professor Smith's visit to Europe would be conducive to the interests of the University, and it was accordingly moved by Mr. Allwood, seconded by the Vice Provost, and carried, that leave of absence from the end of Michaelmas term in 1860 to the commencement of Lent term in 1862 be granted to Professor Smith upon his furnishing to the Senate a written statement from Mr. Watt declaring his willingness to act under the conditions laid down by Smith, and upon the receipt of a satisfactory certificate from the Rev. Mr. Kemp (of Newtown) as to Mr. Watt's moral character. These documents were produced and approved when the Senate met on September 26.

Concerning Mr. Charles Watt, little is known. The originals of Smith's letter to the Senate and of the Kemp testimonial are lost. Watt had been elected to membership of the Philosophical Society of N.S.W. on July 13, 1859, and at once joined, by invitation, its Microscopical Group, the existence of which was due largely to the personal interest taken by Sir William Denison in microscopy. (This group met from time to time at Government House until December, 1860, when Sir William handed over the Governor-Generalship to Sir John Young.) The University records show that from October, 1861, to November, 1863, Watt was also appointed Curator of the Museum (housing the Etruscan, Greek, Roman and Egyptian antiquities collected and donated by Sir Charles Nicholson, the Chancellor, from 1854-1862) at a salary of £25 per year.

Smith left Sydney late in 1860. On August 15 he had spoken "on the Adelong Quartz Reefs" and had demonstrated specimens of Mundic quartz to the 36th Monthly Meeting of the Philosophical Society of N.S.W.; he is not recorded as speaking again until the 66th Meeting, on August 17, 1864, when he discussed "the probable reasons that led Fahrenheit to the adoption of his peculiar thermometric scale". However, he had already been back some time, for he is named in Senate Minutes as present on August 6, 1862, and the date when payments to his substitute ceased is given as the 17th of the following month.

Subsequently, Smith twice requested and was granted overseas leave; he was abroad during 1871-1872 and 1881-1883. That he liked travel is clear. By the end of his life he had visited most of the countries *en route* from Australia to Britain, eastwards and westwards. He published privately two volumes of "Wayfaring Notes", which described his journeys and the places through which he passed, but these contain no references to his chemical contacts and provide[27] "very little material on Smith as a man".

Watt was again named as substitute for Smith in 1871; in 1881 the Rev. Joseph Campbell was temporarily appointed.

Smith's Courses after 1862

Whether overseas travel, and intercourse with eminent conductors of European laboratories, quickly changed Smith's courses is doubtful. The B.A. examination paper set during December, 1867, was as follows:

1. Describe an experiment to prove that when a candle burns the materials are not annihilated.

[27] D. S. Macmillan, "Professor John Smith, and the Beginnings of Photography in Australia", *Proc. Roy. Austr. Chem. Inst.*, 1959, 26, 343, cf. also K. Burke, "Early Photographic Processes and the John Smith Collection", *loc. cit.*, p. 354.

2. It is required to form a cubic foot of steam at 212° F. by the combination of oxygen and hydrogen: how much chlorate of potash will furnish the requisite amount of oxygen, and how much zinc must be dissolved in dilute sulphuric acid to furnish the hydrogen? Give calculations in full.

3. Describe the most exact methods of determining the composition of water by bulk and by weight.

4. State the average composition of atmospheric air. What reasons have we for believing that the oxygen and nitrogen are only mechanically mixed and not chemically combined?

5. What are believed to be the chief sources of carbonic acid in the atmosphere, and the chief agencies that prevent its undue accumulation?

6. What bulk of oxygen is required for the complete combustion of 100 cubic inches of a gaseous mixture consisting of equal bulks of marsh gas and olefiant gas; and how much carbonic acid is generated?

7. Gives the names and formulas of the various compounds of chlorine and oxygen.

8. Write the formulas and atomic weights of saltpetre, common salt, chalk, gypsum, iron pyrites, and galena.

9. State the characteristic tests of each of the metals contained in the above-named substances.

10. Describe the successive operations usually performed in obtaining malleable iron and steel from clay iron-stone.

11. Describe the appearances observed on mixing protosulphate of iron with chloride of gold. Give an equation or diagram to illustrate the reaction.

12. Enumerate the types of chemical compounds proposed by Gerhardt, and state what modification of these types has been generally adopted by Chemists. Give the typical formulas together with examples.

13. State and illustrate by formulas the different views that have been held of the constitution of wine-alcohol.

14. Explain what is understood by the terms monatomic, diatomic, and triatomic alcohols; and give an example of each.

15. Give examples of chemical reactions to illustrate the parallelism that exists between potassium and ethyl.

16. Write the formulas of trimethylamine, and tetrethylammonium, and explain how these compounds may be formed.

17. What are the appearances observed when light is viewed through a prism? Describe how the appearances vary according as the light comes from a luminous solid, or from a luminous gas.
18. Explain the nature of the observations that led Kirchhoff and Bunsen to conclude that certain terrestrial metals exist in the sun's atmosphere.

Comparison with the 1856 paper shows that attention to organic chemistry had increased, although the reference to Gerhardt and "typical formulas" in Q. 12 suggests a treatment not fully in tune with progress. Perhaps Smith was having doubts, for in 1869 at the "Class Examination" he asked "What are the chemical types adopted by Hofmann and others, from which all compounds are supposed to arise by substitution?"

Kekulé's great paper "On the Constitution and Metamorphoses of Chemical Compounds, and on the Chemical Nature of Carbon" had appeared[28] in 1858; it had replaced the "mere pattern formulae" of the type theories by others based on the conception of valency and, by explaining the various ways in which atoms could be linked together, had made understandable such phenomena as homology and isomerism. The ideas of carbon chains and carbon skeletons thus introduced were to lead in 1865 to the fundamentally important proposal of a closed-ring structure for benzene and aromatic derivatives generally.[29]

As far as can be traced, no mention of benzenoid hydrocarbons occurred in Sydney examinations until about 1884, but by this time Smith's direct responsibility for chemistry had ceased.

Smith Seeks an Assistant

By the middle sixties, Smith had acquired commitments additional to his University responsibilities. He had joined the Australian Philosophical Society in 1852 and had remained an active member through its transformations. From 1855 to 1860, and during 1862, he was one of the Honorary Secretaries of the Philosophical Society of N.S.W.; over the period 1864-1866 he served on the Council of Management of that Society. His trusteeship of the Sydney Grammar School, his appointment to the Board of National Education and to its replacement, the Council of Education, have already been mentioned. In 1864, Smith began his first term on the Principal Board of the Mutual Provident Society. His interest in water, undoubtedly first aroused by Clark in Scotland, was continuous. At the fourth meeting of the Philosophical Society of New South Wales, on August 13, 1856, Smith read a paper

[28] *Annalen,* 1858, 106, 129.
[29] A. Kekulé, *Bull. Soc. Chim.,* 1865, 1, 98; *Annalen,* 1866, 137, 129.

"On the action of Sydney water upon lead". A decade later the water supply of Sydney had become an acute and public question. Smith spoke on the subject to the Royal Society of New South Wales on October 14, 1868, and again on May 17, 1869; from the last of these papers it is evident that Smith was chemically examining samples for the Sydney Water Commission (of which he was a member) whose important report occupied the Society for five consecutive meetings from July 7, 1870 to August 17, 1870; these debates attracted attention and were fully described in the daily press.

For various reasons, therefore, Smith asked for assistance with his University work, which for some years had included being Dean of the Faculty of Medicine and one of the examiners in that subject.

On November 21, 1865, the Chancellor (the Hon. Edward Deas-Thomson, C.B.) wrote to Sir Roderick Murchison (President of the Geological Survey) asking for cooperation and assistance in the selection of a "gentleman from England to act as Assistant in the Chemical Laboratory and Lecturer in Practical Chemistry, Geology and Mineralogy"; he enclosed a memorandum prepared by Smith. This document reveals much about the nature and standards of its writer and the general conditions in which he was working. In eleven paragraphs, Smith explains the qualifications necessary for the appointment, describes the duties to be performed by the selected candidate, and gives details of the remuneration which might be expected:

"1. Such a person as would properly meet our requirements must be generally well educated, intelligent, active and tolerably young. If a graduate in Arts or Medicine of any British University, so much the better.

2. Though he may not have had actual experience in lecturing, he ought at least to have the elements of a successful teacher—knowledge, good address, and to be generally "presentable", so as to maintain the credit of the University.

3. In regard to special attainments, he must be an expert analyst, accurate, inventive, and neat handed. He should have given particular attention to the assay of metallic ores, and if he have some experience in the investigation of complex organic bodies, it would be very advantageous, as I believe that labor of this kind has not yet been sufficiently applied to the vegetable productions of the colonies, and could not fail to lead to interesting and useful results.

4. If he had some practical knowledge of Chemical Manufactures and Metallurgy it would enhance his usefulness here, though it would be demanding too much to insist on this.

5. His knowledge of Geology and Mineralogy should not be derived from books solely, or from lectures and museums, but to these should be added practical training in the field.

6. It may seem that we require too many requirements united in one individual, but, I believe that Sir Roderick Murchison has already sent young men to different parts of the world similarly endowed. Dr. Hector, Government Geologist of New Zealand (whom I met lately at Dunedin) was, I think, selected by Sir Roderick and he seemed to me to be just the sort of person we want—so far at least as intelligence, zeal and thorough knowledge of Geology are concerned. I believe his skill in Chemistry, was also sufficient, but of that I had not much opportunity of judging.

7. Again, it may appear that we wish to exact too much labour from one person. No doubt we require him to turn his hands to a variety of work, but there will be no undue demands on his time. During one term he would probably have to superintend with me a class of Practical Chemistry, and during the other two he would carry on his own classes of Geology and Mineralogy. Analysis and other laboratory work would go on at all times (during terms) but his necessary duties at the University would not, I believe, occupy on an average more than five hours a day, if so much, and for eight months in the year. There might, of course, be an occasional press of work, and if he be (as I should hope) an enthusiastic follower of Science, he will for his own pleasure and fame, make additional work for himself, but I am confident he will not find the University duties too severe. Our vacations (if all added together) amount to four months in the year and I should expect that he would be glad to make use of this leisure time in travelling over the colonies (much as I have done) to make himself personally acquainted with the scene and objects of his labours. Indeed, to a young Chemist and Geologist, competent and not afraid of work, I think we offer a tempting field.

8. As to remuneration, the Senate have agreed to allow £300 a year as fixed salary, together with the fees of the students in Geology and Mineralogy, and such proportion of the fees in Practical Chemistry as may hereafter be settled. As these fees will be a material element in the calculation of emoluments, and as they cannot at this stage be exactly estimated, I am willing to guarantee that they shall not be less than £150 a year (one hundred and fifty) this guarantee to hold good for three years,

supposing that I continue in the University during that time. If the appointment however prove a successful one, I have no doubt it will be soon more than what I have estimated (£450 a year).

9. The £100 to be remitted for the purchase of typical rocks, minerals and fossils for class illustration may not go far in the first instance, but the Senate will doubtless be prepared to supplement this sum at a future period, as soon as the state of their funds will allow. Perhaps it might be in the power of Sir R. Murchison to procure for the University a donation of at least a portion of such a collection as I have indicated. The mention of fossils reminds me to state that we have no class of Zoology in the University, it would be highly advantageous if our lecturer in Geology could also give some instructions in the outlines of Zoology. In addition to specimens, I would suggest that the gentleman appointed should also provide himself with some diagrams to begin with, and if necessary, expend a portion of the £100 for this purpose. We have already in the University a set of baked clay models of crystals (got up, I think, by Griffin) that might now be turned to account.

10. As to time of leaving England—if a fully qualified gentleman could be got at once, it might be possible for him to start by the beginning of June, and so be ready to begin work here in Michaelmas Term, but as that term is a short one and much occupied with examinations, there could be little good done by introducing new subjects of study then. I think it would scarcely be worth while to make a commencement before February, 1867, which would not necessitate leaving home before the middle of October (in a good sailing vessel). This would give ample time also for a candidate eligible in most respects, but deficient in one or two points, to make up by special study, our list of requirements.

11. As the fitting up of a lecture room with tables, forms, cases for specimens, etc., will not be proceeded with probably until the arrival of our lecturer, it would be advisable that he should, before leaving England, make himself acquainted with the most approved plans for such fittings, so as to supply our Architect with information as to the best arrangements, proportions, etc."

On April 11, 1866, the Chancellor laid before the Senate a reply from Sir Roderick declaring that, in his opinion, Mr. A. M. Thomson, B.A. and B.Sc. in the University of London, is "better entitled to hold the appointment in question than any other young man of his acquaintance whose services could now be obtained". The selection was approved, £100 remitted for passage money, and £100 "for the purchase of typical specimens of rocks, minerals, and fossils, and if necessary, of diagrams". The University Calendar for 1867 lists Thomson as "Reader in Geology and Mineralogy, and Assistant in the Laboratory".

Alexander Morrison Thomson

Smith's new colleague had been born in London (February 4, 1841) but taken to Aberdeen for his youthful education. When eighteen, Thomson entered King's College, London, matriculated top of the year in 1860, and two years later graduated B.A. with a prize in chemistry and other honours. By 1864 he had added the B.Sc. degree, securing first place in chemistry. During 1866 he was awarded a D.Sc. in organic chemistry, apparently for work carried out in the School of Mines, Jermyn St. He joined the Royal Society of New South Wales on August 7, 1867, and thereafter displayed interests more mineralogical than purely chemical. His published papers included an account of a geological survey of the County of Argyle, Scotland, descriptions of gold deposits in quartz veins, and a report on the diamond fields of Mudgee. He wrote a small book on Elementary Mineralogy. On November 3, 1869, Thomson was appointed as Professor of Geology, but continued to be the "Assistant in the Laboratory". In 1871 he visited the Wellington caves (on the Abercrombie River), famous for mammal remains, and drew up a report later published by the New Zealand Government. While working underground on this project his chest became infected. He never recovered, but died on November 16, 1871, from heart disease and dropsy. His early death was a loss to Australia, where he had quickly made a reputation for his readiness to impart knowledge to all. He is recorded as pleasing students with his charm and fertility of intellectual resource. The entire University attended his funeral.

In 1872, Liversidge came to Sydney as "Reader in Geology" and "Assistant in the Laboratory".

Growth and Interests of Sydney Chemical Circles, 1850-1870

Smith was not long the only chemist in the colony. The establishment of a Royal Branch Mint in Sydney was sanctioned by Queen Victoria during 1853 and was formally opened on May 14, 1855. The first "Deputy Master" was Captain Edward Wolstenholme Ward, R.E. (with a salary of £1000 per annum). Ward and his staff notably contributed to the general scientific life of the city. On the formation of the Philosophical Society of New South Wales in July, 1855, he, Professor Smith, and Dr. Douglass assumed office as joint Secretaries.

At its second meeting on June 13, 1856, among members elected were Charles Elouis, W. Stanley Jevons, and Robert Hunt, whose addresses were given as the Royal Mint. Later, on November 16, 1859, at the 31st meeting, Dr. A. Leibius and Mr. F. B. Miller were admitted; they, too, were from the Mint. These were obviously men with some chemical knowledge and assaying skill; the stimulus they brought can be judged from their papers presented to the Philosophical Society of New South Wales.[30]

For example, on August 10, 1859, Captain Ward "laid upon the table" details of investigations made at the Mint on "Warriora" coal, Bellambi coke, and the heating power of colonial coal; on July 18, 1860, F. B. Miller spoke "On the detection of Spurious Gold" and illustrated his remarks "by testing several specimens of spurious gold dust"; on November 21, 1860 the paper read was "On the Mundic Quartz of the Adelong, by Dr. Leibius, of the Mint". This, too, was "illustrated by various experiments". Leibius also on November 2, 1864, reported "On Osmium and Iridium obtained from New South Wales Gold" and exhibited specimens of the pure metals and their compounds. Later, after the Society had changed its name to the Royal Society of New South Wales, a meeting on December 1, 1869 was occupied with two papers: 1. "On the refining of Gold by means of Chlorine Gas", by F. B. Miller Esq., "which he illustrated with a diagram showing the furnaces and apparatus for generating the chlorine, and conveying it into the molten gold, and with samples of gold in the unrefined and refined condition, and with the silver extracted from it"; and 2. "On a new apparatus for reducing Chloride of Silver", by Dr. Leibius, "illustrated with slabs of fused Chloride of Silver and the apparatus for reducing them to a metallic state in the shape of a galvanic battery arranged in pairs, consisting of plates of chloride of silver and zinc".

To these topics may be added several papers by Smith on water analysis and related questions; others by Smith on Quartz and Gold, Clarke on "The present state of the supply of the Ores of Mercury", and a few more dealing with metallurgical and mining matters, make it clear that chemical interests between 1850 and 1870 were predominantly "inorganic".

In general science, the attitude was more catholic. Photography particularly received attention. On September 9, 1857, Frank Haes spoke "On the waxed paper process of photography", on December 8, 1858, James Freeman discussed the "Progress of Photography and its application to the Arts and Sciences" as a prelude to a photographic conversazione. On August 10, 1859 Freeman exhibited "A Photo-

[30] J. H. Maiden, "A Contribution to a History of the Royal Society of New South Wales", *J. Proc. Roy. Soc. N.S.W.*, 1918, 52, 215.

graphic Panorama of Port Jackson" taken by him from Kirribilli Point and "comprising the harbour from Milson's Bay on the right to Bradley's Head on the left". During December, 1859, the Philosophical Society again held a photographic conversazione, and resolved to award five-guinea medals "for six of each of the following classes of Photography, viz.: Landscapes, Buildings, and Portraits". Pictures by Professor Smith and Mr. Hunt are mentioned as illustrating "several of the localities alluded to" by the Rev. W. B. Clarke on May 10, 1865 when reading a paper "On the Transmutation of Rocks in Australia".

Many other interests are revealed by the early minutes of the Philosophical and Royal Societies . . . snakes and reptiles, snake bites and their antidotes, sanitary reform, sewerage systems, irrigation and dams, caves, insects, economics, statistics, meteorology, anthropology, astronomy, communications by railways, ships and telegraphy (cf. "Electric Telegraphs and Railways between Sydney and London not impossible" by Mr. John Thompson, Deputy Surveyor General, on September 10, 1856), medicine (e.g., "On the use and abuse of Tobacco", by Dr. Berncastle on November 11, 1857, or "Abridgment of a book of papers relating to the History and Practice of Vaccination presented to Parliament by Command of the Queen" by Dr. Greenup of Parramatta, on June 9, 1858, or "The adulteration of milk in Sydney" by the Microscopical Committee members, on August 10, 1859, or "The Hospital Requirements of Sydney" by Mr. Alfred Roberts, on August 14, 1868), etc., etc.

It is clear from the records that, during the period under consideration the two Societies included most people of consequence and responsibility in the city. At meetings the Chair was often taken by the Governor-General, especially while Sir William Denison and Sir John Young were occupants of that office (the former of these presented several papers, on railways, on bridge building, on the Dental System of Mollusca, on the Moon's Rotation, and on the "Filtration of Water through Sand") ; the Earl of Belmore presided three times, on June 3, 1868, June 2, 1869, and May 10, 1871. Among the members were medical and legal men, the Bishop of Sydney, clergy, Government House staff, officers of the Army and Navy, the Chief Commissioner of Railways, people from the Crown Solicitor's Office, the City Engineer's Office, the Surveyor-General's Office, the G.P.O., the Registrar-General's Office, the Museum, from schools and from the University. Julius Lippman, of the Stearin Works, Dixon Street (elected June 13, 1856) may have been a chemist.

The total membership was 153 in 1856 (on the formation of the Philosophical Society of New South Wales) ; there were 108 names on the roll of the Royal Society of New South Wales in 1867; by 1870 this had become 127.

Of the initial contingent from the Mint, little biographical information can be found. Undoubtedly, the most competent chemist among them was Adolph Leibius, Ph.D. He died in 1886, but neither the Chemical Society (of London) nor the Institute of Chemistry (which in 1881 listed him as a Fellow) appears to have published an obituary. Of the rest of the group, W. Stanley Jevons remains today the best known. Under twenty when appointed "assayer" in the Sydney Mint, his enthusiasm for practical chemistry could not have been strong, for in 1859 he returned to University College, London, where he studied mathematics and the moral sciences, obtained successively the degrees of B.A. and M.A., went to Manchester as Professor of Logic, Political Economy, and Mental and Moral Philosophy, was in 1872 elected a Fellow of the Royal Society (of London), and from 1876 was back again in University College, London, as Professor of Political Economy. He died in office in 1880.

Smith's Last Period

With the arrival of Liversidge, Smith, then aged 51, acquired a colleague of 25 with whom he worked harmoniously through the following years. Within and without the University, undertakings initiated by Smith during the previous decades were pursued with renewed vigour.

Evidently the chemistry courses were overhauled. The 1873 Calendar names the books "necessary" for practical chemistry as Chambers' "Practical Chemistry", or Bloxam's "Laboratory Teaching", or Harcourt and Madan's "Practical Chemistry", or Fresenius' "Qualitative Analysis". By 1877 these had been replaced by Thorpe's "Qualitative Analysis", Dana's "Manual of Mineralogy", and Fownes' "Manual of Chemistry". For the first time the syllabus for practical chemistry was set out. It covered

"I. The Preparation and Experimental Study of the more common *Gases,* such as Oxygen, Hydrogen, Nitrogen, Ammonia, etc. Also of the common *Acids,* as Nitric, Hydrochloric, and others.

II. Exercises upon the Reactions or Properties of Chemical Reagents used in Analytical Chemistry.

III. Qualitative Analytical Chemistry. Exercises upon the analysis of simple and compound bodies; these will include ordinary chemical Substances and certain *Ores* and *Minerals.* Special attention will be given to the use of the Blowpipe.

N.B.: Each student will be provided with a set of Reagents, and a separate working bench fitted with drawers, shelves, and cupboards, to which gas and water are laid on. He will, in addition, have to provide himself with a set of small apparatus, which he can obtain at the University at cost price (£2), and which will remain his own property; larger pieces of apparatus for the use of all, ... , are supplied by the University.

These Demonstrations, in common with all the University Lectures, are also open to non-matriculated Students."

Paragraphs on similar lines appeared in subsequent calendars. In 1879 an item IV: "The Reactions and Processes for the Detection of Poisons" was added. The calendar for that year is notable also for giving the "Schedule of Subjects" required for the "M.A. Degree (Honours) in the School of Natural Science". The detailed Syllabuses for Chemistry and Organic Chemistry occupy nearly two closely printed pages and demonstrate the wide coverage of chemical knowledge then being attempted; evidence to the same effect is seen by the inclusion among recommended books of the three volumes of Miller's "Elements of Chemistry" and the five of Watts' "Dictionary of Chemistry"; indeed, these courses as specified would not have been seriously out-of-date 30 years later. In 1880 Roscoe and Schorlemmer's "Treatise on Chemistry", Schorlemmer's "Chemistry of the Carbon Compounds", and Wurtz's "Chemistry" were added to the book-list.

Undoubtedly, part of the credit for the upgrading of chemistry must be given to Liversidge, who—although becoming Professor of Geology and Mineralogy in 1874—continued to hold the position and title of "Demonstrator in Practical Chemistry" until 1880, when Albert Helms, M.A., Ph.D. (Berlin) replaced him in this lower role. Nevertheless, Smith was still "Professor of Chemistry and Experimental Physics"—a combined responsibility he retained for one more year.

During 1881, the Senate "learned with great gratification" that Parliament had voted to increase the endowment of the University "to the extent of £5,000 for the year 1882, besides repeating the vote of £1,000 for Assistant Lecturers". Details of the Senate's "best means of applying the increased endowment" are set out in the Calendar for 1882-1883, pp. 150-152. Seven "Schools" were to be created; nos. 3 and 4 were listed as follows:

3. *School of Chemistry*

Inorganic, Organic, and Practical Chemistry, with Mineralogy and Metallurgy.

Professor (*with half fees*)	900
Assistant Lecturer	350
	£1,250

4. *School of Natural Philosophy*

Experimental Physics, Physics, Mechanics, and Engineering.

Professor (*with half fees*, except *for Engineering*)	900
Engineering Lecturer (*with half fees*)	300
	£1,200

Thus, in 1882, by this redistribution, Smith became Professor of Experimental Physics, and Liversidge Professor of Chemistry and Mineralogy. Together, "after Homeric battles with the powerful forces of Arts", they originated[31] a separate Faculty of Science, of which Liversidge became the first Dean, and by which two new degrees, B.Sc. and D.Sc., could be awarded.

The 1881 Senate Report refers to another innovation: the admission of women to all University privileges and the placing of them academically on an equal footing with men. A move in this direction had started some years before. In 1879 the Chancellor (Sir William Manning, after whom the Women's Union building of today is named), in an address, had said: "I am not at present able to advise whether these students should be admitted to the ordinary lectures concurrently with those of the other sex, or should be instructed separately. . . . The two present Professors (who were teaching suitable subjects) would not object to a trial of mixed classes, if the demand on the part of the young women were sufficient to compensate for the introduction of what we may venture to call a somewhat disturbing element." The two Professors were Smith and Liversidge. Subjects thought suitable for "young women ambitious of superior culture" were Chemistry, Botany, Vegetable Physiology, Mineralogy, and Geology. The Board of Studies had also had misgivings of a practical kind (e.g., how to provide ". . . a suitable retiring room and other necessary conveniences set apart exclusively for female students . . . in the present building there is no room that can be applied to any such purpose . . . without resuming that . . . which has been assigned to the Professor of Classics as his residence") ; these were, however, dispelled by the erection of a small cottage at the rear of the main building. The Professors "pledged themselves to overcome, by the elimination of offensive passages" the objection that female delicacy might be shocked by "the works of certain eminent writers of antiquity". Two women matriculated in 1882; an amending Act was passed in 1884, giving the University power to grant degrees to women; in that year there were

[31] T. W. Edgeworth David, *J. Chem. Soc.*, 1931, 1039.

ten "lady undergraduates". By 1961, 1,520 women had graduated in science; the first to receive a B.Sc. degree was Miss Fanny E. Hunt, in 1888. In this enlightened and liberal attitude to the education of women, supported by its Professors of Chemistry (one of whom, Smith, had already in 1852 displayed *his* convictions in the *Sydney Morning Herald*), Sydney has, by nearly half a century, a priority over many of the Universities in Britain.

Smith's retention, in 1882, of the title "Professor of Experimental Physics" was a curious arrangement, since—as Barff records[32]—"until the appointment of Professor Threlfall to the Chair of Physics in 1886 there were no classes at the University in Practical Physics".

Smith had three more years to live. He sought, and was granted, fifteen months' leave from March 1, 1882, to proceed overseas "as well for the purpose of recruiting his health as for observing closely the rapid advances which all branches of Science are making at the present day". The relevant Senate Minute[33] goes on: "The generosity of Parliament has also enabled the Senate to place in his hands a sum of money, by means of which he will be able to add considerably to the stock of scientific apparatus at present at the University. During his absence the duties of his chair will be discharged by the Rev. Joseph Campbell, B.A., of this University, who has lately distinguished himself by delivering several courses of lectures upon scientific subjects in the Technical College."

Smith left Sydney during the long vacation, arrived in Bombay on January 13, toured North India, and returned to stay with a group of theosophical friends at Bombay; here he had an experience of occultism[34] with Madame H. P. Blavatsky and Colonel H. S. Olcott, founders of the Theosophical Society. Smith's description of the phenomena, in his own words, is given by Davidge; that he was puzzled by them is revealed by subsequent letters he wrote from Naples in March, 1882, and Nice in January, 1883. Between these dates he had been in the United Kingdom. On April 12, 1883, he sailed for Australia from Marseilles *via* Mauritius, and was back for a Senate meeting on June 6.

On April 1, 1885, the Chancellor reported that, on account of serious illness, Professor Smith had been forbidden by his medical advisers to lecture for at least two terms. He also laid on the table Professor Smith's resignation of the office of Dean of the Faculty of Arts. On September 7, the Senate received a letter from Smith asking

[32] H. E. Barff, "A Short Historical Account of the University of Sydney", Angus and Robertson, Sydney, 1902.
[33] Sydney University Calendar, 1882-1883, p. 152.
[34] J. L. Davidge, "Professor John Smith and Theosophy", *Proc. Roy. Aust. Chem. Inst.*, 1959, 26, 356.

for an extension of leave on grounds of continued ill-health. He died on October 12. The news was formally reported to the Senate on October 19; motions expressing the deep sense of loss felt by the University, and of appreciation for Smith's long and meritorious services were then proposed and carried unanimously.

The esteem in which Smith was held by his colleagues and by the community at large can be judged from the account of his funeral given in the *Sydney Morning Herald* for October 13, 1885. There attended "an assemblage of University Professors, graduates, undergraduates, representatives of both Houses of Parliament and gentlemen occupying prominent positions in social and commercial life". He was acclaimed as a man who "thoroughly identified himself with the cause of Australian progress . . . and who had a capacity for work beyond that of most people". He was "one of the worthiest and most prominent of our citizens".

In the Waverley Cemetery his grave is marked by a simple granite cross bearing an inscription telling posterity only of his services to physics; regrettably, chemistry, to which the whole of his scientific life was devoted, is not mentioned. So is commemorated the blacksmith's son who deserves to be ranked highly among Australian pioneers.

Smith's Character and Outlook

In appearance, Smith was a rather gaunt man with keen eyes, side-whiskers and a clean-shaven chin. In several photographs from his collection he can be seen, in a tall black hat, holding a watch. A portrait of excellent quality is reproduced in Findlay's book.[35] Many of Smith's impacts on the young University and its surrounding society have already been noted, but for a just appraisal of his influence more needs to be said.

Smith was not a Professor in an ivory tower. His services to education began as early as 1853 and never stopped. Liversidge says of his predecessor that "he in fact performed gratuitously the work which would have devolved upon the Minister for Public Instruction, had one then existed", and that he devoted "years of self-sacrificing toil without emolument and without hope of reward". Smith was a "zealous promoter of public elementary education". He served on numerous Government boards and commissions; he was twice on Royal Commissions concerned with the water supply of Sydney—on one of these he was the President—and as a result undertook arduous journeys into unsettled parts of central New South Wales, bringing back photographs of wild bushland and primitive places passed *en route*.

[35] A. Findlay, "The Teaching of Chemistry in the Universities of Aberdeen", Aberdeen Univ. Press, 1935.

Smith ardently supported the cause of social security. He served on the Principal Board of the Australian Mutual Provident Society for the terms 1864-1871, 1872-1882 and 1883-1885; he was Chairman during 1873-1880 and again through 1883-1884. In 1877, as Chairman, he laid the foundation stone of a new Head Office building; the solid gold trowel and gold-mounted gavel used on the occasion are now among the historical mementos kept by the Society.

Smith became a member of the Legislative Council in 1871 (hence his title, the Hon. John Smith, in subsequent years); "as might be expected, his speeches in the House were sensible and practical, and evinced large knowledge of the subjects discussed". His old University—Aberdeen—honoured him with an LL.D. in 1876, citing him as one who "has maintained a high position both by scientific labours and in connection with the supply of water to the town of Sydney". In 1877 he was created a Companion of the Order of St. Michael and St. George in recognition of his public services.

Smith's chemical researches were not numerous, his published papers and addresses being mainly on applied or practical topics, exemplified by those relating to water and its analysis or purity, to gold, and to photography. As already remarked, such interests should be evaluated against the background of international chemistry as it was in 1850-1880, not as it is a century later, moreover, some allowance must be made for Smith's isolation from the European centres of lively scientific development. Viewed thus, his contributions were not trivial. That he introduced the teaching of practical chemistry at a time when scarcely a dozen other establishments throughout the world were doing the same is to his credit, and gives the University of Sydney an uncommon claim to fame. Of constant usefulness, too, was the personal influence he evidently had on people around him and the leadership he could thereby give in producing the first effective organization of science in Australia.

What kind of man was Smith? The A.M.P. records describe him as "a man pre-eminently characterized by great honesty of purpose, impartiality, and even disposition, tolerance and uniform courtesy". Of his lectures, it is said that they "were singuarly clear in style and easy to understand . . . full of instruction, and . . . therefore helpful to those privileged to hear them". He was ". . . accustomed to hold weekly examinations, in which the substance of the several lectures that had been delivered was reviewed; by this means it was printed indelibly on the memory. To encourage application he gave a prize every year, of the value of £5, to the student who distinguished himself most in these examinations". The "Smith Prize" still exists; among its many recipients since 1854 have been S. W. Griffiths (later a Premier of

Queensland) and G. E. Rennie (later Professor of Chemistry in Adelaide).

Other clues to the nature of John Smith are afforded by incidents which occurred in 1853, the year following his appointment to Sydney. He remitted to Marischal College the sum of £50, "in repayment of a Bursary of £11/15/- which he gained and held as a student in Arts, directing this donation to be at the disposal of the Senatus, but suggesting its application . . . for the benefit of the College Museum". (How many scholarship-assisted students of to-day react this way?) In November, 1853, the Bishop of Newcastle published in the *Sydney Morning Herald* a letter indicting the University as a corner-stone of a "pernicious educational structure". It taught entirely secular subjects and made no provision for religious instruction. The Professors replied that religious teaching did not reside in specific theological instruction but in a general approach to a subject . . . Smith asserted tersely that "Chemistry is as conducive to the glory of God as is dogmatic theology".

ARCHIBALD LIVERSIDGE

Birth and Training

Liversidge was born at Turnham Green, in the suburbs of London, on November 17, 1847. His early education was at private schools and with tutors. He then entered the Royal School of Mines and the Royal College of Chemistry at South Kensington where he had the good fortune to study under Frankland (who not long before had notably contributed to the development of the concept of valency) and Tyndall (the physicist, remembered today for his work on light scattering). Liversidge, as a senior student, collaborated with the former in experiments on supersaturated solutions. In 1867 he won an open scholarship in Natural Science at Christ's College, Cambridge. He was for a while in Sir Michael Foster's physiological laboratory, then became an instructor in Chemistry at the Royal School of Naval Architecture. In 1870 he was appointed Demonstrator in Chemistry in the University of Cambridge—a position he left to come to Sydney.

Why he should have been attracted from Britain, where his career prospects were promising, is not known. Perhaps he had acquired a desire to travel through his Naval contacts (two of his nephews later became rear-admirals); perhaps his mineralogical interests were the causes. The gold output of New South Wales was then rising to its second peak . . . for long the occurrence and winning of gold remained favourite themes in Liversidge's lectures and investigations.

Expansion of Chemical Interests in Australia

Liversidge arrived in Sydney when an expansion of chemical and scientific activities was beginning throughout Australia.

In 1871 classes in chemistry had been started by William Adam Dixon, F.I.C., F.C.S., in the School of Arts in Pitt Street. In 1883, the management of these was transferred to the newly established Board of Technical Education (of which Liversidge had become a member at its foundation); six years later technical education became a branch of the Department of Public Instruction, and land was secured for new buildings at Ultimo, on the property of John Harris. Dixon had been a student and an assistant under Dr. Anderson of Glasgow, had worked as a chemist in industry in Scotland, and had then been appointed to manage the manure works of Messrs. Bright Bros. at Malden Island in the Pacific. After a short period he relinquished this position, owing to ill-health, and came to Australia. About 1882, his name began to appear in the lists of examiners to the Faculties of Arts and Science at the University. He established himself in practice in Sydney as an analytical chemist and assayer. On his death in 1917, the business was carried on by his son, Andrew James, as Messrs. Dixon and Byrn at Reiby Place, Sydney.

In 1883, a man from Kent, Henry George Smith, aged 31, migrated to Australia and joined the staff of the Sydney Technological Museum, then housed in the Domain. He learned chemistry from Dixon, who warmly encouraged him, so that by 1895 Smith had published five papers describing his first original researches; these were on analytical and inorganic chemical topics. Then appeared an article on eucalyptus kinos and the occurrence of eudesmin; this was to be the forerunner of a long series on the chemistry of Australian flora. By 1924, when he died, he had written over a hundred such papers, of which 62 had been printed by the Royal Society of New South Wales. Mainly through the efforts of Professor John Read,[36] in whose Department of Sydney University H. G. Smith was a guest after retiring from the Museum Laboratory in 1920, the scientific achievements of Smith have now received the world-wide recognition merited by their quality.[37]

The University of Melbourne appointed its first Professor of Chemistry (J. D. Kirkland, M.B., B.S.) in 1882, but the Chair became vacant through death in 1885. It was filled by David Orme Masson with distinction and profit for Australia during the following thirty-seven years. Masson, like Smith and Liversidge in Sydney, was an organizer with marked "capacity for practical achievement in the development of national life in a young British community. He was a great Empire builder, inspired by, and inspiring, the highest ideals of service". His chemical and research interests were mainly physical, inorganic or theoretical in nature.[38]

[36] J. Read, *J. Chem. Soc.*, 1925, 127, 958.
[37] Cf. also, McKern, this vol. p. 315-320.
[38] A. C. D. Rivett, *J. Chem. Soc.*, 1938, 598.

In 1885, the University of Adelaide selected Edward Henry Rennie as its Foundation Professor of Chemistry. For two reasons at least the choice is notable: Rennie became the first Australian-born chemist to be appointed to an Australian chemical chair, and Rennie was—by inclination—an organic chemist. He had been born in Sydney in 1853. His father was Auditor-General for New South Wales, his grandfather was Professor of Zoology in King's College, London. Young Rennie attended the Sydney Grammar School, where he was Captain and Knox Prizeman in 1867, he went on to the University to win, in 1868, the Levey Scholarship for "general proficiency" shown by "an undergraduate of the first year", and in 1870 the Deas-Thomson Scholarship "for proficiency in Chemistry and Experimental Physics"; in 1869 he shared Professor Smith's prize with another student. He graduated as a B.A. in 1871. He then taught at his old school for a few years; but according to him,[39] "only three out of twenty-four boys who did Chemistry had any grasp of it". In 1877, he went to London, where for a time he worked at St. Mary's Hospital Medical School, came under the stimulating influence of Professor H. E. Armstrong (a protagonist of heuristic methods of teaching), acquired the London D.Sc. and published a number of papers in the *Journal of the Chemical Society,* some conjointly with C. R. Alder Wright on "chemical dynamics", others on organic topics.

The records of the Chemical Society of London note the award, in 1881, of a research grant of £10 "to Mr. E. H. Rennie: for the investigation of benzylphenol"; in 1883, of £25 to Dr. Rennie: for the further investigation of Australian sarsaparilla"; in 1886 and 1887 of similar amounts for investigations on the sweet principle of *Smilax glycylphylla* and the red colouring matter of *Drosera Whittakeri.* This interest in Australian plant products occupied the rest of his research life. During the first ten years as Professor in Adelaide, Rennie published seven papers in the *Journal of the Chemical Society* on the subject; later he examined the resins of *Xanthorrhoea* (grass-trees), from which unexpectedly picric acid could be obtained, and which gave cattle a complaint called "cripples". As a teacher, Rennie was exceptionally conscientious and thorough; he lectured on chemistry in *all* its branches, served on the University Council, and a number of times acted as Vice-Chancellor; additionally he accepted willingly responsibilities (e.g., Chairmanship of the School of Mines, of the South Australian Branch of the Commonwealth Council of Science and Industry, the Presidentships of the Australian Chemical Institute, and of the Australasian Association for the Advancement of Science) in fields wider than those merely academic. He could have had but little leisure for the labora-

[39] "The Sydneian", Centenary Number, Sydney Grammar School, 1957.

tory; nevertheless, he founded a tradition of organic chemical research in Adelaide, which has continued, through A. K. Macbeth and G. M. Badger, to the present day. He died in January, 1927, after one of the busiest years of his life, during which he had produced his last paper—a valuable survey of Australian plant chemistry, past, present, and future.

No record of the progress of Australian science from the 1880's onward should omit the name of William Sutherland. Sutherland had been born in 1859 in Dumbarton, Scotland; in 1864 his family emigrated to Sydney, and six years later settled in Melbourne. In 1876, after schooling at Wesley College, he entered the University of Melbourne, emerging as a B.A. in 1879. He then went to England and enrolled at University College, London, to take chemistry, physics and biology. He found the first of these still under Williamson (whose pioneering work was then behind him), but Sutherland was disappointed. He considered[40] Williamson's lectures "opinionative, out-of-date, and boring. . . . The practical work in chemistry was meagre, and the equipment poor". Professor Ray Lankester (Comparative Anatomy) he found breezier but too detailed and too slavishly devoted to Huxley. In physics, conditions were more agreeable. Professor G. Carey Foster took an interest in the young Australian, entertained him at home, gave him the run of his library and laboratory, and secured a seat for him at the historic Faraday lecture by Helmholtz[41] when the natures of forces working between, and at distances from, atoms were discussed, when definite electric charges on atoms were supposed, and when the conclusion was reached that the very mightiest among the chemical forces are electrical in origin.

In mid-1881, Sutherland sat for the final B.Sc. examinations securing first-class honours and a Clothworkers Scholarship. The last he did not take up, but toured France, Germany and Italy *en route* for Melbourne, which he reached in February, 1882.

He decided to seek contentment in creative work, supporting himself modestly by coaching, examining and writing occasional newspaper articles. In July, 1882, he was offered the Superintendentship of the Ballarat School of Mines, with a salary starting at £500 per annum, but this he declined. In 1884, the Adelaide Chair of Chemistry was advertised. "Sutherland thought himself well equipped for the post. He had been reading deeply in that borderland between physics and chemistry . . . and realized his advantage in mathematical equipment

[40] W. A. Osborne, "William Sutherland", Lothian Book Publishing Co., Melbourne, 1920.

[41] H. L. F. Helmholtz, "On the Modern Development of Faraday's Conception of Electricity", *Trans. Chem. Soc.*, 1881, 277.

over the chemists of the day", but his feelings were mixed.[42] "Not in the least disappointed, he saw this position going elsewhere, and with something like relief plunged again into his researches." In 1888 he accepted a temporary lectureship in physics at Melbourne University, following the sudden death of Professor Andrew, but was slow in applying for the vacant Chair, to which he was beaten by Lyle. He sought no more academic posts "except the Chair of Physics in Sydney, for which he was disqualified by age".

In retrospect, it can be asserted that Australia's scientific reputation would have been enhanced had Sutherland occupied one of these Chairs and used the laboratory facilities thereby available. This country could have been in the forefront of those in which "chemical physics" or "physical-organic chemistry" have developed. Among the earliest of his papers are several on intermolecular attractions; he deduced that the forces were inversely proportional to the fourth powers of the intermolecular separations. Others deal with molecular refractions and the Gladstone-Dale or Lorenz-Lorentz functions for this property; they were written early in the period in which Brühl in Germany was investigating the additive-constitutive nature of refractivity and opening up a non-destructive physical route for the determination of the structures of molecules. Had Sutherland gone to Adelaide in 1885—two years *before* the Pulfrich refractometer was introduced—it is hard to believe that his thinking would not have progressed in the same way.

In 1893, there appeared the paper on gaseous viscosities for which Sutherland is perhaps best known. Postulating forces between molecules and using planetary theory, the dependence of viscosity η on temperature T was predicted to be:

$$\eta/\eta_0 = (T/T_0)^{1.5}.(T_0 + C)/(T + C)$$

where C is "Sutherland's constant". Since experimental results often agree very well with this equation it is still much used. Subsequent workers have found many relations between C and other properties.

Sutherland's papers over the next few years deal with thermochemistry, surface tension, osmotic pressure, latent heats of evaporation of metals, the molecular constitution of water, spectra, etc. In 1902, he published the first of several which incorporated the concept that electric doublets (dipoles) were located in *atoms*. He argued "that the properties of matter were electric in origin. The attraction of molecules is an attraction between doublets". Rigidity, elasticity, viscosity, ionization, dielectric capacity, and spectral character, could all be embraced by applying the same fundamental and unifying idea. He calculated the values of the moments of these doublets for various

[42] W. A. Osborne, "William Sutherland", Lothian Book Publishing Co., Melbourne, 1920.

elements "on the principle that if atoms did exert force on each other it would be necessary to do . . . work to remove an atom from a mass of many others, and that this work would depend upon the magnitude of the forces involved. Sutherland succeeded in finding an expression for this work in terms of the moments of his electric doublets". Later, in 1912, an analysis of dielectric polarization based on *molecular* doublets was made by Debye and received quick acceptance. Sutherland, isolated and alone in Australia, had come close to anticipating many suggestions from subsequent investigators by nearly a decade.

By 1911, when Sutherland died, he had written sixty-nine papers. Their titles show the powerful influence which Helmholtz's lecture had evidently had on him, as indeed it had had on everyone who heard it. Hinshelwood[43] speaks of it as shining out like a beacon, revealing for the first time the full implications of Faraday's laws, and opening the way for the whole modern electronic theory.

Sutherland's place in this history is seldom mentioned, even by Australians. During his life, his work seems to have passed almost unnoticed by his fellow-countrymen. Perhaps his own outlook was partly the cause:[44] "In pure science it is a matter of ten or fifteen years before work begins to bear fruit . . . moreover, I do not care about publicity, there is so much of an impure form of it."

Liversidge, a Planner and Organizer

Reference has already been made to the improvements, in the University chemistry courses, which quickly followed Liversidge's arrival. Students were then few in number and ill-prepared for university work. One of Liversidge's first self-appointed tasks was to secure proper recognition of science in both secondary and tertiary education.

He became[45] an original member of the Board of Technical Education, "and it was largely due to his efforts, ably seconded by his close friend . . . H. C. Russell . . . that technical education was inaugurated in New South Wales and that its teaching, notably in . . . Chemistry, made such good progress".

In 1878, the University Senate received a request from the Minister for Public Instruction that Liversidge be given two months' leave to cooperate "in procuring information respecting the system of industrial and technological instruction in Europe". In the same year,

[43] C. N. Hinshelwood, "Address on the Occasion of the Centenary Celebration of the Chemical Society", *J. Chem. Soc.*, 1947, 1271.
[44] W. A. Osborne, "William Sutherland", Lothian Book Publishing Co., Melbourne, 1920.
[45] T. W. Edgeworth David, *J. Chem. Soc.*, 1931, 1039.

also, his services were sought in connection with the establishment of a museum to parallel and help such instruction.

Science subjects were introduced into the matriculation examination in 1873. A Faculty of Science in the University was created in 1879. By 1882, when Liversidge became Professor of Chemistry and Mineralogy, the accommodation inherited from Smith was proving inadequate. The Senate Report for 1881 had already adverted to the situation; in 1883 it was again mentioned. Temporary additions made at the rear of the main building caused procrastination. It was not until 1889 that chemistry could be given new and suitable quarters in a detached building on "Science Road", close to where physics, engineering and biological studies were centred.

Designs were by Liversidge. A full description by him is in ref. 46; Tilden[47] gives an account which, although shorter, is of interest for showing a number of photographs of the interior and exterior of the completed building. Outstanding features included were a couple of big laboratories, each capable of holding over a hundred students at one time, two lecture theatres seating approximately 100 and 200 respectively, and ancillary rooms for instruments, workshops, stores, etc. Space was provided for the Professor himself and for research activities on a most generous scale. Whether judged as a total concept, or by the many novel well-thought-out details incorporated in it, Liversidge unquestionably gave the University a chemistry department planned on extraordinarily advanced lines. As a large nucleus, around which extensions were added at various later dates, it continued to serve chemistry right through to 1959, when the present School was opened[48] near City Road and the original premises handed over to pharmacy.

Liversidge's lasting reputation as a planner rests, however, on more than material structures; he was an *organizer,* both within and without the University. Several examples have already been mentioned.

Soon after arrival he had joined the Royal Society of New South Wales (on November 10, 1872) and within a few years had stimulated it to a new order of activity. His was the "principal driving power" which procured for the Society its own House in Elizabeth Street[49] . . . "we never got a move on till Liversidge came" according

[46] Report of the First Meeting of the Australasian Association for the Advancement of Science, Ed. A. Liversidge, M.A., F.R.S., Robt. Etheridge, Junr., publ. by the Association, Sydney, 1889.

[47] W. A. Tilden, "Chemical Discovery and Invention in the Twentieth Century", George Routledge and Sons Ltd., London.

[48] R. J. W. Le Fèvre, *Chemistry and Industry,* 1951, 415, 1953, 737, 1957, 551; *Nature,* 1960, 187, 833.

[49] J. H. Maiden, "A Contribution to a History of the Royal Society of New South Wales", *J. Proc. Roy. Soc. N.S.W.,* 1918, 52, 215.

to Dr. Leibius, whose membership went back to 1859 and who worked with Liversidge as a fellow Secretary. Maiden,[50] writing in 1918 of those who have "performed exceptional services to our Society" includes "Liversidge, who practically re-founded the Society when he became Honorary Secretary in the year 1875, organized its activities on proper lines, and made it the power for good it is today. He is our greatest living benefactor". Professor John Smith, the first non-Vice-regal President, has also recorded his testimony in cordial and appreciative terms.[51]

Without question, however, Liversidge's greatest organizational success was the giving of reality to a germinal idea first conceived by Smith prematurely—as events showed—by two decades.

During 1866, plans were in hand for an Intercolonial Exhibition to be held in Melbourne. On August 1, 1866, Professor Smith was Chairman of the 81st meeting of the Philosophical Society of New South Wales. The minutes note that "some conversation then followed on the subject of a Scientific Congress. . . . The Chairman . . . had no doubt that at some future time there would be an Australian Association for the Advancement of Science, but he did not suppose we had the material for it yet. If anything was done now it would have to be done in connection with some other attraction, such as the Exhibition, which would bring a large number of persons together. Dr. Bedford concurred with the Chairman. The proposal was more likely to be carried into effect in Melbourne than in Sydney, for the Exhibition there would collect a large number of persons interested in science and art, and they might use the intervals of leisure which they then only possessed in the way proposed. We were not yet ripe for the complete arrangements such as were carried out in the British Association at home. . . ." After some observations of similar purport, the matter was allowed to drop. It lay dormant for eighteen years.

On September 16, 1884, Professor Liversidge wrote a letter to the *Sydney Morning Herald,* which was subsequently reproduced by most of the other colonial and some of the home newspapers. In it he refers to suggestions that a future meeting of the British Association should be held in Australia. He mentions that the oviparous nature of the platypus and Australian porcupine had reawakened interest in the peculiarities of Australian natural history, and that the Victorian Premier "with commendable promptitude" had telegraphed the necessary invitation for the Association to visit Melbourne. Liversidge proceeds: "I am, however, very much afraid that, although Australia,

[50] J. H. Maiden, "A Contribution to a History of the Royal Society of New South Wales", *J. Proc. Roy. Soc. N.S.W.*, 1918, 52, 215.
[51] J. Smith, *J. Proc. Roy. Soc. N.S.W.*, 1881, 15, 1.

New Zealand, and the Islands offer great attractions to many of the members . . . yet, but comparatively few could afford the time and money to come out here. . . . The round voyage could scarcely be squeezed into the long vacation of those fortunate enough to have one, and the necessary travelling expenses would considerably exceed the whole year's income of many—for the pursuit of science is not a lucrative one, and as a rule its followers are poor. . . . I do not think we could expect more than fifty members, if so many. . . . Therefore, instead of looking for a near visit from the Association, I would suggest that we should rather be preparing the way for issuing an invitation later on, when we have made suitable provision to entertain our intended scientific guests, and as a preliminary step I would venture to suggest, as a member of the parent Association, that we might try to bring about a federation or union of the members of the various Scientific Societies in Australia, Tasmania, and New Zealand, into an Australasian Association for the Advancement of Science on the lines of the British Association, with a view to hold the first general meeting in Sydney, on the hundredth anniversary of the Colony, when there will probably be an International Exhibition to celebrate that event. I mooted the question during the last Exhibition in Sydney, in 1879, but . . . now, perhaps, with the greater advancement in numbers and in wealth, something might come of it in 1888. . . ."

Liversidge returned to the subject in his Presidential Address to the Royal Society of New South Wales on May 5, 1886. A few weeks later, on June 6, the Council of this Society approved a motion from him that steps should be taken to form an Australian Assciation for the Advancement of Science, and resolved to take part in the initiation and furtherance of such a project on the lines laid down in the President's Address.

Accordingly, during July and August, six thousand circulars were sent out to members of Scientific Societies in Australia, Tasmania and New Zealand, and notices inserted in the leading colonial newspapers. By 1886, there were, throughout Australasia, some 38 scientific societies; 34 of these expressed their intention of joining the Association and 28 appointed delegates to a preliminary meeting, held on November 10 in the Royal Society's House, at No. 37 Elizabeth Street North, when provisional rules were framed and a date fixed for the first general assembly of the proposed A.A.A.S. The delegates were called together again on March 7, 1888 and elected H. C. Russell, F.R.S. (Government Astronomer of New South Wales) to be the Foundation President, Baron F. von Mueller, K.C.M.G., F.R.S. (Government Botanist, Melbourne) to be Russell's successor, A. Liversidge, F.R.S., to be Permanent Honorary Secretary, and Sir

Edward Strickland, K.C.B., to be Honorary Treasurer. A Council of 42 members (including a New Zealand chemist, S. Herbert Cox) was also appointed.

The historic first general meeting duly took place from August 27 to September 5, 1888, in the University of Sydney; 805 members and 45 ladies attended. The scientific programme was spread throughout ten sections. Chemistry and Mineralogy occupied Section B; its President was Professor J. G. Black of the University of Otago, New Zealand, who addressed the Section "On Chemistry in relation to Education". Current interests can be inferred from other papers presented "On Butterine as an Article of Food", by C. A. Smith, F.I.C., "On the occurrence of Tellurium in New South Wales ores", by J. C. H. Bingaye of the Mines Department, Sydney, "Notes on Silver Smelting" by Edgar Hall, F.C.S., "The Formation of Coal and Carbonaceous Minerals", by W. A. Dixon, F.I.C. of the Sydney Technical College, "On some Means of Popularising the Study of Crystallography", by F. Ratte of the Australian Museum, Sydney, "On the Dissolved Matter contained in Rain-water collected at Lincoln, Canterbury, New Zealand", by George Gray, Lecturer on Chemistry, School of Chemistry, Lincoln, New Zealand, "The Composition of Fahlerz and Embolite from New South Wales", by G. S. Mackenzie, Ph.D., F.I.C. of the Athenaeum Club, Sydney, "On Gold: Its Formation in our Reefs and Notes of Some Newly Discovered Reactions", by William Skey of the Geological Survey, New Zealand, "On the Proposed Chemical Laboratory at the University of Sydney", by A. Liversidge, M.A., F.R.S., "On the Action of the Nepean Water on Tubes and Boiler Plates, with Some Remarks on Corrosion Generally, by William M. Hamlet, F.I.C., Analyst to the N.S.W. Government, Sydney, and "Bibliography of the Chemistry of Indigenous Australian Vegetable Products", by J. H. Maiden, Curator of the Technological Museum, Sydney.

Except for Black's address and two notes by Liversidge (on some Australian minerals, and on the Thunda meteorite of Queensland) the texts of the Section B papers were later printed[52] in full; the limited attention then being given to organic chemistry is apparent.

This successful first meeting set the pattern for the future. Apart from Sectional activities, there were popular evening lectures, excursions, a civic reception and a garden party. . . . Russell's inaugural Presidential Address (pp. 1-21 of ref. 52), delivered on August 28 in the Great Hall of the University with the State Governor present, is especially notable. Details of the early history of science in Australia, and of the steps leading up to the new Association, were recounted. Russell made clear to whom he thought the greatest credit was due, namely, to Professor Liversidge, "who is himself an institution for the advancement of science, and knows no fatigue in that service. Round him everything has revolved in perfect order to the complete preparation for this meeting".

Russell eloquently argued that the yearly coming together of like-minded men would give a stronger impulse and a more systematic direction to scientific enquiry . . . that a people cannot have material advancement without a previous advance in science . . . that science has social and cultural values as well as utilitarian . . . that man and nature are correlative . . . ; these and many other of Russell's themes remain as relevant today as they were in 1888.

In 1930, the Association changed its name from A.A.A.S. to A.N.Z.A.A.S., thus belatedly replacing "Australasian" by the names of the two separate Dominions.

Liversidge as a teacher

Inspection of the floor plans[52] of his 1889 building reveals spacious provisions for demonstrations in the lecture theatres. Liversidge evidently deemed such facilities to be highly important. He acquired a reputation for his "remarkably successful and impressive" practical demonstrations and lecture experiments.[53] He was quick to show anything new. The *Daily Telegraph* of August 17, 1889, reports a lecture by him on liquid air (then a novelty only a few years old): "The lecturer's explanations were so lucid and he presented his facts so clearly that his hearers were able to follow him easily, and showed their appreciation of this by frequent applause. . . . Professor Anderson Stuart moved a vote of thanks which was carried amid loud cheers."

In truth, however, Liversidge was never an *eloquent* lecturer; he found difficulties in enunciating certain consonants. Despite his considerable public services, he was somewhat shy and retiring. All his life he remained a bachelor. (It is traditionally reported that he would never interview a woman student without his door being open and a laboratory attendant being within earshot.) Nevertheless, at his retirement in 1907 he left a Department with a staff of seven dealing with two hundred or more students working through syllabuses as full and wide as those in use in the larger chemical centres of the United Kingdom.

A portrait of Liversidge hangs today in the Great Hall of the University; the painting—by Sir John Collier, R.A.—was paid for by

[52] Report of the First Meeting of the Australasian Association for the Advancement of Science, Ed. A. Liversidge, M.A., F.R.S., Robt. Etheridge, Junr., publ. by the Association, Sydney, 1889.

[53] T. W. Edgeworth David, *J. Chem. Soc.*, 1931, 1039.

subscriptions from members of the Royal Society of New South Wales; it presents its subject in a lecturing pose, holding a pointer in one hand and a mineral specimen in the other.

Liversidge and Chemical Research

Soon after his appointment in 1872 to the University, Liversidge began investigations which were to be continued through all his years in Sydney. His first paper, on December 11, 1872, was "On the Deniliquin Meteorite"; his second, on October 1, 1873, was a "Note on the Bingera Diamond District . . . illustrated by a collection of minerals from the locality"; his third and fourth, on December 9, 1874, were on "Iron and Coal Deposits at Wallerewang" and on "Nickel Mineral from New Caledonia". Except the first, these were presented at meetings of the Royal Society of New South Wales with Professor Smith in the Chair.

Such studies went on steadily. For his contributions to mineralogy he was in 1882 elected a Fellow of the Royal Society (London). By 1888 he had gathered enough data to publish his major work—a book entitled "The Minerals of New South Wales"—which he deliberately timed to appear coincidentally with the centenary of the founding of the colony. Introducing the subject, he said, "The descriptions of the minerals given are almost entirely from specimens which I have either collected myself or have come under my personal observation. . . . Special attention has been paid to chemical composition; but on account of the great length of time required to make complete analyses and the difficulty of obtaining specimens sufficiently pure for the purpose the number of minerals analysed is by no means equal to my wishes. . . . The amount of exact information upon the chemical composition of the various minerals occurring in New South Wales which has yet been published is extremely small and by no means equal to what might naturally be expected from a Colony so rich and prosperous and so well endowed with mineral wealth".

The book was approvingly reviewed, e.g., the *Glasgow Herald* wrote: "Its appearance is opportune, not merely because it is a record of the progress in the knowledge of mineralogy of New South Wales during the first hundred years of the Colony's history, but because it coincides with the extraordinary development of mining speculation which has been experienced this year as a result of the opening up of silver mines in the Barrier Ranges, which has generated a demand for scientific information concerning the general metalliferous resources of the Colony."

Liversidge had a continuing interest, also, in meteorites and collected and analysed many of them; he was the first to detect the existence of gold and the platinum metals in these bodies. He was thus led to study cosmic dusts, particularly those fine red deposits which are sometimes moved a thousand miles over Australia by circular storms and anti-tradewinds. He satisfied himself that mostly these were not meteoric but terrestrial in origin.

The metallurgy of gold was another of his interests. Several of his papers deal with the origin and precipitation of this metal, with the possible growth of gold nuggets in Australian alluvial deposits, with the gold and silver contents of various ashes, and with the apparent occurrence of gold in sea water.

After much analytical effort, Liversidge[54] concluded: "All . . . evidence is in favour of gold being present in sea water off the New South Wales coast in the proportion of about 0·5-1 grain per ton, or in round numbers from 130-260 tons . . . per cubic mile." If the world's oceans occupy 4×10^8 cubic miles, and if gold be uniformly distributed, the total amount involved could approach 10^{11} tons of gold.

Many years later, after the defeat of Germany in 1918 and the imposition by the Allies of demands for war reparations, to be paid in gold, amounting—in weight—to 50,000 tons, Professor Fritz Haber (of Berlin-Dahlem, a Nobel Laureate for his ammonia synthesis, and a holder of the high title "Geheimer Regierungsrat") persuaded the German Government to fit out a ship with filtration plant, laboratory, staff, etc., and then send it into North and South Atlantic waters to extract the required gold. The expedition was a disappointing failure . . . plainly, all previous estimates of concentrations had been erroneously high. Exhaustive further investigations, lasting until 1928, showed that minute traces of gold from reagents and vessels employed had misled earlier workers—and Haber's group as well! In fact, the gold content of sea water proved to be *ca.* one thousandth of that initially supposed[55] Liversidge's only known mistake was not his alone!

Altogether, Liversidge contributed to the Chemical Society, the Royal Society of New South Wales, and the Royal Society of London, more than one hundred papers. Such an output of research work was remarkable, especially in view of his many other activities which must have absorbed so much time and energy. He was clearly dedicated to chemistry.

After retirement from Sydney in 1907, he moved to England and continued to work in the Davy-Faraday Laboratory of the Royal Institution, London. Recognition came to him in many ways—thirteen Universities and scientific bodies gave him honorary degrees or

[54] *J. Proc. Roy. Soc. N.S.W.*, 1895, 29, 335.
[55] J. E. Coates, "The Haber Memorial Lecture", *J. Chem. Soc.*, 1939, 1642.

memberships; he became a Vice-President of the Society of Chemical Industry (1909-1912) and of the Chemical Society (1910-1913). In Australia he had three times been President of the Royal Society of New South Wales (1886, 1890 and 1901) and from 1888-1890 was President of the A.A.A.S. It is strange that he received no honours from the Crown.

Liversidge died from heart trouble on September 26, 1927.

He left bequests to the University of Sydney, to the Royal Society of New South Wales, to the Chemical Society of London, and to A.N.Z.A.A.S. for the founding of research lectureships. His will directs that the lectures "shall not be such as are termed popular lectures . . . nor such as are intended for the ordinary . . . instruction of undergraduates, but shall be such as will primarily encourage research and stimulate the lecturer and the public to acquire knowledge by research . . . and I direct that the lecturers appointed shall be the most suitable and eminent men procurable in their respective branches of knowledge".

These directions have been followed faithfully by the recipient bodies and "Liversidge Lectureships" are today prestige appointments for chemists in Australia and England. The lectures provide a lasting memorial to one whose ideal for unity and comradeship in science was measurably realized in his lifetime, who for 35 years was certainly the greatest organizer of science that Australia has seen, than whom "surely no one . . . ever worked more unselfishly and with greater singleness of purpose . . . to serve science for its own sake". In writing thus in 1931 Sir Edgeworth David[56] must have considered also the developments made in and from Melbourne by David Orme Masson.[57]

In their capacities for practical achievement and wise guidance of academic and public affairs, Liversidge and Masson had similarities. Both created standards of teaching and research; both built up their Schools to levels not surpassed in many Universities overseas; both made effective impacts on national life; both received personal recognition from fellow scientists; both were elected to the Fellowship of the Royal Society, Liversidge in 1882, and Masson in 1903.

If it seems that Masson, through the part he took in forming the Australian National Research Council, and what are today the C.S.I.R.O. and the Royal Australian Chemical Institute, has left larger and more visible results than has Liversidge, it should be remembered that Masson came to Australia fourteen years after Liversidge, was eleven years younger, and did not retire from the Melbourne Chair

[56] T. W. Edgeworth David, *J. Chem. Soc.*, 1931, 1039.
[57] A. C. D. Rivett, *J. Chem. Soc.*, 1938, 598.

until 1923 while his Sydney counterpart had left his in 1907. The intervening period was one of excitement and turmoil; Masson became involved with the Antarctic expeditions of Mawson and Shackleton and, during 1914-1918, very much with war work. It was then and later that the three bodies mentioned above had their origins.

Some of Liversidge's ideas were ahead of the time, e.g., he viewed Federation in 1900 as an opportunity for the introduction of a decimal coinage and as a suitable occasion to form an Australian Academy of Science with its Headquarters in the Federal Capital. Yet only since 1966 have we had decimal coinage, and fifty-four years were to pass before "The Australian Academy of Science was constituted by Royal Charter presented to the first Council by Her Majesty Queen Elizabeth II, in private audience at Canberra, on the 16th day of February, 1954". The event was historic. Between 1662, when Charles II handed the Royal Society its Charter, and 1954, no monarch had thus acted personally towards a new scientific body.[58] Liversidge tried hard to establish an Australian equivalent of *Nature,* and distributed prospectuses for an *Australian Journal of Science,* which, however, did not appear until 1938—some thirty years *after* Liversidge's initial efforts.

CONCLUSION

To record in any detail the growth of chemistry in Australia since the retirement of Liversidge would require a book by itself. The intention of this Chapter has been to emphasize the oustanding qualities of two great pioneers, one who founded chemistry within Australian science, the other who built wisely and widely on the structure created by his predecessor. To observe that chemistry first took root and flowered in New South Wales in no way diminishes the credit due to Rennie in South Australia, or to Masson in Victoria, or to sundry other workers who have been mentioned. Altogether, they have made it possible to report[59] that in 1967 "Australia has more than 266 highly qualified chemists in positions of responsibility for basic research; that these produce more than 640 publications a year, about 1·5 per cent of the world's pure chemical output, and that substantial work is being done . . . in all three divisions of chemistry". Put another way: in 1967, Australia contains at least thirty-eight Professors of Chemistry (not counting biochemists, pharmaceutical or agricultural chemists); in 1867 there was only one: John Smith.

[58] The full text of the Queen's Charter is printed in all Year Books of the Australian Academy of Science from 1956 onward.

[59] Cf. P. N. G. Armstrong, S. C. Hill and I. G. Ross, *Vestes,* 1965, 8, 246.