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Donald Eric Weiss 1924–2008

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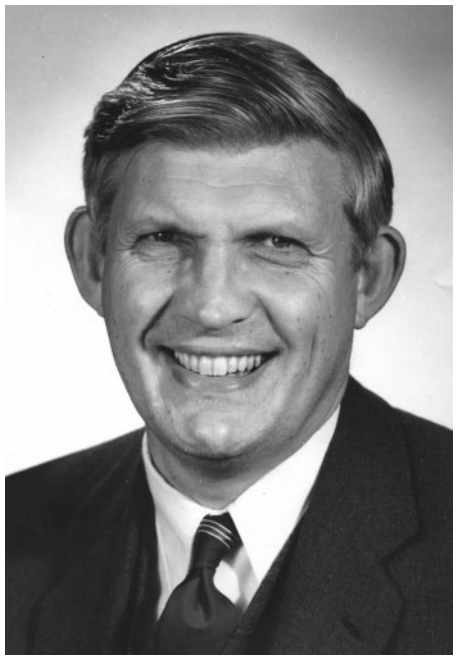
Don Weiss was born in the Melbourne suburb of St Kilda on 4 October 1924 and died in Melbourne on 30 July 2008. He was educated in South Australia, at Scotch College, the South Australian School of Mines and Industry, and the University of Adelaide. He joined the Council for Scientific and Industrial Research (CSIR) in 1948 and worked for CSIR and its successor organization, CSIRO, until his retirement in 1984. He was the Chief of the CSIRO Division of Chemical Technology from 1974 to 1979 and Director of CSIRO's Planning and Evaluation Advisory Unit from 1979 to 1984. He was a highly imaginative and creative scientist whose work was always driven by his clear understanding of its application. He made important contributions to separation science but is best known for his contributions to technology for water and waste water treatment. His enduring legacy is the more than twenty MIEX plants that have been installed around the world.

Family Background

Donald Eric ('Don') Weiss was born on 4 October 1924 in the Melbourne suburb of St Kilda, and died in the eastern suburb of Blackburn on 30 July 2008. His parents were Herbert Vernon ('Vern') Weiss, a librarian, and Lillian Kate ('Lill') née Le Lievre, a school teacher. They had married in 1914 and separated when Don was about 3. Don was their only child, born when Vern was 38 and Lill 37. After the separation Don and his mother moved to Adelaide to live in the house owned by Lill's older, widowed sister, Nellie Moyes. Also living in the house were Nellie's son Owen (born 1906) and Lill's younger sister Florence ('Floss'). Floss never married. All three sisters trained as teachers but Lill did not work after her marriage. Scotch College, Adelaide, was founded in 1919 and was close to the Moyes-Le Lievre-Weiss household. Floss worked in the College's preparatory school until retirement age and presumably contributed some income to the household. In notes written for his family, Don claims to have few memories of his childhood in this unusual household. He was not interested in sport but recalls an absorbing interest in his Meccano set. He attended Mitcham Primary School and remembers playing the fife in the school band, winning a competition in Renmark.



Don married Betty Axford Evans in 1951. Betty was the only daughter of William Edgar Evans, a jeweller in the Melbourne suburb of Hampton, and Constance Vera Dolan. She was born on 9 March 1919 and died on 29 March 2010. She was educated at Hampton High School and at the Melbourne Business College. She joined Gollin and Co., in the now heritage-listed

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Queen Anne style building at 561 Bourke Street in the city centre, as a stenographer in 1933. Attracted by the extra week's leave offered by CSIR, she joined their Head Office in East Melbourne early in the Second World War. At the end of the war she joined G. Gramp and Sons, the makers of Orlando Wines, as secretary to the managing director. She met Don through a colleague in the Gramp office. She did not have paid employment after her marriage. She and Don had two sons. The older, Robert Andrew, was born in 1952, is a chemical engineer and was elected a Fellow of the Institution of Chemical Engineers in 2003. Peter William was born in 1956 and is an architect. Don had three granddaughters and a grandson.

Secondary School

Don commenced his secondary education at Scotch College, Adelaide, in 1937 and completed his Leaving Certificate in 1941. He graduated from playing the fife to playing the flute and in 1941 was the first flautist in the school orchestra. He maintained an interest in the flute for the rest of his life. He was also a keen member of the school's Model Engineering Group, where he learned how to use metal-working tools and machines.

He was not very interested in studying until introduced to chemistry by the school. He was fortunate in having two first-class chemistry teachers, John E. Smith and John Dow, who inspired his life-long interest in chemistry. Smith had a BSc from the University of Adelaide but left the school in September 1940 to join the Army. To replace him, Dow, who had done some study at the University of Melbourne, was recruited from a farm in rural Victoria. Don decided at an early age that he was going to be an industrial chemist and set about visiting factories, even if they did not make chemicals. Imperial Chemical Industries of Australia and New Zealand (ICIANZ) built a soda-ash plant in Osborne, South Australia in 1940 and this fascinated Don when he saw it on the skyline as he visited his Uncle Philip in nearby Salisbury. He had his own home laboratory and taught himself to use chemical glassware.

In his last year at Scotch College he won the Science Prize, shared the Mathematics Prize and shared the Special English Prize for Form VI B. He did not stay the extra year to do Leaving Honours and so was never eligible to win the Professor Rennie Chemistry Prize. He later won the Rennie Memorial Medal of the Royal Australian Chemical Institute (RACI), an award made to young chemists.

Tertiary Education

Given Don's ambition to become an industrial chemist, it is not surprising that in 1942 he enrolled in the Diploma of Industrial Chemistry at the South Australian School of Mines and Industry (now part of the University of South Australia). In the first two years of this course he did most of the subjects at the adjacent University of Adelaide and in 1944 he transferred to a BSc course at the University. Due to wartime manpower restrictions he was not able to complete two of the Diploma subjects. In the third year of the degree he was enrolled in Inorganic and Physical Chemistry III, Organic Chemistry III and Electrical Engineering I. He failed the latter subject and had to repeat it by correspondence from Tasmania where he had found employment in the paper industry. He was awarded the BSc degree in 1945. He had to pay fees to the University of Adelaide even when enrolled at the School of Mines and Industry. The degree cost him £98 or about $5,000 in 2010 dollars. His starting salary at CSIRO in 1948 was £545 so the fees were quite modest. He did not proceed to an Honours degree and learned to do research on the job. He was awarded a DSc from the University of Adelaide in 1960 for his thesis 'Adsorbents and Adsorption Processes'.

Early Employment

Don had vacation employment at the Ewell Winery and Distillery, Glenelg, South Australia, and then at the Australian Pulp and Paper Manufacturers (APPM) mill at Burnie, Tasmania. Subsequently APPM employed him as a shift chemist at the Burnie Mill in 1945–46. (The mill closed in June 2010.) He wanted to be involved in research so, in 1947, he took a position as a development chemist at the Commonwealth Serum Laboratories in Melbourne. He was engaged in experimental laboratory and pilot–plant investigations of penicillin production. CSL was then a facility owned and operated by the Australian Government and while Don enjoyed the work on

penicillin production, he found the bureaucratic restrictions tiresome.

Recruitment to CSIR/CSIRO

Don's recruitment into CSIR was not atypical of the times. Early in 1947 Don attended a meeting of the RACI where he met R. G. Thomas, who at that time was the leader of the Minerals Utilization Section of the CSIR Division of Industrial Chemistry. They had a conversation about his work and his tentative design of a device for carrying out continuous fractional precipitations and analogous processes. A few weeks later, Don sent Thomas details of the design. Thomas showed the design to his colleague Ian Brown who thought that it showed promise and might be patentable. In April 1947, Thomas wrote a note to his Chief, Ian Wark, telling him about Don and his ideas and saying: 'I have no hidden motive in bringing Weiss and his talents to your notice. I incline to the opinion that some day he may be a valued member of this Division but I am not rushing in with a request just yet.' Wark's interest was evidently roused because he asked W. T. Cooke from the University of Adelaide for a reference. On the day in July that he received Cooke's strong reference, he wrote to Don saying: 'I would like to see you as soon as it can be arranged. I wonder if you would mind telephoning me for an appointment.'

The discussion must have gone well because Wark asked for Don's notes on his 'Improvements for Fractional Precipitation' so that he could show them to Keith Sutherland, the leader of the Physical Chemistry Section. Soon after that an advertisement appeared for a Research Officer in the Chemical Engineering Section—whose leader, D. R. Zeidler, was not included in any of the informal discussions—and Don duly applied, including with his application a cardboard model of his invention. There were seven applicants, including one supported by the Minister for Trade and Customs, Senator the Hon. B. Courtice. Don was offered the position and the Minister in Charge of CSIR, J. J. Dedman, advised his parliamentary colleague that his friend had been unsuccessful. Don commenced duty at Fishermens Bend on 2 January 1948 as a Research Officer, Grade I, at a salary of £545 per annum. He spent the rest of his career in CSIR/CSIRO.

The CSIR Division of Industrial Chemistry was established in 1940 with Ian Wark as the Chief. The Division commenced with seven sections including Minerals Utilization, Physical Chemistry and Chemical Engineering. Weiss joined the Chemical Engineering Section in 1948 but was transferred to the Physical Chemistry Section in 1952. Meanwhile CSIR had become CSIRO in May 1949. In October 1958 the Division was split into three Divisions (including Physical Chemistry, of which Weiss remained a member, and Mineral Chemistry) and three Sections (including Organic Chemistry and Chemical Engineering). The Organic Chemistry Section was accorded Divisional status in March 1961 but in August 1966 it was combined with the Division of Physical Chemistry to form the Division of Applied Chemistry (Schedvin and Trace 1978).

Career Progression

Weiss's early work greatly impressed Wark who, in his note to the CSIR Secretary in February 1949 recommending Weiss's reclassification to Research Officer, Grade II, wrote: 'It seems necessary now only to state that he is one of the most brilliant recruits the Division has had.' Weiss's first paper was published in *Nature* and was entitled 'New method for the preparation of adsorbents for chromatography' (1). Wark, in a further letter to the CSIR Secretary in March 1949 recommending that Don receive a double increment, noted that the paper had 'excited much interest around the world, judging from the number of reprints that have been sought'. Wark did not mention the actual number of requests received but it has only been cited a modest ten times.

Don was promoted to Senior Research Officer in 1953, to Principal Research Officer in 1955 and to Senior Principal Research Officer in 1959. In 1962 the Division of Mineral Chemistry decided to establish a Process Development Group and advertised for a Group Leader. There were twenty applicants, including eight from the UK and two from Canada, but Don was offered the position. The Chief of that Division, I. E. Newnham, noted: 'His infectious enthusiasm should prove most stimulating to the senior members of this Division who, for their part, will exercise a critical appraisal of the many new ideas which Weiss is sure to disseminate.'

Don commenced duty in the new position in July 1962 but there must have been too much critical appraisal because he returned to the Division of Physical Chemistry in August 1963, where he was promoted to Chief Research Scientist (I) in 1965. In 1971, two sections of the Division of Forest Products were transferred to the Division of Applied Chemistry and placed under Don's direction. He was designated Assistant Chief of the Division and simultaneously promoted to Chief Research Scientist (II). As outlined in more detail below, in February 1974 the Division of Applied Chemistry was split to form the Divisions of Chemical Technology and Applied Organic Chemistry, with Don being appointed Chief of the Division of Chemical Technology. He remained in that position until February 1979, when he was appointed the Director of CSIRO's newly established Planning and Evaluation Advisory Unit. He retired from the Organisation in October 1984.

The creation of the two separate Divisions was a consequence of Sefton Hamann's announcing his intention to retire from his position as Chief of the Division of Applied Chemistry. When CSIRO advertised for a new Chief of the Division, two strong candidates emerged, Don Weiss and D. H. Solomon. The Executive decided not to choose between them but to split the Division. The two prospective Chiefs were given some flexibility in the allocation of the staff between their new Divisions. In conformity with his philosophy, Don chose the more applied groups, while Solomon took the more basic groups. Solomon was also the leader of the then highly confidential Currency Note Research and Development (CNRD) project and was mindful of that project's needs in his selection of staff.

Research Approach

Don had a consistent approach to his work in CSIRO. In his notes written for his family, he says:

> Our work, with few exceptions, has always involved some form of collaboration with an industrial partner usually brought about through discussions with industry before undertaking any significant project. Since I believed it was our job to help industry financial support was only sought for major projects, notably Sirotherm and Sirofloc, which required large expenditure. A few times this resulted in CSIRO not receiving the credit due to a successful innovation. It has always been my belief that industrial-type research, in an organisation like CSIRO, should mainly aim to be long term and highly innovative; only industry has the detailed knowledge of technology, markets and timing for devising most short-term improvements to existing products and processes although CSIRO can assist with specialist knowledge and/or technology.

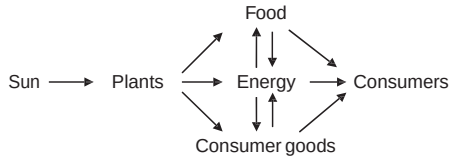

Figure 1. Integrated Photosynthetic Product Industries (IPPI) have potential to produce, by fractionation of plants, food products, materials, chemicals and energy.

Don's appointment as Chief of the Division of Chemical Technology gave him the opportunity to put this philosophy into practice. It was a new Division formed from parts of the Organisation with long traditions of working with industry and Don had a hand-picked group of colleagues to help put his ideas into action.

He got down to it straight away. In the Preface to the first Research Review of his new Division, Don spelled out his approach: 'chemical technology', he said, 'represents the major tool being used in scientific research, rather than the subject of study. The new Division will apply chemical and polymer technology to two major Australian resources—plants, particularly those with useful fibres, and water' (CSIRO Division of Chemical Technology 1974). He developed a concept to describe his approach. It was the Integrated Photosynthetic Product Industries (IPPI) concept, shown diagrammatically in Figure 1.

In the same Preface, Don stated his view of the role of basic research in his Division: 'In each of our programs we must become involved in basic research, either here or in other Divisions, to the extent necessary to solve our problems. Where necessary this will be supplemented by collaborating with universities and colleges of advanced education.'

Stokes suggests that there are three broad approaches to research (Stokes 1997). Research that advances knowledge and provides economic

outcomes belongs, he says, in 'Pasteur's quadrant', in contrast to work in the 'Bohr quadrant' that seeks advancement of knowledge alone and in the 'Edison quadrant' that seeks utility alone. CSIRO has generally thought of its work as being in Pasteur's quadrant. Don's description was going close to Edison's.

The Division under Don's leadership is remembered by Tony Priestley as having 'great and creative times'. Apart from the Division's great contribution to water and waste water treatment, it assisted the James Hardie company in replacing asbestos fibre in their cement products with cellulose fibre, and commenced a major project to convert otherwise waste timber into a usable product, SCRIMBER. This was commercialized by Repco but never achieved commercial success.

Royal Australian Chemical Institute

Don was a very active member of the RACI. The records at the RACI National Office indicate that he joined the Institute in 1946 when in Burnie, Tasmania. On the letter sent to him in August 1996 by the then RACI President, Barry Noller, congratulating him on achieving fifty years of membership, Don annotated: 'does not include my membership in Burnie and SA'. He was elected a Fellow in 1957.

Don started his long involvement in the affairs of the RACI as Chairman of the Victorian Chemical Engineering Group from 1955 to 1960. He was a member of the Victorian Branch Committee, 1961–65, during which time he helped to organize the Institute's third National Convention, held in Canberra in 1966. He was Vice-President of the Victorian Branch in 1970 and President in 1971. It was during this period that he became very interested in environmental issues and he was responsible for the Victorian Branch producing a book, *Nature in the Balance*, of which he was a co-author.

When he moved to Canberra in 1979 to become Director of the CSIRO Planning and Evaluation Advisory Unit, Don was immediately recruited to the ACT Branch Committee (1980–81). In those days the responsibility to nominate the national Vice-President (and hence by succession, the President) of the Institute fell to each Branch in turn. In 1981 it was the turn of the Tasmanian Branch, which nominated Don. He was Vice-President in 1982 and President in 1983.

Don is the only person to have won all four flagship medals of the Institute. He was awarded the 1950 Rennie Memorial Medal (Figure 2). This is now awarded to a member with less than eight years' post-qualification experience who has contributed most towards the development of some branch of chemical science; in 1950 it was to a member under the age of 33. He was awarded the H. G. Smith Memorial Medal in 1966, this being the Institute's senior award for contributions to science. The Leighton Memorial Medal is the Institute's most prestigious medal and is awarded in recognition of eminent services to chemistry in Australia in the broadest sense. Don was awarded that in 1977. In 1980, the Institute introduced its Applied Research Award for significant contributions to the development of or innovation through applied research, or in industrial fields. This medal is named each year after a notable applied chemist. Don won the 1981 award, which was named the K. L. Sutherland Medal. His colleague B. A. Bolto won the award in 1983 as the A. J. Parker Medal. In 1971, Don was awarded the Archibald D. Olle Prize of the New South Wales Branch of the Institute for his papers on 'Energy Transducing Mechanisms in Biological Membranes' (45–49).

Australian Academy of Science and Australian Academy of Technological Sciences and Engineering

Don was elected a Fellow of the Australian Academy of Science in 1971. He served on the Bilateral Activities with China committee from 1978 to 1980 but was otherwise inactive in the affairs of the Academy.

The Australian Academy of Technological Sciences (since 1987, the Australian Academy of Technological Sciences and Engineering) was inaugurated in February 1976 with Ian McLennan as President and sixty-five Foundation Fellows. Don, along with eleven fellow Chiefs or former Chiefs of CSIRO Divisions, was a Foundation Fellow. He was very much involved in the early activities of the new Academy. In 1977, he was a member of the committee that recommended the Academy's distinctive logo, he was Chairman of the International Relations Committee 1977–80, member of the Council

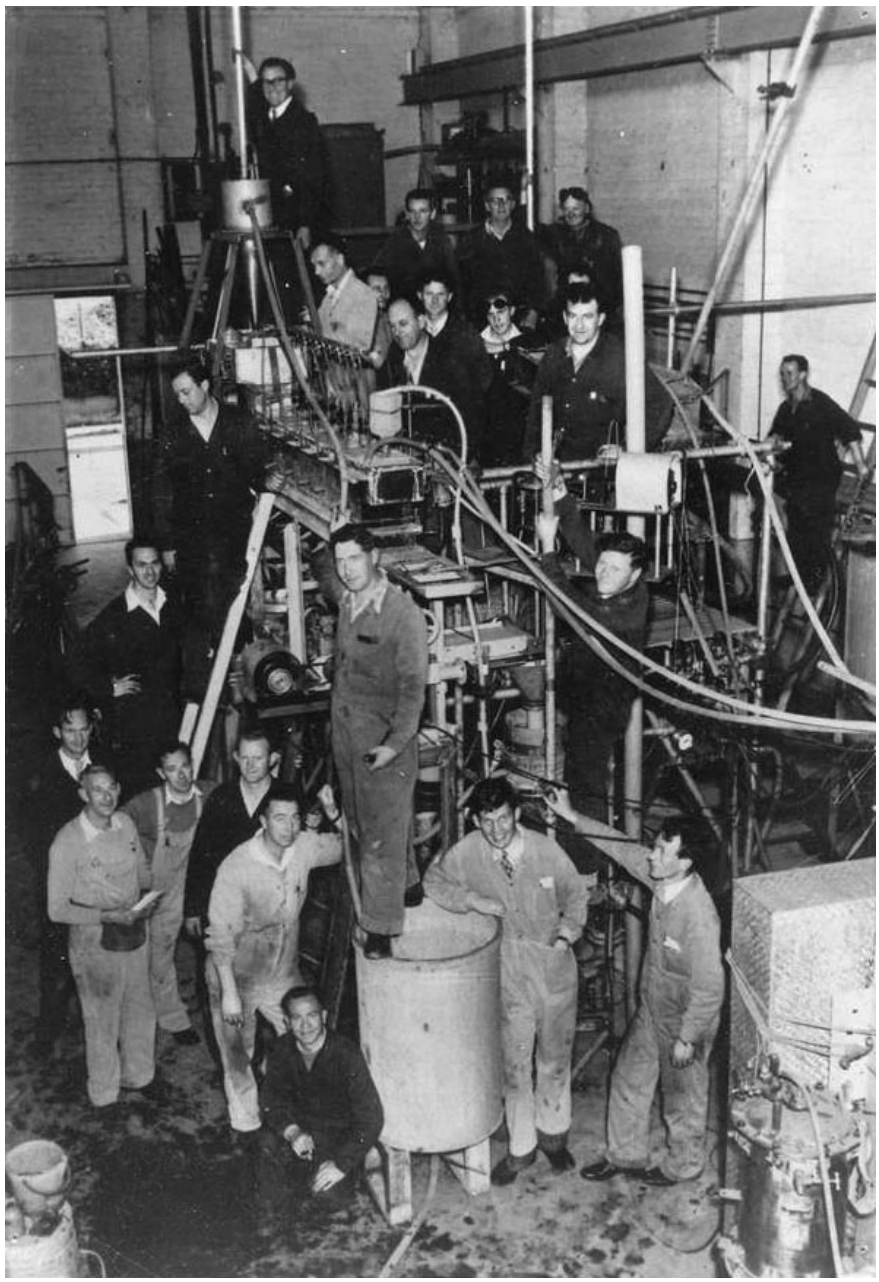

Figure 2. CSIR Division of Industrial Chemistry, workshop at Fishermens Bend in the early 1950s, near Don Weiss's flotation cells, celebrating the award of the Rennie Medal.

1978–80 and Chairman of the ACT Division 1980–81.

The inaugural Council of the Academy of Technological Sciences decided to produce a series of publications entitled 'Innovation in Australian Technology' listing Australian innovations. There was a description of each innovation and comments on its application, value and

advantages. Don was a regular contributor to this series, which ceased in the mid-1980s.

Other Professional Activities

Don was a great contributor to professional associations relevant to his technological interests.

He was involved with the Society of Chemical Industry of Victoria (SCIV) and the British-based Society of Chemical Industry (SCI). The Society of Chemical Industry of Victoria was formed in 1900 and merged with the Society of Chemical Industry in 1999. Don was a member of the SCIV committee, 1959–60, and was a frequent speaker at SCI conferences in the UK. The Mirrabooka Sirofloc Plant built for the Perth Metropolitan Water Board and based on Weiss's technology won the SCIV's 1981 'Plant of the Year' award. He was given an award for 'Innovative Contributions to Ion-exchange Technology and its Application in Practice' in 1992 by the SCI.

Don was very active in the Victorian Branch of the Australian Water and Wastewater Association (AW&WA, now the Australian Water Association (AWA)), an association that brings together individuals and organizations involved in all aspects of the water industry. Don was on the Victorian Branch Committee from 1965 to 1976 including being the Vice-President in 1972 and the President in 1973–74. Don was active in the international association, the International Association for Water Quality Pollution Research (now the International Water Association), as an Executive Member of the Australian Branch from 1970 to 1978 and President in 1979.

The Water Resources Council of Australia was the Ministerial Council, which, from 1962 to 1992, worked to further Commonwealth-State co-operation and collaboration on water matters. Its functions are now part of the Natural Resource Management Ministerial Council. Don was a member of the Water Quality Technical Committee from 1971 to 1973 and the Water Quality Research Sub-Committee from 1972 to 1979.

Early in Don's career, in 1955, the University of Melbourne awarded him its Grimwade Prize. In his letter of congratulations, the Dean of Science, S. D. Rubbo, reported that 'the examiners were impressed with the distinctive and original features displayed in your work'. The Grimwade Prize has been awarded since 1906 when Frederick Sheppard Grimwade presented the sum of £1,000 to the University for the promotion of the study of industrial chemistry.

Contributions to Science and Technology

Don devoted his entire scientific career to separation science. He was either trying to recover a valuable component from a dilute solution or mixture, or to separate impurities from a valuable solvent. His work was user-driven. He did not think that the work was finished until it was embodied in a plant operating on a commercial scale. This often was frustrating for him because the companies with which he worked often changed their direction before the technology could be implemented. For Don this frustration was only ever temporary. His natural enthusiasm always enabled him to move on to the next problem. Some of Don's many ideas did not survive the scrutiny of his colleagues, some ended as great contributions to knowledge, some as successful processes developed and commercialized by others, some commercialized by CSIRO but of limited commercial success and some, like MIEX, of significant commercial value. Most scientists are content to have made a contribution to knowledge. Don is one of a small group to have a lasting commercial legacy.

On 2 September 1992, the SCIV, RACI, AAS, AATS&E and AW&WA jointly organized a function to present Don's SCI award to him. At that function he reminisced on his forty years of research and an edited version of that talk has been published by one of his collaborators, E. A. ('Bob') Swinton (Swinton 1993). Don himself left an expanded version of that talk in his notes to his family. What follows includes extracts from both documents.

Despite the interest of Wark and others in his cardboard model of a multistage centrifuge for the extraction of penicillin broth, the Division decided that developing the idea was inappropriate for a chemical research group. A similar device was later developed and sold by Westfalia Separator.

In his own notes about his professional career, Don recalls that when he was working as a shift chemist at the APPM mill at Burnie he observed that dyes, added at very low concentrations in

a white paper stock, often concentrated and separated on foams formed in waste-water channels beneath the paper machines. So instead of developing his cardboard model after he joined CSIR, he set about turning this chance observation of fractionation in foam into a usable process. He did this in collaboration with his former employee, CSL, in a project for extracting penicillin. His first project was to attempt to improve the capacity of a foam column by incorporating adsorbents at the foam interface. He did this successfully by adsorbing a fatty acid with oleyl alcohol to produce an adsorbent that could be floated and which had ion-exchange properties (1).

This project suffered a fate not unfamiliar to Australian public-sector scientists working with private firms (although CSL was at that time a Government-owned commercial enterprise). It came to an abrupt end because CSL had acquired a new mould that increased yield and reduced colour and so did not require a separation process. At this time, CSL asked the Division of Industrial Chemistry to assist with a process for streptomycin production. Don developed a process where oleic acid coated with activated carbon became an ion exchanger. When this was incorporated into a foam it could be used to extract streptomycin. CSL decided not to proceed with streptomycin production and Don's collaboration with CSL ended.

His research, however, continued. As Swinton reports:

> Instead of using a foam, the activated carbon was coated over the surfaces of discrete bubbles of air, which floated up a column against a rapid downflow of broth, thus achieving countercurrent extraction. Further development replaced air bubbles by coarse quartz bubbles, coated with water-wet diatomaceous earth, held tenaciously by surface forces. Moving a bed of this material down against a rising flow of solvent enabled countercurrent purification of crude penicillin, similar to fractional distillation. To move the bed of particles steadily against the upflow, the principle of the mineral dressing jig was used, whereby a pulsation was applied to the upflow, generating a semi-fluidised, but non-turbulent, bed.
>
> The details were published in (8) and (9).

Since CSL no longer had an interest in the technology, Don applied the idea to ion-exchange and developed a continuous water softening system (13). This was shown to delegates at the Fifth Empire Mining and Metallurgical Congress, held in Australia in April and May of 1953. Some of the delegates saw that the system had potential for the direct recovery of uranium from a slurry of leached mineral ores (15, 21). This was at the height of the Cold War, so negotiations were needed in order to obtain a security clearance for Don to visit some ion-exchange uranium extraction plants operating in the Colorado desert in the USA. Don learnt that there was a need for a better technology for extracting uranium from unfiltered leach liquor. In 1952, the Australian Government funded the setting up of a mine and treatment plant to provide uranium oxide concentrate from the Rum Jungle deposit to the UK-US Combined Development Agency under a contract. The Government, through the newly established Australian Atomic Energy Commission (now ANSTO), was responsible for the mine, although it was managed on a contract basis by Territory Enterprises Pty Ltd, a subsidiary of Consolidated Zinc Pty Ltd (now Rio Tinto Ltd). Consolidated Zinc supported Don to develop a pilot plant which, when operated at Rum Jungle, demonstrated the ability to pass a desanded slurry counter—currently through a pulsated bed of ion-exchange resins that extracted the uranium ion. The process was patented and licensed to the Permutit Co. of the UK (now Siemens Water Technologies), which built a full-scale plant in London, then erected it at the mine site at Rum Jungle. The approaching wet season meant that the project had been set a tight deadline, but the bed kept on blocking, something that had never happened in the pilot plant. Despite desperate trials by the team of young engineers from Permutit, Territory Enterprises and CSIRO, the decision was made to terminate the project and the team disbanded.

However, Bob Swinton, the CSIRO scientist involved, requested permission to conduct at least one trial at leisure. By patient observation he discovered that the failure had been caused by Permutit's decision in their tests in London to replace the vacuum system by a cheaper, compressed-air pulsation technique. The jet of air impinged on the surface of the slurry of ground ore, which contained particles of a hydrophobic mineral to which minute bubbles of air became attached. These were carried into the bed of ion-exchange resin beads and

attenuated the pulsation, causing blockage by the slurry. The London trials had been conducted on a suspension of local clay that had completely different surface properties from a real ore. Technology transfer from a public research institute to a company always requires vigilance!

The work begun by Don continued in Russia and in Japan, where Asahi developed from it the first commercially successful continuous ion-exchange process for the treatment of boiler feed and industrial water. The power station built in the Melbourne suburb of Newport employs this equipment. Don worked with Comalco (now Rio Tinto Ltd) to show that a slurry of lime passed through a pulsating bed of ion-exchange resin could produce a dilute solution of caustic soda without producing chlorine. Concentration proved too expensive for the process to be commercially successful (28).

In 1962, Don saw in the literature that the American company Chlormetal had developed a cheap electrolytic method of producing caustic soda or sodium. He thought that with a cheap source of sodium, an old process for producing aluminium in which sodium was used to reduce aluminium chloride might be economical. CSIRO decided to offer the first opportunity to support further development to Consolidated Zinc (soon to be CRA). As noted earlier, in 1962 Don had applied for and obtained a position as leader of the Process Development Group at the Division of Mineral Chemistry and had commenced there in July 1962. CRA agreed to invest £250,000 over two and a half years in the project, which commenced in the first half of 1963. Don coordinated the project while in the Division of Mineral Chemistry but left the project when he returned to the Division of Physical Chemistry in August 1963 (Bear *et al*. 2001).[2]

In the early 1960s, Don decided to turn his attention to municipal water treatment. He studied the needs and markets carefully. He visited the municipal water authorities in Melbourne, Adelaide, Perth, Sydney and Brisbane and came to the conclusion that the problem that was of most concern and the one to which he could contribute was the expected rise in salinity of municipal water supplies in Perth and Adelaide. This became his main scientific interest for the rest of his career and his achievements in this area are his greatest legacy to the nation.

His view was that ion-exchange technology had potential if chemical regeneration could be replaced by some physical means such as heat or electricity. Initially he could not see how to use heat and so decided on an electrochemical approach using activated carbon electrodes.

In December 1948, the Minister for Postwar Reconstruction, J. J. Dedman, had announced that Victor Garten, a German physical chemist, had arrived in Australia and would be working in the area of plastics and rubber research. Garten came to CSIR and worked on the mechanism for carbon black reinforcement of rubber. Don Weiss and Garten decided to work together on a study of the fundamental properties of activated carbon and carbon blacks. The collaboration was a scientific success, including the pioneering synthesis of electrically conducting polymers (14, 16–19, 22, 23, 26). They reported high conductivity in oxidized iodine-doped polypyrrole. They achieved the quite low resistivity of 1 ohm.cm with these polymers. In a later paper they reported a substituted polypyridine with a remarkable resistivity of 0.03 ohm.cm (30–37). They also provided a guide to the synthesis of conducting polymers: ‘organic polymers of good conductivity can be prepared by directly crosslinking small aromatic or heterocyclic units into three-dimensional non-planar structures in which the number of cross-links should be as large as possible. Either electron-donating or electron-accepting structures, but not both, may be present in the one polymer’. However these polymers could not be applied to desalination and that line of work was abandoned. This was unfortunate because conducting polymers were ‘rediscovered’ in 1977 by Heeger, MacDiarmid and Shirakawa (Shirakawa *et al*. 1977) and they won the 2000 Nobel prize in chemistry ‘for the discovery and development of conducting polymers’.

In 1967 Don started thinking again about heat regeneration of ion-exchange resins. As Bob Swinton reports:

> A clue was obtained from a study of biological processes where cell energy is used to move substances against concentration gradients (a relevant example being to ability of seabirds to perform desalination).
>
> Observation of changes in pKa in a basic dye attached to a protein led to a realisation that organic bases show marked changes in basicity

> with increasing temperature. From this emerged the concept of the 'Sirotherm' process, whereby salt is extracted from brackish water by a mixture of weak acid and certain weak base resins which are then rinsed with hot water. Heating the weak base changes its basicity causing the adsorbed ions to be released as a more concentrated effluent.

The process worked in laboratory trials but with the resin bead sizes designed for fixedbed plants was far too slow. Finely grinding the resin did increase the rate but with impractical hydraulics. 'Plum pudding resins' overcame the problem. The active micron-sized resins were the 'plums', dispersed within a porous matrix bead of the standard size. In 1970, ICI Australia became the commercializing partner, in charge of manufacturing the resins. A pilot plant was built and operated in Perth for some months that showed that saline waters could be treated. In 1975, ICI operated the first commercial plant at its Osborne plant in South Australia, as a precursor for treating boiler feed. By this time, Don had become Chief of the Division of Chemical Technology and Brian Bolto was the leader of the group. He made significant new developments to the process by replacing the matrix with an amphoteric structure. In collaboration with David Solomon's team at the Division of Applied Organic Chemistry, more efficient resins were prepared, leading to significant cost reductions.

An alternative to the plum pudding resins that were adopted in the early Sirotherm process was the concept of 'magnetic resins' that arose from a discussion with D. L. Ford, Chief Research Chemist at Union Carbide Australia Ltd (and the inventor of 'Glad Wrap'). The idea was to achieve rapid reaction rates by using micro-beads of resins, each bead containing a proportion of gamma iron oxide (Patent n). Unmagnetized, they dispersed readily, but when passed through a magnetic field, they flocculated and settled rapidly and could also be pumped around a circuit. Using such resins, and with finance from the Australian Government's Department of Productivity, a demonstration plant was erected for the Perth Metropolitan Water Board at Leederville. Unfortunately, the weak-acid components of the Sirotherm resins were easily fouled by calcium and magnesium, and the commercial softening pre-treatment that had been installed was not reliable. Although desalination was achieved, ICI lost interest and the Isotherm project ceased.

In 1969, Don published a series of papers in which he used his knowledge of the properties of rubber and of ion- and electron-exchange polymers to develop models to explain energy transducing reactions in biological membranes. The first paper was a letter to *Nature* (45) and Don then developed his ideas in four papers in the *Australian Journal of Biological Sciences* (46–49). The papers presented qualitative models and aroused some controversy within both the chemical and biological communities. Dr Max Day, a distinguished entomologist who was at the time a member of the CSIRO Executive, expressed the view that if further papers were to be published, they should have more biological input. He drafted a letter to be sent to Don in which he indicated that he had discussed the papers 'with Bob Robertson and Ralph Slatyer'[1] and that they had proposed that Don spend three months in Canberra further developing the ideas in the papers. Day proposed that the three months should come after Don had spent the next nine months on the Sirotherm work. Don's Chief, Sefton Hamann, was not very enthusiastic about the idea of Don spending time in Canberra. He told Day

> I heard earlier Bob's suggestion that Don should work for a while with some biologists, and thought it a fine idea. The only reservation that I had, and still have, concerns the timing of Don's stay in Canberra.
>
> First, I have the impression that although Don's ideas are obviously novel and exciting, they are also controversial. There might be some merit in allowing a little time for them to be digested and to bring what reactions they may. But of course one could also argue that any criticism of them (and there has been some) would itself be a justification for encouraging Don to pursue the work further.
>
> I am more concerned with the danger of diluting Don's efforts on the Sirotherm process….
>
> For that reason, I feel it would be unwise to suggest a particular time for Don's diversion to biochemistry.

[1] The eminent botanist Sir Rutherford Robertson was then the Master of University House at the Australian National University, while Professor Ralph Slatyer was Professor of Biology at the University's Institute of Advanced Studies.

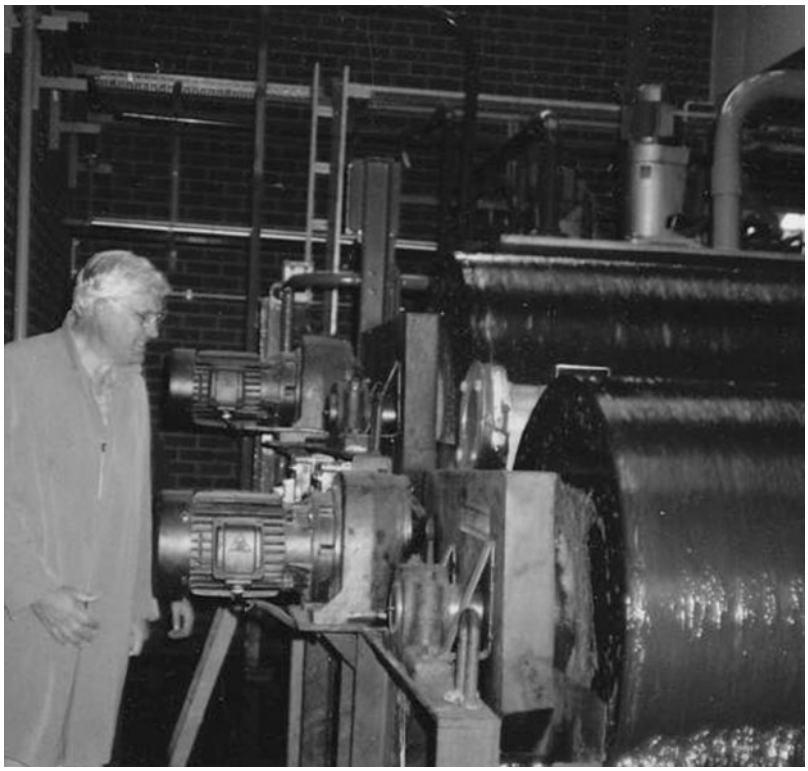

Figure 3. Don Weiss inspecting the Sirofloc magnetic regeneration train at Bell Bay.

The letter Day had drafted was never sent and Don did not publish in this area again.

In the mid-1970s, Don realised that the removal of colour and turbidity from ground and surface waters was a problem. In some early work it was shown that gamma iron oxide could adsorb colour from acid waters and release it under alkali conditions. Gamma iron oxide was, however, difficult to demagnetize and was replaced by magnetite (Fe_3O_4), which could be easily magnetized and demagnetized. After experimenting with various resins, it was discovered that the magnetite particles themselves, if treated with alkali, would adsorb colour and turbidity (50, 71, 73, 74). This led to the Sirofloc process, which was demonstrated on a commercial basis at Mirrabooka near Perth in 1981.Commercial plants were constructed in Tasmania, New Zealand, England and Ireland, while the Sirofloc concept was also applied to sewage treatment and the recovery of heavy metals from effluents from mineral processing. One Sirofloc plant is still operated by the Esk Water Authority in northern Tasmania. CSIRO awarded the Sirofloc team (N. J. Anderson, B. A. Bolto, D. R. Dixon, L. O. Kolarik, A. J. Priestley, W. G. C. Raper and D. E. Weiss) a CSIRO Medal in 1989 (Figures 3 and 4).

The concept of magnetic ion-exchange resins was further developed by the CSIRO Division of Chemical Technology and its successors, the Divisions of Chemical and Wood Technology, Chemicals and Polymers and Molecular Science, and is now licensed to Orica. MIEX technology, as it is now called, has been successfully applied for the removal of dissolved organic carbon from potable water sources. The first commercial MIEX plant was built for South Australia Water at Mount Pleasant in the Adelaide Hills in 2000. More than twenty plants have been installed around the world.

The Planning and Evaluation Advisory Unit (PEAU)

In October 1976 the Australian Government established an independent inquiry into the

Figure 4. The Sirofloc team with their CSIRO Medal. Left to right: A. J. Priestley, N. J. Anderson, B. A. Bolto, L. O. Kolarik, D. E. Weiss, D. R. Dixon and W. G. C. Raper.

CSIRO chaired by A. J. Birch. This reported in August 1977 (Birch 1977) with 122 recommendations, most of which were adopted by the Government.

Recommendation 41 was

> A Planning and Evaluation Advisory Unit should be established, responsible to the Deputy Chairman, to provide advice and assessment related to economic, industrial and social factors, to assist the Executive in its development of strategies and priority allocation of resources.

To implement this and other leading recommendations required amending the Science and Industry Research Act. This was done by the end of 1978 to allow the new arrangements to commence on 1 January 1979. The position of Director of the Planning and Evaluation Advisory Unit was not advertised but offered to Don for an initial period of three years. He accepted the position, which required him to move to Canberra, and commenced in March 1979. He was in the position until October 1984 when he retired from the Organisation.

In his notes about this time he says:

> My first task was very challenging. It was to create a directory of CSIRO's research to show what was going on and why. … At first that seemed quite straightforward since by then all CSIRO's research was grouped within Programs the headings of which were intended to describe the scope and objectives of the work. The difficulty was that whilst most of the Divisions did this very well, and their purpose was well appreciated, in others this did not occur.

He did eventually succeed in producing a directory of projects and he considered this the most important achievement of the unit.

G. H. Taylor, a member of the CSIRO Executive from 1982 to 1986, outlined how the work of PEAU had assisted the CSIRO Executive to select high-priority research topics for its manufacturing industry research (Taylor 1984). He reported that in 1982–83, PEAU carried out a major planning study for CSIRO's

manufacturing-industry research. The report was 1,500 pages long and had three main elements:

- a series of industry studies, addressing such matters as economics, contribution to national wealth, technology needs and awareness, and future growth potential for each sub-sector of manufacturing industry;
- a series of research studies surveying CSIRO's current research for manufacturing industry and addressing future opportunities; and
- discussion of a series of issues for manufacturing industry as a whole: for example, role in the Australian economy, structure, concentration, foreign ownership, technological change.

The unit did similar studies for energy, water resources and agriculture. This was a pioneering unit that did not survive Don's retirement. In a letter to Don on his retirement, the Chairman of CSIRO, Paul Wild, acknowledged the difficult task he had been given:

> In addition, it is now history that the Executive asked you to do a very difficult job in heading up the Planning and Evaluation Advisory Unit from 1979. The Executive was aware of the stress it was placing on you because we were all in unfamiliar territory and you were asked to embark on a 'trail blazing' exercise. We believed that, at the outset, the Unit should be led by a research manager widely accepted and respected and that we were grateful indeed that you took on the job. You completed a prodigious task in surveying economic and social interests relevant to all sectors of CSIRO's research effort, and your work has provided the basis for the next phase of planning which is currently under consideration by Keith Boardman in his review.

That review recommended many changes to CSIRO's planning activities (CSIRO 1984). The 1984/85 CSIRO Annual Report noted that:

> A corporate planning system has been introduced. Each cycle will start with planning guidelines from the top management, giving managers at all levels an indication of the broad directions they should follow in formulating plans. Plans will be formulated at Division, Institute and Corporate levels. Research users will be involved in the development of plans and the evaluation of progress.

A Corporate Planning Unit was established at that time but no senior appointment was made until the appointment of Don MacRae in 1987. Planning of research priorities became more formalized in the Organisation after the appointment of Dr John Stocker as Chief Executive in 1990. The elements of his National Research Priorities Framework had some similarities with Taylor's description of Don's study.

Post-retirement Activities

Following his retirement, Don took a few years off from professional activities while he and his wife rebuilt their lives in Melbourne. In the process of tidying up his large collection of papers and books in 1989, he re-read his first published papers (1–3), in which he had described the preparation of bubbles individually coated for use in separation processes. After a forty-year break he was very impressed with the work and decided to have another look at it. He obtained financial support from Davy Pacific and spent 1990 working with an assistant at the Royal Melbourne Institute of Technology (RMIT). It took him a while before he was able to repeat his earlier experiments. He eventually discovered that it was a kinetic problem. He needed a high enough mixer speed to enable the air bubbles to hit the wall of the tank where they picked up the carbon made hydrophobic by adsorption of the oleyl alcohol. He then set about devising a less energy-intensive process by using a column of louvres that RMIT had been using for another purpose. Illness prevented any further work in 1990. In 2001, with some funds from CSIRO, he resumed the work at RMIT but it was never published or taken up by industry.

Legacy

Don Weiss devoted his career to applying science and technology for the benefit of the Australian economy. This was his primary interest. On the way, he and his team made important contributions to separation science, carbon chemistry, polymer science and process engineering. The many MIEX plants that are operating around the world are testament to the strength of his ideas and to the value of perseverance.

Don was a creative and enthusiastic scientist. A tall man, he was a towering presence in more ways than one, and never seemed to join in ordinary conversation; his brain was always employed elsewhere. His flow of ideas needed

critical sorting and he was fortunate in having many collaborators who assisted him in bringing his better ideas into practice. Towards his colleagues and assistants, he was infallibly courteous, even when they lagged far behind in comprehension of his more complicated theories.

He was not a bureaucrat and did not enjoy his time as one in the CSIRO Head Office in Canberra. He nevertheless was one of the first to recognize the importance of a multidisciplinary approach and the vital importance of involving end-users in the selection and management of projects in publicly funded research organizations.

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