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Ian Mackay Ritchie 1936–2014

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Ian Ritchie AO, BA, MA, MEng, PhD, ScD, FTSE, FRACI, FAIMM; scientist, engineer, teacher and humanist, brought fresh understanding and relevance to the relationships between metals and fluids through his work on metal oxidation, electrochemistry and hydrometallurgy. Passionate about education, society and the environment, he constantly sought new ways to interest young people in science and its role in the future wellbeing of human society and the fragile Earth. He served the community with energy and dedication as a valued advisor to government, industry and academia. He contributed much to the establishment of air quality standards in Western Australia, and is credited with preventing the dismantling of the WA Government Chemical Laboratories and steering them to rebirth as the ChemCentre. He was the founding CEO of the AJ Parker CRC for Hydrometallurgy, which became the world's foremost centre for hydrometallurgical research under his inspirational leadership. Ian was a kind and humble man with huge talent who was always ready to share his wisdom. He was a passionate and prolific scientist, but his greatest joy came from his family—Ann, the love of his life, and his three wonderful children, Kathy, Andrew and Alex. Driven by a deep sense of fairness, he railed against injustice and stupidity wherever he saw it. All who knew him will miss his ready wit, awesome erudition and endless creativity, but the imprint of his contribution and influence will never fade. He was inducted to the Western Australian Science Hall of Fame in 2016.

Early Days

Ian Mackay Ritchie was born on 18 March 1936 at Tidworth, England, where his father, William (Bill) John Ritchie, an army lieutenant colonel, was garrisoned. With the outbreak of war in 1939 Bill was seconded to the intelligence service at the War Office in London. He was away from the family for much of Ian's childhood. Bill and Lily (née Broadhurst) already had a daughter, Shelia. The military background ran deep—Lily was named after the *Canna* lilies of Bermuda where her father worked as an army engineer; Bill was inspired by his father who died fighting in the Boer war.

Ian became a keen Boy Scout. He loved to lead hiking and camping expeditions and he excelled in problem-solving. In 1953 he was one of the 50 elite Queen's Scouts at Queen Elizabeth's Coronation Ceremony in Westminster, and was the chosen runner who rushed the historic film to its flight so that the newsreels in the USA would have it by dawn.

He completed schooling at Watford Grammar School, on the north-western outskirts of London. Despite a bout of rheumatic fever (no anti-inflammatories then), he was a keen sportsman and competitor—member of the cricket team, tennis team captain, and feared equally on the badminton court (he was later awarded a Blue in badminton at Cambridge University) and the chessboard.

During a brief stay in hospital for minor surgery during his high school years, a pretty nurse caught Ian's eye, and he invited her to come with him to the school play. Her name was Ann McMahon. She agreed, and so began a lifelong romance. Later, punting on the Cam and tea at a pub in Grantchester led to marriage and enduring love and support for each other.

The hallowed halls of Cambridge beckoned. In his undergraduate studies in general science, Ian shone in mathematics. Keen to apply his talents to practical outcomes, he made chemical engineering his

specialty to complete his BA. That required completion of a six-month practical project off-campus. He jumped at the chance to work with Frances Thomas (Tom) Bacon (a direct descendent of Sir Francis Bacon, the quintessential Renaissance man who came

up with 'Baconism'—the inductive method of inquiry or Scientific Method—the basis of all scientific endeavour) on new types of electrodes for his revolutionary hydrogen-oxygen fuel cell that was later adopted by the Apollo space program. Bacon was so impressed with Ritchie's work that he used it to support an application for research funds. When the project was over he said: 'Now my boy, do some good with your life and work on the oxygen electrode'. They remained friends—decades later the Bacons stayed with the Ritchies in Perth when Tom came to Australia to receive a prestigious award of the Electrochemistry Division of the RACI. So began Ian's lifelong interest in electrochemistry. It was also the start of a long association with Cambridge University, where he was awarded an MA in 1963, M Eng in 1993, and ScD in 1997.

Ian loved to create things with his own hands. While at Cambridge he fashioned a beautiful guitar that he proudly presented to his bride on their wedding day. The guitar remains a family treasure. It also helped him get his dream job at the boundaries of space when an interviewer from the American semiconductor manufacturer Transitron said: 'great academic record, but are you any good with your hands?' 'Well, I've just finished making a guitar that plays pretty well …' he replied. And so west they went, to a Massachusetts semiconductor honeymoon, and the start of a stellar scientific career.

Scientific Research

Author of over 100 journal and 40 conference papers, Ian brought fresh understanding to the relationships between metals and fluids through his work on metal oxidation, corrosion and displacement reactions, hydrometallurgy and electrochemistry. But for him, understanding by itself was not enough—it had to be good for something. Every project started with a practical problem that needed to be solved. Why is this device failing and what can we do about it? How can we make this process more efficient? How can we reduce production costs? How can we improve the quality of this product? Can we find an altogether new and better way of doing this? He knew that understanding mostly comes not through flights of brilliant fancy, but through the trudging mist of failure. It takes conviction, obsessive attention to detail and stamina to carry the Baconian method forward to new light. Research is an extreme sport—Ian excelled at it.

Oxidation of Metals—Baptism by Gas

Ian's 1960s sojourn with semiconductors in America was brief but intense. It was where his perennial obsession with surface films on metals began. He became particularly interested in their electrical responses to temperature—the thermoelectric effect—and how this can be used to make devices for measuring temperature or to illuminate the physics and chemistry of the films themselves. So came papers on thermoelectric films[1] including one on the use of silicides for power generation in space,[2] and he patented a way of solving the problem of bonding metals to the best thermoelectric material available, lead telluride.[3]

But the surface gloss of space research was soon tarnished for Ian as he became aware of dubious dealings by companies in competition for lucrative contracts. Unsettled by what he saw as at best corner-cutting, and at worst downright dishonesty, he opted for a return to academia via a teaching position and PhD scholarship even further from home—at the University of Melbourne. He landed in Australia with a swag of questions about how metals oxidise and a desire to unlock the mysteries of myriad materials we usually take for granted: protective aluminium oxide films fundamental to flying; stainless steels in buildings and art; rectifying layers in electronic devices and solar-electric collectors; protective barriers on archaeological artefacts; microprobes to monitor our vital signs in surgery, and so on.

Surface oxide skins are the survival secret of metals under the relentless attack of aerial oxygen. Those that do it well are the metals that support us—iron, aluminium, titanium and others that would otherwise be rapidly reduced to a pile of useless powder. By 1965 there were several sophisticated theories on how thin oxide films grow on metals. Each predicted that the growth would follow a logarithmic law—rapid reaction quickly becoming infinitesimal as the barrier layer increases the resistance to its own growth.[4] This was satisfyingly in line with what actually happens, but each theory gave a different reason for it, and it was very difficult to distinguish between the alternatives to see what actually controls the reaction rate. But to develop new devices or reduce rust, you have to know: is the rate-limiting step the movement of electrons or electron holes, positive or negative ions, or some uncharged species? Ian set about devising elegant experiments to fill the gap.

His approach was to *perturb* the reaction and measure the effect on rate. For example, the growing film could be doped with electron holes with a trace of iodine,[5] or an electric potential difference could be impressed across it,[6] or the pressure of the oxidising gas could be suddenly changed.[7] Careful measurement of the resulting kinetic responses illuminated the underlying mechanisms. Thus he was able to demonstrate that aluminium and chromium oxidation at low temperatures is controlled by field-assisted ion transport,[8] whereas for nickel and zinc it is a surface electronic process that is important. At high temperatures, chromium and nickel oxidise by the diffusion of metal ions. He also used a resistance marker technique with a porous platinum film to make electrical connection to the top of growing films to distinguish between diffusion of metal or oxygen as the rate-determining step, and pioneered the use of the Seebeck effect (the potential difference caused by a temperature gradient in a conductor or semiconductor—the sign of the effect reveals whether conduction is via electrons or electron holes) to decide whether electrons or electron holes were at work.[9]

The excellence of this work was recognized by the University of Melbourne with the 1971 Grimwade Prize for Industrial Science, and by the Australasian Corrosion Association, which honoured him as Australasian Corrosion Medallist and PF Thompson Memorial Lecturer in 1979. His doctoral thesis won high praise for its innovative use of random walk theory to explain oxidation mechanisms.[10]

Ian would be the first to emphasize that he did not do any of this alone. Always a great collaborator, he attracted and actively sought out the most brilliant colleagues and students to turbocharge his work. The University of Melbourne was a rich vein of talent. Ian's students at this time included Philip Weickhardt who went on to become a senior executive in ICI Australia, and Robin Batterham, whose stellar career in industry and academia included a stint as Chief Scientist of Australia. Ian also developed enduring friendships with colleagues. Peter Fensham collaborated with Ian on the fundamentals of semiconductors, and was also instrumental in Ian's enduring passion for chemical education, an area that Peter later specialized in and became a national icon. Morning tea in the Chemistry Department was a lively forum for debate on how to teach chemistry, often led by the wit of Peter Thistlethwaite, moderated by the thermodynamic precision of Robert Craig and given theoretical resonance by Richard Harcourt. Robert and Peter later collaborated with Ian to produce a remarkable 'little book of problems', a journey through practical problems that broke new ground in chemistry teaching.[11] Two of us (GP and IM) first met Ian during our undergraduate days at Melbourne. He encouraged us by telling us he had little regard for the simply brilliant—'they just can't help it', he would say. Like Menzies, he most admired talented people with the persistence and passion 'to strive, to seek, to find, and not to yield'.[12]

Cementation Reactions—Metal Displacement in Solution

Ian first became interested in solution-based metallurgy during a visit to the Electrolytic Zinc Co. (EZ) plant at Risdon, Tasmania, in the late 1960s. This power-hungry process was attracted to Tasmania by the promise of cheap, reliable hydroelectricity for the foreseeable future and beyond, and was one of the biggest such plants in the world. The first aluminium smelter in the southern hemisphere had been built at the other end of the island state for the same reason. Ian's interest was caught by one of those small make-or-break details common to all hydrometallurgy—how to maintain the purity of the process liquor, the recirculating lifeblood of the plant. The way the Risdon liquor was purified was deceptively simple. Pure zinc powder was mixed in with a side-stream of liquor before electrolysis to remove metals that would otherwise contaminate the zinc product. The zinc powder dissolved and the contaminants, mainly copper and cobalt, were precipitated out of solution in metallic form. The problem was that this process, alternatively called *cementation* (from the Spanish, *cementación* = precipitation) or *metal displacement*, was not very efficient and nobody knew how to make it work better.

Back at the University of Melbourne, Ian started a research programme on cementation, with some modest funding from EZ, and one of us (GP) as a new PhD student:

> I returned to Melbourne after a short period teaching high school chemistry in Tasmania, eager for the opportunity to work with Ian. I think my interest in teaching was one of the reasons Ian agreed to bring me into his research group.

Our critical review of the field in 1976 laid out the principles of cementation as a special kind of corrosion reaction for the first time.[13] Barely a year into the project, Ian received an offer too good to refuse—a position as Associate Professor in chemistry at the University of Western Australia (UWA) that he took up in 1972. So began three decades of research in which Ian's group pioneered the combined application of kinetic and electrochemical measurements to investigate cementation, using rotating discs and cylinders to control the hydrodynamics.[14] Experiments on model systems led to a comprehensive theory of cementation based on electrochemical principles,[15] which was used to illuminate the mechanisms of commercially important cementation reactions: the removal of cobalt and other impurities from zinc plating solutions,[16] the zincate immersion process for pre-coating aluminium before electroplating,[17] and copper winning with sacrificial zinc.[18]

Corrosion in Solution—the Hidden Destroyer

Ian was always fascinated by tarnishing and corrosion. Alloying insights from cementation with knowledge of how gases attack metals led him to an original, elegant way of explaining how metals corrode in solution.[19] The new theory was based on the principle of mixed potentials, according to which the electrochemical potential of a corroding metal is a weighted average, or *mix*, of the potentials of the individual metals. Measurements of electrochemical potential can then be used to understand reaction mechanisms and solve practical problems.

One such problem was the corrosion of alloy engine blocks in Perth's new fleet of buses, which was shown to be due to attack by nitrite,[20] then a common ingredient of engine coolants including the formulation recommended by the respected European manufacturer. Ian and PhD student Phillipe Hyde (CEO of ChemCentre from 2004 to 2009) demonstrated that while nitrite is great for protecting steel, it is disastrous for aluminium because it reacts with it to form ammonia. The reaction is hidden at first as the aluminium oxide film slows the attack. The induction period may be days or weeks, but the protective layer inevitably succumbs and runaway corrosion of the naked metal ensues. Component failure is sudden and unexpected. Changing to a nitrite-free coolant solves the problem, and their work led to the phasing out of nitrite in coolants generally. Then there was the bizarre case of a rash of failures of radiators in brand new luxury cars from another European maker. Ian traced this to a combination of cheap low-tin solder and Perth's high chloride water—small savings on solder brought large losses on warranties. Similarly, working with colleague Peter May at Murdoch University, Ian discovered that common coolants can be highly detrimental to the copper in car radiators because of the glycolic and formic acids formed by oxidative degradation of ethylene glycol, particularly if there is chloride in the water.[21] The real mystery is why glycol, an antifreeze, is universally used in Australia anyway.

Organic- and Bio-Electrochemistry—Back to Bacon

In the early 1980s the idea of adsorbed enzymes catalysing very specific reactions in solutions at room temperature captured Ian's imagination. Responding to Tom Bacon's distant echo, he won funding from the University of Western Australia to develop a fast oxygen electrode for fuel cells and other applications such as chemical analysis. As well as providing a way to harness catalase to improve the kinetics of an oxygen electrode, this research yielded an innovation in enzyme analysis. A new way of determining enzymes electrochemically was demonstrated by using a redox mediator to detect the concentration changes caused by the action of an enzyme on a substrate, a method that has since become common practice. Ian and his co-worker demonstrated the technique in the analysis of tyrosinase, the enzyme responsible for the production of melanin pigments that is used as an indicator of cancerous growths. In this case, the rate of tyrosinase-catalysed oxidation of *ortho*-benzoquinone was measured by using *para*-benzoquinone as the mediator for electron exchange at a rotating platinum electrode.[22]

Quinones are important electron-transfer agents in the biochemical energy cycle and are prime candidates for use in biochemical electrodes, but there was little known about their electron transfer rates. Ian, Stuart Bailey (now a well-known corrosion chemist and consultant, and previously a senior lecturer at Curtin University) and co-workers filled this gap with a series of studies of the electron-transfer and mediator properties of quinones in solution and adsorbed on to various electrodes, using potential-pH ('Pourbaix') diagrams[23] to elegantly summarize and interpret the results.[24]

Ian was awarded the Stokes' Medal of the Royal Australian Chemical Institute (Electrochemistry Division) in 1997 for his outstanding contribution to electrochemistry.

Shipwrecks, Anaesthetics and Leaves—Extramural Musings

Ian Macleod writes:

> I often went to Ian for inspiration, a helping hand, or just a friendly chat about things scientific or cultural. I remember once I had just come from a 17th Century shipwreck off the coast of Western Australia (WA) with a bag of silver coins, some of which I was sure were genuine fakes—the most interesting of all. But the classical crooks were clever—they made sure all external marks were kosher and they meticulously manipulated the size to account for the lower density of the counterfeit copper core. To make things worse, nearly four centuries of chloride ingress and corrosion made density measurements useless. So I had a dilemma—how to tell fair from fraud without destroying the treasure? After a brief explanation of my problem Ian said 'why not just measure the corrosion potential?' That penetrating flash of brilliance from a Renaissance mind begat the quick, conclusive method that everyone now uses to safely prove the provenance of coins and other priceless artefacts rescued from the sea.[25] That's just one example of how he would so often surprise us, instantly synthesizing the seemingly unconnected into something new and exciting.

Perth anaesthetist Ben Corman also enjoyed dipping in to Ian's well of knowledge and inspiration when faced with difficult theoretical problems. Their collaboration led to a series of papers on the physical chemistry of anaesthesia.[26] Earlier in his career, Ian had collaborated with biologists at the University of Melbourne to investigate the mechanism of formation of wax layers on the leaves of eucalypts and other plants. Ian's skills in vacuum deposition and knowledge of crystal growth mechanisms were crucial in demonstrating that the patterns we see in waxes come from deposition from an evaporating solvent rather than other possibilities such as extrusion through apertures in, or diffusion across, the cuticular surface.[27]

The Move to Murdoch

Murdoch University opened for business in 1974 with A. J. (Jim) Parker as foundation Professor of Chemistry. Brought up in WA, Jim had established himself internationally as a brilliant organic chemist. But it was his drive to develop new and exciting technologies for processing minerals that secured his spot at Murdoch, where he soon became director of the new Mineral Chemistry Research Unit (MCRU).[28] From across the river, Ian watched these developments with keen interest. He had great admiration for Jim and was fascinated by his work. As Jim added energy storage batteries and electrochemistry to his research portfolio, he and Ian became friends with a lot to talk about. Jim was keen to grow the MCRU into a national Centre of Excellence for minerals research, and involved Ian as a way of including UWA in the bid. But that all came to an abrupt halt when, in 1982, Jim died suddenly after a short illness.

Ian was overseas at the time and was shocked by the news. By the time he returned to WA, Murdoch University had begun the international search for a professor of chemistry who could realize Jim's vision. Ian waited with interest to see who that would be, and whether he would eventually become involved in a new research institute centred at Murdoch. As time went on he became persuaded that it would in fact be he who would take on that challenge.

Ian was appointed Professor of Chemistry at Murdoch University in January 1984. He was determined to revitalize the MCRU and to find a way of transforming it into a vibrant international research centre. The opportunity came nearly a decade later, with the advent of the Commonwealth Co-operative Research Centres (CRC) program. Ian was chosen to lead the bid for a CRC for hydrometallurgy at Murdoch. He insisted that it be named the A. J. Parker CRC for Hydrometallurgy, which became known succinctly as 'The Parker Centre'.

Top of the World: the Parker Centre

By the late 1990s, the Parker Centre had become the world's leading research hub for hydrometallurgy. From garnering support from government and industry to establish the Centre in 1992, Ian's exemplary leadership got it to the top of the world in an extraordinarily short time. It was his crowning professional achievement. By the time Ian retired as CEO in 2001, the Centre had won numerous national and international awards and was the undisputed global leader in its field. It continued to produce world-class research for another decade, but ultimately fell victim to the Global Financial Crisis, waning industry support and changes in government priorities.

Formed from an alliance of four research providers (CSIRO Minerals, Curtin University, Murdoch University and the Department of Minerals and Energy (WA), later joined by University of Queensland) and with the equivalent of 75 full-time staff and over 40 students, it was the largest centre of its type. It was also highly productive: in just one year (1999/2000) the Centre hosted 17 visiting scientists from all over the globe and published 25 journal papers, 28 conference papers, 2 books and 86 reports to industry, as well as running vibrant education and outreach programs. Underpinned by funding from the CRC program of the Commonwealth of Australia, the Parker Centre enjoyed substantial financial and in-kind support from twelve mining companies (AngloGold Australia Ltd, Alcoa World Alumina, BHP Research, Comalco Aluminium Ltd, Nabalco Pty Ltd, Normandy Mining Ltd, Pasminco Ltd, Queensland Alumina Ltd, Resolute Resources Ltd, Rio Tinto Ltd, WMC Resources Ltd, Worsley Alumina Pty Ltd). It had numerous links to other research entities within Australia and overseas, and organized a constant stream of visits and seminars. It was organized into seven Programs: Alumina; Gold; Base Metals; Leaching, Reduction and Separation Processes; Crystallisation; Engineering; and Education. Each Program had its own Research Leader and Industry Advisory Panel.

Ian was celebrated as an international icon of hydrometallurgy at the 5th International Symposium on Hydrometallurgy, named in his honour.[29] This prestigious meeting is held every five years by the American Institute of Mining, Metallurgy and Petroleum Engineers, dedicated to the leading international hydrometallurgist of the time. The first non-American to receive the honour, Ian's nomination attracted twice the usual number of papers and delegates.

> The A. J. Parker CRC is one of the real success stories of the CRC program. I well remember the intense difficulties and frustrations of the early efforts to win a place in the CRC sun. Ian Ritchie's vision . . . his dedication to the concept and his clear view . . . ultimately

> brought victory. But that was only the start…Ian could see that his CRC was well positioned to become the leading centre of excellence in hydrometallurgy in the world. He made that his clear target and worked tirelessly to achieve it. The rest is history…[30]

The Science of Hydrometallurgy—Gentle Extraction

Traditional metallurgy is a fire and brimstone affair, involving very high temperatures, glowing molten metals and slags, and vast belching clouds of offensive gases. Treatment at moderate temperatures by leaching—hydrometallurgy—offers a gentler solution to the problem of teasing metals from ores. Ian made major contributions to the science and practice of hydrometallurgy in four main areas: cementation, titanium dioxide extraction by the Becher Process, extraction of alumina from bauxite, and extraction of gold from sulfide minerals.

The Becher Process for the conversion of ilmenite to synthetic rutile is iconic to WA. Its discovery by R. G. (Bob) Becher of the WA Government Chemical Laboratories (the forerunner to ChemCentre) was central to establishing WA's position as a major global supplier of titanium dioxide. It starts with a high-temperature reducing roast to convert ilmenite, a titanium-iron oxide, to a titanium dioxide matrix honeycombed with metallic iron. Then comes the really clever bit—a corrosion reaction: the roasted material is slurried in an ammonium chloride solution and purged with oxygen, turning the iron to *rust* that can be washed away as a red slime. The remaining rutile can then be processed to brilliant white titanium dioxide. But the rusting was never complete and further treatment with sulfuric acid was needed to remove intractable iron, an inefficiency that compromised the economics of the whole process. Ian saw that it could not be fixed by trial and error—the detail of the iron corrosion mechanism had to be understood first. Ian and post-doctoral fellow John Farrow (who went on to lead the hydrometallurgy research programme at CSIRO) used a combination of polarization, mixed potential and aeration rate measurements to reveal the roles of ammonium and hydroxyl ions, quantify the impact of surface passive films, and expose mass transport limitations.[31] They were then able to work with plant metallurgist Peter Mangano at Associated Minerals to apply the new understanding to improve the control and economics of the process.

Extraction of alumina from bauxite by the Bayer process is the world's biggest hydrometallurgical process, and one of Australia's largest export industries. As leader of the Parker Centre, Ian initiated a broad program of research on fundamental aspects of alumina production. One of these was about lime—known as the 'Aspirin' of the Bayer process because it relieves many ills, from excess carbonate to poor filtration. Although lime is expensive, the industry uses a lot of it. But operators had been using it for a hundred years without really understanding why it worked. The Centre's research on quicklime slaking,[32] slaked lime dissolution,[33] and lime reactions with carbonate[34] and aluminate[35] revealed the fundamentals of those key reactions, knowledge that is essential to the economic and environmental longevity of the industry. This work was the basis of Bingan Xu's PhD thesis, co-supervised by Dion Giles. Bingan was one of first of Ian's many students from China. He went on to a long career as a research scientist at CSIRO.

Similar benefits came from industry-sponsored projects on the fundamental science of precipitation, flocculation and settling, filtration and alumina product quality.[36]

Gold's iconic status in WA mining lore was recognized by an extensive program of related research in the Parker Centre. Fundamental research with Steve Thurgate and his research team shed light on the mechanism of adsorption of gold cyanide on activated carbon,[37] a key reaction in the carbon-in-pulp process, which is a hallmark of the success of the WA gold industry. Special techniques, including a rotating quartz crystal microbalance, were developed to study the recovery of gold from carbon,[38] the leaching reaction that underpins gold extraction. That was the start of a career in electrochemistry for PhD student Matthew Jeffrey, who subsequently worked at Monash University and CSIRO before joining Newmont Mining Corporation. As with all good research, the project started by looking at the behaviour of pure gold in pure cyanide solution. To the team's astonishment, the reaction didn't work—pure gold appears *stable* in pure cyanide solutions, the rate of dissolution is so slow. They showed that the reason it works in the field is the presence of impurities, such as lead, that work as catalysts[39]—useful to know if you are a process metallurgist wanting improve the control and economics of extraction.

With the toxicity of cyanide becoming of increasing concern, Ian was keen to promote the use of thiosulphate as an alternative leachant. The idea was not new—mobilization of gold, silver and copper by selective bacterial leaching involving thiosulfate led to the vast sulfide deposits of WA. Methods using thiosulphate for winning gold back from ores had been patented in the 1970s, but hadn't caught on. The Parker Centre program on thiosulfate-based gold processing led by Bill Staunton, previously a student of Ian's, laid the foundations for on-going research to establish thiosulfate as the reagent of the future for gold hydrometallurgy.[40]

As Director of the Parker Centre, Ian's collaborations with research colleagues and mentoring of students became more and more extensive. One of us (KD) held a post-doctoral fellowship with Ian, focused on the mechanism of gold leaching in complex ores:

> I recall that Ian prided himself on taking 'bright young things' and putting them on the 'useful path' of hydrometallurgy. I had just returned to WA, with a brand-new PhD and the beginnings of a career in pharmaceutical synthesis. Unfortunately WA has no pharmaceutical industry to speak of. Ian quickly offered me a job that required electrochemistry and hydrometallurgy – he figured I'd work it out! I soon realised that I was immediately recognised throughout the Parker Centre as 'Ian's latest protégé'!

Instructor, Performer and Mentor—a Born Teacher

Ian's legendary lectures, full of memorable demonstrations and forgettable jokes, inspired a generation of scientists. His scientific leadership and pastoral care were exceptional—graduate students clamoured to be part of his research team. He mentored many leaders in fields ranging from mineral leaching to artefact conservation, air quality to marine corrosion—it's hard to go anywhere in the WA research community without running across a Ritchie protégé; they include researchers and managers at all levels, industry Chief Chemists and Research Managers, a university Vice-Chancellor and a Chief Scientist of Australia.

Teaching ran in the family—Ian's father was a teacher in the army Education Corps and his sister was a maths teacher. From his days as a senior scout, Ian constantly sought ways of passing knowledge on to others. For him chemistry was founded in fascinating practicality; he was dismayed to witness its teachers' gradual withdrawal from empirical reality into the arcane realms of molecular physics, starting in the 1960s.

He strove to retain reality in his lectures, which became famous for their ingenious, even hazardous, demonstrations. He illustrated the properties of aluminium and hydrogen with a film clip of the last moments of the stricken Hindenberg, and the connection between surface tension and surface charge by touching an iron nail onto a ball of mercury under a sea of acid in a Petri dish sitting on an overhead projector. Spectacular quicksilver beating-heart convulsions danced larger than life on the wall. Pre-YouTube, Ian was a creative genius with the overhead projector for visualizing chemical experiments to a large audience. Another favourite was his demonstration of magneto-hydrodynamics and bimetallic corrosion by visualizing ionic flow with lycopodium powder.[41]

He could even make Boyle's Law interesting. He would run around the lecture theatre with his thumb in the mouth of a test tube half-full of water, from time to time withdrawing his thumb just enough to nucleate bubbles on the inside of the tube to illustrate a discourse on the bends. He later made the demonstration more sophisticated, using real blood, a bell jar and vacuum pump to generate the genuine, fatal pink foam. The Red Cross commissioned it as a training video. Boyle, who was the first to use a vacuum pump and bell jar to investigate the effects of reduced pressure on all sorts of things (including a bird and a snake) would have been well pleased.

Soon after arriving in WA in 1973, Ian's fame as a favourite public performer was assured by a spectacular failure. It was his first Bayliss Youth Lecture (a tradition of annual lectures instigated by in the early 1970s by Professor Sir Noel Bayliss to inspire school students towards chemistry through real-life demonstrations); the subject was electrochemistry; the demonstration was to power a large light bulb with a molten-salt battery; the flaw was a trace of moisture in the melt. The explosion, safely contained behind a screen, was spectacular. Somewhat shaken, Ian went on with the show to the rapturous applause of the delighted students. Later lectures always included some form of controlled explosion, such as filling a colourful balloon with hydrogen made from aluminium foil and caustic soda in a milk bottle, and touching it with a lighted taper. But the real favourite was the hydrogen organ[42] in a darkened theatre to end the lecture with a BANG!

Chemistry as a Public Service: ChemCentre, Clean Air and Community

Ian championed the retention and renewal of the WA Chemistry Centre, in stark contrast to the loss of public chemistry capability in other states. A key government advisor and foundation board chair, he guided its rebirth as the now world-class, vibrant 'ChemCentre', provider of essential public services in forensic analysis, emergency response, environmental management, community education and general chemistry consulting to government, industry and community. ChemCentre's new facilities in the Curtin Chemistry Precinct are now aptly named 'The Ritchie Wing'.

He was a foundation member of the WA Premier's Science Council and the Scientific Advisory Committee to the WA Clean Air Council, where he was the first to plead for a ban on lead in petrol—the committee's failure to heed that advice was a source of great distress to him. But the chemical detective work needed to bring polluters to account brought him great pleasure and success. He contributed significantly to the clean air standards and laws that we now take for granted, including the Kwinana Airshed regulations in WA. He was also a member of the Joint Minerals Council Tertiary Education Taskforce, and the Working Group of the WA Minerals and Petroleum Education Research Institute.

Ian took his passion for science education to the wider community at every opportunity. He instigated and presented several Parker Centre Youth Lectures, and gave two Bayliss Youth Lectures that toured WA, and a Youth Lecture on electrochemistry that he also took to South Australia. He enthusiastically embraced outreach programs to promote chemistry and general science. In retirement he relished the chance for more frequent talks and demonstrations at schools, and spread his influence for a science curriculum more connected to community interests, needs and aspirations. People achieve great things by standing on the shoulders of giants,[43] and Ian gave many of them such an opportunity—he was always willing to lend a hand up to anyone with the desire and aptitude to benefit from a better view.

Epilogue—Final Years of a Renaissance Spirit

Inspired by Oliver Sachs' opinion that science, like any other subject, could be presented to the public in a very personal way, Ian was appalled by the dry, impersonal, overly theoretical trend in chemistry teaching that was disillusioning a whole generation of students. Why not present it more like Simon Winchester's oceans, Richard Dawkins' genes or Tim Flannery's environment? So after he retired from his full-time academic position he set about writing a new sort of chemistry book, based on practical examples and applications, personal anecdotes and surprising snippets to capture the interest and spark the imagination. Twelve draft chapters and endless notes later but with time running out, his wish was that it may yet become the nucleus of a new inspiration.

Ian embodied the Renaissance spirit—interested in everything, widely read and blessed with an encyclopaedic memory; able to discourse authoritatively on diverse subjects (sometimes to the extreme ennui of his children!). He encouraged the family in music and delighted in their ensemble playing—Kathy on flute with grandsons Jack and Tim on viola and violin. He travelled extensively but was always happiest at home. His boys remember him fondly as footy team manager, and coach of tennis and cricket (he never took the bat in the nets, but was a fearsome bowler). And as the home tutor with an interesting story behind every theorem and a penchant for deriving them from first principles.

In retirement, as well as working on his writing, Ian developed a wonderful collection of demonstrations and talks for children. He and Ann became popular visitors at primary schools keen to inspire their pupils with practical science. Another major project for the couple was working with son Alex to restore and renovate a weatherboard cottage in Victoria Park—a bigger project than making a guitar, but similarly hands-on.

Ian was a victim of ill health in his later years. After defeating the first onslaught of cancer with debilitating chemotherapy, he then overcame an aneurism that sapped his body but not his spirit. Sensing that time was of the essence, the ChemCentre Board mounted a bid for Ian to be awarded an Order of Australia for his services to science, industry and education. The honour was announced only a few months before the cancer returned to claim him in his 79th year. Ian was quite stunned to be given an AO. But the ensuing flow of tributes and reminiscences from friends and colleagues near and far was a wonderful gift that brought colour and a chuckle to his final weeks. Surrounded by family and friends in his last days, he said he was disappointed at having to leave so soon, but declared that his life had brought him so much more than he had ever dreamed of as a young man. And that he felt he had been very lucky indeed; as are we who had the privilege to know him. His story is a rich history with many players—students and colleagues who came and went, family and friends who endure—a tapestry he wove with golden threads of creativity, dedication and humanity.

Ian Ritchie was inducted to the Western Australian Science Hall of Fame in 2016.

Endnotes

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