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Elected FRS 1962

BY ALLAN H. REDDOCH AND WILLEM SIEBRAND FRSC

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William George Schneider OC FRS FRSC was an eminent Canadian chemist and science administrator. At the National Research Council of Canada (NRC) in Ottawa, he made high-precision measurements relating to the gas laws, to phase changes and to critical phenomena. He showed experimentally the need to reduce the gravitational density gradient in measurements of the critical point and used ultrasonic studies to support the concept of dynamic cluster formation. After a decade, he switched to nuclear magnetic resonance. He did pioneering work on the analysis of high-resolution spectra of protons in organic compounds and on the information that can be derived about intramolecular and intermolecular interactions. These studies were the basis for an influential book, *High-resolution nuclear magnetic resonance*, written with Harold Bernstein and John Pople. Concurrently, he investigated the photoconductivity and semiconductivity of insulating organic crystals, in particular anthracene. He explored the conditions necessary to make accurate measurements and then studied the electronic processes in anthracene. The advent of lasers allowed him, with Boris Stoicheff, to probe more deeply into these processes. This work was of considerable interest to major high-technology companies. Bill rose rapidly through the managerial structure of the NRC and became its president in 1967, serving for 13 years, the longest of any president. After retiring, Bill served for several years with the International Union of Pure and Applied Chemistry, two of them as its president, and remained active as a chemical consultant, advising small start-up companies. He died at the age of 97 years in Ottawa.

EARLY YEARS

The earliest record of Bill’s ancestry is his account of his Austrian grandparents, Friederich Schneider and his wife Berval. Friederich, born in Austria in 1842, is described as a farmer,
butcher and tailor. He was also a polyglot, fluent in seven, mainly eastern European, languages; in the 1880s he made several voyages to Canada as an interpreter on emigrant ships. Then, in 1891, he, with his wife, their daughter and three of their four sons, immigrated to Canada and settled in Saskatchewan.

The 1916 Canadian census shows that Friederich’s youngest son, Michael, Bill’s father, was farming near Wolseley, Saskatchewan, and that he was born in Bukovina. This one-time duchy, at present inside the western border of Ukraine, became part of the Austrian Empire in 1774. Because it had good agricultural land and a small population, the Empire decided to encourage German farmers to settle there. With the formation of the Austro-Hungarian Empire in 1867, Hungary acquired control of Bukovina and undertook to replace the German farmers with those who spoke Hungarian. If the census reference to Bukovina is correct, this history may explain the presence of Friederich Schneider in Bukovina, his facility with eastern European languages and his emigration to Canada.

When the family arrived in Canada on 7 March 1891, they acquired virgin farmland near Neudorf, about 100 km east of Regina, under the Dominion Lands Act. This programme, designed to attract settlers, provided 160 acres (65 ha) of land for $10 and an undertaking to build a house and cultivate one-quarter of the land within three years. The quality of the land was variable, as was the stamina of some settlers. Not all of them were successful, but Friederich was, as were his two youngest sons, Fred and Michael, when they became old enough to obtain farms of their own.

Michael Schneider married Canadian-born Phillipina Kraushaar and in 1914 acquired a high-quality farm near Wolseley, Saskatchewan, where Bill and his five siblings grew up. In 1920 Phillipina died in the worldwide influenza epidemic, and Bill’s father carried on with the help of hired hands and housekeepers until 1925, when he married Josephine Fleishacker of Vienna, Austria. She was a city woman who had to make a big adjustment to life on a pioneer farm. Being well educated, she worked hard to ensure that her stepchildren also got a good education, even if that caused financial difficulties.

**Education**

Bill’s formal education began in a one-room school house about 2 km from home. It had one teacher and about 30 students in grades 1 to 8. In the winter he went to school with a horse and sleigh. In warmer weather he and his brothers would go by horse if one was available; otherwise, they walked, sometimes barefooted. There were few books in the school, but they included a 20-volume set of *The book of knowledge*. If Bill finished a class assignment early, he enjoyed the opportunity to read these books and so tried harder to finish his assignments early.

Having completed elementary school, Bill wanted to attend high school. His parents agreed in principle, but hesitated because he would have to go to Luther College in Regina, some 100 km away, and that would be expensive. After many discussions, his stepmother prevailed and he enrolled in 1929. He earned his room and board at the college by serving as a waiter in its dining room. He found the first two years very difficult because, coming from a one-room school, he felt ‘very much retarded intellectually and socially’ in comparison with many of his classmates, but he would not give up because he knew the sacrifices his parents were making. By his third year, the situation had improved, and he could compete with the top students. The
William George Schneider

subjects he became most interested in were chemistry and physics. On graduating, he received the Principal’s Gold Medal for General Proficiency.

After graduating from Luther College, which was on the campus of the University of Saskatchewan, Bill was eager to enrol at the university. His fifth year at the college qualified him to start in the second year. Once again the problem of finances arose. In 1934 the country was in the depth of the Great Depression, and the prairies were in an extended period of drought. At this point, he went to see Henry Taube (FRS 1977; subsequently a Nobel Laureate in Chemistry), who lived in the area and was one year ahead of him academically. Taube offered to share his boarding-house room with Bill. Then Bill’s older sister, Lydia, who had completed teacher training and was then teaching in the one-room school that both had attended, agreed to give him a loan to cover his tuition fees. With these arrangements and the somewhat reluctant approval of his parents, he enrolled in the honours chemistry programme at the University of Saskatchewan.

The university did not have a strong graduate school but set high standards for the undergraduate programme, particularly in chemistry and physics. Among its staff were Thorbergur Thorvaldson, a noted cement chemist, John W. T. Spinks, a pioneer in radioactive tracer techniques in soil chemistry and in radiation chemistry, and Gerhard Herzberg (FRS 1951; subsequently a Nobel Laureate in Chemistry). In his senior year, Bill held a University Scholarship and a laboratory instructor assistantship. In 1937 he began a two-year MSc programme with Thorvaldson, having been awarded a bursary by the NRC. Bill worked on the chemistry of the high-alumina cements, which are noted for their quick setting and their resistance to seawater and sulphate-containing waters. This required very careful measurements to clarify the chemical composition of some of the calcium aluminates present in these cements and to determine their reactions during dehydration and rehydration. He published four papers on these studies. He graduated in the spring of 1939 but continued with Thorvaldson until he began a PhD programme in physical chemistry with Otto Maass (FRS 1940) at McGill University in September.

At the beginning of September, World War II began. A few days later, Bill received a telegram from Maass advising him not to enlist but to come to McGill immediately because his skills would be needed for defence-related research there. Three days later, he took the train from Saskatoon to Montreal. During the two-and-a-half-day trip, his first time away from the Saskatchewan prairie, he was greatly impressed with the vastness and beauty of the mostly unsettled Canadian Shield. At McGill in Montreal, he was also pleased to be at the centre of that cosmopolitan city.

Maass believed, on the basis of his earlier postdoctoral experience in Germany, that the Germans would apply their growing experience with inorganic fluoride compounds to the development of new poison gases because many of these compounds are gaseous and toxic. (In fact, they had been investigating sarin and related nerve gases based on organic phosphorus fluorides.) Thus Bill was assigned to a group synthesizing new fluoride compounds such as SF₆, S₂F₁₀, and PF₃, and determining their chemical and physical properties. Their suitability for use as poison gases would be studied by others. The university allowed this research, despite the fact that it was highly secret and likely to remain so for a long time, to be accepted as part of the requirements for his PhD.

For Bill’s second year, Maass suggested that he should do a project on critical phenomena. These phenomena occur in systems in which two phases coexist up to the critical temperature, above which only a single phase is present. The measurements must be very accurate and are
difficult to make. The details of the behaviour at the critical point were not understood and no valid theory was available. It was thought that cluster formation might be occurring near the critical temperature, but it would be three decades before the concepts of scaling and critical exponents would provide that theory. Bill worked on a two-component system consisting of a 1:1 mixture of ethylene and propylene, which formed a single phase above 58.3 °C, but he found no evidence of cluster formation within the precision of the experiment.

In May 1941, Bill received his PhD. That summer he took a temporary position at the NRC in Ottawa to determine the properties of another potential fluoride war gas.

In the meantime he had been awarded a Royal Society of Canada postdoctoral fellowship for one year to work with George Kistiakowski at Harvard University. At this time the USA was not yet at war, but preparations were under way. Kistiakowski proposed that Bill should use the recently developed technique of radioactive tracers to investigate the mode of action of mustard gas by using $^{35}$S. A method of synthesis had to be developed to incorporate that isotope into the gas molecules. A small spot of the liquid mustard gas was applied to the skin of an animal. The spot of skin was then excised and sectioned, permitting the relative amounts of mustard gas at each depth of the skin to be determined. The results showed that there was rapid skin penetration causing local blistering, but some of the agent got through the skin and caused toxic systemic reactions. Similar tests with Lewisite using $^{74}$As showed little penetration and severe skin blistering but reduced systemic reactions.

In the spring of 1943, Bill was reassigned to the Oceanographic Institute at Woods Hole, Massachusetts. Here he was involved in the physics of underwater explosions to improve the effectiveness of antisubmarine weapons. It was necessary to design new equipment to measure parameters such as the peak shock-wave pressure and total energy on very short timescales. With this equipment it was possible to determine the underwater trajectory of aerial bombs dropped from aircraft. One application of these studies showed that a bomb entering the water at high speed carried a trail of bubbles behind it, which decreased the pressure experienced by the detonator and caused the bomb to explode at a much greater depth than intended. As a result, the bomb design was changed, as were the calibration tables.

At the end of the war, the hectic work had to be documented, and final reports had to be written. Then, in 1946, Bill returned to Canada. Soon after his return, he was formally presented at the American Embassy in Ottawa with a Certificate of Appreciation from the US War Department and the US Navy Department for ‘an outstanding contribution to the Office of Scientific Research and Development during World War II’.

**NATIONAL RESEARCH COUNCIL**

*Critical phenomena*

As the war work was winding down, Bill had been considering his future. He had some lucrative American offers in military research, but he felt that, considering all the support he had received in Canada, he should return home. He had an invitation from E. W. R. Steacie (FRS 1948), then director of the Chemistry Division at the NRC, to establish a physical chemistry section there. Bill regarded this as an excellent career opportunity and came to Ottawa in April 1946.

Steacie was noted for his approach to building a laboratory for basic research: select people who are doing good work and give them a free hand in what they choose to do. Because
Bill had spent the previous six years doing applied military research, he needed some time and study to select his basic research programme at the NRC. His choice, closely related to his PhD work with Maass, was the study of intermolecular forces and critical phenomena in liquid–gas and binary liquid systems. In 1948 the NRC Postdoctorate Fellowship programme, an initiative of Steacie’s, was established. It gave well-qualified PhD graduates one or two years of full-time research experience before taking up a position at a Canadian or other university, at the NRC or in industry. Typically, Bill had two postdoctoral fellows each year.

Bill chose to study the compressibility of gases and he published 10 papers under that title, among others. This work required very precise measurement of the volume and pressure of a very pure measured sample of gas and liquid phases of the chosen element or compound at a series of temperatures. The results could be used to make more precise tables of thermodynamic values, to check the accuracy of the gas laws, to deduce the intermolecular potential, and to try to elucidate the behaviour immediately around the critical temperature, $T_c$. Some measurements claiming high precision were in the literature, but they were, in fact, mutually incompatible. Many details had to be accounted for to obtain accurate results. Two of these were to ensure sufficiently vigorous stirring to achieve equilibrium, and to minimize the height of the sample to avoid pressure gradients caused by gravity in liquid–gas systems near $T_c$.

The most useful and popular form of gas law, following the three-century-old work of Robert Boyle FRS, was J. D. van der Waals’s equation of 1873. This equation makes corrections for the repulsive force experienced by two molecules in close contact and for the attractive force between molecules in the gas phase, which leads to condensation at lower temperatures. The equation predicts a critical temperature above which no liquid phase occurs but does not give a good description of the behaviour near that temperature. Previous experimental work from other laboratories did not give a consistent picture in that temperature range.

The intermolecular potential describes the combined effect of the above two forces as a function of the intermolecular separation. Several empirical equations were available for this potential, perhaps the most popular being the Lennard-Jones 12:6 potential, partly because of the ease of its evaluation in the pre-computer era.

Bill was aided in these measurements by his chemical technician, Yves Lupien, who worked with him throughout his laboratory career, and W. A. Stevenson, a machinist who constructed the high-pressure equipment. They were joined by the postdoctoral fellows whose names appear below and are not otherwise identified. The first work was done with J. A. H. Duffie (1)* and Y. L. Yntema (2, 3). They measured the second virial coefficient of helium from 0 °C to 1200 °C, extending the range of available data, which went to 400 °C. From these data they calculated the intermolecular potential over the temperature range and found that the standard Lennard-Jones potentials and others gave a poor fit. They supported a modified Lennard-Jones potential with an exponential repulsion term instead of the usual inverse 9th-power or 12th-power term.

Next, Bill turned to three polyatomic molecules: carbon dioxide ($\text{CO}_2$) and two fluorides that he would have been familiar with from the war gas project, carbon tetrafluoride ($\text{CF}_4$) and sulphur hexafluoride ($\text{SF}_6$). The work was done with K. E. MacCormack (5, 6). With $\text{CF}_4$, a Lennard-Jones potential fitted the experimental second virial quite well, but the fit for $\text{SF}_6$ was not as good. It would be adequate for some applications but not for a study of the forces

* Numbers in this form refer to the bibliography at the end of the text.
involved. They suggested that the problem might arise from the force-field contribution of the fluoride atoms, along with that of the central atom, as Hildebrand (1947) had previously proposed for tetrahedral fluorides. For CO$_2$ (4), the Lennard-Jones potential was successful over the range 0–150 °C but not for the wider range 0–600 °C. They thought it likely that dimer formation might need to be taken into account.

At this point, Bill turned his attention to critical phenomena. For this study he used the monatomic inert gas xenon, which avoids the above complications of polyatomic molecules and has a convenient critical temperature, $T_c$ = 17 °C. There were two questions to be answered: is there a discontinuity as the temperature rises through $T_c$, and is molecular clustering occurring, as some workers had suggested?

In some much-cited papers with M. A. Weinberger (9) and H. W. Habgood (13), detailed measurements were made within a few degrees above and below $T_c$. The results showed that the critical isotherm, the plot of pressure against volume at $T_c$, was not flat-topped as some workers had reported. However, the critical isotherm was clearly broader than predicted by the van der Waals equation.

An important consideration in measurements just above the $T_c$ is that the compressibility of the fluid state is very high, and, consequently, a density gradient develops in the vertical direction. This problem was discussed by Gouy (1892), but the implications had not been realized. Weinberger and Schneider (10) were the first to undertake an experimental study of this effect by measuring the relative density as a function of height. Additional measurements were made by Schneider and Habgood (12). The three investigators used a radioactive tracer method similar to that used by Bill in the wartime study of skin penetration by poison gas. In the present case, they used a radioactive xenon isotope as a tracer and a counter with a shallow horizontal slit aperture. The sample tube was then moved up and down in front of the aperture. These trials showed clearly that the gravitational effect had to be recognized and minimized, which was achieved by using long, narrow sample tubes in a horizontal instead of a vertical orientation. With this improvement, Habgood and Schneider (13) made a final set of xenon measurements.

In the final papers of the series on compressibility of gases, Schneider, with E. Whalley (11, 15, 17) and G. A. Nicholson (18), as well as Y. Lupien, made measurements on the remaining three inert gases, neon, argon and krypton, and derived their intermolecular potentials and thermodynamic properties. The papers on carbon dioxide, xenon and argon had quite high citation counts. It is particularly striking that some of these papers have been used and cited 60 years after their publication.

The possibility of cluster formation near $T_c$ was widely, but not completely, accepted. However, the compressibility technique was not very helpful. For this reason, Bill did some acoustic experiments that could examine dynamic phenomena. With A. G. Chynoweth (7), he found that ultrasonic acoustic waves were greatly attenuated near $T_c$ in the binary systems aniline + n-hexane and triethylamine + water, and also in xenon. Bill made similar observations with SF$_6$ (8). He showed that the most likely reason for such attenuation is the formation of dynamic molecular clusters near $T_c$. It would be another 15 years before the concepts of scaling and critical exponents would provide a quantitative description of cluster formation.

In 1952–53 Bill took sabbatical leave to work with Sir John Lennard-Jones FRS at Cambridge. Subsequently he published a paper (16) applying the equivalent orbital developed by Lennard-Jones and John (later Sir John) Pople (FRS 1961) to study hydrogen
bonding. The principal qualitative insight was that the hydrogen bond is strongest when it is collinear with the axis of the lone pair. With this guidance, Bill, with D. Cook and Y. Lupien (20, 21), examined the stoichiometry and geometry of several donor–acceptor complexes of hydrochloric acid with alkenes, alkynes, benzene and methyl benzenes. These complexes were found by using thermal analysis to construct phase diagrams showing the stable complexes.

**Nuclear magnetic resonance**

In about 1955, Bill terminated his studies of phase transitions and critical phenomena, and switched from classical chemical studies of bulk matter to quantum-mechanical studies of electrons, atoms and molecules. He initiated two new programmes in the fairly new fields of high-resolution nuclear magnetic resonance (NMR) and of organic semiconductors. In these studies he was assisted by J. R. Nicholson, an electronics technician, and by Y. Lupien, the chemistry technician.

High-resolution NMR was based on protons, which have very narrow resonance lines compared with those of many heavier nuclei with spins greater than $\frac{1}{2}$, thus opening up the vast array of organic compounds for investigation. NMR spectrometers of high resolution and quality had recently become commercially available, and Bill acquired one. Its resolution of a few parts in $10^8$ in frequency and magnetic field would be essential for his programme. Because high-resolution studies were in their early stages, his first few years were devoted to developing a quantum-mechanical framework for analysing spectra and to exploring the phenomena that could be studied. In this work he collaborated with the theoretician John Pople for spectrum analysis, and with his NRC colleague Harold Bernstein for the experimental aspects.

In 1956–58, several papers appeared by these authors (22, 24, 27, 28, 31). Pople provided the quantum-mechanical analysis of a series of progressively more complex spectra produced by the two experimentalists. He showed how two parameters would suffice to interpret the pattern of the spectral lines and their relative intensities. These two parameters are (i) the spin–spin interaction between the protons in a molecule and (ii) the chemical shift resulting from the electronic currents in the molecule induced by the applied magnetic field, which slightly reduced that field.

The experimentalists could then study the environmental effects that governed the magnitude of the spin coupling and the chemical shift. Concurrently with the above programme, Bill published, with L. W. Reeves, four papers on various aspects of hydrogen bonding, a topic he had worked on previously. These papers dealt with complex formation of chloroform in aromatic solvents (25), keto–enol equilibria associated with proton transfer in molecules such as acetylacetone in solution (30, 32), and monomer–dimer equilibria in various solvents (34). Also in the same period, Bernstein and Schneider collaborated with R. U. Lemieux of the University of Ottawa and his graduate student R. K. Kullnig in a highly cited study (33) of a series of acetylated sugars.

In 1959 the book *High-resolution nuclear magnetic resonance* by Pople, Schneider and Bernstein (36) appeared, providing very extensive coverage of the literature on the subject as well as their own work. It was the book on the subject for some years to come. J. D. Roberts, who had published a book on the same topic some months earlier, stated in a retrospective 2005 review (Roberts 2005) of the Pople, Schneider, Bernstein book that it was ‘a truly seminal treatise on nuclear magnetic resonance … authoritative and comprehensive’.

Over the next several years, Bill continued to explore the application of NMR to the structure and interactions of organic compounds. With T. Schaefer, a visitor from the University
Biographical Memoirs

of Manitoba, and A. D. Buckingham (FRS 1975), then of Oxford University, Bill published several papers (37–39) dealing with the effects and mechanism of solvent properties on the spectra. In particular, it was shown that solvents could modify the chemical shifts. This observation led to a technique in which a set of spectra of a compound would be run in several solvents. With complicated poorly resolved spectra, the different chemical shifts assisted in unravelling their structures. It was also possible to study situations in which a weak complex is formed with a solvent molecule. The general topic of solvent effects in NMR spectra, both experimental and theoretical, is discussed in a much-cited paper by Buckingham, Schaefer and Schneider (39).

Three much-cited papers resulted from the work of H. Spiesecke and Schneider. Two of these (40, 41) discussed the effects of substitutions on the proton resonances of methane, ethane and benzene. They show that the magnetic anisotropy of the substituent is the dominant effect on the chemical shifts, which also show a moderate correlation with the electronegativity of the substituent atom. The third paper (42) reports the chemical shifts of the protons of the non-alternant hydrocarbon azulene. It shows that these shifts yield estimates of the \( \pi \)-electron densities that agree quite well with values in the literature based on quantum-mechanical calculations.

Organic semiconductors

In the mid 1950s, Bill, inspired by a report on light-sensitive rhodopsin in the retina of the eye and aware of the rapid developments in the field of solid state physics of inorganic semiconductors, started a study of the photoconductivity of organic solids, a subject that hitherto had received scant attention from the scientific community. Given the overwhelming diversity of organic materials, he chose to focus on a relatively simple molecule that could readily be obtained in the form of sizeable pure crystals, namely anthracene, a compound that had found application in scintillation counting and had long been known to become photoconductive when illuminated with ultraviolet radiation in the region of the lowest absorption band. The first results of his study, dealing with the photoconductivity of anthracene crystals, were reported in 1954 in a paper with A. G. Chynoweth (14). It laid down the ground rules for such an enterprise by showing the need for ultrapure single crystals, for separation of surface and bulk effects, and for specialized electrodes. The experiments indicated that the induced current was sensitive to ambient gases and that most of it was carried by holes rather than electrons. The paper drew wide attention and was followed by a long series of studies in which these properties were explored in greater detail. Although anthracene remained the principal focus, other crystalline materials were not neglected.

Measurements performed with the assistance of D. M. J. Compton and T. C. Waddington (19, 23) on the photoconductivity of organic crystals in the presence of ambient gases showed the need for strict control of the experimental environment. Molecules such as oxygen acting as electron donors generally increase the photoconductivity, whereas molecules acting as electron acceptors, such as water, decrease it. To separate bulk from surface conductivity, a guard ring was introduced, and to maintain proper contact with the charge-injecting electrodes, solid platinum electrodes were replaced by evaporated metals or colloidal carbon electrodes. The spectral response of photoconductivity under strictly controlled conditions was studied with the help of two other postdoctoral researchers, J. Kommandeur and G. J. Korinek (26, 29), leading to new insight into the effect of traps resulting from impurities and imperfections. The crystals used in these experiments were grown by Y. Lupien from
zone-refined ingots of steadily improving quality. This made it possible to gradually achieve a separation of the intrinsic properties of the pure crystal from the extrinsic properties that tended to dominate actual crystals.

The first action of light on anthracene crystals is the creation of mobile excitons, which, to contribute to the conductivity, would need to dissociate to yield independent electrons and holes. This process required energy, and it was shown that this could be supplied either thermally or optically. The presence of traps (35), which selectively could immobilize not only electrons and holes but also excitons, had complicated the interpretation of early experiments, but the improved purity of the crystals led to a much clearer picture of the intrinsic processes induced by light. When in 1962 Bill and his colleague F. R. Lipsett organized a Symposium on Molecular Crystals in Ottawa, it became evident that the rapidly evolving subject had gained the interest of several industrial giants, such as DuPont, IBM, General Electric and Xerox, which had started their own research and reported the measurement of the mobilities of the electrons and holes in anthracene crystals.

To maintain its prominent role in this competitive field, the Schneider group in the Division of Chemistry teamed up with a group of spectroscopists in the Division of Physics led by B. P. Stoicheff (FRS 1975), who had just introduced the ruby laser as a new research tool. It turned out that, owing to the high intensity achievable with the laser, photoconductivity could now also be induced by irradiation in the visible region of the spectrum, which gave rise to the direct formation of triplet excitons either as a weak, spin-forbidden one-photon process or as a result of two-photon absorption. When other lasers emitting at different wavelengths became available, such processes could be measured separately. A careful kinetic analysis of the data provided evidence for two new processes, namely the fusion and fission of excitons, in which two triplet excitons with the proper relative spin orientations could form a singlet exciton and, alternatively, a singlet exciton with the appropriate energy could decompose into two triplet excitons. These results were reported in 1965 in a joint, often cited, paper of the two NRC groups (45). Combined with papers published by other groups, it led to a quantitative understanding of the diffusion, decay and interaction of singlet and triplet excitons in anthracene.

The final step was made by W. Helfrich and Schneider, who further elucidated the interactions between excitons and charge carriers in two papers (46, 47) that became very popular, as shown by the more than 650 citations in publications by other groups. In their experiment, both electrons and holes were simultaneously injected into the crystal from electrodes consisting of solutions of negative and positive anthracene ions, respectively. This injection generated a zone of blue fluorescence close to the positive electrode. It could be shown that recombination of the charge carriers produced both singlet and triplet excitons, namely in the proportions predicted by standard spin statistics. The two processes could be distinguished because triplet excitons survive much longer than singlet excitons. These results, combined with previously measured carrier mobilities and exciton diffusion coefficients, completed the description of the photoconductive properties of anthracene, and showed the similarities and differences between the properties of electronic transport in molecular organic and atomic inorganic solids.

Although the picture of carrier transport in conduction and valence bands used for inorganic semiconductors proved to remain valid for anthracene, at least at low temperatures, the bands were much narrower in the organic crystals, which explains why the mobilities of the charge carriers were so much lower. The proximity of the fluorescent zone to the positive electrode
was traced back to two causes: (i) the higher mobility of holes relative to electrons and (ii) the
distribution of traps, which favoured electron trapping (43). However, the excitons responsible
for the fluorescence showed a behaviour that differed sharply from that of electron–hole pairs
observed in inorganic semiconductors. They exhibited no polar character, and the dissociation
of the singlet excitons into electrons and holes turned out to be strongly endothermic. The
triplet excitons, characterized by a much longer lifetime and a much lower energy, could
also produce charge carriers, but only via an exciton–exciton annihilation process, leading to
a singlet exciton as an intermediate. All these processes allowed manipulation by judicious
doping.

At this point in his career, Bill terminated his direct research activities, in his own words
‘very regrettably’, to assume the presidency of the NRC. However, this did not end the
activities of this research group, because during his tenure as group leader and director of the
Division of Chemistry, he had added new staff members to the organic semiconductor group,
first W. Siebrand as a theorist and later D. F. Williams as an experimentalist, both of whom
worked, often independently, on these or closely related subjects. Thus the work on anthracene
described above was accompanied by work on several other systems, including charge-transfer
complexes built from pairs of organic molecules of opposite electron affinities. A typical
example is the perylene–fluoranil complex, whose solution-grown crystals were studied by H.
Kokado, K. Hasegawa and Schneider (44). These crystals showed a photoconductive response
down to the far infrared, with rise and decay times extended to minutes. Studies of this type
continued under the direction of Williams (48, 49). In a natural way, this study of fundamental
properties of a representative organic solid had produced results that suggested the practical
application of molecular materials with well-defined properties in electronic devices.

As a spin-off of the above work, Bill acquired an electron spin resonance spectrometer
in 1960 and assigned A. H. Reddoch, a postdoctoral fellow, to use it to seek the occurrence
of ferromagnetism in the organic charge-transfer complexes mentioned above, but none was
found. At the same time, Reddoch monitored solutions containing anthracene anions being
used as electrodes in the work described above. His observation that the spectral parameters
of the anthracene anions differed from those in the literature led to the study of such solvent
effects. Bill gave Reddoch a staff position and did not involve himself further in work on
electron spin resonance.

**Presidency of the National Research Council**

Just before World War II, the NRC, of which Bill became president in 1967, had employed a
work force of only about 300 employees, located in a single, grand, but half-filled, building.
After the war, it had about 3000 people there and in about 20 new buildings on a new campus
east of Ottawa. The period of Steacie’s presidency came to be regarded as the golden age
of the NRC, especially in the basic sciences. The laboratories, particularly in chemistry
and in physics, were invigorated by a steady flow of postdoctoral fellows, who obtained
two years of full-time lab experience before moving on, in many cases, to staff positions in
Canada’s growing universities. The NRC was also a major source of funding for the science
and engineering departments of those universities. It provided support to Canadian industry
through its Technical Information Services group and, somewhat later, its Industrial Assistance
Research Program.
The historian D. J. C. Phillipson has suggested that the NRC became a victim of its own success in fostering the growth of science and engineering in Canadian academia and industry (Phillipson 1991). He has also suggested that it was a victim of the concept of ‘science policy’ and of continuing attempts to have it conform to the standard Canadian public service procedures. These pressures are exemplified by the Glassco report (Royal Commission on Government Organization 1963) and the Lamontagne Report (1970, 1972, 1973) of the Special Committee on Science Policy of the Canadian Senate. From the scientific point of view, pressure to terminate basic science at the NRC, which had never represented more than 20% of the Council’s personnel or financial resources, in spite of claims to the contrary, was ominous.

During Bill’s 13-year tenure as president of the NRC, several major changes occurred. In 1970, the Dominion Astrophysical Observatory at Victoria, BC, along with the radio telescopes at Algonquin Park, Ontario, and Penticton, BC, were transferred to the NRC from the Department of Energy, Mines and Resources. In 1972, agreements were reached with France and Hawaii to construct and operate the Canada–France–Hawaii 3.6 m optical telescope on Mauna Kea. This programme replaced an earlier plan to construct a telescope named after Queen Elizabeth II in British Columbia. Subsequent international agreements led to Canadian investment in, and access to, the James Clerk Maxwell infrared telescope in Hawaii, the twin Gemini optical telescopes in Hawaii and Chile, and the Atacama Large Millimetre/submillimetre Array in Chile. In 1975, the Herzberg Institute of Astrophysics was created in the NRC to administer and operate these facilities and arrangements, as well as Herzberg’s spectroscopy laboratory.

In 1975, the NRC Postdoctorate Fellowship programme was phased out, partly because government finances required reduced spending and staffing, but also because the programme had achieved its goals brilliantly. In 30 years, some 6000 fellowships were awarded, 1900 of these being held in NRC laboratories. Of these latter, more than 600 were from the UK and 200 from Canada. Those fellows remaining in Canada found employment helping to build up scientific staffs in universities (199 fellows), the NRC (129), government departments (115) and industry (97) (Tickner 1991).

Also in 1975, the NRC undertook the management of the contract of SPAR Industries of Mississauga, Ontario, for the design and production of the Canadarms mounted on the US space shuttles and the space station. In 1976, the NRC took over the government’s interest in TRIUMF, Canada’s national laboratory for particle and nuclear physics, with its meson beam source and research facility on the University of British Columbia campus. In 1978, all NRC financial granting operations were transferred to the Natural Sciences and Engineering Research Council.

In 1977, Bill was made an Officer of the Order of Canada. The citation accompanying his award read ‘Research physicist of international stature. For his support of scientific research in Canadian universities and for the leadership he has given as President of the National Research Council.’

**Retirement**

Bill retired from the NRC at the mandatory age of 65 years in 1980. At his retirement reception, he received various gifts from groups within the NRC. One of these was a chainsaw to replace
the one he had burnt out cutting a mile-long trail through the forest at his chalet (figure 1). In his thanks, he used the term ‘homesteading’, an explicit reference to his childhood when his family was breaking ground in the prairies. Another gift was an apple pie made with apples from ‘Newton’s apple tree’. This tree, growing in front of the NRC physics building, was a descendant of the same cultivar as Newton’s tree and was a gift from the UK National Physical Laboratory.

Between 1981 and 1987, Bill served two years each as vice-president, president and past-president of the International Union of Pure and Applied Chemistry (IUPAC), following his previous service on IUPAC committees. He also became a chemical consultant for small Canadian high-tech start-up companies. He said that having for some time advocated the formation of such companies, he should practice what he preached. Perhaps the most successful of these companies was Philom Bios of Saskatoon, Saskatchewan. It was founded
by J. Cross, G. Khachaturians, J. Schaw and Schneider in 1981. Bill was the first chairman of the board. Its main product was a fungal inoculant that could convert soil phosphates to a form more readily taken up by crops. This technology can be traced back to scientific studies of fermentation processes at the NRC’s Division of Applied Biology in Ottawa and at its Prairie Regional Laboratory in Saskatoon. Philom then developed, manufactured and marketed the product. It later combined the phosphate inoculant with an established bacterial nitrogen inoculant for use with legume crops. In 2013, Philom had sales in 44 countries.

Through the years, Bill maintained an interest in the NRC and attended numerous special events there. On his 91st birthday, 1 June 2006, he cut the ribbon that officially opened the National Ultrahigh-Field NMR Facility for Solids in the W. G. Schneider Building at the NRC (figure 2). His last public appearance was on 10 September 2012 when, as an Officer of the Order of Canada, he was given the Queen Elizabeth II Diamond Jubilee Medal by the Governor General, His Excellency the Right Honourable David Johnston. On 18 February 2013, Bill died at the age of 97 years.

**FAMILY**

Bill and Jean Frances Purves met while at the University of Saskatchewan, and they were married in 1940 in Montreal. Jean was born in 1919 in Prince Albert, Saskatchewan, and obtained a BA at the University of Saskatchewan. She became an accomplished pianist, having pursued advanced courses from the Toronto Conservatory of Music before her
marriage and subsequently having spent two years at the Boston Conservatory while Bill was involved in war work. Their two daughters were born in Massachusetts, Judith Ann in 1944 and Joanne Frances in 1946. When the children entered secondary school, Jean took a Bachelor of Library Science degree at the University of Ottawa. She worked for several years for the Association of Universities and Colleges of Canada building up its library. She died of cancer on 12 January 1981.

Both daughters were outstanding and popular students at Lisgar Collegiate in Ottawa. Judith obtained an honours BA in biology from Queen’s University in Kingston, followed by an MA in urban geography at Queen’s. She took a position in research and policy analysis at the Central Mortgage and Housing Corporation in Ottawa. In 1967, she married Peter Connolly and has three children and three grandchildren. Subsequently she married Ray Saunders. Joanne attended the University of Toronto, where she received a BArch in architecture. After two years with a Vancouver firm, she spent two years with a Canadian firm in Abu Dhabi, United Arab Emirates, before returning to Toronto to practice architecture and project management. In 1983, she married Robert Spurrier.

In 1983, Bill married Marjorie Clarkson (née Brown), a widow, who survives him. Marjorie was born in Cheshire and attended Cheltenham Ladies College. She came to Canada just before World War II, joined the Canadian Army and married a Canadian army officer. Like Bill she was a tennis enthusiast, and they met at the Rockcliffe Lawn Tennis Club.

**THE PERSON**

Bill was motivated by a strong sense of indebtedness and gratitude to his benefactors. This was seen in his perseverance during his first two years at university, his decision to return to Canada despite lucrative American job offers at the end of World War II, and his consultancy for high-tech start-up companies. He was very focused on the task at hand. For five days a week it was science. At foreign conferences he would seek out delegates for discussions during free afternoons rather than going sightseeing. On weekends he and Jean usually retreated to their chalet near the ski area of Mont Tremblant, Quebec, some two hours’ drive from Ottawa. The chalet, where they chose not to have a telephone installed, was designed by their architect daughter, Joanne.

He was a careful and valued listener, and was readily available to his staff, including postdoctoral fellows and technicians. He was hospitable, especially to new postdoctoral fellows, inviting them on family hiking trips in the Gatineau Hills or to dinner at his home. His main recreations were athletic. He was a good skier, both downhill and on trails, and was still skiing in his eighties. On the first weekend in March 1947, Ottawa had a 73 cm snowfall. On Monday morning, no vehicles were moving even in the centre of the city, and non-moving cars were marked only by the mounds of soft and damp snow covering them. Bill skied north from his home in Rockcliffe Park to the Ottawa River, and then west on the river to his laboratory at the NRC, a distance of 3 km. He enjoyed swimming and had a heated indoor pool at his chalet. He played a good game of tennis. At one of the annual Gordon Conferences held in New Hampshire, two German attendees asked whether Bill would be coming, apparently looking forward to scientific discussion. On being assured that he would be arriving somewhat later, they replied ‘good, we are looking forward to playing tennis with him’! In his retirement, he also took up golf following his wife Marjorie’s influence, and it became another of his passions.
CONCLUSION

William George Schneider was a man of many talents. A child of poor immigrants, growing up in a remote agricultural community, he learned early the virtues of hard work and perseverance, which allowed him to make optimal use of the opportunities offered to him by his family and by the country at large, opportunities for which he remained humbly grateful to the end of his life. He developed early into a prominent scientist, first starting to build on his work as a student and then, after learning the ropes, branching out into two new and very different fields, in which he did pioneering work that has had a lasting impact. He was early, perhaps too early, called away from active research after his managerial skills and diplomatic gifts were recognized. But because he had an overriding sense of duty, he accepted the Herculean task of guiding the NRC through a period of major adjustment. Through it all, he maintained a happy family life and a healthy lifestyle. He reached a ripe old age and remained active until close to the end, putting his knowledge and experience generously in the service of society. With his death, the scientific community lost a great advocate and friend.

DEGREES, HONOURS AND AWARDS

Degrees

1937 BSc, University of Saskatchewan
1939 MSc, University of Saskatchewan
1941 PhD, McGill University

Honorary degrees

1966 DSc, York University
1968 LLD, University of Alberta
  LLD, Laurentian University
  DSc, Memorial University
1969 DSc, McMaster University
  LLD, University of Saskatchewan
1970 DSc, University of New Brunswick
  DSc, McGill University
1976 LLD, University of Regina
  DSc, Acadia University

Awards

1946 Certificate of Appreciation, US War Department and US Navy Department
1951 Fellow, Royal Society of Canada
1953 Fellow, Chemical Institute of Canada
1961 Chemical Institute of Canada Medal
1962 Fellow, Royal Society of London
1969 Henry Marshall Tory Medal, Royal Society of Canada
1973 Montreal Medal, Chemical Institute of Canada
1975 National Lutheran Award, Luther College (University of Saskatchewan)
1977 Officer, Order of Canada
Biographical Memoirs

1981 Gold Medal, Professional Institute of the Public Service of Canada
1989 Honorary Fellow, Chemical Institute of Canada
2006 W. G. Schneider Building, NRC Magnetic Resonance Facility
2012 Queen Elizabeth II Diamond Jubilee Medal

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Biographical Memoirs


