The Department of Chemistry
University of Saskatchewan
1959-2019

Introduction and Scope

The University of Saskatchewan was established by an act of the legislature of the Province of Saskatchewan in 1907, and its first classes were offered in the Drinkle Block in downtown Saskatoon in September, 1909. Seventy students enrolled; tuition was $30.00 for the academic year. In 1910 Sir Wilfred Laurier laid the cornerstone of the university's first permanent building, the College Building (now the MacKinnon Building), which opened in 1912. The history of the university has been documented in detail by several authors including Michael Hayden, a former professor of history [1], Carlyle King, a former professor of English [2], and J.W.T. Spinks, who joined the faculty of the Department of Chemistry in 1930 and who served as the University's President from 1959 to 1974 [3,4]. These publications provide detailed insight into the establishment and evolution of the university until the early 1980s.

The Department of Chemistry was established in 1910, and in 1912 conducted its first laboratory instruction in poorly ventilated space in the basement of the College Building. The first students majoring in chemistry graduated at the university's second Convocation in 1913; the first Masters degree in chemistry was awarded in 1919. The importance of chemistry across the disciplines of agriculture, engineering and science was clearly evident from the beginning. Dr. R.D. MacLaurin, the first Professor and Head, pursued research into nitrogen fixation and the production of gaseous fuels by the anaerobic destructive distillation of straw.

A classic picture of MacLaurin's straw gas-powered vehicle is shown in an early photograph (left). MacLaurin left (under a cloud of controversy [1]) in 1919 and was succeeded as Department Head by Prof. T. Thorvaldson who had joined the faculty in 1914. Thorvaldson remained as Head until 1948, and his research in applied physical-

analytical chemistry had an enormous impact on the Department's direction and reputation.

The university's golden jubilee in 1959 prompted Chemistry faculty and staff to produce a 96-page booklet describing the Department's first 50 years [5]. This document provides *"A historical summary of its activities, personnel and achievements since it was established in 1910."* It contains comprehensive lists of all faculty, staff, graduates and research publications to that date, brief descriptions of the research interests of active faculty, and a set of remarkable photographs of the Department's early days. Copies are still available in the Department Head's office and through University Archives and Special Collections. Additional information about the early development of the chemical sciences in Saskatchewan may be found in a chapter written by Professor R. J. Woods and published in a volume celebrating the University's first 100 years [6].

The present script will not contain an attempt to précis the information that exists in these published documents. Rather, this is intended to be a more personal recollection of the evolution of the Department starting in 1959, by coincidence the date of the author's first official contact with the University of Saskatchewan. To gauge the magnitude of the changes that have taken place since then, consider that in 1960 the full-time enrollment at the University of Saskatchewan was *ca.* 5000 (*cf*. 24,000 now); full-time tuition was $200 *p.a.* in Arts and Science (*cf*. $5920 *p.a.* now - an increase by a factor of 30 compared with an increase in the Canadian consumer price index by a factor of 8.6 over the same period).

The campus is now physically much bigger; an aerial view of the 1959 campus with the beginning of construction of the Arts tower in the foreground is shown here (photo courtesy of U of S Archives).

A few words about the distinguished early days of the Department will establish some context.

The Legacies of Thorvaldson and Spinks

During its entire existence the Department of Chemistry at the University of Saskatchewan has enjoyed the benefits of the teaching and research of a host of exceptional faculty members. In the first fifty years of the department's operation the contributions of two professors, Thorberger Thorvaldson and John Spinks, stand out.

An Icelander by birth, Thorberger Thorvaldson graduated with an honours B.Sc. from the University of Manitoba in 1906 and subsequently obtained both the M.Sc. and Ph.D. degrees from Harvard. After completion of a two-year Harvard Travelling Fellowship in Europe, he was hired by the U of S in 1914 as Assistant Professor. Specialising in physical-analytical chemistry, his impact as an outstanding research scientist was immediate. Promoted to Professor in 1917, he became Department Head upon MacLaurin's unusual unanticipated departure in 1919. Thorvaldson, known as T.T. to his colleagues, remained as Department Head until 1948 and took on extra administrative duties in 1945 as the University's first Dean of Graduate Studies. Thorvaldson was awarded a D.Sc. by the University of Manitoba, was elected Fellow of the Royal Society of Canada (and awarded its Henry Marshall Tory Medal), and was made a Knight of the Order of the Falcon in his native Iceland. Following his death in 1965, the newly renovated and extended Chemistry Building was renamed in his honour.

Thorvaldson's main contribution to chemistry research centered on his work to improve the performance of concrete, specifically its resistance to chemical degradation. During the 1920s and early 1930s, Thorvaldson uncovered both the nature of the problem of deteriorating buried concrete structures (alkaline, sulfate-containing ground water) and its solution (using Portland cement whose components were of specific chemical composition and purity). Details may be found in the journal citations of reference 7. Implementation of the results of his research was widespread and continues to be of enormous economic value worldwide. However, neither Thorvaldson nor the University received any direct financial benefit from this research.

John William Tranter Spinks received his B.Sc. and Ph.D. degrees from King's College London and was hired as Assistant Professor immediately after graduating in 1930. He was the first in a long line of researchers in the Department specializing in pure and applied photochemistry and molecular spectroscopy, with extensions during WW II to include radiation chemistry and the use of radioactive tracers in applied science. He served as Department Head from 1948 to 1959, as Dean of the College of Graduate Studies from 1949 until 1959, and was appointed President of the University in 1960. Spinks served as President until 1975, a period of extensive university expansion that saw the somewhat controversial [1] elevation of Regina College into the independent degree-granting University of Regina.

Spinks too was a dedicated, successful researcher, despite starting his independent academic career during a period of world economic depression and Canadian prairie drought that made progress difficult. In 1933, Spinks and other unmarried academic faculty were compelled to take year-long leaves at greatly reduced pay, and Spinks went to Darmstadt, Germany, to work with spectroscopist Gerhard Herzberg. To his great credit, when the antisemitism of the Nazis began to make Herzberg's situation difficult (his wife was Jewish) Spinks arranged with President Walter Murray in 1935 to bring the future Nobel Laureate to the University of Saskatchewan. Herzberg established a rudimentary spectroscopy laboratory in the Physics Building and began publishing in English the series of four books that grew to constitute the bible of small molecule spectroscopy [8], a seminal underpinning of his award of the 1971 Nobel Prize in Chemistry. Spinks helped translate both Volume 1 of this series and a preceding monograph on atomic spectroscopy into English from the original German, and Volume 1 was dedicated to President Murray. Herzberg's biographer, physicist Boris Stoicheff (the current President's father), concluded [9] that Herzberg always held Spinks, Murray and the University of Saskatchewan in very high regard for their actions and support. Herzberg's daughter, Agnes, attended the University of Saskatchewan in the 1960s where she obtained her M.Sc. and Ph.D. in mathematics.

The Thorvaldson, Spinks, Herzberg legacies live on in the form of the University of Saskatchewan's Institute of Space and Atmospheric Studies, the Canadian Light Source, the Saskatchewan Structural Sciences Centre, the Spinks Lecture series, and a host of graduates and later faculty influenced by them.

Early Distinguished Graduates

The Department of Chemistry has graduated many students who have gone on to distinguished careers in science and beyond. The most celebrated of these is Dr. Henry Taube from Neudorf SK, who obtained his B.Sc. degree in 1935 and his M.Sc. degree in 1937 working under Spinks' supervision. The University of Saskatchewan did not offer the Ph.D. degree until 1948, and Taube went on to obtain his doctorate from the University of California, Berkeley. This was followed by an academic research career that consisted of sequential appointments at Cornell, Chicago and Stanford. In 1983 he was awarded the Nobel Prize in Chemistry *"for his work on the mechanisms of electron transfer reactions, especially in metal complexes."* His contributions have been recognized by many awards and honorary doctorates, including a D.Sc. from the University of Saskatchewan in 1983. A plaque located at the university's Nobel Plaza honours his achievements. It is cast in bronze (initially, and unintentionally humorously, with text to recognize his research on *"election transfer"* - now corrected).

Dr. Weldon G. Brown was described by Thorvaldson as *"a brilliant scholar and an adept experimenter"* when presented to Convocation in 1959 for an honorary doctor of laws degree. From Saskatoon, Brown had obtained his B.Sc. (1927) and M.Sc. (1928) degrees from the U of S by the age of 20 while concurrently playing Huskie football and serving as editor of The Sheaf. He went on to obtain his Ph.D. from the University of California, Berkeley, and to establish a long and productive academic career at the University of Chicago, where he is credited with introducing the technique of paper chromatography and the widespread use of lithium aluminum hydride as a reducing agent. To honour his parents, Brown established the Samuel and Ethel Brown Memorial Fund for the support of research students in Chemistry. This gift has provided the longest-established ongoing private financial support for students in the Department's history.

The Department's 1959 Golden Jubilee booklet [5] lists by name and occupation all 575 B.A., B.Sc., M.A., M.Sc. and Ph.D. graduates of the first 50 years. Of these 180 were graduate degrees, but only 10 were at the Ph.D. level - the latter all graduating between 1952 and 1959 after the post-war introduction of the Ph.D. program at the U of S. Many of these Chemistry graduates rose to positions of considerable academic, government and industrial distinction. They include a university President (Harry Thode, former President of McMaster University), several Directors of corporate research (e.g. Joe Muchowski, Syntex S.A., and Norman Grace, Dunlop Canada), and a President of the National Research Council of Canada (Bill Schneider, who later also served as President of IUPAC). This trend of achievement among the Department's graduates has continued to the present day. Some 500 research students have graduated with M.Sc. and Ph.D. degrees in Chemistry from the University of Saskatchewan since 1959. The complete list is available in Excel format from the Department of Chemistry. Contact the Department's office staff for a digital copy (and please do tell us of errors or omissions).

Department Evolution, 1959-2020:

(a) Faculty and Staff

The late 1950s and early 1960s saw big changes in Chemistry Department academic personnel, both at the University of Saskatchewan and elsewhere in Canada. In 1957 Sputnik accelerated the space race; the first commercial lasers were being developed; the computer era had just begun. (Slide rules were out; electronic calculators were in; the Apple II was just around the corner!) Science and technology were booming just at a time when many of the previous generation of faculty were moving on to higher administrative positions or were retiring. In Chemistry, C. C. (Chuck) Lee (organic chemistry), R. A. (Rudy) Abramovitch (organic chemistry), E. Brian Tinker (chemical engineering), Keith M. Thompson (chemical engineering), and K. Lenore McEwen (theoretical chemistry) were all hired in the late 1950s. They joined Profs. Ken McCallum, John Bardwell and Dick Eager (all physical chemists), Jim Pepper (organic chemistry), Allan Van Cleave (inorganic chemistry), and Ernest (Ace) Bailey (analyst) to form a teaching staff of eleven. Twenty-six more individuals with specializations in either chemistry or chemical engineering were recruited in the 1960s; twenty stayed on as tenure-track faculty

members. Faculty and staff working in the Department from 1959 to the present are listed in Appendices 1 and 2, in approximate chronological order of their hiring.

The early emphasis on applied chemistry morphed into a demand for chemical engineering that grew enormously through the 1950s and early 1960s. Nine faculty with chemical engineering backgrounds were hired during this period as the numbers of undergraduate engineering students rose steadily. By 1966 all of the chemical engineering laboratories, including those for unit operations requiring high head space for equipment, were located in the newly-expanded Thorvaldson Building and the importance of this division was recognized as the department changed its official name to the Department of Chemistry and Chemical Engineering. This change formalized a long period of academic cooperation and administrative convenience, but dissolved when the possibility of expansion and new space for Chemical Engineering in the newly renovated Engineering Building emerged. Chemistry resumed using its Department of Chemistry name in 1982-83 following the formal separation, and began a three-year process of re-examining its operations. The Department of Chemical Engineering, however, remained in the Thorvaldson Building until the construction of new dedicated space in the Engineering Building complex was completed in 2004. Since the departure of chemical engineering, the number of active tenure-track faculty in chemistry has remained at a steady state of 18 ± 3.

Over the last sixty years the support staff complement has varied considerably in both numbers and work assignments (Appendices 1 and 2). Many staff members served the needs of the department continuously for several decades during this period, a testament to their adaptability. Those with particularly long service include Elaine von Oder, Brenda Weenk, Brenda Duncalfe and Ronda Duke (office and administrative staff); Jim McGowan and Dilys Maloney (chemistry stores); John Fisher, Jerry Munroe, Garth Parry and Rick Elvin (shops); Keith Brown and Ken Thoms (research instrumentation). Ronda Duke is representative of the very best in the Department's staff over the years. Hired initially in 1979 as a part-time assistant in Chemistry Stores, she held a variety of positions, in due course becoming "the Head's Secretary" (a label that vastly understated her knowledge and capabilities) for 15 years until she retired in 2018. She was a deserving recipient of the College of Arts and Science Distinguished

Staff Member Award in 2015. Keith Brown, who worked in the Department from 1986 to 2018, exemplifies the high level of continuing academic research support that has been available in the Department. Appointed initially as a postdoctoral fellow to work with Prof. John Weil on the electron paramagnetic resonance spectroscopy of solids, Keith became the go-to person for assistance with all varieties of magnetic resonance spectroscopy. Over three decades he managed the increasingly sophisticated NMR infrastructure available to the Department, and near the end of his career published a reference book entitled "Essential mathematics for NMR and MRI spectroscopists" [10].

The need for shops personnel and facilities was particularly pressing when chemical engineering was part of the Department, and then included both mechanical and electrical/electronics shops housed within the Thorvaldson Building. Until glassblower Rick Elvin was hired in 1986, custom glassblowing either had to be outsourced or - as was often the case for those needing glass high vacuum systems - had to be carried out to less than professional standards by faculty and students who learned by trial and error. Now the university's machine shop with a research support mandate is centralized in the Physics Department and the demand for electrical/electronics trouble-shooting has been almost entirely replaced by the need for computer hardware servicing and more general IT support. However, to this day the Department continues to house the only professional scientific glassblower in the Province of Saskatchewan, providing a significant advantage to researchers in Chemistry and beyond with custom glassware requirements.

The outstanding work of the professional staff who organize and teach in the undergraduate chemistry laboratories has been a positive aspect of the operation of the Department over its entire history. The main duties of this group of staff members have historically consisted of delivering laboratory programs for the large numbers of first and second year undergraduate students taking introductory courses. These responsibilities now involve not only organizing the lab programs, but also include choosing, vetting and writing up experiments that help illustrate the course lecture materials; training, supervising and evaluating teaching assistants; ensuring lab safety; data management, and servicing many in-person student needs. Many of the same lab staff also supervise the upper year laboratory

programs taken by chemistry majors, where a detailed, advanced knowledge of the subject matter is required in order to grade reports and provide the required student support. They are superb contributors to the Department's teaching responsibilities.

An approximately chronological listing of the lab staff employed since the early 1960s is assembled in Appendix 1. Those of long service who are also graduates of the U of S include Muriel Finlayson who obtained her Honours B.Sc. in chemistry in 1946 and was Senior Demonstrator in Chemistry at her retirement in the early 1960s; Patricia Currie, (M.Sc., physical chemistry, with Prof. Ken McCallum); Linda Connell (B.Sc., organic chemistry); Barbara Nelson (Ph.D., physical chemistry with Prof. John Weil); Valerie MacKenzie (Ph.D., physical chemistry, with Prof. Ron Steer); Marcelo Sales (Ph.D., organic chemistry, with Prof. Dale Ward); Pearson Ahiahonu (Ph.D., bioorganic chemistry, with Prof. Soledade Pedras).

(b) Research

For much of its 20th century history, chemistry as a discipline was divided for teaching and collegial administrative purposes into four subdivisions: analytical, inorganic, organic and physical. (This particular arbitrary division excludes biochemistry, which at the University of Saskatchewan has existed as a separate department within the College of Medicine). For many decades the needs for teaching expertise to cover these subdisciplinary areas was most frequently the deciding factor in recruiting faculty, and hence, by default determined the areas in which new faculty would do their research. However, the boundaries between these subdivisions have always been somewhat arbitrary and in the 21st century are rapidly disappearing. Research in chemistry now involves significant interdisciplinary character so the need for teaching expertise confined to the traditional subdisciplinary areas has diminished accordingly. Chemical biology, geochemistry, computational chemistry, chemical physics, environmental chemistry, materials chemistry and industrial chemistry, for example, are now well-established areas of mainstream research within Chemistry Departments. To illustrate, note that the American Chemical Society now publishes 61 separate research-oriented journals ranging (alphabetically) from *ACS Applied Electronic Materials* through the traditional *Analytical Chemistry, Inorganic Chemistry, Organic Chemistry and Physical Chemistry* titles to *ACS Synthetic Biology.* Current faculty in the Chemistry Department at the U of S carry out their

research in areas of biophysics, chemical biology, materials chemistry, environmental chemistry, chemical physics, radiochemistry and industrial chemical processes, as well as in the traditional subdisciplinary areas.

In this university Department's early years, analytical and agricultural chemistry were both a priority and a source of considerable interaction and impact both within the institution and beyond. Thorvaldson's work on cement depended largely on wet chemical analyses, and full-time Analysts and Assistant Analysts were employed continuously within the Department until E. C. (Ace) Bailey's retirement in 1981. Spinks' work with radioactive tracers found widespread application in agricultural research; an entire laboratory was devoted to Kjeldahl nitrogen analysis for cereal chemistry. Over the last sixty years agricultural chemistry has continued to maintain strength in both the Department and the College of Agriculture. In Chemistry, C.C. Lee continued Spinks' applied radiotracer work, J.M. Pepper focussed on lignin chemistry, and D.R. Grant researched plant protein chemistry. Professor Soledade Pedras, appointed in 1994, was named Tier 1 Canada Research Chair in bioorganic and agricultural chemistry in 2005, and served in that capacity until her retirement in 2019. She continues her outstanding research in this area as Distinguished Professor Emerita.

At the University of Saskatchewan researchers in the traditional subdivisions of organic and physical/theoretical chemistry have thrived throughout the Department's history. The longstanding contributions to organic chemistry of Professors Jim Pepper, Bob Woods, Peter Smith, Guy Tourigny, Marek Majewski and Dale Ward are well-recognized and are now continued by Professors Michel Gravel, David Palmer, David Sanders and Chris Phenix with an increasing emphasis on systems of biochemical importance. The research of Professors Dale Ward and Michel Gravel in synthetic organic chemistry is particularly noteworthy. In physical/theoretical chemistry, the contributions of Professors Dick Eager, Art Knight, John Weil, Bill Waltz, Paul Mezey, Ron Verrall and Ron Steer are now continued in the expanded materials science context of the subdivision by Professors Richard Bowles, Ian Burgess, Matt Paige, Steven Urquhart, Lee Wilson, Rob Scott, Tim Kelly, Eric Price and Amy Stevens.

However, during the last decades of the 20th century those in both analytical chemistry and inorganic chemistry have struggled at times to maintain continuity of research impact. Undergraduate instruction in these areas has never been compromised but at times - such as the 10-year span ending in 1985 - the numbers of faculty with active analytical and inorganic research programs fell below the critical threshold needed to maintain a nationally competitive presence.

Both of the analytical and inorganic subdisciplines had achieved national and international prominence during the Thorvaldson-Spinks era. However, by the early 1960s Thorvaldson was in full retirement and none of the new faculty hired in the 1960s who specialized in analytical chemistry stayed for more than a few years. Consequently, undergraduate teaching (but not graduate supervision) was delivered by Ace Bailey, the Department's long-standing Analyst, and subsequently by physical chemistry recruits such as Professors Brian Roberts (briefly) and Ron Steer (immediately after Roberts), both of whom introduced instrumental analytical chemistry methods into the undergraduate curriculum. However, the legacy of this lack of research expertise in analytical chemistry in the 1960s and 1970s was a weakened presence of the subdiscipline within the Department. This situation was ameliorated by successful recruiting efforts starting in the 1980s when Professor Andrzej Baranski, a superb analytical electrochemistry specialist, was hired. This was followed by successful efforts to recruit more senior established analytical chemists such as Professors Ken Jackson and Richard Cassidy who, in sequence, maintained active research programs for over a decade. Support also was derived from Professors Laurie Bader and Steve Reid who were trained in analytical chemistry but focussed much of their academic careers on teaching.

In the inorganic chemistry area, Prof. Allan B. Van Cleave (Van to his colleagues), a successful research-active inorganic chemist, moved into full-time administration at Regina College in 1962. Professors J. Wilson Quail and John B. Senior, each with an inorganic chemistry background, were then hired in the mid-to-late 1960s to replace rather poor sessional lecturers who had been brought in to teach the senior inorganic chemistry courses. Although both of these faculty appointees established active research programs, neither found conditions that enabled them to continue their externally funded research for extended periods. This situation,

among other factors, also contributed to the decline in the numbers of students enrolled in the Department's chemistry graduate programs, which fell to a minimum of 20 in the early 1980s. Fortunately, Wil Quail continued to make important contributions both to the university (employee benefits programs) and to the Department's research – in the latter case by providing valuable expertise in crystallography using the x-ray diffraction facilities initially housed within the Saskatchewan Structural Sciences Centre (SSSC), and now provided via the Canadian Light Source (CLS).

Analytical chemistry research has now been reinvigorated with the recruitment of Professors Matt Paige (analytical physical chemistry) in 2002, Ian Burgess (spectroanalytical electrochemistry) in 2005 and Tara Kahan (Canada Research Chair in environmental analytical chemistry) in 2018, all of whom have active research programs. Analytical chemistry at the U of S has also taken on a new dimension via the commissioning in 2004 of the Canadian Light Source. With its world-class instrumentation for chemical analysis and structure determination, this facility now provides major analytical tools employed by several additional chemistry research groups.

Research in organometallic chemistry was sustained for several decades by the work of Professor Ron Sutherland who was also active in international efforts to control chemical weapons. Organometallic chemistry has thrived in the Department over the last fifteen years, with the hiring of Profs. Jens Mueller in 2002 and Steven Foley in 2003. Andrew Grosvenor, hired in 2007, has established a strong program in solid-state chemistry with an emphasis on the sequestering of radioactive waste. A major emphasis on the synthesis, characterization and utilization of useful inorganic and organometallic materials has been a hallmark of all three of these research groups. Prof. Foley has taken his work on the recovery of gold from used electronics to commercial development, with some considerable media publicity [11].

The decision of an NSERC special committee in 1996 to recommend building the Canadian Light Source (CLS, synchrotron) at the University of Saskatchewan and the subsequent decisions of a consortium of government, university and corporate institutions to provide funding for it, has had an enormous positive effect on the research carried out by Chemistry Department faculty in the 21st century. Major funding ($56.4M) for the CLS was provided to the

U of S from the Canada Foundation for Innovation (CFI) in its first competition (1999). As a result research in materials science at the U of S has been brought to the forefront of international competitiveness via the recruitment of world-class faculty who use the CLS beamlines as either their major or minor tools. In Chemistry, Professors Urquhart, Scott, Burgess and Grosvenor are major CLS users; Professors Sanders (crystallography) and Kelly (materials for solar cells and radiology detectors) are frequent users. Professors Tom Ellis (CLS Director of Research from 2005-2015) and Rob Lamb (current CEO), both with academic backgrounds in physical chemistry/chemical physics, have held major roles in the scientific leadership of the CLS.

Almost unnoticed at the time, the first of two CFI grants for instrumentation that led to the establishment of the Saskatchewan Structural Sciences Centre (SSSC) was also awarded to the U of S in the 1999 CFI competition. This first award of $1.9M, led by Chemistry Department faculty, was complemented by an application in the following competition led by Prof. Soledade Pedras that resulted in a further grant of $1.6M, primarily for instrumentation for biomolecule characterization. These two CFI awards ultimately led to a total expenditure of about $15M when building renovations to accommodate the purchased instruments and technical staff were complete. The SSSC's NMR and mass spectrometry facilities are now located in the wing of the Chemistry Building that once housed all the first and second year undergraduate labs, while lasers and other spectroscopic equipment are situated in space formerly housing the unit operations laboratories for chemical engineering. This Centre is open to both academic and private sector researchers. Policy and planning are guided by a Director (to date drawn exclusively from Chemistry Department faculty) and Advisory Board, and operations are managed by Dr. Ramaswami Sammynaiken (Sammy to all), a physical chemist hired in 2000 at the outset of the SSSC's activities. Instruments are run and maintained by a professional staff who also act as instructors for students who need to become hands-on instrument operators.

(c) Graduate Students

Research in the Department of Chemistry has always been carried out with and by a cohort of graduate students enrolled in Masters and Doctoral programs. Of interest, the Master of Arts (M.A.) degree was awarded to Masters program graduates in chemistry about as

frequently as the Master of Science (M.Sc.) degree until the last M.A. degree in Chemistry was awarded in 1968. (What has happened to the Art of Chemistry?) Also of interest, the relative numbers of Masters and Doctoral graduates has changed dramatically since the introduction of the Ph.D. program in 1948. The first Ph.D. in Chemistry at the U of S was awarded in 1952, and over the last sixty years the ratio of M.Sc.:Ph.D. degrees awarded has changed from *ca.* 3:1 to the present 1:4. In the early days of the Department, very few women were enrolled in chemistry programs. Fewer than 10 percent of graduate students in chemistry were female in the early 1960s, and that fraction did not change substantially until the beginning of the present century. The present proportion is *ca*. 30% and rising, encouraged strongly by the U of S Women in Chemistry (WiC) organization. In the first 50 years of its existence, the Department graduated almost no Masters or Doctoral students of international origin. This situation began to change rapidly in the 1960s when students primarily from Africa and Asia enrolled in increasing numbers. At present *ca*. 90% of the Department's graduate students obtained their first university degree(s) abroad.

The numbers of students enrolled in graduate programs has always been a critical factor in determining the ongoing research health of the Department. The decline in the total number of graduate students registered in Chemistry's M.Sc. and Ph.D. programs that occurred during the late 1970's and early 1980s is reflected in the numbers of graduate degrees awarded, as shown in Figure 1. This decline was primarily due to the failure of chemists within the Department to attract sufficient external grant funding and, following the departure of Chemical Engineering, led to an internally initiated external review of the Department's research and graduate programs in 1985-86.

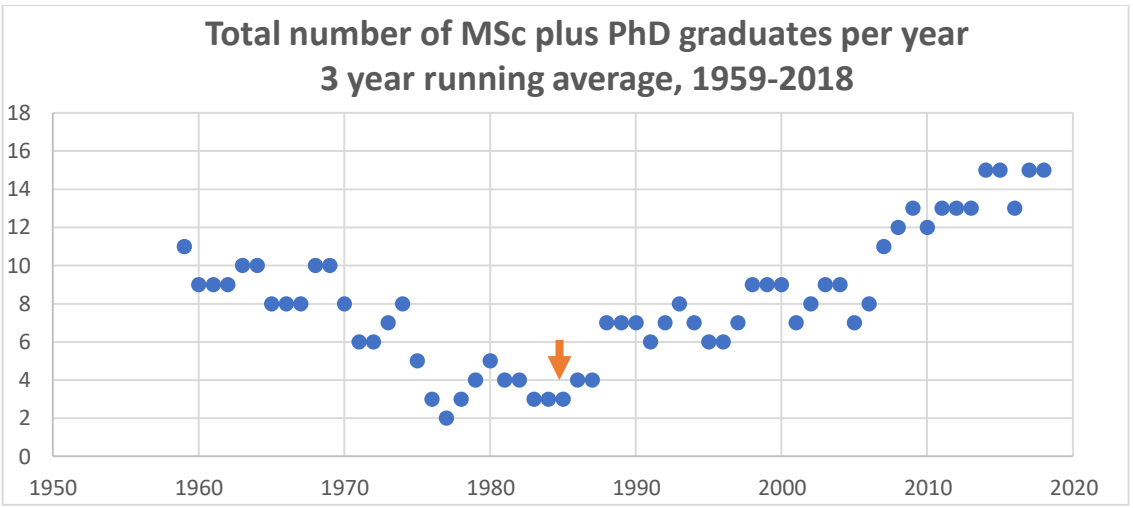


Figure 1: Three year running whole number average of the total number of M.Sc. plus Ph.D. graduates in chemistry per year. The arrow marks the year of a special external review of chemistry's research and graduate programs (see text).

Professors Howard Alper (University of Ottawa) and Alex MacAuley (University of Victoria) produced a report of the "Special Committee to Review Research in the Department of Chemistry" [12] that resulted in an immediate improvement in the support for research and graduate studies. Two recommendations, both implemented without delay, had particularly important effects. First, the reviewers recommended that the department repurpose its undergraduate laboratory teaching resources to establish a Teaching Assistantship program staffed primarily by graduate students. Implementation carried difficult staffing and instructional quality implications, but had an enormously positive effect on graduate student funding and teaching opportunities. Second, implementation of a recommendation to fully revise the undergraduate curriculum resulted in the current programs of academic instruction in chemistry that are nationally accredited. Together with other positive developments in subsequent years, the result has been a four-fold increase in the total numbers of graduate students registered in chemistry-based graduate programs, leading to the 2019-20 all-time high of 87.

(d) Undergraduate Teaching and Learning:

The Chemistry Department has taken pride in offering up-to-date laboratory and lecture course instruction of high quality from the very beginning. As a result, students majoring in

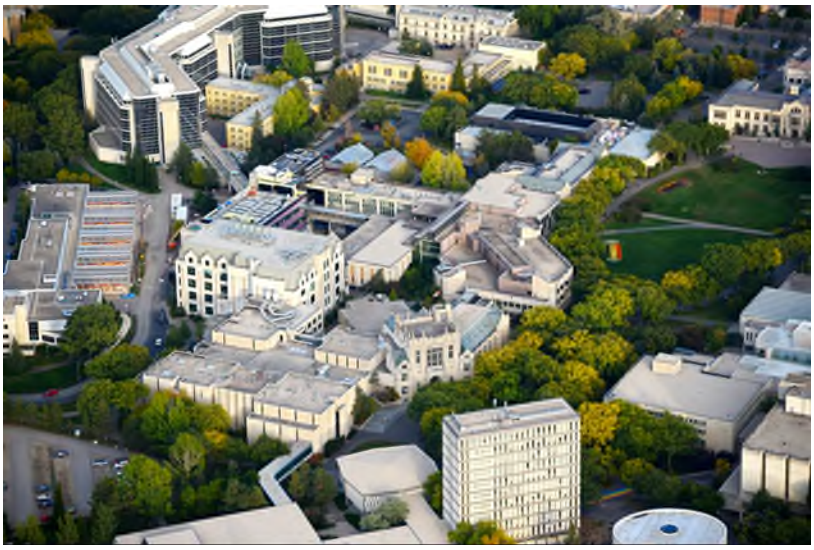
chemistry and graduating with bachelor degrees have been accepted continuously into graduate programs and positions of employment around the world since 1913. Providing the academic programs and particularly the laboratory facilities and instrumentation needed to accomplish this has, however, never been easy. The first laboratories were situated in the basement of the College Building and, with poor ventilation, were not well-suited to this function. The Chemistry Building, which opened in 1924, provided world-class facilities, but was criticized as being much too expensive and, with the onset of the depression, a planned north wing was never built. The massive influx of undergraduate students following WW II resulted in untenable overcrowding in the 1924 building and prompted the university to purchase nine surplus military huts. These were located immediately to the north of the Chemistry Building and were joined to provide what became known as the Chemistry Annexes. These drafty structures were used for senior undergraduate labs and research space until the mid-1960s.

The modern history of the Department's undergraduate laboratory facilities started with the design of the extension that led to the opening of the Thorvaldson Building in 1966. For the previous four decades all of the laboratory components of the large undergraduate courses in introductory general and organic chemistry were held in the "laboratory wing" of the Chemistry Building - space that is now fully renovated and occupied by the SSSC. The extension to the Chemistry Building that opened in 1966 provided entirely new space for all of the first year laboratories. These facilities were designed in large measure by the undergraduate laboratory staff of the day, including particularly Mrs. Muriel Finlayson, (Senior Laboratory Demonstrator), and - after several internal refits - remain in use to the present day.

Students in the large introductory organic chemistry courses initially were not so fortunate. Most of the laboratories for these courses remained in the old laboratory wing of the 1924 building after the opening of the extension in 1966. Although gutted and refurbished with new lab benches and fume

1924 view of The Bowl from atop Chemistry

hoods, this laboratory space remained an unattractive eyesore with its leaky cracked glass roof and jury-rigged fume hoods. These facilities would never have met modern day safety standards but remained in use until the opening of the Spinks addition to the Thorvaldson Building in 2003. The new upper year labs are excellent, however, so patience has had its reward.



2017 aerial view of the U of S campus (photo courtesy of U of S Communications)

The curriculum presented to undergraduate students seeking to major in chemistry has changed remarkably over the past 60 years. In 1960 the fall term started at the end of the third week of September; there were no mid-term breaks. Classes were all of 50 minutes duration and were held in Monday-Wednesday-Friday and Tuesday-Thursday-Saturday sequences. Saturday morning classes were not eliminated until the early 1970s. Introductory courses in the College of Arts and Science were almost all of academic-year-long duration (the equivalent of the current 6 credit unit offerings) and "Christmas" exams were in January, making extended holiday relaxation difficult for serious students. In chemistry, most mainstream second and third year courses were also year-long, and the only research-based course that students could take for credit was a "half-course" in their senior year. Students doing an Honours undergraduate program in chemistry were required to take foreign language courses - an out-of-date but lingering consequence of the fact that considerable mainstream early 20th century scientific research literature was written in French or German or Russian. Science students were also required to take several mainstream courses in the humanities and social sciences, a positive aspect of the integration of the arts and sciences. However, to the chagrin (amusement, annoyance?) of many science faculty in the College this requirement was not reciprocal because most science courses required of social

science and humanities students were not mainstream (*i.e.* they had fewer prerequisites and were not allowed for credit for science students). Sixty years ago computer science did not exist as an undergraduate program and computational chemistry had yet to evolve.

In contrast, for the last two decades almost all lecture-based courses in chemistry have been of the 3-credit unit variety. The only 6-credit unit course undergraduate chemistry majors can take at present is a supervised research project in their senior year. Three credit unit research-based courses are also available in both the third and fourth year levels, illustrating the increased importance of introducing chemistry students to research early on in their studies. Computational chemistry is a required element of undergraduate training and is of widespread use in graduate research.

The revolutionary shift to more and more powerful instrumentation for quantitative and structural chemical analyses has also had enormous implications for the chemistry curriculum. In the field of magnetic resonance spectroscopy, the Department first acquired EPR instrumentation for radiation chemistry research in the late 1950s. The first NMR spectrometer, a Varian A-60 permanent magnet instrument, was purchased in the early 1960s. The inevitable transition from wet to instrumental methods in undergraduate analytical chemistry was started with the introduction in the mid-1960s of a senior instrumentation course offered by Prof. Brian Roberts, a junior faculty member appointed in 1962. Following Roberts' departure in 1969, this course was substantially modified and in 1972 a new instrumental methods course was introduced at the second year level to complement a wet methods course of long-standing.

Over time, these activities have evolved within all subdisciplines to provide current students with both the theoretical background and the hands-on laboratory experience in all important spectroscopic and analytical chemical methods. Now, thanks to the efforts of Professor Tom Ellis, senior undergraduates in our Chemistry Department have the opportunity, unique in Canada, to do synchrotron-based experiments using the Canadian Light Source. Progress from the poorly ventilated laboratory space in the College Building to the present could not be more dramatic.

(e) Lessons Learned, Trends Revealed

The single overarching lesson that the Department of Chemistry's history has provided is that the integration of teaching and research creates a whole that is much greater than the sum of its individual components. Universities are uniquely positioned to accomplish such integration and the Department of Chemistry has led this process in the sciences at the University of Saskatchewan from its very beginnings.

Another important observation is that, over the course of the last 60 years, the academic role once played by the senior years of secondary school has been taken over by the introductory years of instruction at universities and colleges. The fraction of the school student population graduating high school has increased substantially over this time period. This is commendable, but the academic preparation of graduates of the secondary school system has not remained the primary focus. It has been extremely difficult for schools in Canada to keep up with the enormous innovations in science and technology over the past several decades. This is particularly evident in Saskatchewan where the performance of the province's youth in science and mathematics is among the poorest in Canada according to the internationally recognized OECD PISA study of 2018 [13] (*cf.* Alberta 15 year-olds who are among the best in Canada). Moreover, substantial grade inflation in the secondary schools - a common phenomenon in Western countries, but particularly in the Province of Saskatchewan - has occurred, with the result that a significantly larger fraction of the increased graduating school student population now meets the relatively unchanged numerical entrance standards for direct entry into university in Colleges such as Arts and Science. Consequently, according to a 2011 U of S study Saskatchewan secondary school graduates entering universities in Canada experience, on average, some of the largest drops in their scholastic averages [14]. (School graduates in neighboring Alberta perform among the best in Canada by this same metric. Note, however, that it is difficult to obtain up-to-date, reliable information on this subject.) Nevertheless, University of Saskatchewan Departments are under administrative pressure to ensure that undergraduate drop-out rates are kept to a minimum so that a constant or increasing cohort of students continues to pay tuition. As a consequence, potential employers in technical or scientific fields now often view three year degree graduates in the same way as they viewed

high school graduates 60 years ago. Similarly, a Master's degree in science from a graduate school has taken the place of the four-year university major; a Ph.D. alone often is not enough to assure its holder of a shot at a permanent academic or research-based position; postdoctoral experience is now almost always required. The declining ratio of M.Sc.:Ph.D. graduates of the Chemistry Department at the U of S, and the generally increasing ages of faculty at the start of their tenure-track academic careers reflect this long-term trend.

Final Comments:

The Department of Chemistry has existed for 110 years at the University of Saskatchewan. During the last 60 years faculty and staff have been responsible for graduating 500 students with M.Sc. and Ph.D. degrees and over 600 with B.Sc. degrees. During the same period many millions of dollars have been awarded competitively to researchers in Chemistry, resulting in well over 2000 papers published in peer-reviewed journals. Research activity is currently at an all-time high and the department shows substantial promise of continuing on its demonstrated path of excellence. These positive developments in research are soon to be complemented by a significant revamping of the undergraduate chemistry curriculum that is designed to capture the enduring importance of chemistry in our daily lives. Watch for it!

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Prepared By: Professor Emeritus Ron Steer, 2020

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Appendix 1: Faculty and Laboratory Staff 1959-2019

Past Faculty: (i) Chemistry

K. J. McCallum	1942-84
E. C. Bailey	1943-81
R. L. Eager	1947-84
J. M. Pepper	1947-85
J. A. E. Bardwell	1950-85
C. C. Lee	1955-88
R. Abramovitch	1957-67
K. L. McEwen	1959-77
B. A. Bohm	1962-64
D. R. Grant	1962-93
B. Roberts	1962-69
J. A. S. Williams	1963-82
A. R. Knight	1964-93
J. W. Quail	1964-03
D. B. Russell	1964-96
R. J. Woods	1964-95
J. B. Senior	1965-96
H. Spencer	1966-69
L. W. Bader	1967-96
E. G. Hoehn	1967-69
M. D. Silbert	1967-69
R. G. Sutherland	1967-02
G. Tourigny	1967-96
P. J. Smith	1969-96
R. P. Steer	1969-16
W. L. Waltz	1969-07
R. E. Verrall	1969-04
J. A. Weil	1971-96
P. G. Mezey	1977-03
H. Marshall	1980-82
A. S. Baranski	1983-11
K. W. Jackson	1984-88
R. S. Reid	1984-19
M. Majewski	1985-18
D. E. Ward	1985-19
R. M. Cassidy	1988-00
M. C. S. Pedras	1994-19
R. Silerova	1997-02
M. P. Singh*	1997-05
H.-B. Kraatz	1998-07
H. Iwai	2003-05

* on permanent leave

(ii) Chemical Engineering[#]

K. M. Thompson	1956-61
E. B. Tinker	1957-66
C. A. Shook	1961-83
W. E. DeCoursey	1962-83
N. N. Bakhshi	1964-83
J. F. Mathews	1966-83
M. Greaves	1967-74
D. G. McDonald	1968-83
T. Zabel	1969-72
J. H. Masliyah	1972-77
J. Peters	1975-80
J. Postlethwaite	1975-83
M. N. Esmail	1976-83

[#] until 1983 when Chemical Engineering and Chemistry separated

Present Chemistry Faculty

D. R. J. Palmer	1999-
S. G. Urquhart	2000-
J. Mueller	2002-
D. A. R. Sanders	2002-
M. F. Paige	2002-
R. K. Bowles	2003-
S. R. Foley	2003-
I. J. Burgess	2005-
R. W. J. Scott	2005-
L. D. Wilson	2005-
M. Gravel	2006-
A. P. Grosvenor	2008-
T. L. Kelly	2011-
T. H. Ellis	2015-
C. P. Phenix	2016-
E. W. Price	2016-
T. F. Kahan	2018-
A. L. Stevens	2019-

Past Laboratory Staff

M. Finlayson
W. Bykowy
M. Byrnes
B. Naphin
K. Ward
P. Currie
J. Brown
K. Connell
D. Elliott
D. Mullord
B. Wilson
P. Gillies
D. Carlson
B. Weenk
V. Gummadi
B. Nelson
S. Ravindran

Present Laboratory Staff

L. Connell	1975-
V. MacKenzie	2002-
P. Wennek	2003-
A. Bartole-Scott	2008-
J. Fu	2009-
M. Sales	2010-
P. Ahiahonu	2011-
A. Clark	2016-

Appendix 2: Stores, Shops, Technical, Office and Administrative Staff 1959-2019 (in rough chronological order)

Staff: (a) Stores

J. McGowan
R. Duke
J. Pengelly
D. Maloney
A. Siu
V. Lundquist
L. Coates
L. Diechert
R. Gilmour
S. Hleck
J. Konkin
A. Wilde
J. Mauerhoff
D. Reynaud
C. Surtees
T. Holowaty
H. Lynchuk
T. Friesen
F. Lane
L. Duxbury*
B. Brososky*

Staff: (b) Shops & Technical

R. Teed
B. Green
J. Williams
J. Fisher
A. Bibbey
G. Rogers
J. Munroe
G. Parry
D. Beaudoin
K. Brown
K. Thoms*
R. Elvin*
K. Fransishyn*

Staff: (c) Office & Admin.

E. Von Oder
B. Duncalfe
L. Beckstead
P. Steer
J. Dahl
P. Walters
R. Peressini
L. Garvie
C. Green
F. Elash
K. Hughes
T. Skjeie
J. Buck
A. Listoe
R. Lenton
B. Boden
S. Hertz
V. Isaac
C. Ouellet
S. Mason
C. Young
L. Hildebrandt
J. Brown
B. Weenk
R. Duke
B. Wong*
E. Wasylow*
A. Bornhorst*
M. Kennedy*

* current staff (2019)