Re: Written response to External Review report, Department of Chemistry & Biochemistry

The verbal response to CCAM by the Department Head was provided during the August 20, 2018 meeting. The unit review took place March 22 and 23, 2018. The Department would firstly like to acknowledge the time and efforts of the unit review committee (membership: Professor Jed Harrison UofA; Prof Masoud Jelokhani-Niaraki Wilfrid Laurier University and internal reviewer Prof Amr Henni from Faculty of Engineering and Applied Science). The Department has had several department meetings related to the review process (March 27, April 10, and Aug 8, Nov 16, Nov 22, 2018 and Jan 15, 2019) to respond to the recommendations of the unit review and we continue to build strategies for improvement of delivery of our programs.

As many of our successes and challenges encompass the same issues this written response has grouped as follows:

(1) enrolment pressures and delivery of our internal and external service requirements,

(2) senior undergraduate program delivery;

(3) graduate student completion times; and

(4) research capacity building and major infrastructure need (critical need for 300 Mhz NMR replacement)

Items taken from the unit review report are noted in italics. Departmental responses and additional notes follow each of these items.

(1) Enrolment pressures and delivery of our internal and external service requirements

a. *There has been substantial growth in the number of students in service courses over 20% in the past 5 years and even more (over 200%) during the past 10 years. "extraordinarily high service load for a department of a modest size*. *Impact of the growth needs to be addressed* **– our high-demand service courses include CHEM100, 104, 140 as well as we are seeing additional high pressure on BIOC220/221 and CHEM241 as noted in our predictions of future enrolment pressures in the department**
b. *Regarding the current size of the Department of Chemistry & Biochemistry , any reduction in its size can severely damage its teaching and research ability*
c. *The Department has taken a number of steps to accommodate the increased teaching workload, but it appears that the demands on staff are high and the available resources are stretched to the limit*
d. *TA support needs to be increased within our budget*

The unit review report also highlighted our strengths. Our introductory program is strong, we have well managed labs, we have made efforts to continually update our labs within resources available, and the $200,000 budget line item for faculty of science is essential in meeting our demands for

continual updating and managing enrolments. Our enrolments in the fall 2018 and winter 2019 have continued to put pressure on our programs. We have continued to do make efforts to accommodate the increases in enrolment and our department has been already stretching to the limit for several years.

Update for the fall 2018 and winter 2019 semester

We have kept enrolment in CHEM140 and CHEM104 in fall 2018 semester at a similar level to fall 2017 which is consistent with our plan to manage enrolment of these labs between the fall and winter semester as we are at our limit of delivery for our current faculty and laboratory instructor complement and lab space availability. For CHEM104 current enrolment is 425 in fall 2019 semester (similar in 2017 and 2018) and 191 in the winter semester (we also teach CHEM105 in the winter semester in the same lab space which has similar enrolment to CHEM104). CHEM105 has already reached the capacity of the class. Figures below show enrolment trend updates for the last 4 academic years (fall and winter semester). These courses provide service to our biochemistry and chemistry programs, other science programs in science, faculty of engineering and applied science (CHEM104 and CHEM140) and pre-professional programs.

To meet the needs of incoming students who do not have the pre-requisite requirements for CHEM104, we moved our offering of CHEM100 into the fall semester and have seen an increase in enrolment (CHEM100: 96 current enrolment fall 2018; fall 2017 enrolment of 77). There are no labs associated with this class.

Additional pressures to CHEM241 and BIOC220/221 are occurring due to enrolment increases from pre-professional programs and other science programs including the Biology program.

CHEM241 is a course requirement for the pre-pharmacy students so we have seen increased pressure over the last several years and we have reached our maximum capacity. CHEM241 Organic Chemistry II (**59 current enrolment**) with 2 larger lab sections in fall 2018 requiring additional TA support; fall 2017 **37** and 2 lab sections. We are at our highest enrolment in this course and would not be able to accommodate additional enrolment in the future without additional lab space, laboratory instructor, and a new faculty member in the department. If there is need for increased enrolment in future in addition to the lab pressures we will likely need to think about having two sections for this course. With our current faculty complement we do not have the capacity in organic chemistry at this level to accommodate development of a 2nd year course for pre-professional programs that would still meet pre-pharmacy program requirements or two offer two different lecture sections. We are also at the limits of our lab space and lab instructor complement. For fall 2019 we have increased the lab to three sections and balanced this with reduction of one section of CHEM140 in the fall 2019 semester (CHEM140 is also taught in the winter semester and are expecting a small decline in number of engineering students taking CHEM140 due to changes in their program requirements from CHEM140 to CHEM105 –estimated about 30 students). This was our best current option to deal with the increased enrolment with our current faculty complement and lab space availability.

The enrolment in the biochemistry program has also increased over the last several years particularly with the changes in medical school requirements. This continues to put pressure on the BIOC220/221 courses which service the biochemistry program, chemistry program (BIOC220), biology program, and pre-professional programs. BIOC 220 fall 2018 current enrolment is 141 (our highest on record) and also BIOC221 (winter 2019 is 83, the highest on record). We added two laboratory sections in the fall and with this enrolment we have reached our maximum laboratory capacity (6 lab sections) and have accommodated overloading lab instructor workload with additional TA support. In comparison fall 2017 enrolment was 90 with 4 lab sections. Similarly in winter we are at our maximum capacity.

Availability of a classroom of this size is also a limitation for offering this course in one section for the lecture and additional TA support is needed to address both increasing enrolment and changes in the background of students enrolled in the class.

In fall 2019 our department is also evaluating a change in lab for CHEM104 from every other week to weekly with students doing problem exercises in the alternating weeks. We will manage this with two faculty members and TA reassignments. Further though into supplemental instruction is needed to address the changing background preparation of students.

Departmental Action –Our greatest need to deal with both program delivery needs, service needs to other departments and faculties, and research capacity building is in growth of our faculty complement.

i. The department submitted a budget request to Faculty of Science which included a request for a new base budgeted position for a faculty member in chemistry in our department (see attachment below). Enrolment increases in both chemistry and biochemistry have continued putting additional pressure on the delivery of service courses at the 1xx and 2 xx level and our ability to modify our program at the 4xx level to better meet the needs of students in chemistry and biochemistry majors

ii. The department submitted an LOI for a CRC Tier II candidate in biochemistry which is moving forward and the Department has currently established a search committee.

iii. We are also anticipating retirements in the upcoming years of faculty members in areas of both chemistry and biochemistry. As noted in the unit review any reduction in faculty complement will severely damage our ability to meet requirements for internal and external service requirements. Our faculty complement currently consists of 4 biochemistry faculty members, 7 chemistry faculty members, and 5 laboratory instructors (1 term position), 1 technician, and 1 administrative assistant. The number of experienced sessionals is also very small in our department and it is very difficult to find sessionals with suitable background for our upper level chemistry & biochemistry classes which makes it challenging to accommodate increasing enrolments and leave requests.

iv. Shared laboratory LB320 with Biology and other options are still under consideration do deal with potential enrolment growth beyond winter 2019.

As noted in the unit review report " Due to the high teaching load to 1st and 2nd year courses the department has limitations in offering senior courses on a regular basis. Notable disadvantage for undergraduate students"

–our senior program would benefit from some structural changes to strengthen our availability of offerings within our limitations of faculty complement.

Response:

With our size of our faculty complement is has been challenging to address needs for changes at the 4xx level, and we are currently at the minimum in offers required to meet student program requirements due to our high internal and external service requirements at the 1st and 2nd year level.

Senior course and graduate courses were highlighted as a limitation and to address this we started to introduce team taught courses with the first offerings approved for winter 2019 semester (BIOC428AH and CHEM490AH). We have scheduled one team taught course in chemistry and one in biochemistry in fall 2019 (course syllabus development underway) and winter2020 to allow most faculty to teach this new course style.

Our department has had several department meetings related to the CHEM/BIOC4xx/8xx offerings and the possibility of team taught (two instructor teaching these courses with two different topics allowing for greater rotation and integration of areas of specialization) as was suggested by the review team. These discussions have included how to combine topics that are most feasible and the pre-requisites for these courses to accommodate students in Honors program (possibly Honor students taking a 4xx option in their 3rd year).

In winter 2019 we offered our first team taught courses at the 4xx level in both the chemistry and the biochemistry program. The CHEM/BIOC8xx option has different requirements than the 4xx option and reading classes at 8xx level will also continue to be offered as needed in our department.

(a) The two team taught courses for winter 2019 include (I) CHEM490AH/CHEM857AC Electrochemistry and Photochemistry (co-taught by Stephen Cheng/Scott Murphy) and BIOC428AH/827AQ Chemical Basis of Biological Systems/Chemical Basis of Biological Systems (co-taught by Dennis Fitzpatrick/Dae-Yeon Suh). Our department will aim to get student feedback and identify the challenges and successes of offering team taught courses as we move forward.

(b) We are also planning to offer team taught courses at the 4xx level in fall 2019/winter2020 semesters to allow most of our faculty members an opportunity to teach this new style of course. Our current plan for winter is in Chemistry (Lynn Mihichuk/Brian Sterenberg) and in Biochemistry (Dae-Yeon Suh/Scott Murphy); followed by CHEM (Allan East/Stephen Cheng) and BIOC (Tanya Dahms/Mohan Babu) in winter 2020. After this period it is expected that the department will do a review of the team taught approach to decide if this is a direction the department wants to continue with and will look for feedback from instructors and students each semester .

(c) Our department does not have the faculty complement to support teaching separate CHEM8xx level courses and has recommended no change at current time while we introduce team-taught courses.

(2) Time to Completion of graduate students and writing requirements within the graduate program. With an eye to streamlining the number of literature, proposal, and presentation exercises required. Feasibility of reducing the number or the expectations of these requirements.

- This has also been discussed at our department meetings since the unit review. We identified that CHEM/BIOC 800 and 801 and progress report requirements need to be managed more. (see attachment for new recommended timeline for incoming Fall 2019 students). The department Head has also meet with graduate students as a group who currently in this program to discuss the timeline. Supervisors are also discussing expectations with those students that have longer time to completion. We have seen significant progress on progress reports and thesis preparations for students on maintenance status.
- We have created a Chemistry 800/801 and Biochemistry (800/801) coordinator role in our department which will rotate between different faculty members on a 2-year basis. The same individuals will also act as coordinators for CHEM/BIOC 401/402 coordinators. We have used graduate studies and research recommendations for thesis committee membership and roles as the minimum requirements. This should also alleviate some of the workloads of faculty to sit on multiple committees and scheduling of these meetings in a timely manner.
- The graduate coordinator will also track student progress of each student.
- The department Head has met with the graduate students in March to go over the new timeline expectations and also do address questions of students regarding sequence of courses, progress reports, thesis that are in their programs.

(3) A number of key individual labs form a major component of research infrastructure -many of this infrastructure was obtained in the last 15 years (so its aging)

The infrastructure development/equipment replacement budget ($200000) of the Dean of Science is recommended to continue

For department to maintain research productivity the department and Faculty of Science should consider growth in graduate programs. Increased graduate student support through Teaching Assistantships would be helpful for both graduate and undergraduate programs

-it is essential to increase the success rate of external funding by attracting high quality graduate students, as well as maintaining, updating and expanding the existing research infrastructure

Departmental Response: The $200,000 budget line item for faculty of science is essential in meeting our demands for continual updating and managing our internal and external service requirements and sustaining and building our research capacity in the department. Our major research and teaching infrastructure in the department is aging. Over the last 5 years we have made significant improvements in our undergraduate laboratories, but efforts need to continue to tackle aging infrastructure.

The department relies heavily on funds from Faculty of Science $200,000 to update and replace aging equipment in our undergraduate laboratories and to support our research infrastructure. The department also utilizes some of its budget as outlined in the unit review to update or improve instrumentation in the undergraduate laboratories. Although we have made significant progress in the last 5 years in improving our instrumentation in our undergraduate laboratories, there is still significant need to repair, replace, or update equipment that is aging. We still have instrumentation in excess of 15 or even 30 years. Each year, the department targets firstly items for immediate need of replacement for continued operation of undergraduate labs, and where possible updates to existing instrumentation.

Department Response: Critical need- Replacement of the 300 MHz NMR by Sept 2019. Currently not operating and was approximately 15 years of age.

It is recommended that a new 400 MHz NMR be purchased to meet both undergraduate and research requirements with an estimated in $400 K range. This NMR is essential to the delivery of our programs and is considered to be a core piece of infrastructure at all Canadian Universities with a chemistry program. We initially anticipate this replacement needs to be completed within a 3 year time window, however the 300 MHz NMR stopped operating in March 2019 and repair is no longer feasible. The Dean of the Faculty of Science has set-up an account to support the budget for this replacement and the $200,000 for the supplement for the next fiscal year will be critical to the ability of the faculty to replace this NMR in time for the fall 2019 semester.

The department has also submitted a budget request that includes support for a new faculty member in the department. The chemistry faculty job description for a new faculty member in chemistry highlights NMR experience (see attached). The department anticipates submitting an EOI for CFI Innovation in 2020 related to the replacement of the 500 MHz NMR which is also ~15 years of age.

The current level of UGRS scholarships is insufficient to fund the number of graduate students that meet the requirements for these scholarships or to grow our graduate program further. The department is tackling the time to completion of graduate students to reduce the number of students on maintenance status which should provide opportunities for growth in the graduate program. However, the availability of scholarships relative to other Chemistry & Biochemistry programs in Canada limits our ability to attract HQP. The research infrastructure and potential for a supervisor to provide research support for students is also dependent upon success rates at NSERC, CIHR, and other external sources. New faculty members would aid in building the research capacity to obtain successful instrumentation and research grants. Additional TA support in our budgets to accommodate increasing enrolments will also provide stable funding support for our graduate students.

Dr. Babu also submitted an expression of interest for internal competition for CFI innovation in March 2019 entitled Mitochondrial Network (MitoNET) Centre for High-throughput Functional Proteomic Studies in Human Health and Disease and will build on the expertise in mass spectrometry of current faculty members in the department in both chemistry and biochemistry research foci.

The department has developed research themes to guide our direction for development of our faculty complement (see attachment on research themes).

Items incorrect or needing additional clarity

Introduction of research into introductory courses –deliberate fashion in first year courses, as a means to recruit both department Majors/Honours and future graduate students. The review committee encourages all approaches to increase program enrollment in these categories.

To support the research strength of the department, it is essential to increase the success rate of stable external funding by attracting high quality graduate students, as well as maintaining updating and expanding the existing research infrastructure

This item is also related to infrastructure and our research funding success rates in the department. Our ability to grow the graduate program is more limited by research operating funds and HQP scholarships. In our faculty the scholarships for the dept are determined by the number or registered graduate students not on maintenance status – we will likely see our scholarship amount decline so it is unclear about the statement on pg 11 of the unit review report "the funding for GS may be more stable than department faculty perceive. Many in the department still feel that their availability of external funding sources and FGSR funding limits their ability to compete with other universities for highly quality graduate students.

The majority of the existing research infrastructure in the department was obtained by faculty applications to NSERC RTI or CFI programs. New faculty members in the department would improve the success rate of future proposals for new infrastructure and research activities.

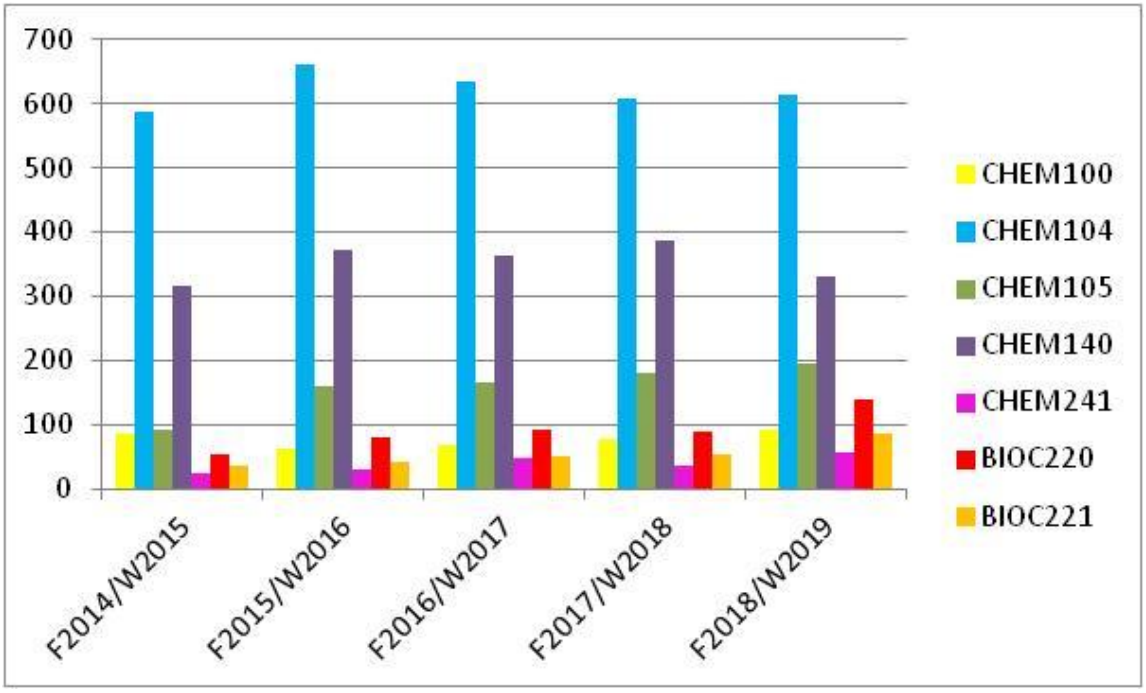
Incorrect Item: Department should take advantage of training lectures on literature searching that are offered by the Library, and other library resources, as part of the curriculum within at least one course, perhaps further motivated by a graded assignment in that course.

A number of our faculty in 3rd and 4th year courses were already taking advantage of this resource and have done so for several years. However, the department will further strengthen this and has additional volunteers at 2nd -4th year level in both lab and lecture to offer the library resource for literature searching. It is common to have written term papers, posters or class presentations in our 3rd and 4th year class.

Attachments

1. Figures of recent enrolment changes (updated to Feb 28 2019)
2. Potential Job description for new faculty member in the Department of Chemistry & Biochemistry
3. LOI for CRC Tier 2 Chair

4. Research themes for Department of Chemistry & Biochemistry
5. Recommended Time to Completion Timelines and course sequences for M Sc and Ph D graduate students in the Department of Chemistry & Biochemistry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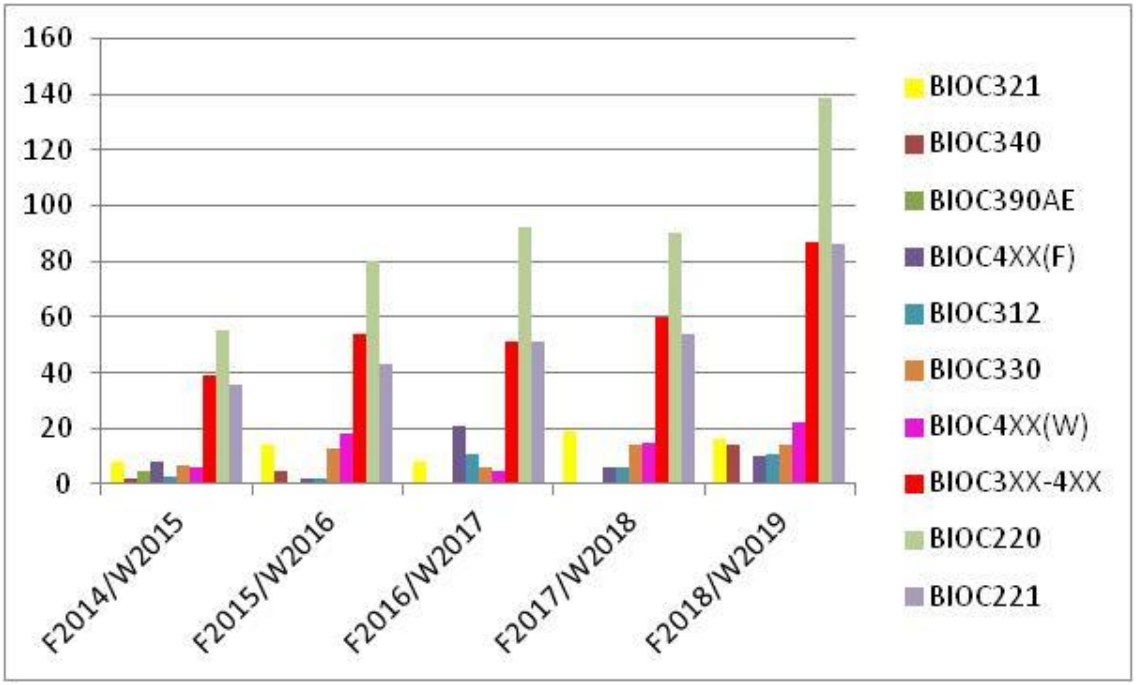
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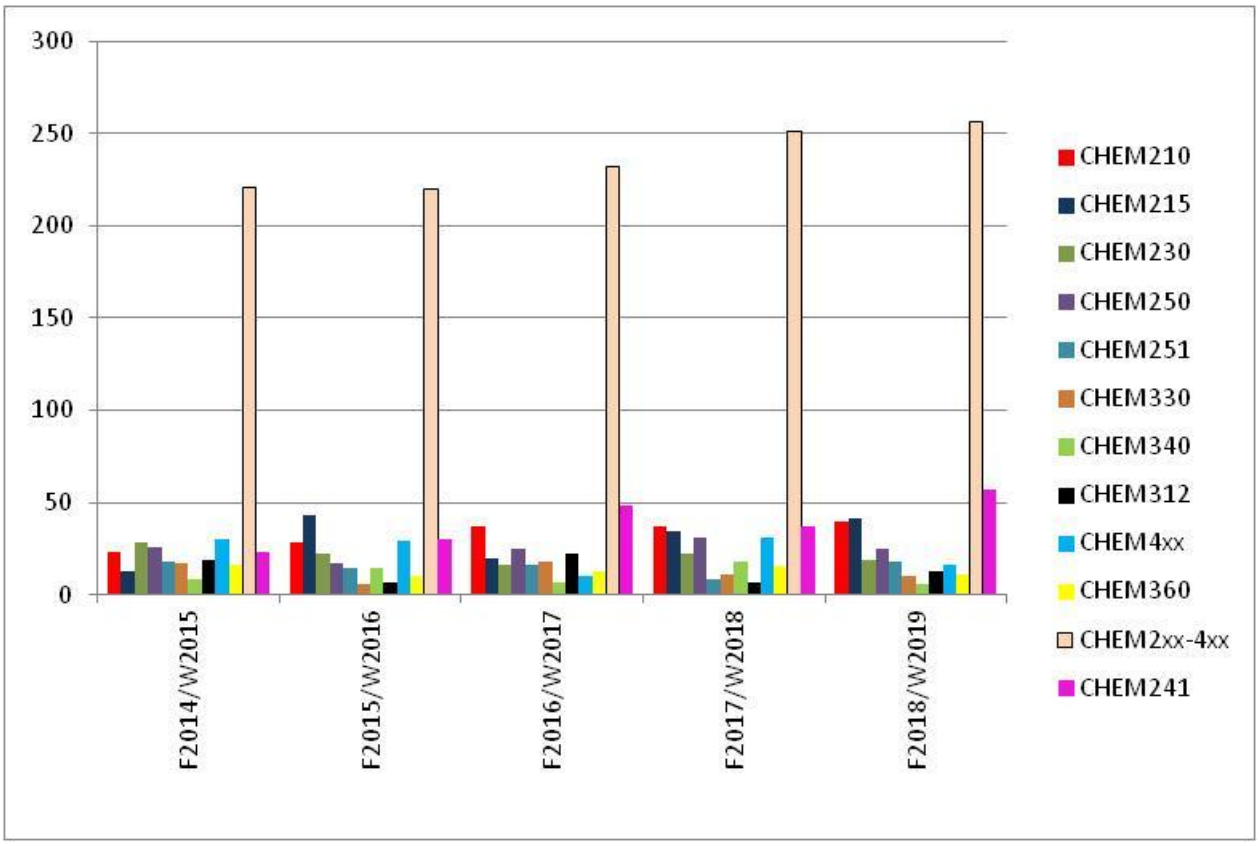

Updated 2/28/2019

Description of a New Faculty Line Position in Chemistry for the background to 2019/2020 budget submission (for further detail see Chemistry & Biochemistry budget request submission Nov 29 2018)

The Department of Chemistry & Biochemistry at the University of Regina invites applications from outstanding individuals for a tenure-track appointment at the Assistant Professor level, start date July 1, 2020. The successful applicant will have a Ph.D. in chemistry and postdoctoral experience along with a record of research excellence that is consistent with becoming internationally recognized in the future. The candidates will be expected to develop an independent research program suitable for graduate and undergraduate research that will be funded by Canadian agencies (i.e. NSERC, CIHR), and which may lead to industrial collaborations. Preference will be given to candidates with the pedagogic ability to teach chemistry including advanced classes in analytical, inorganic, organic, or physical chemistry.

Candidates with research programs in chemistry with NMR-centric themes are encouraged to apply. The candidate should be able to become a major user of the NMR facilities (currently 300 MHz NMR and 500 MHz NMR with ^{1}H-^{19}F/^{15}N-^{31}P 5 mm PFG Probe, ^{1}H{^{15}N-^{31}P} 5mm PFG Indirect Detect Probe; variable temperature) and be an advocate for proposal development for a new NMR. Candidates with research programs in novel NMR methods and applications that use NMR spectroscopic techniques are of interest including rationale design of functional molecules, spectroscopy method development, and computation characterization of chemical or biochemical significant systems. Application areas may include agriculture, environment, material science, medicine, and engineering.

In addition to the NMR facilities, other departmental facilities include the Cellular Impacts Facility, Data Centre: Dextrose and Entropy Supercomputers, Proteomics and Genomics Core Facility, and the Trace Analysis Facility. The Faculty of Science also houses a new Scanning Electron Microscopy (expected in 2019), and the Institute of Environmental Change & Society, and the Institute of Microbial Systems and Society.

Tier-II Canada Research Chair (CRC) in Chemogenomics and Host-Pathogen Interactions

1. Rationale for the research chair allocation:

a. Research strengths in the proposed field. The University of Regina (UofR) Strategic Research Plan identifies human health as a research priority. This strategic goal is implemented by the researchers in the *Integrated Human Health: Equity, Disease, and Prevention Research Cluster*. The proposed Tier-II CRC research program, in the CIHR research priority area, will support and strongly enhance the University's health research capability by building upon existing capacity within the Department of Chemistry and Biochemistry, with the ultimate goal of developing effective new therapeutic strategies to counter the rapidly emerging threat of the antibiotic-resistant 'superbug' strains. The greatest and most *urgent threat to* public *health is the* increasing prevalence of *antibiotic-resistant bacterial pathogens, which are* annually responsible for millions of deaths from infectious diseases, and costing health care systems billions of dollars annually (Source: Canadian Antimicrobial Resistance Surveillance System Report, 2016). In response, the development of new effective therapeutic approaches has been identified as a Provincial and National priority. However, the development of new antimicrobials remains slow in comparison to the continually evolving antibiotic-resistant microbes. Even when a drug is discontinued for years, removing antimicrobial drug pressure resistance does not disappear in the bacterial pathogenic population, suggesting that the bacteria have adapted with full fitness.

Anecdotally, a similar phenomenon happens within the human population; introduction of a new antibiotic regimen initially leads to the emergence of distinct drug-resistant lineages, however, these are eventually replaced by a dominant strain. This ongoing 'collecting' of resistance determinants has resulted in an absence of effective treatment options and the emergence of many 'superbugs', with 1 in 7 infections usually contracted in hospitals. The design of new, logical antimicrobial strategies against drug-resistant bacteria requires an understanding of: (1) the cellular mechanisms by which pathogens becomes resistant to antimicrobial drugs through host-pathogen interactions; (2) the evolution and spread of resistance; and (3) techniques for combating resistance. These areas will be the focus of the proposed CRC. One approach to mitigate antimicrobial resistance is the use of combination therapies, targeting two (or more) pathways at once to achieve a synergistic response, or finding antibiotics that are synergistic and more effective than a single antibiotic. Over the past decade, chemogenomics and chemical-genetic approaches have been developed to study pathogenic processes, and to identify target genes and pathways affected by libraries of small molecules. The mechanism of bioactive molecules and drugs, and the biochemical pathway pairs that are targeted concurrently for maximal clinical impact remain unclear. These tools will be applied by the CRC to develop strategies to combat antibiotic resistant pathogens and to identify drug synergies.

b. Potential of attracting a high-caliber candidate. The proposed CRC program represents exciting and critical research, ensuring that we will attract a promising young

researcher with an excellent track record in host-pathogen interactions, chemogenomics, informatics, and human-bacterial-pathogens interactions, capable of leading the UofR into a new research direction. This research field also has a high probability of recruiting national and international female candidates. For example, several female postdoctoral researchers from the Universities of Alberta, Saskatchewan, Toronto, and Madison, with strong publication records, have expressed an interest in joining the UofR during collaborative work-related visits to our department. Some of these candidates would be an ideal fit for the proposed CRC and our department. The CRC would teach biochemistry at the undergraduate and graduate levels, and provide graduate training in biochemistry, chemical biology, microbiology, and pharmacology. The Department of Chemistry and Biochemistry has seen a ~2.5-fold increase in enrolment in biochemistry over the last 5 years, and currently has the largest number of biochemistry majors since the inception of this program. With an upcoming retirement (expected within 2 years) there is an urgent need to increase the biochemistry faculty complement in the department to maintain strength in both teaching and research, and to bolster our ability to provide research experiences at the undergraduate level. The CRC chair would play a critical leadership role, by building teaching and research capacity, recruiting/training highly qualified personnel (HQP), and developing synergies with other departments (Biology, Computer Science) and health care practitioners (Regina Qu'Appelle Health Region (RQHR), Roy Romanow Provincial Laboratory (RRPL)).

2. Potential impact of CRC allocation:

a. Expanding, growing, and increasing research activity and impact. The CRC program will aim to develop chemogenomic-based strategies and new therapeutic options to treat drug resistant-bacterial infections. The strategy to achieve this goal will evolve as the program develops, while retaining flexibility to exploit new opportunities and identify new lines of inquiry, including innovation and exploration in critical areas of bacterial/chemical biology. The objectives include:

1. Identifying cognate host targets of bacterial effectors (i.e. proteins secreted by pathogenic bacteria) using chemical genomics;
2. Identifying bacterial pathways for synergistic targeting with new antibacterial combinations;
3. Screening existing bacterial antibiotics in combination with off-patent drugs to identify non-obvious synergizers that could be implemented into therapy in the short term;
4. Finding targets for antibiotic adjuvants through chemical genetic screening against gene knockout mutant libraries to identify genes that can be exploited in drug discovery projects for new combination therapies;
5. Determining collateral sensitivity (i.e. when one drug sensitizes the bacteria to the second drug), and collateral resistance (i.e. resistance to one drug confers resistance to the second drug); and
6. Developing experimental strategies to validate new target combinations of antimicrobials.

Notably, such CRC activities will have a positive impact by: (1) Identifying new drug targets that can be exploited to eliminate or suppress antibiotic resistance in bacterial pathogens, and translate into new therapies in the clinic; (2) Revealing a diversity of drug resistance mechanisms exploited by bacterial pathogens, and generate an unparalleled wealth of resources for the bacterial research and clinical community; and (3) Providing avenues for therapeutic intervention with the pharmaceutical industry.

b. Leverage additional resources. The CRC program would leverage resources by offering major health and economic benefits to Canada. It will seek to uncover new drug targets to aid the development of therapies for treating human infections caused by bacterial pathogens that are now showing resistance to a large fraction of existing antibiotics. Life-Science products have generated over $14 billion in revenue annually for Canadian businesses. This CRC would realize economic benefits by identifying a large number of putative new drug targets that interact either with proteins or drug targets already known to be associated with particular diseases. This unique CRC program is expected to considerably mitigate heath care costs while providing downstream commercialization opportunities that will benefit Canada's economic future, maintain Canada's leadership in antimicrobial research, provide the health care workers and policy makers with proficiency to capitalize on the benefits provided by the proposed cutting-edge technologies, and improve human health nationally and internationally. The proposed CRC program has the potential to generate over $10M in transformative and sustainable research funding in its first 10 years of operation based on real applications to health and agricultural communities in Saskatchewan and the rest of Canada. This estimated budget is very much achievable through CIHR or NIH grants like those received by one of our department members, who would be available to mentor a new faculty member. Similarly, the proposed CRC could take advantage of funding from various federal agencies (CIHR, Genome Canada, NSERC), provincial foundations (SHRF), and international (NIH) agencies. In fact, recently, the Canadian government and US congress have approved ~$500M (to CIHR) and $1.2B dollars (to NIAID) in funding, respectively, for multidisciplinary genomics approaches to study host-pathogen interactions in association with antibacterial resistance. As such, the UofR could benefit directly from this rapidly growing research area with the proposed CRC program. Short-term (< 5 years) benefits include high-quality publications, patents, and HQPs, while long-term (>5 years) benefits will have a sizable impact on the health and socio-economic status of Canadians. Most notably, it is expected to stimulate the Canadian economy, since chemogenomic and chemical-genetics have been broadly acknowledged nationally and internationally by industry and academia as drivers of innovation in this modern era of biomedicine.

c. Knowledge outreach activities (see below for interdisciplinary collaboration). The CRC will work within the UofR's strategic focus on public outreach activities to expedite further advances in biomedical and health-related sciences. Research results will be proactively disseminated to academia, the health system, and public partners such as the RQHR, Public Health Agency of Canada, Saskatchewan Public Health and Education Research, and the Indigenous Peoples Health Research Centre. Research findings will also be disseminated and translated, not only with health policy researchers

and traditional academic media (e.g., peer-reviewed publications), but also in non-academic outlets such as patents, commercial ventures, and industrial partnerships. The CRC will address this vital research need by working closely with high school students in the Regina area through the Let's Talk Science Program, explaining the utility of chemogenomics, the logic behind the emergence of antibiotic resistant strains, and treatment failures against the antibiotic resistance. Through our institutional initiatives, the CRC will provide community outreach programs to First Nations people, Inuit, and non-Aboriginal Canadians as they face serious health-related challenges, such as high rates of infectious diseases and shorter life expectancy. The proposed CRC will be committed to outreach, encouraging healthy lifestyles, and reducing disease incidence rates in the province and Canada.

d. Recruit and train highly qualified student researchers. Through their exposure to the proposed CRC's research, trainees will learn state-of-the-art concepts and techniques as well as principles underlying specialized technologies such as chemogenomics, chemical genetics, computational chemistry, and bioinformatics. The latter uses computational models and computer aided assessment of ligand-target interactions to develop new machine learning computational procedures to understand *gene*-drug and *drug*-environment *interactions*. The trainees will have hands-on experience identifying new targets, allowing them to test their clinical relevance through collaboration with RRPL (adjacent to UofR) and VIDO-INTERVAC (Vaccine and Infectious Disease Organization - International Vaccine Centre, Saskatoon). The CRC program would foster interdisciplinary training in biochemistry, chemical biology, host-pathogen interactions, and bioinformatics, providing opportunities for students in biochemistry, biology, chemistry, and computer science, while preparing trainees for careers in academia, health care, and the private sector. Identifying new targets for antimicrobial drug discovery is a top priority for many pharmaceutical companies, with a correspondingly high demand for HQP. There is an enormous potential to attract and train HQPs with this progressive research to support both the provincial and national goals.

3. Research environment and interdisciplinary collaboration:

a. Building critical mass and closing a knowledge gap in an existing high-impact research group. Recruiting researchers with strong records to the Department of Chemistry and Biochemistry, and Faculty of Science has led to continued high-level funding from national and international agencies to UofR. Placement of the CRC into this interdisciplinary environment will allow the Department and Faculty of Science to build critical mass in research and teaching, while filling a specialization gap and provincial/national needs to tackle the global threat of drug-resistance bacterial infections. The proposed CRC would also help fulfill our faculty complement in biochemistry to support the associated departmental teaching needs as we experience ever increasing biochemistry enrolment and face the upcoming retirement of a teaching-focused biochemistry faculty member. This first time CRC request from the department will be crucial to support core biochemistry classes, graduate and undergraduate programs, and to meet the growing enrolment pressures from within our department,

other faculties, and pre-professional programs. The CRC is also expected to fill a knowledge gap, by supporting interdisciplinary collaboration with Dr. Dahms, who is characterizing the impact of xenobiotics on bacteria, fungi, and mammalian cells using correlative microscopy; Dr. Suh, who investigates the mechanistic role of biosynthetic enzymes in plants using biochemistry and molecular tools; and Dr. Babu, who studies protein assemblies in microbial and human diseases using proteomics. The CRC will also complement current strengths of the Faculty of Science by generating opportunities for collaborative research with other members in the Departments of Chemistry and Biochemistry (Sterenberg and Wee in synthetic chemistry, Murphy in drug delivery, and East in computational chemistry), Computer Science (e.g. Zilles and Sadaoui in machine learning, Butz in Bayesian network and deep learning, and Hilderman and Yao in data mining), and Biology (Yost in identifying new bacterial pathogenic mechanisms, Stavrinides in evolutionary biology, and Cameron in understanding gene expression in clinically-relevant pathogenic bacteria).

b. CRC complementing the research environment within the academic/research unit. A continuously expanding "University Research Park" and state-of-the-art research and innovation centre (RIC) will provide a dynamic environment for the CRC to develop novel applications, interdisciplinary research collaborations, and multi-sector partnerships. The requested CRC will be housed in the RIC building and will have access to substantial wet laboratory facilities and existing advanced NSERC-RTI and CFI-funded instrumentation (~$4M in total) to initiate the program. The CRC will also be able to utilize the Engineering/Science jointly operated 500 MHz nuclear magnetic resonance (NMR) spectrometer for structural studies on ligand-protein interactions, and support a proposal for new NMR facilities needed by the department. The existing infrastructure will allow the CRC to start their program immediately, without losing any research time, and additional equipment, if needed by the CRC, can be acquired through the 40% earmarked CFI-JELF ($75,000) fund allocation to CRCs. The remaining project costs will be obtained from Innovation Saskatchewan (40%), and other sources such as vendor discounts or the Faculty of Science (20%). Thus, housing this CRC in Chemistry and Biochemistry will take advantage of existing and future cutting-edge facilities, and will provide long-term sustainability, networks of research collaborations, and opportunities for team applications for federal and provincial funding.

4. Strategic research plan:

a. Impact on the research profile of the unit and UofR, and fit with the University's strategic research plan. The UofR strategic plan identified sustainability as an overarching theme. This CRC program will directly align both environment sustainability and the sustainability of our healthcare system. Firstly, antibiotic resistance develops in the environment as a result of sewage effluent and pharmaceutical waste, from manufacture and human use, posing a serious environmental risk. Secondly, increasing antibiotic resistance poses a serious threat to our healthcare system. In just one year in Canada, for example, methicillin-resistant *Staphylococcus aureus* alone was estimated to have cost the country's health care system $200-250 million. As antibiotic resistance grows, infection will become more and more difficult to treat, threatening our ability to

carry out surgical and other procedures. If we do not tackle antibiotic-resistance infections, 10 million people every year globally are expected to die by 2050, which is more than current cancer-related morbidity (Antimicrobial Resistance by Jim O'Neill, 2014). The science generated by the CRC will contribute solutions to this threat. Therefore, the requested CRC will be a key pillar for UofR's human health priority area as it aligns well with the *Integrated Human Health: Equity, Disease, and Prevention Research Cluster*. The proposed CRC will be further supported by strong research ties between the UofR Chemistry/Biochemistry, Biology and Computer Science departments, and between the UofR and the UofS (see below); as well the strategic priorities of the province/federal governments that focus on public health, prevention, and treatment of infectious diseases and antimicrobial resistance.

b. Positioning UofR in the Saskatchewan/Canadian context. Part of the UofR's research mission is to attract, retain, and develop outstanding research faculty and trainees to conduct innovative research, using their exceptional talents and discoveries to understand and resolve present and future challenges to public health. The proposed CRC program is well aligned with those goals. Based on future collaborations and complementary expertise, the proposed CRC would position UofR nationally and internationally and strengthen several high priority health areas, contributing to the maintenance of Saskatchewan's and Canada's strategic positioning in biomedical research in human health and disease. Notably, the Faculty of Science has promoted strong research ties between health research groups and government agencies focusing on public health and microbial threats, such as the RRPL and RQHR, to explore basic scientific discoveries and their clinical applications. The proximity of this CRC to the UofR Research Park will strengthen ties between the UofR researchers and health scientists at RRPL, allowing for joint lab meetings and co-supervision of undergraduate and graduate students. Formal research partnerships could be initiated between this CRC and the University of Saskatchewan's (UofS) College of Medicine, UofS PRISM (Proteomics Research in Interactions and Structure of Macromolecules), Protein Characterization and Crystallization Facility, and the Molecular Design Research Group. All of these research clusters take full advantage of the Canadian Light Source and the Saskatchewan Structural Sciences Centre to focus on protein structure and function and molecular mechanisms of therapeutic development. Health related research at the UofS College of Pharmacy and the Fedoruk Centre (e.g. assessing microbes in soil using nuclear imaging) provide opportunities for collaboration. By building synergies with UofS, the CRC would strengthen provincial goals and attract additional provincial funding.

The CRC will have access to RRPL and RQHR**,** which houses a vast repository of clinically-relevant bacterial pathogens, and tremendous research resources such as blood samples, and diagnostic equipment, which will facilitate expanding the research program. Dr. J.R. Dillon (UofS), collaborator of several department members, is associated with the World Health Organization initiative for combating antimicrobial resistance; the data pertaining to the new discoveries can be transferred effectively through this vital global connection. Any potential drug targets identified from this program can be evaluated for clinical development by partnering with biotechnology institutes such as VIDO-INTERVAC, and pharmaceutical companies such as Cangene

(Winnipeg) and Roche (Switzerland) that has vast impact on the global market. Collectively, these resources will further the research work of CRC, and initiate collaborations at SDCL, RQHR, VIDO-INTERVAC, UofS, and industry partnerships.

At the provincial and national level, the CRC will participate in the Canadian Integrated Program for Antimicrobial Resistance Surveillance network, which connects scientists from across Canada, with the goal of uncovering critical *host targets and* new antimicrobial targets. The CRC is expected to make connections to a group of internationally recognized researchers with complementary strengths from Canadian institutions (e.g. Eric Brown and Gerry Wright from McMaster) who focus their research on clinically-relevant, cutting-edge technologies to promote Canada's continuing leadership in antimicrobial research.

5. Plan for faculty line and resources:

a. Address equity with the four designated groups. While the CRC is open to both genders and based primarily upon scientific excellence, advocates for equitable hiring practices in Canadian higher education have introduced new guidelines to curb the bias against woman in the CRC nomination process (Source: University Affairs). UofR is committed to achieving a representative workforce and this proposed research field attracts a relatively high proportion of national and international female researchers, providing an opportunity to attract highly qualified candidates within the designated equity groups.

b. CRC's position and budgeted faculty line at the conclusion of the term. At the end of the CRC term, the proposed CRC will assume the position of an existing biochemist, who will be retiring. Therefore, this position is a necessity for delivery of our biochemistry program.

c. Commitment to support the CRC's research program. In addition to the support provided by the Department to the proposed CRC through shared equipment, student teaching assistantships, and department top-up awards, the Faculty of Science would guarantee the CRC standard start-up funds; laboratory space in RIC, requiring only minor renovations; and protect 75% of their time for research, with a reduced teaching load as per the CRC guidelines.

In summary, this CRC will create a critical mass of biochemistry researchers, transform the UofR into a centre of excellence for chemogenomics, chemical-genetics, and host-pathogen interactions, and will deliver therapies and diagnostic tools for diseases that threaten human health. In doing so, the proposed CRC will support a primary goal of the UofR's strategic plan.

Submitted Jan 14 2019

Research Themes for the Department of Chemistry & Biochemistry

The Chemistry and Biochemistry department has several areas of strong research focus including

Rational design of functional molecules for applications in health, medicine, agriculture, and material science and engineering.

Biochemical health research, in particular drug target discovery using proteomics and advanced microscopy. In future, we will recruit faculty who are addressing similar health questions using chemogenomics, allowing us to build a cohesive research environment that will bridge biochemistry, biology and chemistry.

Environmental chemistry and biochemistry research focuses on the application of analytical and biophysical methods to identify and evaluate contaminants, including endocrine disrupting chemicals, pesticides, and other chemicals, in food, environmental matrices, microbes and human cells. This research provides insight into the means by which these compounds are transported and transformed in the environment, and the mechanisms by which they cause cellular dysfunction.

Science education research applies and assesses interdisciplinary approach to develop and implement curricula, programs and online resources to engage and empower students at all levels.

Updated Aug 20 2019

Recommended Schedule for PhD and MSc Degrees **Effective starting Fall 2019**

PhD:

Date	Student	Committee	FGSR
1st year	BIOC/CHEM 8xx BIOC/CHEM 8xx		
End of 1st year	research proposal due	Committee meeting 1	FGSR progress report submitted by supervisor
2nd year	BIOC/CHEM 800 Department Seminar 1		
End of 2nd year	Progress Report 1 due	Committee meeting 2	FGSR progress report submitted by supervisor
3rd year	BIOC/CHEM 801		
End of 3rd year			FGSR progress report submitted by supervisor
4th year	Department Seminar 2 Progress Report 2 due	Committee meeting 3. Approval to write thesis	
End of 4th year	Submit thesis. Defense	Thesis approval. Defense	Thesis approval. Defense

Note: Students not prepared for Progress Report 2 during the 4th year of their PhD must apply to the Department of Chemistry and Biochemistry Head for a deferral. The length of the deferral will be determined by the Head in consultation with supervisor and student.

MSc:

Date	Student	Committee	FGSR
1st year	BIOC/CHEM 8xx BIOC/CHEM 8xx		
End of 1st year	progress report 1 due (application for transfer to PhD if applicable)	Committee meeting 1. (approve transfer to PhD if applicable)	
2nd year	BIOC/CHEM 800 Progress Report 2 Department Seminar	Committee meeting 2. Approval to write thesis	
End of 2nd year	Submit thesis. Defense	Thesis approval. Defense	Thesis approval. Defense