FOR INFORMATION S.90-32

SIMON FRASER UNIVERSITY

MEMORANDUM

TO: Senate

FROM: Liora Salter
Acting Vice-President
Academic

SUBJECT: External Review

DATE: April 26, 1990

The Senate Committee on Academic Planning, at its February meeting this year, approved a motion accepting the external review report of the Department of Chemistry, together with responses from the Department and the Dean of Science. These materials are attached for the information of Senate.

SIMON FRASER UNIVERSITY
MEMORANDUM

To: Prof. L. Salter, Acting
V.P. Academic

From: C.H.W. Jones, Dean
Faculty of Science

Subject: **External Review of Chemistry**

Date: January 30, 1990

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Please find attached the External Review Report of the Department of Chemistry and the Department's response which is incorporated into a document entitled: The Department of Chemistry Five Year Plan, 1989-1993.

The Department has responded in a direct and positive way to many of the recommendations made in the report. I would like to make the following comments about the report and its recommendations.

1. The Review Process
   The review of the Chemistry Department was conducted with only one external reviewer, together with two internal reviewers, one from the Department and one from outside. The reason for the unusual nature of this committee composition arose from the fact that the Department was not enthusiastic about having a review in 1987-88 because an external review of Biochemistry had been held as recently as 1986. As a result, the Vice President, Academic proposed a mini-review with one external reviewer. In retrospect, this was not the best course to have taken and this point was commented on by the external reviewer himself.

   Nevertheless, a wide range of constructive and important recommendations were made in the report and the Department has responded positively with its five year plan.

2. Undergraduate Programmes
   i) The Department has restructured its lower level courses and has introduced Organic Chemistry into the second semester of the first year. This restructuring and the renumbering of the courses was approved by Senate in November 1989.

   ii) Steps have been taken to address the concerns about the poor fumehood facilities in the Organic Chemistry teaching laboratory. A new, modern, well-equipped organic chemistry laboratory is included in the plans for the new IMBB building. In the interim, the fumehoods in the existing laboratory have been made more accessible to students. Moreover, many experiments have been scaled-down and are now conducted on a micro-scale so as to reduce the need for extensive ventilation.

3. Graduate Programmes
   The Department has redefined the M.Sc. and Ph.D. degree course requirements and has introduced a number of new courses including a student and research seminar course for both the M.Sc. and Ph.D. degrees. These were approved by Senate in January 1990.

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4. Research

The external reviewer provided a very critical analysis of the research strengths of the Department. In so doing the reviewer, who had acknowledged his own concerns about assessing the areas of physical chemistry and nuclear chemistry for example, did not give, in my view, appropriate weight to the interdisciplinary nature of the department. While it is true that the NSERC research support from the Chemistry Grant Selection Committee is below the national average on a per faculty member basis, the Department has distinct strengths in Biochemistry and in Nuclear Science. As we move through the 1990's the traditional boundaries between the science disciplines and their subdisciplines will become less marked and indeed less significant. Many of the new, forefront areas of research are very interdisciplinary in nature and departments which have strong interdisciplinary programmes will be well-positioned to develop in those areas.

Moreover, since the time of the report external research support to the Department has increased significantly, placing the external reviewer's assessment in a somewhat different light.

Nevertheless, the external reviewer's comments about the value of adding high-profile senior appointments to the Department have been recognized as valid. The vacant biochemistry position referred to in the report will be filled by a senior (Professor) appointee and a retirement vacancy in the Department has been authorized to be filled by a senior Organic Chemist.

There are many other recommendations in the report which are of value and which are deserving of consideration. Many are addressed directly or indirectly in the Department's Five Year Plan and that document should be consulted for further information.

C.H.W. Jones

C.H.W. Jones

CHWJ:rh:Encl.

c.c. A.C. Oehlschlager, Chair
Department of Chemistry

REVIEW OF THE DEPARTMENT OF CHEMISTRY

SIMON FRASER UNIVERSITY

APRIL 1988

T. Durst
Department of Chemistry
University of Ottawa

R. Morrison
Department of Physics
Simon Fraser University

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Department of Chemistry
Simon Fraser University

REVIEW OF THE DEPARTMENT OF CHEMISTRY

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Executive Summary

As a prelude to the development of plans for improvement of undergraduate and graduate programs, resource planning and faculty renewal the Department of Chemistry held an internal review in the Spring of 1987. The Mission Statement developed at that time provided documentation for an external/internal review held in the Spring of 1988 which is the subject of this report. A five year plan for Departmental development will be prepared in the Summer of 1988 based on these two reviews.

The present reviewers are of the opinion that the undergraduate programs in chemistry and biochemistry produce graduates of very high quality. Courses are offered at levels comparable to other Canadian universities. Only a few areas of course material overlap/gaps were identified. It was recommended that course content be reviewed and rationalized on a regular basis. Faculty teaching quality at the undergraduate level is good to excellent on a departmental wide basis and the department is commended for its ongoing assessment of faculty teaching quality.

It is suggested by the review committee that the Chemistry Department discuss internally the resequencing of its first two years of general and organic chemistry to offer organic chemistry to the freshman class in the second half of the first year. This change from current practice of offering organic chemistry in the first half of the second year has been implemented with favorable results at the institution of the the external reviewer.

A strength of the undergraduate program as seen by the faculty is the intimate contact between student and professor allowed by the tutorial system. The chemistry faculty are committed to the tutorial system even though it's demands on faculty time are high. The review committee recommends that the department review its goals for the tutorial system and streamline where possible.

The department offers its first two years and some upper division courses on a year around basis in support of the COOP program. It is commended for its participation in this obviously successful program as well as its active involvement in community relations work in the high schools.

Undergraduate teaching laboratories are under stress due to increasing enrollments in the recent past. Laboratory instructors are clearly overburdened. Methods to streamline some of the teaching functions carried out by these individuals are suggested. The upgrading of equipment in undergraduate teaching laboratories begun in 1987 should be continued. Particular attention should be given to upgrading the equipment central to the advanced physical and analytical chemistry laboratories.

The most significant requirement for chemistry in terms of resource allocation is the upgrading of the ventilation in its undergraduate organic laboratories. The external reviewer took the view that the standards used for installation of the ventilation in these laboratories predated the construction of the university.

While the final level of achievement of the postgraduate students in the

department is comparable to that at other Canadian institutions, there was a perception that course and cumulative examination requirements for M.Sc. students are excessive. The review committee suggests that the department survey M.Sc. requirements at other institutions and revise its requirements downward if this perception is borne out. Several suggestions are offered as to how this might be carried out. The course and cumulative examination standards for the Ph.D. degree are comparable to those of other Canadian universities.

Attraction of excellent graduate students is a problem besetting almost all Canadian chemistry departments. Success in this area was seen to require two elements both of which can be addressed by future planning. The first and most easily addressable element is that of financial support for incoming graduate students. In the Canadian environment the competition for graduate students in chemistry is keen and the stipends offered by SFU are seen to be on the low side of the national average. The Department is encouraged to approach the administration for assistance in this area. As well, the Department should be creative in finding ways to offer competitive stipends.

The second, and most dominant element, acting to attract excellent graduate students to a university chemistry department is that of the excellence and visibility of the research of its faculty. The external reviewer took sole responsibility for evaluation of the Department in this area. He pointed out that it is generally recognized that the Department has a unique connection with TRIUMF and suggests that these ties be strengthened by the appointment of appropriate TRIUMF scientists as Adjunct Professors.

The Department is also different from most traditional chemistry departments in that its research and teaching activities include biochemistry. The biochemistry group is seen as a small but highly active group in teaching and research. The group is having difficulties mounting its course offerings, a situation that will be made worse by the departure of one of its members. A replacement appointment of an associate or young full professor should be the top priority of the Department. Additional staff in the area of biochemistry should be added through the IMBB initiative. These should be in addition to positions targeted by the Department for biochemistry. It is recognized that biochemistry is a "hot" area and that mid-level appointments will be expensive.

The organic group is also quite small but has high visibility due to the pheromone research group and the physical organic chemists. The teaching requirements in this area are significant and this group has 40% of the graduate students in the Department. The external reviewer concludes that the appointment of an associate or young full professor of star quality (~$70K, NSERC, top 10%) to this group and the reasonable progress of existing members could reasonably yield an excellent graduate program in organic/bioorganic chemistry.

The inorganic group is a solid, active group with good prospects for increased grant support and a NSERC-URF with excellent potential on board.

The physical chemistry group is the largest from a faculty point of view but the least active in research. This group carries most of the teaching responsibility for the freshman courses. Because of the undergraduate and graduate teaching requirements in biochemistry and organic chemistry revitalization of the physical chemistry group from a research point of view may not be feasible at this time. One of the most popular areas from an undergraduate and graduate point of view has been polymer chemistry. The projected retirement of a senior

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faculty member should provide an opportunity for a new faculty member with expertise in this area.

Teaching and research is also conducted in theoretical chemistry and there is stability in this area.

There is no research in analytical chemistry. It is recommended that the Department be innovative in its approach to the acquisition of a staff member knowledgeable in this area. One option is to combine requirements in biochemistry with those in analytical chemistry by an appointment of a faculty member with research interests in biosensors.

The case is made by the external reviewer for the appointment of one or more faculty of star quality (≥$70K, NSERC). The benefits seen to accrue from this course of action are: a) immediate visibility in the chemical community; b) increased ability to attract the best young faculty in what is expected to be a very competitive next decade; c) increased ability to attract funding for big ticket capital equipment which should also be of use to younger faculty; and d) increased ability to attract the very best graduate students.

PREFACE

Personal Comment of External Reviewer:

After the initial contact was made the external reviewer discovered that he was the only reviewer not connected with SFU. The external reviewer expressed the opinion that a committee made up of two or more external reviewers whould produce a report with fewer shortcoming and possibly less bias. The external reviewer feels confident in assessing organic chemistry and some aspects of biochemistry and organometallic chemistry. He feels much less confident in assessment of physical, theoretical and nuclear chemistry and thus feels he may have missed pointing out important opportunities, possible shortcomings, etc., in these areas. The university administration and the chemistry department should be fully cognizant of this. This comment is not a criticism of other committee members, Drs. Morrison and Oehlschlager. Since they were dealing with their own departments and colleagues they could not be expected to be in as good a position to make comparisons. Their presence was, however, valuable in explaining in detail all aspects of the SFU operation, and they provided substantial input into the Review. The external reviewer strongly recommends that future assessment committees contain two or more reviewers not associated with SFU.

INTRODUCTION

The review committee had access to much analytical information in addition to the 1987 Departmental Mission statement. The committee was able to interview faculty, laboratory instructors, undergraduate and graduate students during a two day period.

The review committee would like to thank all those who participated. It was very favorably impressed with the frank and open discussions of affairs of the department and the significant effort that had gone into the preparation of the supporting documentation for the review.

UNDERGRADUATE PROGRAM

Quality

The department made the case that the undergraduate program at SFU is of good to excellent quality, certainly comparable to that of other chemistry departments in Canada. Data to support this contention such as the breadth of the course offerings and student performance as measured by the MCAT scores in chemistry of SFU undergraduates and performance of SFU chemistry graduates in the graduate programs of other universities are presented in the 1987 Departmental Review. The interviews with the undergraduates indicated that the students feel they are getting a good education in chemistry. The external reviewer was able to peruse a number of upper level organic chemistry examinations and he feels that the level is comparable to those at the University of Ottawa and most likely other Ontario universities. It is assumed that the same comments could be made of the other sub-disciplines.

Structure

Tri-semester Operation

The committee noted that SFU operates on a tri-semester basis and that the chemistry department offers most of its first and second year and a few third year courses in each semester. The faculty and students are in agreement with and strongly supported the frequency of current offerings.

Tutorial System

The committee noted that SFU operates a tutorial system. The ramifications of the operation of this system are felt most heavily in the first two years of the program where large lecture course enrollments are subdivided into smaller (20-30 students) tutorials each met by a professor or teaching assistant. Each fall or spring semester this generates 30-40 (37 in 1987-3) tutorial session contact hours each week. Since the corresponding lecture components of the first and second year courses typically involve 20-30 (27 in 1987-3) lecture contact hours, the tutorial system more that doubles the time commitment by the

department. The faculty interviewed recognize the significant investment in human energy in the tutorial system and were enthusiastic about it. Generally the faculty felt that the tutorials offered a chance for students to be coached in problem solving, to be challenged and become more conversant with the discipline.

In view of the high human resource commitment involved in the tutorial system the review committee make the following recommendation.

Recommendation: *The Chemistry Department should examine the tutorial system, especially as executed in the first two years, to define the purpose of the tutorials. The department should evaluate the methods used in the tutorials to ensure the goals are likely to be achieved. Finally, the department should convince itself that the pedagogical goals defined for the tutorial system are worth the human resource effort put into this method of instruction. If it is no longer certain that this is the best way to utilize its professorial resources, the other approaches, such as marked problem sets, might be considered.*

Recommendation: *The scheduling of tutorials in upper level courses where enrollment is less than 20 students could be formally discontinued. At this level students should be encouraged to work on their own and to seek individual help from professors, if necessary.*

The Co-Op Program

It was clearly pointed out in the 1987 mission statement that the department and the faculty are pleased with the Co-Op Program. The response of the students who met with the review committee was also highly positive. The present frequency of course offerings was seen as necessary to adequately support the significant involvement of the department in Co-Op. The Co-Op coordinators interviewed by the committee commented that chemistry has been a most cooperative department in mounting summer courses at the upper division and expressed the hope that this practice would continue.

The review committee supports this initiative and offers the following

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recommendation for a possible further improvement in the quality of the program.

Recommendation: *The department should continue its commitment to offer high quality undergraduate courses in the summer semester in order to best serve the students in the Co-Op program.*

STUDENT EVALUATION OF COURSES

The department is to be commended for the practice of course evaluation. The currently available evaluations indicate that the quality of teaching within the department is generally good to excellent. The opinion was reinforced in discussions with undergraduate students. The current practice of having a student in each class designated to convey the evaluation results to the chairman's secretary and the maintaining of confidentiality until after the grades are issued is a good one.

Recommendation: *In the few instances where faculty receive a student course evaluation much below the departmental average the chairman should encourage the faculty members to address the criticisms made by the students.*

LECTURE COURSE DEFICIENCIES

The students indicated that there were instances of overlap and repetition in various courses. They expressed the feeling that professors were often not aware of the overlap and, in some instances, only very broadly aware of what was being taught in prerequisite and co-requisite courses. This is not an uncommon situation in most departments. It can be easily addressed and remedied if the department carries out course reviews from time to time.

Recommendation: *The department should review its undergraduate course contents with the view of identifying and rationalizing, if necessary, overlaps and omissions in these courses.*

POSSIBLE REARRANGEMENTS OF FIRST AND SECOND YEAR

A modified approach (shown below) to teaching general and organic chemistry has been implemented in the external reviewer's institution. It involved earlier

exposure to the concepts of organic chemistry as well as the structures and properties of biologically important molecules. This approach is considered by biologists at the University of Ottawa to be useful and beneficial to their students. A second year descriptive inorganic chemistry course has become a strongly recommended option for biologists at Ottawa.

Organic chemistry is taught in the first year at many American universities. The external reviewer is aware that a number of chemistry departments in Ontario (Ottawa, Waterloo, McMaster) have rearranged the traditional sequence to the modified sequence described above. It is also the committee's understanding that the first year chemistry course at UBC has an organic chemistry component approximating nearly 50%. This indicates that British Columbia students are as capable as Ontario students in following the modified approach.

The modified approach does not decrease the amount of time available for chemistry in the first two years, it merely rearranges it.

The external reviewer is convinced that the approach is pedagogically sound and feasible. After a term of general principles the students are quite capable of completing successfully a term of organic chemistry. Some of the "basic" material that might have been missed by those not taking the second term of general chemistry such as bonding and hybridization can easily be taught in and in fact is usually taught as part of organic chemistry.

The relative merits of the traditional and modified approaches continue to be argued in many universities. The proponents of the traditional approach claim it is necessary to spend the two terms on general chemistry in order to bring students with various levels of background to a common solid level from which the upper level courses can properly be taught. The experience of the external reviewer is that one of the oft-heard complaints of the general chemistry course, especially from students with good backgrounds in high school chemistry, is that they are introduced to very few new concepts. The course is boring and their interest in chemistry decreases.

The advantage of the modified approach is that a new area of chemistry is introduced. This area is of interest to a broad range of students, especially those in the biological sciences. If taught well it is likely to increase student interest in chemistry or biochemistry and could result in a substantial increase in the number of chemistry/biochemistry majors in the department.

Recommendation: *The following is proposed to the chemistry department for discussion of a potential reorganization of the teaching of its first year general and second year organic program.*

The review committee feels that the modified approach has considerable merit. Even though it has not had sufficient time to consider all of the ramifications to the SFU chemistry department and science faculty it recommends a serious evaluation of the modified approach or a variation thereof.

Present (traditional) sequence:

Year	Term 1	Term 2
1	General Chemistry	General Chemistry
2	Organic Chemistry I	Organic Chemistry II

New (modified) sequence:

Year	Term 1	Term 2
1	General Chemistry (Chemical Principles)	Organic Chemistry I
2	Organic Chemistry II	Descriptive Inorganic Chemistry

Students in chemistry (biochemistry) and biology would follow the modified sequence outlined above. Those students who normally do not take organic chemistry (physics, mathematics, engineering, earth sciences) would be allowed to take Descriptive Inorganic Chemistry in the second term of their first year and be joined by the 2nd year chemistry and biochemistry majors.

UPPER DIVISION COURSES

The review committee received presentations from each subdiscipline on their projected course offerings. By virtue of his previous experience the external

reviewer felt competent to assess only the submission presented by the organic group. (See personal comment above.)

As presently constituted, the organic chemistry offering allows students to take two terms of organic chemistry in the 2nd year, a third year course mainly dedicated to spectroscopic identification of organic compounds followed by fourth year electives. The organic faculty expressed the view that students reaching the fourth level had lost touch with the organic chemistry taken earlier and have proposed a 300 level organic chemistry course become part of the core chemistry and biochemistry program.

Recommendation: *The external reviewer is in support of the proposal to add a 300 level organic chemistry lecture course to the core of the chemistry and biochemistry program.*

Recommendation: *In view of the importance and the increasing use of spectroscopic methods, especially NMR, in all aspects of chemistry, biochemistry and biology, a course emphasizing the application of spectroscopic methods to these fields in the core program is recommended.*

LABORATORY COURSES

Laboratory Instructors and Instruction:

The laboratory instructors pointed out that there were extremely high demands on their time and it was recognized by the committee that this was true. Mechanisms to reduce the workload on laboratory instructors are advisable. Time to develop new laboratory experiments is practically non-existent since laboratory instructors are responsible for instruction during all three semesters.

Recommendation: *Laboratory instructors should consider replacing the weekly laboratory quizzes by an end of term exam or less frequent common quiz schedule. Laboratory instructors and professors instructing in counterpart lecture courses should consider the option of alloting time each week to the lab lecture in a regularly scheduled lecture.*

In this case the lab lecture would be given once instead of six or so times and the laboratory experiment could more easily be related to lecture course material.

The committee noted that in general all laboratories taught in a sub-discipline were taught and overseen by a specific laboratory instructor. It believes that this is not ideal from a pedagodic point of view - no more so than if all instruction in organic or physical chemistry were given by a single, however dedicated, professor. In order that laboratory experiments reflect changes or new approaches in the counterpart lecture courses and to help ensure that they reflect the rich variety of each subdiscipline we make the following recommendations.

Recommendation: *In general the faculty should take a strong interest in the development of the laboratories.*

This is particularly important in the biochemistry laboratories where the same lab instructor is responsible for all of the four biochemistry laboratories.

The undergraduate students pointed out that some of the foreign graduate students who serve as teaching assistants have poor English language skills and thus have difficulty in understanding questions and/or giving useful answers. It is recognized that these students need the financial assistance provided by a teaching assistantship. It is also important that undergraduates receive good instruction.

Recommendation: *The department should make efforts to use foreign students with poor English language skills in duties other than laboratory instructors, e.g., grading.*

It is recognized by all concerned that the quality of the laboratory instruction by the graduate student teaching assistants contributes significantly to the excellence of the undergraduate program. The teaching assistants therefore should be given access to the student evaluation forms in order to profit from the comments and improve their teaching skills. True excellence

should be rewarded and fostered.

Recommendation: *The department should consider recognizing excellence among teaching assistants by awarding three or four awards valued at $100 or more for teaching excellence in each calendar year.*

DEFICIENCIES

Analytical Chemistry

The basic analytical laboratories should be upgraded to include instrumentation techniques currently used in industry and the health field. It is the feeling of the committee that much of the current Chem 218 deals with classical analytical chemistry. One mechanism of determining possible experiments is to interview returning senior Co-Op students. Students in Co-Op streams expressed the view that the analytical laboratory offering should be upgraded. The department should not be satisfied by the statement that "our analytical course is as good as another university's". It should strive to lead in this area, especially in view of the Co-Op program. A second analytical laboratory course should be mounted and devoted to advanced instrumental techniques. The committee understands this (Chem 318) is under active development by the department. Consideration should be given to the inclusion of important nuclear science techniques such as X-ray fluorescence into this course.

Recommendation: *The department should review its analytical chemistry laboratory courses in light of the above suggestion. New equipment should be acquired (if necessary) so that these courses reflect modern techniques used in industry and in the health fields.*

The external reviewer notes that the room devoted to the organic chemistry laboratory was constructed to standards that predate the university. The fumehoods are placed in an area that makes them practically inaccessible to students. Furthermore, many of them are being used for storage space and thus not available for experiments. This has led to the selection of experiments that, while adequate, are restricted in scope because of the inadequacy of the

ventilation in this room. The external reviewer toured other available undergraduate laboratories and found no other room contained appreciably better ventilation facilities. The present situation in the organic laboratory with respect to the ventilation must not be tolerated.

Recommendation: *Efforts should be made to install hoods over each of the student work stations if at all feasible. Available fumehoods should be utilized as much as possible for student experiments rather than as chemical storage areas.*

EQUIPMENT FOR UNDERGRADUATE LABORATORIES

The Department Mission statement contained several Tables listing obsolete equipment. During 1987 the department began to replace this equipment but the replacement is not complete. Obsolete equipment was most noticeable in the laboratories devoted to physical and instrumental analytical chemistry.

Recommendation: *The commitment to the upgrading of obsolete equipment and introduction of modern instrumentation initiated in 1987 MUST be maintained.*

LIBRARY FACILITIES

The library at SFU has suffered from the same financial and space problems as other university libraries and has cut the number of journal and book purchases. The cost ($7.50/article) and the lengthy delays experienced in getting photocopies of papers from the UBC library was noted. It is recommended that the SFU librarian be asked to negotiate better and less expensive access to the UBC library for all SFU researchers.

COMMUNITY SERVICE

The committee met with several faculty who described the department's efforts to make SFU more visible to the general public, Grade 11 and 12 high school students. The initiatives described seem appropriate, are important, and should be continued.

Suggestion: The committee offers the following suggestion for attracting more scholarship quality high school students to SFU. A very successful University of Western Ontario practice guarantees Ontario scholars space in the university

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scholarship quality high school students to SFU. A very successful University of Western Ontario practice guarantees Ontario scholars space in the university residence. This practice raises the stature of the university residences in the eyes of both good students and their parents. Adoption of a similar practice may make SFU more attractive than other universities (UBC for example) to scholastically superior students.

GRADUATE PROGRAM

The M.Sc. Degree

Data compiled over the last three years indicates that the average time to complete an M.Sc. in Chemistry is slightly over 3 years. While this is not as long as the university average the committee feels that three years is excessive for M.Sc. completion (1980-1987 Ottawa-Carleton Institute average M.Sc. = 2.3 years, probably still too long). It was noted that the course and cumulative requirements for the M.Sc. are significantly heavier than those at many other universities. Representations from faculty involved in graduate student supervision as well as graduate students also pointed to excessive course and cumulative requirements as a major contributing factor for lengthy completion times for the M.Sc. In many cases students do not begin their research until eight months after commencement of M.Sc. studies. There was considerable divergence of opinion as to the amount of research required of M.Sc. students. If the department is serious about reducing the average time required for the M.Sc. to approximately two years, then both of the above issues must be addressed. The outside world is unlikely to consider that an M.Sc. from SFU is better than one from Ottawa or Carleton. It is therefore unfair for SFU to ask its chemistry students to spend 25% longer in order to receive this degree unless SFU maintains that its entering students are not comparable to those entering other programs and thus must be kept longer in order to bring them to an acceptable Canadian standard.

Recommendation: *The department should survey a suitable number of Canadian universities to obtain a representative sampling of course and examination requirements. If, as is strongly suspected by the committee, the SFU requirements are excessive then the department could consider the following possibilities to decrease reliance on present structured courses.*

Present SFU regulations currently requires 12 semester hours (4 courses) for the M.Sc. The department should consider asking the university to reduce this to 6 semester hours (2 formal courses). If the university agrees, then the requirement for the M.Sc., in addition to a thesis, should be 6 semester hours (2 formal courses) Cum-1 as redefined below, and a literature seminar. [The requirement at the Ottawa-Carleton Chemistry Institute is 2 one term courses of 2h/week + student seminar + thesis.]

If the university does not agree to change the 12 semester hours (4 course requirement then the department could consider assigning a course credit to each of the Cum-1 and the literature seminar.

The course requirement for the M.Sc. be reduced according to one of the plans above, in order to bring it in line with other universities in Canada, in order to help reduce the residency time for the M.Sc.

The committee received strong complaints from the graduate student representatives concerning the excessive requirements of the present Cum-1. As mentioned above, in many instances the combination of Cum-1, other courses and laboratory teaching prevents many students from commencing research for two or more terms. The students feel that Cum-1 is a major hurdle, i.e., another exam. A candidacy exam should not be necessary for the M.Sc. degree. To alter the perception of Cum-1 and still allow the students' research committee to monitor the research progress we make the following proposal.

Recommendation: *That Cum-1 become a research report. This report should be scheduled in the first month of the student's fourth term. This cum should be structured similarly to the present Cum-1 and involve a short typed report and an oral presentation followed by discussion and questions (this is not the seminar discussed below).*

This process would allow the committee to monitor the progress of the student's research and offer advice on the direction of the research.

The introduction of graduate students literature seminars was discussed in the review committee and with the graduate student representatives. Positive feedback was received on the proposal outlined below. Guidelines for the literature seminar could include the following:

(1) The topic should be agreed upon not longer than two or three weeks prior to the seminar date so that the student will not spend an undue amount of time preparing for the seminar.

(2) The seminar topic should be outside the student's immediate area of research.

(3) The student should be encouraged to use both the blackboard and overhead transparencies or slides in order to become confident using both techniques.

(4) The student should prepare a short abstract with key references which could be appended to the seminar announcement.

(5) The chosen topic should not be the subject of a recent review so that the student will have to read and assimilate data from the primary literature.

Recommendation: *Introduction of a graduate student seminar program is advised. The committee envisages the possibility that an M.Sc. student would give one seminar based on a literature topic and a Ph.D. student would give two seminars, the second of which would be a thesis seminar. Under present circumstances this would amount to 15-20 seminars per year in the department. Attendance of all graduate students should be mandatory and course credit for this activity should be given, if necessary. Assessment based on presentation and understanding of the seminar material is suggested. A group of two or three staff members could be assigned on a yearly basis so that reasonably consistent assessments are made.*

STRUCTURE OF THE GRADUATE PROGRAM

The Ph.D. Degree

The length of time for completion of the Ph.D. degree was addressed and found to be similar to the national average. Based on the experience of the external reviewer the seven courses requirement for the Ph.D. is average for this degree. Should the survey recommended above differ substantially from this figure, the department may then wish to make an adjustment.

Suggestions for requirements for the Ph.D.

(a) From the B.Sc. (Honours)

6 courses + Cum 1 (altered as above) + 2 seminars + research proposal

(b) from the M.Sc.

4 courses + thesis seminar + research proposal

The major changes from the present requirements for the Ph.D. from B.Sc. would be:

(i) reduction in one formal course requirement from 7 to 6

(ii) replacement of the present Cum 1 by a progress report type Cum as described above

(iii) replacement of Cum 2 by a seminar program

(iv) a redefinition of Cum 3 according to:

Cum 3: The preparation and defense of a research proposal near the end of the Ph.D. degree was seen to be a highly worthwhile requirement. The present practice of fulfillment of this requirement by an obvious extension of the thesis topic should not be considered acceptable, and should be discontinued.

Introduction of these suggestions will have the adverse effect of decreasing the demand for graduate courses and thus in all probability decrease the frequency of offering and variety of courses available to graduate students. To counteract this, each sub-discipline should offer one key course in their area on

a regular basis to ensure that students in all areas can meet their course requirements within a reasonable time period.

Stipends and Entrance Scholarships

The available data shows that SFU stipends, for M.Sc. or Ph.D. candidates, are, at best, barely competitive with those of other chemistry departments in Canada. It must be recognized by the administration of the university that the supply of Canadian graduate students is limited. It would be unfortunate if prospective students decided not to come to SFU because of lower than competitor stipends.

Similarly the department should pressure the administration to ensure that NSERC and other scholarship holders find SFU attractive and competitive not only in research but also from the financial point of view.

Recommendation: *The department should strive to make its stipend offering for both the M.Sc. and the Ph.D. competitive with other universities in B.C. and in the remainder of Canada. Consideration could be given to a zero or the smallest possible differentiation between M.Sc. and Ph.D. candidates. [They do the same teaching, and initially at least similar amounts of research.]*

Recommendation: *Additional university scholarships to major scholarship holders should be made at competitive (or higher) levels in order to attract more students of excellent quality.*

Grading of Students and Internal Scholarships:

The students expressed the opinion that SFU merit scholarships should be awarded with less emphasis on grades and courses. More weight should be placed on research productivity.

There seems to be a feeling among students that course marks are not given uniformly and that it is hard to compare marks for different courses and that a relative ranking might be a better standard for scholarship allocation and within

courses.

Graduate Student Enrollment:

Statistics supplied by the DGSC show an intake of about a dozen students per year. This has resulted in a relatively constant graduate student population of about 50. Nearly 60% of this total are visa students. The potential problems associated with foreign students whose English language skills are poor have already been noted. The comment in the DGSC submission that graduate student enrollment is not limited by the number of applications but by research funds is undoubtedly true but probably refers to the many potentially acceptable applications from foreign students rather than from qualified Canadians. No doubt the SFU chemistry department would welcome an increase in its Canadian graduate student contingent. Recommendations to increase the basic stipend and the additional SFU scholarships offered to external scholarship holders have already been made. The increase is especially important for potential M.Sc. students since such students represent the major portion of the new students entering each year. In the end, a significantly greater number of high quality Canadian graduate students will not materialize until the research visibility of the department compares favorably with its major geographical competitors.

University Support of Graduate Studies and Research:

The review committee did not discuss in detail the total support offered to the department by the administration for graduate student assistantships and storeroom supplies and research equipment. The department should gather data - probably available from the Canadian University Chemistry Chairmen - to support its position that it requires additional funding from the university in order to be competitive and have a chance to excel. The administration must take action to ensure that researchers receive at least a competitive amount of university support when compared to UBC or the University of Victoria.

Interface with IMBB:

The IMBB members resident in chemistry expressed a desire to have chemistry maintain biochemistry as a high priority for future faculty appointments. These IMBB members were not in favor of the Institute becoming a separate department in the near future.

Recommendation: *The committee recommends that the appointments funded by the IMBB allocation be continued to be distributed between the departments and the appointment of younger faculty capable of developing an interdisciplinary team be given priority. The director/dean should favor proposals leading to interdisciplinary research in this area. Hiring of new faculty for the Institute should emphasize scholars who are likely, by virtue of background and personality, to become involved in interdisciplinary research.*

EVALUATION OF RESEARCH

The following comments are made by the external reviewer and reflect his analysis and bias. Comments concerning the shortcomings of a "single reviewer" analysis were made earlier in this report.

General Comments

The SFU chemistry department is somewhat unusual in that its members obtain operating grants from four different NSERC committees (1988 figures): chemistry, 12 + X-ray infrastructure; cell biology, 4; interdisciplinary, 1; sub-atomic physics, 1. Cross committee comparisons should be made with care. The SFU chemistry situation is further complicated by the project grants awarded to the nuclear science group (TRIUMF).

A short analysis of the largest group, those who receive their operating grants from chemistry follows. The average 1988 grant for the 12 chemistry grant recipients is $28.6 compared with the national average of more than $36K (estimated) for all chemistry grantees. The corresponding figures for 1987 were SFU (13 grantees) average = $27.6 vs the national average of $34.6K.

Comparisons are made for the same group for the years 1982 and 1985 in the Table below in order to detect possible trends.

Year	Number of SFU Grants	Average SFU Chem. Grant $K	Average Canada Chem. Grant $K	SFU/Canada
1982	15	17.3	~24	0.72
1985	13	25.2	31.9	0.81
1988	12 (13)*	(28.6) 28.3*	~36	0.79

*Includes Infrastructure Grant

To a first approximation one could argue that SFU has increased its stature in the eyes of the chemistry grant selection committee since 1982, but most of the progress was made in the 1982-1985 period. Nevertheless, the average SFU

operating grant from the chemistry committee is still less than 80% of the national average. Furthermore, amongst the SFU chemistry operating grants only two are presently clearly above the national average and none, as yet, in the above $70K range, the amount received by the top 10% of chemistry grantees (top 50 out of 500 grantees).

Data can be massaged in many ways to "prove" a point. The department flattered itself in its 1987 review by claiming parity with "McMaster and Ottawa in terms of NSERC operating grant support and only behind the big six (Toronto, Alberta, McGill, Western, UBC and Waterloo)", (p. 42 and Table on p. 46).

The SFU computer printout of research grants made available to the committee show 19 NSERC operating grants from four committees (chemistry, cell biology, physics, interdisciplinary) with a value of $515K. The SFU chemistry department average, excluding TRIUMF, for 1986 was $27.1K placing SFU at the bottom of the list, below Manitoba and Carleton. This suggests a very different picture than that painted by the department.

Neither of these extremes is completely correct, since the nuclear chemists do belong and contribute to the department. The point is made that statistics alone can often be misleading unless all contributing factors are taken into account.

Finally, if one wants to use NSERC operating grant data as a measurement of research activity a better indicator would be average grant per faculty member. For example, at Ottawa the average grant size increased substantially several years ago when a faculty member's grant was reduced from 7K to nil. Obviously it wasn't a better department as a result of this; in fact, the opposite was true. At SFU 7 of 28 (25%) faculty members do not receive NSERC operating grants or project grants at TRIUMF, for the University of Ottawa chemistry department 14/17 (82%) receive NSERC chemistry operating grants.

Using these comparisons the chemistry department at SFU does not compare favorably with McMaster or Ottawa. This is not to say that some members of the department do not have impressive ongoing research and excellent future prospects. Overall, again not including the nuclear chemistry group which I cannot judge, I would conclude that at present, the department's research quality and productivity places it in the lower half, probably in the lower third, of the following major Canadian departments: (West to East): Victoria, UBC, SFU, Calgary, Alberta, Saskatchewan, Manitoba, Windsor, Western, Waterloo, Guelph, McMaster, Toronto, Queens, Carleton, Ottawa, McGill, Montreal, Sherbrooke, Laval, UNB, Dalhousie, Memorial.

Comments on the Sub-disciplines

(i) Nuclear Chemistry

Most Canadian university chemists are aware of the close connection that the SFU chemistry department has with TRIUMF. Its nuclear chemistry group is recognized as unique in Canada. Most of us are unable to judge the quality of the program but the perception is that it is good and it is known that relatively large project and team grants are obtained by this group. The connection with TRIUMF should be maintained and advantage should be taken of new initiatives at TRIUMF. Expertise could be added to the department from TRIUMF in the form of Adjunct Professors who could direct graduate students (if available) and PDF's. Teaching requirements in nuclear chemistry do not justify additional full-time staff in this area.

(ii) Biochemistry

Most Canadian universities have both chemistry and biochemistry departments with the latter being either in their Faculty of Science or in Medicine, or sometimes in both. The biochemistry group in the chemistry department at SFU is small and quite active in research. At present, the group has difficulty in

mounting the courses necessary for both an effective undergraduate and graduate program and several important gaps including nucleic acid and protein biochemistry have been identified by the group.

The department and the university have recognized the importance of this field and have made major commitments towards its future.

Recommendation: *It is recommended that the efforts to attract new faculty to biochemistry continue since this field is attracting excellent students at both the undergraduate and graduate levels.*

The biochemistry group in the chemistry department will suffer a major setback with the impending departure of one of its members.

Recommendation: *It is important that the department replace the leaving faculty member by someone of comparable stature in order that this research group not lose its upward momentum. This replacement must be in addition to the recent IMBB appointment. The committee recognizes the problem of attracting an outstanding person in a "hot" field; the "price" is likely to be high. Nevertheless, the effort must be made.*

(iii) Organic Chemistry

The pheromone research group has high visibility amongst chemists and population biologists. It is well funded by both operating and strategic grants and is obviously an area of excellence at SFU. Another member is a highly respected physical organic chemist and a new appointee shows all of the signs (energy, ability to attract students and grants, excellent teaching skills) to suggest that he will acquire a national and international reputation.

This group is quite small and one member is within a few years of formal retirement. The range of expertise in terms of research interests and course offerings at the senior and graduate level is consequently limited. This group could strongly benefit from the addition of another member with an established or

growing research reputation. An argument could be made that the area of expertise of the additional member might be in synthetic organic chemistry. That person would complement the pheromone group and give considerably more flexibility in graduate course offerings.

The present organic chemistry group has more than 40% of the graduate students of the department. In addition it must teach all of the undergraduate organic chemistry program. These are considerable teaching and research commitments. In addition, one member has accepted a 5-year mandate as chairman. The department has made a commitment in its 1987 review to add organic chemistry staff in the near future; it should keep this promise.

Recommendation: *Serious consideration should be made to an addition at the associate or young full professor level in the area of organic chemistry.*

If such an addition is made then SFU could reasonably claim an excellent graduate program in organic/bioorganic chemistry.

(iv) Inorganic/Organometallic Chemistry

This group in the main obtains approximately average operating grants from chemistry for their age profile. It would seem a reasonable expectation that the research support for this group should increase substantially in the next few years. The productivity of one member in particular has increased substantially in the past few years and a new appointee shows excellent potential as a URF.

Recommendation: *It is important that the department recognize and support the initiatives by the inorganic group.*

(v) Physical Chemistry

This group is the largest (8 or 9 depending on the definition used) from a faculty point of view in the department. It is relatively inactive in research and graduate studies (6 graduate students) and has very modest research grants. (The grant analysis is quite different if one adds TRIUMF to this group. One

TRIUMF member has an impressive $66K operating grant but it is not strictly comparable to the others in chemistry since it comes via Sub-atomic Physics, a committee which traditionally gives relatively high grants). Four members of this group have not been active in research for some time. One member is "scheduled" for formal retirement in 1989. This leaves only four involved in research in physical chemistry.

This area of research is clearly a major problem area for the department. It supplies a lot of undergraduate teaching manpower but outside of first year the group has relatively few teaching demands.

The other undergraduate and graduate teaching requirements dictate that new staff be added in biochemistry or organic but this group needs it most of all from a research point of view. It is almost impossible to address all requirements in the same time period. In the end, because of the tenure situation and other teaching demands the revitalization of research in physical chemistry may have to be sacrificed.

(vi) Theoretical Chemistry

The department manages its teaching commitment in this area with essentially one faculty member and there is reasonable stability in this area.

(vii) Analytical Chemistry

There is presently no research in this area at SFU. The department could consider using the IMBB as a vehicle for entering this field in a non-traditional way - analytical chemistry emphasizing biosensors and biological diagnostics. These areas are presently of tremendous interest and have great potential. The point was made in the 1987 review that UBC has an active program in analytical chemistry (traditional?) and thus it might not be wise for SFU to compete directly with UBC in this area.

In summary, the external reviewer rates the present situation with respect to research and graduate studies in the sub-disciplines as follows:

Biochemistry: reasonable, but the group is small and thus cannot provide the breadth necessary for this broad area. The loss of one member in 1988 is a serious blow and his replacement must be a first priority. The IMBB, if properly staffed, could have a very positive effect on this group.

Inorganic/organometallic Chemistry: reasonable, with good prospects for improvement if the more recent appointees reach their potential.

Nuclear Chemistry very good, unique in Canada.

Physical Chemistry: weak, more likely to deteriorate than improve.

Organic Chemistry/Bioorganic: high visibility in the insect pheromone field but only two other active researchers.

Theoretical Chemistry: one researcher.

FACULTY RENEWAL

Assuming formal retirement at age 65, four positions will become available between now and 1994 and seven by 1997. On the surface, this offers a chance for renewal and a recommitment to research excellence. In reality, if the department has to depend solely on opportunities created by retirements, progress and improvements in various research areas will be relatively slow since three of the four retirees are amongst the active researchers in the department.

Thus, if the university is strongly committed to improving research and graduate studies in chemistry in the near future, other means of adding research oriented staff must be found. It is left to the university and the department to develop possible initiatives.

The question of whether to add faculty with an established or rapidly growing research program ("stars") or young staff was discussed at length amongst committee members and the department and with the Dean of Science.

Arguments made for the hiring of young staff were based mainly on the age profile of the department. Opinions were also given by the faculty that it would be difficult to attract established stars to SFU. ("Why would they want to come here?") The university's ability and willingness to commit resources (money, space, equipment) was not mentioned.

The departmental age profile should be taken into account when planning for the future and hiring new faculty but it must not be the primary factor. If excellence in research is considered an important goal then other factors may have to take precedence. I will argue that assuming excellence is the goal, the hiring of faculty at the senior or mid-career level, rather than junior appointments is crucial.

Admittedly, it is difficult and takes considerable effort to identify and attract active researchers. Scarce money and space resources have to be

reallocated to make it attractive for such a person to move from a present position. Nevertheless, it has, and continues to be done, even in Canada. Such researchers have had or will have an immediate impact on their new departments, very much more so than a young URF or assistant professor.

The appointment of one or several excellent scientists in mid-career immediately strengthens the department's ability to attract funding for equipment. The acquisition of such equipment may be crucial to the development of other research in the department. The atmosphere and the enthusiasm for research in the department will likely improve dramatically as people realize that the commitment of the university to research in the department is indeed strong. All members will tend to speak of their department, faculty and university with greater pride. The additional visibility is likely to result in increased enrollment of high quality graduate students. The presence of more excellent students has a positive effect, not only research but the quality of demonstrating in the undergraduate labs.

Finally, and also very importantly, the presence of a number of "stars" and the atmosphere which this creates has a strong effect on the hiring of future young staff. Highly promising young scientists will have many more opportunities for employment in universities in Canada in the coming decade than in the past due to more openings resulting from the many anticipated staff recruitments. Given a choice, the best will gravitate to departments which have excellent research and graduate programs already in place. By not acting decisively now, the SFU chemistry department may find itself unable to compete effectively against other Canadian universities when junior staff positions become increasingly open in the middle to late 1990's.

Recommendation: *That the administration grant the department the opportunity to*

make two or preferable three appointments at the middle or senior levels in addition to any appointments relating to the IMBB.

These appointments are crucial for the near and long term development of the future of the chemistry department. Without these it is doubtful that SFU will be able to claim confidently, in the foreseeable future, to be the second-best chemistry department in British Columbia.

EQUITABLE WORKLOADS - TEACHING AND RESEARCH

The question of what constitutes equitable teaching assignments when comparing faculty who do little or no research as compared with those who have major research operations was discussed a number of times. Many wise men have grappled with this problem. Their analyses and solutions have been acceptable to some but never to everyone. Despite the fact that the problem is a difficult one, it nevertheless needs to be addressed as fairly as possible since it is a source of friction in the department.

The external reviewer would like to state his position as follows: "In general I would argue that formal teaching is more of a finite activity than research which, if good, demands essentially an open-ended commitment. In teaching, preparations for a full course or individual classes are made, the course is given, individual problems are discussed with students. The assignments, essays or exams are marked and the job is more or less finished. The cycle repeats itself when the course is given for a second and subsequent time. For courses at the introductory level of the subject, irrespective as to whether this is first year general, 2nd year organic or physical or quantum chemistry in the 3rd year, the preparation time become significantly less after one or two presentations. Courses on a subject near the present state of knowledge are likely to require many hours of preparation per lecture no matter how often they are given."

I would also like to make a distinction between graduate teaching and research. The department readily gives credit for formal graduate teaching whether the course is given to one or fifteen students yet it seems reluctant to give credit for teaching a student how to do research, how to write a paper or a thesis, prepare a seminar and all other duties involved with training an M.Sc. or Ph.D. candidate.

A perusal of the teaching assignments in the department over the past two years indicated that there was often some differentiation between those who have active research programs and those whose research efforts are relatively small. The differences did not seem substantial. It must be pointed out that it was difficult to decide the extent of involvement in the department's tutorial system, nor did I come to grips with administrative duties which various professors might have had.

The department is strongly urged to re-evaluate its teaching assignments in order to attempt to remove some of the friction this is causing. The informal teaching of graduate students could be included in a new formula. It might be agreeable to all that a maximum of a one course credit per year, compared to the average load, could be earned by a professor having 3 or more graduate students.

I would be reluctant to grant greater release from teaching than the one course mentioned above since it is important that undergraduate students come in contact with researchers. These professors are often good and even excellent teachers, eager to share their enthusiasm of the subject and their research with the students.

It need not be stressed that good teaching is important to a department. Professors who provide it make important contributions. A number of professors in the chemistry department at SFU who have low or limited involvement in research groups have received very good and even excellent teaching ratings from students. Such professors could be asked to do an extra course/term (2 extra courses/year). This request should not be seen as punishment for not doing much research but a rationalization and realization that each member of the staff has different talents, some are best at teaching, others at research and some have talents in administration. Ideally, each person's talents should be used to the fullest extent.

It will take considerable wisdom and tact on the part of the administration and the chairman, and cooperation from the faculty to bring about substantial changes in order to use everyone's talents to the fullest extent. In principle the rewards will make the effort worthwhile since it should make everyone feel that they are carrying their share of the load and making worthwhile and important contributions to the overall development of the department.

SPACE REQUIREMENTS

The committee toured the space available for various research groups. It was obvious that some of the labs were overcrowded. The committee did not identify much underutilized space. It concludes that the comments on the shortage of space in the 1987 Departmental Report are realistic.

RESPONSE TO THE REVIEW OF THE DEPARTMENT OF CHEMISTRY SIMON FRASER UNIVERSITY

FEBRUARY 1989

INTRODUCTION

A review of the Department was held in April 1988 by a committee consisting of Professor Tony Durst, Department of Chemistry, University of Ottawa, Professor Roy Morrison, Department of Physics, Simon Fraser University and A. C. Oehlschlager of the Department of Chemistry, Simon Fraser University. The Committee had access to much analytical information in addition to the 1987 Departmental Mission statement. The committee interviewed faculty, laboratory instructors, undergraduate and graduate students during a two day period. A report was issued by the Committee in the Summer of 1988 which was discussed by the Department at several meetings in the Fall of 1988. The departmental response to the Report is contained in this document.

UNDERGRADUATE PROGRAM

QUALITY

The Department made the case, accepted by the Review Committee, that the undergraduate program at SFU is of good to excellent quality, in comparison to those of other chemistry departments in Canada.

STRUCTURE

TRI-SEMESTER OPERATION

The Committee noted that SFU operates on a tri-semester basis and that the faculty and students are in agreement with, and strongly support, the frequency of the current offerings.

TUTORIAL SYSTEM

The Committee noted that the tutorial system as operated in the Department requires the investment of 30-40 tutorial session contact hours each week in the Fall and Spring semesters. This more than doubles the time commitment by the Department to mount its first and second year lecture courses. In view of the high human resource commitment involved in

the tutorial system, the review Committee recommended that *the Department examine the tutorial system, especially as executed in the first two years, to define the purpose of the tutorials. The Department was directed to evaluate the methods used in the tutorials to ensure the goals are likely to be achieved. Finally, the Department was directed to convince itself that the pedagogical goals defined for the tutorial system are worth the human resource effort put into this method of instruction. If it is no longer certain that this is the best way to utilize its professorial resources, the other approaches, such as marked problem sets, should be considered.*

Response: The Department examined its use of the tutorial system and determined that it is essential to the maintenance of the high quality of the undergraduates produced by the Department.

The Committee also recommended that *the scheduling of tutorials in upper level courses where enrollment is less than 20 students could be formally discontinued. At this level students should be encouraged to work on their own.*

Response: The Department rejected this recommendation and elected to maintain the current system.

THE CO-OP PROGRAM

It was evident to the Review Committee that Chemistry is an enthusiastic participant in the Co-Op program at SFU. The Committee supported this initiative and recommended that *the Department should continue its commitment to offer high quality undergraduate courses in the summer semester in order to best serve the students in the Co-Op program.*

Response: The Department has and will continue to increase its summer offerings in support of the Co-Op program. In 89-2 it will continue to offer its high demand upper division organic chemistry and biochemistry courses.

STUDENT EVALUATION OF COURSES

The Department was commended for the practice of course evaluations and the current high quality of teaching within the Department. The review Committee recommended that *in*

the few instances where a faculty member receives a student course evaluation much below the Departmental average the chairman should encourage those faculty members to address the criticisms made by the students.

Response: The members of the Department recognize the value of excellence in teaching as a critical component in the life of the Department and will endeavor to maintain high teaching standards. The chairman will implement a process of counselling with individuals who have identifiable areas in which substantial improvement could be achieved.

LECTURE COURSE DEFICIENCIES

The Committee identified a few situations of overlap and repetition in various Departmental courses. To remedy this situation the Committee recommended that *the Department review its undergraduate course contents with the view of identifying and rationalizing, if necessary, overlaps and omissions in courses.*

Response: This is an ongoing process which has been accelerated by the review. The DUGSC and the Chairman are undertaking this process. Detailed course outlines have been required for some time and are now scrutinized by the DUGSC.

POSSIBLE REARRANGEMENTS OF FIRST AND SECOND YEAR

The Committee recommended a modified sequence of general and organic chemistry courses with earlier exposure to the concepts of organic chemistry and as a result the structures and properties of biologically important molecules. This modification would not decrease the amount of chemistry in the first two years, it would merely rearrange it. *The committee proposed, to the Department, the following reorganization of the first year general and second year organic program.*

Present (traditional) sequence:

Year	Term 1	Term 2
1	General Chemistry	General Chemistry
2	Organic Chemistry I	Organic Chemistry II

New (modified) sequence:

Year	Term 1	Term 2
1	General Chemistry (Structure and Bonding)	Organic Chemistry I
2	Organic Chemistry II	Descriptive Inorganic Chemistry

Response: The DUGC analyzed this proposal from the standpoint of pedagogy, student program design, manpower and facility requirements, and recommended its implementation over the next two years. After detailed discussion the Department adopted this recommendation and is now in the process of discussing the proposal with other Departments whose students will be affected.

UPPER DIVISION LECTURE COURSES

Since the external reviewer was an expert in organic chemistry, this subdiscipline received the most scrutiny at the upper division. *The external reviewer supported the proposal made by the organic chemists to add a 300 level organic chemistry lecture course to the core of the chemistry and biochemistry program.*

Response: The Department supported this recommendation but warns that until additional organic faculty are added, it is not feasible to offer another course in this discipline. In anticipation of this possibility a redesigned organic curriculum has been formulated. Inclusion of an additional organic course in the core chemistry or biochemistry curriculum is not probable since these core programs currently match university credit maxima. This issue is will be assessed by the DUGSC. It was also recommended that, *in view of the importance and the increasing use of spectroscopic methods, especially NMR, in all aspects*

of chemistry, biochemistry and biology, a course emphasizing the application of spectroscopic methods to these fields in the core program be implemented.

Response: The Department agrees with this recommendation. Faculty with knowledge in this area are formulating such a (third year) course and recommending appropriate revisions to other courses.

LABORATORY COURSES

Laboratory Instructors and Instruction:

It was recognized by the Committee that laboratory instructors have extremely high demands on their time and resources. Mechanisms to reduce the workload on laboratory instructors and provision of time to develop new laboratory experiments were deemed advisable. The Committee recommended that *laboratory instructors should consider replacing the weekly laboratory quizzes by an end of term exam or a less frequent exam schedule. Laboratory instructors and professors instructing in counterpart lecture courses should consider the option of alloting time each week to the lab lecture in a regularly scheduled lecture.*

Response: The Department left this operational aspect of the laboratory courses to the discretion of the laboratory instructors. The instructors considered replacing weekly quizzes with less frequent quizzes but rejected the recommendation as a change that would lead to a decreased understanding by students of their laboratory experiences.

The Committee did not agree with the practice of responsibility for each course resting permanently with a given laboratory instructor. It was recommended that *the faculty take a strong interest in the development of the laboratories.*

Response: The chairman and the laboratory instructors will devise a schedule of long term rotating laboratory assignments to ensure that the goals of continuity and renewal are

achieved. Teaching assignments in 1988 and 1989 reflect the inclusion of some faculty in upper division laboratory course design (336/356/357/366/367/416). Faculty will be asked to provide consultancy to laboratory instructors in the review and upgrading of laboratory courses. The key to redesign and upgrading is the provision of manpower to develop new experiments. This was begun in 1988-3 with the assignment of part of a teaching assistant to Chem 256 micro refitting. The only visible source of support for manpower to conduct development is via the work study program and this is being pursued.

Undergraduate students pointed out that some of the foreign graduate students who serve as teaching assistants have poor English language skills which impedes their teaching function. The Committee recommended that *the Department should make efforts to use foreign students with poor English language skills in duties other than laboratory instructors, e.g., grading.*

Response: No foreign graduate students known to have poor English language regardless of skills are assigned to direct laboratory teaching as of 1988-3! All such students, regardless of their need for financial support, are either not given teaching assignments or are given grading assignments. There is a maximum of one grading position per semester.

It was recognized by both the Department and the Committee that the quality of the laboratory instruction by the graduate student teaching assistants contributes significantly to the excellence of the undergraduate program. True excellence should be rewarded and fostered. Accordingly the Committee recommended that *the Department consider recognizing excellence among teaching assistants by awarding three or four awards valued at $100 or more for teaching excellence in each calendar year.*

Response: The Department debated this recommendation vigorously and was divided on the issue. There was reasonable doubt on the part of a substantial number of faculty that fair implementation was possible or that the measure would lead to improved teaching quality. The laboratory instructors and the chairman are to develop a proposal for consideration.

UNDERGRADUATE COURSE DEFICIENCIES

Analytical Chemistry

The Committee felt that the Department should strive to lead in the area of analytical chemistry, especially in view of the Co-Op program. It felt that much of the current Chem 218 dealt with classical analytical chemistry. A second analytical laboratory course, devoted to advanced instrumental techniques, which was under development by the Department, was seen as highly desirable. The inclusion of important nuclear science techniques such as X-ray fluorescence into this course was recommended. The Committee recommended that *the Department review its analytical chemistry laboratory courses in light of the above suggestions. New equipment should be acquired (if necessary) so that these courses reflect modern techniques used in industry and in the health fields.*

Response: The DUGSC made the case to the Department that the current structure of the analytical program allowed students to become familiar with the fundamental concepts of equilibria, solubility and redox chemistry in the first course (218). In the advanced course (416) instrumental methods were introduced. Students going through these courses report that they fare quite well in adapting to the newer, more sophisticated techniques utilized in industrial laboratories. The Department decided to maintain Chem 218 and 416 in their current format. The latter is team taught by persons knowledgable in each instrumental technique (e.g., chromatography, atomic adsorption and X-ray fluorescence).

The external reviewer stated that the room devoted to the organic chemistry laboratory was constructed to standards that predate the university. The fumehoods are placed in an area that makes them practically inaccessible to students. Furthermore, many of them are

being used for storage space and thus not available for experiments. This has led to the selection of experiments that, while adequate, are restricted in scope because of the inadequacy of the ventilation in this room. The external reviewer toured other available undergraduate laboratories and found no other room contained appreciably better ventilation facilities. The review committee maintained that the present situation in the organic laboratory with respect to the ventilation must not be tolerated. Accordingly, it recommended that *efforts be made to install hoods over each of the student work* stations if at all feasible. Available fumehoods should be utilized as much as possible for student experiments rather than as chemical storage areas.

Response: Three avenues to correct this situation have been pursued: 1) The fumehoods in this laboratory were cleaned and painted in 1988-2 to make them more conducive to work. Stored items were moved to positions not occupying work space so students have access to these hoods. 2) Discussions were initiated with the Dean of Science that led to the inclusion of space for organic laboratory classes in the proposed IMBB building. 3) Professor Slessor and Mrs. Shirley Black carried out a cost analysis for the implementation of micro experiments in the organic laboratory. Implementation of avenues 2) and 3) will lead to a virtually fume free laboratory environment for organic chemistry. It is envisioned that acquisition of micro equipment and the supporting instrumentation (≈$200K total) will proceed and the conversion be implemented over the next two years. This will reduce the hazardous vapor pollution in the present laboratory although not to acceptable levels due to the overcrowding that will result through implementation of the organic laboratory into the first year program. The move to properly ventilated facilities planned for the IMBB building will complete the changes necessary in this area.

EQUIPMENT FOR UNDERGRADUATE LABORATORIES

The Department Mission statement contained several Tables listing obsolete equipment. During 1987 the Department began to replace this equipment but the replacement is not

complete. Obsolete equipment was most noticeable in the laboratories devoted to physical and instrumental analytical chemistry. Accordingly the Committee recommended that *the commitment to the upgrading of obsolete equipment and introduction of modern instrumentation initiated in 1987 be maintained.*

Response: The Department endorsed this recommendation. In the 1988-1989 fiscal year the Department requested $449,879 in capital and renovations. It received $129,000 and allocated a greater portion of its capital budget ($79.2K) to the acquisition of equipment for undergraduate teaching laboratories than has been done in any other experimental science Department. With these funds the Department acquired a new atomic absorption instrument for the advanced analytical laboratory and enabled Professor Gay to begin the renewal of the advanced physical chemistry laboratories by implementation of computer interfaced experiments. In the 1989-1990 capital budget submission the acquisition of equipment for the undergraduate laboratories will also be a high priority.

LIBRARY FACILITIES

The Committee *recommended that the SFU librarian be asked to negotiate better and less expensive access to the UBC library for SFU researchers.*

Response: This recommendation will be pursued by Professor Gay.

COMMUNITY SERVICE

The Committee applauded activities in the area of high school liaison carried out by members of the Department. In 1988 the faculty were especially active in this area. Members participated in Shad Valley Day, Science Day and Futures. They also hosted Chemistry Enrichment and Chemistry in the 80's programs.

The Committee suggested that a mechanism for attracting more scholarship quality high school students to SFU would be to guarantee scholars space in the university residence.

Response: The Department endorses this recommendation. On behalf of the Department the Chairman has written to the Director of Student Services recommending that the number of rooms reserved for scholarship holders in the SFU residences be increased from 30 to 100 (which is the number the Director Vern Lowen feels confident he could effectively utilize).

GRADUATE PROGRAM

The M.Sc. Degree

The Committee determined that the average time to complete an M.Sc. in Chemistry is slightly over 3 years compared with 2.3 years at the external reviewer's home institution (Ottawa-Carleton Institute). Representations from faculty involved in graduate student supervision as well as graduate students pointed to the excessive course and cumulative requirements as a major contributing factor for lengthy completion times for the M.Sc. The Committee recommended that *the Department survey other Canadian universities to obtain a representative sampling of course and examination requirements. If, as was strongly suspected by the committee, the SFU requirements are excessive then the Department could consider alternative program structures to decrease reliance on present structured courses.*

The committee recommended possible options. Among them that *Cum-1 become a research report and be scheduled in the first month of the student's fourth semester. This cum should be structured similarly to the present Cum-1 and involve a short typed report and an oral presentation followed by discussion and questions (this is not the seminar discussed below).*

The committee also recommended *introduction of a graduate student seminar program. The committee envisaged the possibility that an M.Sc. student would give one seminar based on an assigned literature topic and a Ph.D. student would give two seminars, the second of which would be a thesis seminar. This would amount to 15-20 seminars per year in the Department. Attendance of all graduate students should be mandatory and course credit for this activity should be given. Assessment based on presentation and understanding of the seminar material was suggested. A group of two or three staff members could be assigned on a yearly basis so that reasonably consistent assessments would be made.*

Response: The DGSC conducted the survey and determined that an alternate program structure would be desirable to bring our course requirements into line with those at other Canadian institutions. At the M.Sc. level the proposed program involves the replacement of Cum I by a Research Seminar course (805) in which the student would normally enroll in his fourth semester. Students would be required to make written and oral reports on their research progress in Chem 805. Another seminar course, Chem 801, also requiring a student presentation would replace one of the formal lecture courses. Thus, two lecture courses, Chem 801, Chem 805 and a successful thesis examination would be required of M.Sc. graduates.

These changes have been given approval in principle by the Department.

STRUCTURE OF THE GRADUATE PROGRAM

The Ph.D. Degree

The Committee found length of time for completion of the Ph.D. degree to be similar to the national average. Based on the experience of the external reviewer the seven courses requirement for the Ph.D. is average for this degree. To keep the M.Sc. and Ph.D. degree requirements consistent the committee suggested some revisions to the Ph.D. degree program structure might be necessary. **Response: The DGSC recommended changes to the Ph.D. program structure which were consistent with those changes recommended for the M.Sc. Specifically, student seminar courses Chem 805, 801 and 802 were recommended to replace Cum I, II and III respectively. Each of the seminar courses would be given credit so only four lecture courses would be required.**

These changes have been given approval in principle by the Department.

It is recognized that introduction of these suggestions will have the adverse effect of decreasing the demand for graduate courses and decrease the frequency of offering and variety of courses available to graduate students. To counteract this,

each sub-discipline will offer one key course in their area on a regular basis to ensure that students in all areas can meet their course requirements within a reasonable time period.

Stipends and Entrance Scholarships

The Committee noted that SFU stipends, for M.Sc. or Ph.D. candidates, are, at best, barely competitive with those of other chemistry departments in Canada. The Department should pressure the administration to ensure that NSERC and other scholarship holders find SFU attractive and competitive not only in research but also from the financial point of view.

The Committee recommended that *the Department strive to make its stipend offering for both the M.Sc. and the Ph.D. competitive with other universities in B.C. and in the remainder of Canada. Consideration could be given to a zero or the smallest possible differentiation between M.Sc. and Ph.D. candidates. [They do the same teaching, and, initially at least, similar amounts of research.] Additional university scholarships to major scholarship holders should be made at competitive (or higher) levels in order to attract more students of excellent quality.*

Response: The Department has initiated the practice of using NSERC operating funds to increase the stipends of graduate students during semesters they are on teaching assistantships. The payments are presently $600 per semester and will be increased to keep our stipends commensurate with those of other B. C. Universities.

Grading of Students and Internal Scholarships

The students expressed the opinion to the Committee that SFU merit scholarships should be awarded with less emphasis on grades and courses. More weight should be

placed on research productivity. There was a feeling among students that course marks are not given uniformly, that it is hard to compare marks for different courses and that a relative ranking within a single course might be a better standard for scholarship allocation.

Response: The implementation of the revised graduate program structure will allow all students to be compared in the same course (Chem 805 or 801 or 802) each year. This should make evaluation of research progress and inter-student comparisons much fairer.

Graduate Student Enrollment

The Department has an intake of about a dozen graduate students per year. This has resulted in a relatively constant graduate student population of ≈50 of which ≈60% are visa students. A significantly greater number of high quality Canadian graduate students will not materialize until the research visibility of the Department compares favorably with its major geographical competitors.

University Support of Graduate Studies and Research

The committee did not discuss in detail the total support offered to the Department by the administration for graduate student assistantships and storeroom supplies and research equipment. The administration must take action to ensure that researchers receive at least a competitive amount of University support when compared to UBC or the University of Victoria.

Response: These comparisons will be made in the Five Year Plan.

INTERFACE WITH IMBB

The IMBB members resident in Chemistry expressed a desire to have Chemistry maintain Biochemistry as a high priority for future faculty appointments. These IMBB

members were not in favor of the Institute becoming a separate Department in the near future. In light of these attitudes the Committee recommended *that the appointments funded by the IMBB allocation be continued to be distributed between the Departments and the appointment of younger faculty capable of developing an interdisciplinary team be given priority. The director should favor candidates with demonstrated excellence who by virtue of their interpersonal skills would be likely to become involved in interdisciplinary research.*

Response: The Department agrees with this approach and has undertaken two initiatives to strengthen ties between IMBB and non-IMBB members in chemistry with common research interests: 1) It has actively pursued funding of major equipment such as NMR facilities which are crucial to new experiments planned by IMBB and non-IMBB members. 2) It has encouraged the formation of a Molecular Recognition Group involving IMBB and non-IMBB members to facilitate fund raising by the Development Office.

EVALUATION OF RESEARCH

The evaluation of research in the Department was made entirely by the external reviewer and the response was prepared by the Chairman.

General Comments

The external reviewer recognized that the SFU chemistry department is unusual in that its members obtain operating grants from four different NSERC committees (1988 figures): chemistry, 12 + 1 infrastructure (X-ray); cell biology, 4; inter-disciplinary, 1; sub-atomic physics, 1. The situation is further complicated by the project grants awarded to the nuclear science group (TRIUMF).

His only analysis was of the single largest group, namely those who receive their operating grants from Chemistry. **He pointed out that the average 1988 grant for the 12 chemistry grant recipients has been consistently ≈80% of the national average for all chemistry grantees (Table 1) and that there are no chemists at SFU with operating grants in the >$70K range, the amount received by the top 10% of chemistry grantees (top 50 out of 500 grantees.**

Average SFU Chemistry Operating Grant vs National Average

Year	Number of SFU Grants	Average SFU Chem. Grant $K	Average Canada Chem. Grant $K	SFU/Canada
1982	15	17.3	~24	0.72
1985	13	25.2	31.9	0.81
1988	12 (13)*	(28.6) 28.3*	~36	0.79

*Includes Einstein Infra-structure X-ray Grant

Publication Rates at SFU, McMaster and Ottawa

	# Faculty	# Publications (1985-86)	Ratio	Faculty with no publications (%)
SFU	28	147	5.25	5 (18)
McMaster	32	239	7.5	3 (9)
Ottawa	16	178	11.0	0 (0)

He then argued on the basis of this data that the chemistry department at SFU does not compare favorably with McMaster or Ottawa but that the quality may more closely parallel that of, for example, Manitoba. He then concluded that at present, the department's research quality and productivity places it in the lower half, probably in the lower third, of the following major Canadian departments: (West to East): Victoria, UBC, SFU, Calgary, Alberta, Saskatchewan, Manitoba, Windsor, Western, Waterloo, Guelph, McMaster, Toronto, Queens, Carleton, Ottawa, McGill, Montreal, Sherbrooke, Laval, UNB, Dalhousie, Memorial.

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Response: The external reviewer made several arguments based on the data that the average of the operating grants obtained from the chemistry grant selection committee of NSERC by mainline chemists in the Department are below the national average for chemistry departments of major institutions.

We accept this analysis as pointing to a weakness in our departmental research profile. We also accept that our interdisciplinary strengths do not release the mainline chemists of the professional obligation to be competitive with respect to their counterparts in other institutions. We also consider that our interdisciplinary strengths and balanced record in both basic and applied research are strengths on which we wish to build.

It is widely recognized that chemistry is a mature discipline and that the rate of growth of knowledge in the core of the discipline is growing appreciably slower than that at the bridging areas such as biochemistry and surface chemistry. In this respect SFU is ideally positioned to proceed into the next century by expanding its already identified high priority area of biochemistry.

The funds flowing into NSERC operating grant budgets have not kept pace with inflation over the last two decades while funds to interdisciplinary programs have grown substantially above the inflationary rate. This trend indicates that the evolving view of government is that university research laboratories are a resource to be utilized in the solution of problems of perceived national interest. Regardless of the validity of this view the trend is clear. In 1978 over 80% of funding to SFU chemists came from NSERC operating grants while in 1988 this has decreased to <60%. As we proceed into the next century the chemical community can expect to see the funds available for curiosity driven research, with no apparent mission, to decrease. Accordingly the departments whose faculty recognize the changing trends and are able to establish track records for

timely solution of meaningful chemical problems will be in the best position to capitalize on the future growth in the funding for this discipline. We consider ourselves to have a good record in this area and expect to fare well in future funding competitions.

One high Departmental priority is to raise its research profile in the international arena and its standings in the competition for NSERC operating funds from the chemistry grant selection committee. To achieve this the Chairman believes the Department would be best served by providing the time and resources to our best researchers so that they can develop to the point where they are recognized and rewarded by the chemistry grant selection committee. According to reviewers this is the case with some of the Department's members and we trust that the NSERC-CGSC will respond to their achievements. We will also attract mid-career chemists that are in similar situations at other institutions but are recognized by the chemistry grant selection committee. The Chairman believes that a large part of the excellent research grant profile of the Department of Biological Sciences is due to the early recruitment of an entire block of top flight scientists from an eastern Canadian government laboratory. This single action gave that Department instant recognition on which they have built.

COMMENTS ON THE SUB-DISCIPLINES

(i) Nuclear Chemistry

This sub-discipline was recognized as being unique and it was recommended that expertise be added to the Department from TRIUMF in the form of Adjunct Professors who could bring new initiatives to this area at SFU.

Response: Dr. Tom Ruth, a Senior Research Scientist at TRIUMF has been appointed an Adjunct Professor in Chemistry effective Jaunary 1, 1989. He and Professor J. D'Auria are developing a Summer Institute in Radiopharmaceutical Synthesis to commence in 1989

or 1990. The funding for this initiative will come from external sources.

(ii) Biochemistry

The biochemistry group in the Chemistry Department at SFU is small and active in research. At present, the group has difficulty in mounting the courses necessary for both an effective undergraduate and graduate program and several important gaps including nucleic acid and protein biochemistry have been identified by the group. The Department and the University have recognized the importance of this field and have made major commitments towards its future. The external reviewer recommended *that the efforts to attract new faculty to biochemistry continue since this field is attracting excellent students at both the undergraduate and graduate levels.* He also recognized the major setback suffered by the Department with the departure of one of the biochemists. He felt that it was *important that the Department replace him by someone of comparable stature in order that this research group not lose its upward momentum. This replacement must be in addition to a recent IMBB hiring. The committee recognized the problem of attracting an outstanding person in a "hot" field; the "price" is likely to be high. Nevertheless, the effort must be made. The replacement should be in addition to the designated IMBB position.*

Response: This case was forwarded to the University by the Department. The University has accepted this position and will permit the biochemistry replacement to be at the Senior Protein Biochemist level.

(iii) Organic Chemistry

The external reviewer made the argument that the addition of a senior associate or young full professor in the area of organic chemistry and the expected development of Pinto could reasonably lead to an excellent graduate program in organic/bioorganic chemistry at SFU.

Response: This case was forwarded to the University by the Department. The Department understands that the Dean of Science has recommended to the University that a top CFL priority for the Faculty of Science in 1989-1990 should be authorization of a Senior Organic Chemist. The Department is confident that this recommendation will be accepted.

(iv) Inorganic/Organometallic Chemistry

It was expected by the external reviewer that the research support for this group would increase substantially in the next few years. The reviewer recommended that *the Department support the initiatives by the inorganic group.*

Response: The expansion of this group by one member will appropriately amplify the efforts of this group. The Department plans to include a CFL request for the Inorganic/Organometallic group in its top priority list in the next two years.

(v) Physical Chemistry

As of late 1989 only four of the eight faculty remaining in this sub-discipline will be active in research. This is clearly a major concern for the department. This group supplies most of the undergraduate teaching manpower but has relatively few upper division teaching demands. It was the view of the external reviewer that because of higher teaching demands in other sub-disciplines the revitalization of research in physical chemistry may have to be sacrificed.

Response: The Department recognizes that it must build on its strengths and that areas with higher student demand at the senior undergraduate and graduate level should receive proportionally more support. The question is how to foster the continuance and improvement in the research profile of this group with minimal financial impact on other priorities. Initial efforts have been to replace a retiring faculty member whose teaching and research efforts are in the popular

area of graduate physical chemistry - polymer chemistry. The Department nominated a NSERC/URF applicant whose specialty is polymer chemistry and who could use much of the equipment available in this area.

(vi) Theoretical Chemistry

The department manages its teaching commitment in this area with one faculty member. His latest NSERC grant improved considerably from previous levels and indicates reasonable stability in this area.

Response: The Department has no plans to add faculty in this area.

(vii) Analytical Chemistry

The reviewers recognized that there were no faculty at SFU with specific training in analytical chemistry. They recommended that the department explore the option of using biochemistry as a vehicle for entering this field in a non-traditional way - analytical chemistry emphasizing biosensors and biological diagnostics. These areas are presently of tremendous interest and have great potential.

Response: Advanced analytical chemistry at SFU (Chem 416) is successfully taught by a team. The two faculty with strongest analytical interests are Professors D'Auria and Peterson. Both conduct analytical research in which established instrumental techniques are used to probe biological and ecological questions. It is expected that these efforts will expand. The addition of an electrochemist to amplify the expertise in this area is envisioned if funding currently being explored can be found external to the university (eg., NSERC Industrial Chair).

FACULTY RENEWAL

Assuming formal retirement at age 65, four positions will become available between now and 1994 and seven by 1997. If the department has to depend solely on opportunities created by retirements, progress and improvements in research stature will be slow since three of the four imminent retirees are among the active researchers.

The external reviewer argued that if excellence in research is considered an important goal the hiring of some mid-career chemists with exceptional records, rather than only young faculty, is crucial. It was argued that this recommended strategy would make a fast and significant short term impact on the research profile of the department and provide a basis for:

- attraction of larger numbers of bright graduate students who will inspire undergraduates as teaching assistants,
- attraction of the next generation of bright young faculty who will have many positions from which to select, and
- attraction of major equipment funding essential to maintaining a competitive edge.

By not acting decisively now, it was argued that the Department may find itself unable to compete effectively against other Canadian universities when junior staff positions become increasingly open in the middle to late 1990's due to retirements of aging faculty. Accordingly, the reviewer recommended *that the administration grant the Department the opportunity to make two or preferably three appointments at the middle or senior levels in addition to any appointments relating to the IMBB.*

These appointments are crucial for the near and long term development of the future of the Department. Without them, it is doubtful that SFU will be able to claim confidently, in the foreseeable future, to be the second-best chemistry department in British Columbia.

Response: The Chairman agrees with this analysis. In 1987-1988 several tenure track positions were advertised by Canadian Chemistry Departments. The number of responses in comparison to previous searches was astonishingly low. On average, only 23 qualified (Canadian Citizen or Landed Immigrant) candidates applied for each of these positions. Many universities are now in the position where they are unable to find any candidate to whom they are willing to make an offer. It is expected that this situation will worsen in the 1990's.

The Department hopes to make the following CFL appointments within the next five years. Placement of the Senior appointments early in the schedule is in accordance with the reviewer's arguments, the Department's wishes and the Administration's commitments.

REPLACEMENT SCHEDULE BY AREA AND YEAR

Area	1988	1989	1990	1991	1992	1993
		+	+	+	+	
Bich	4	Protein Biochem (Senior) + Nucl acid Biochem (IMBB) (Junior)	Protein Nucl Acid Biochem (IMBB) (Junior)		Membrane Biochem (expected)	Struct Biochem (Junior)
Inorg	4			+ Inorganic Photochem		
Org	6	+ Synthetic Org (Senior)		- Bio-organic		+ Org (Junior)
Phys	10	- Polymer				- Spectro
Nusc	3					
Anal	0		+ Electrochem			

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EQUITABLE WORKLOADS - TEACHING AND RESEARCH

The reviewer noted that a perusal of the teaching assignments in the Department over 1986-1988 indicated that there was often some differentiation between those who have active research programs and those whose research efforts are relatively small. The differences did not seem substantial. The Department was strongly urged to re-evaluate its teaching assignments in order to attempt to remove some of the friction this is causing. The teaching of research methodology could be included in a new formula. It might be agreeable that a maximum of a one course credit per year, compared to the average load, could be earned by a professor having 3 or more graduate students. The reviewer would be reluctant to grant greater release from teaching than the one course since it is important that undergraduate students come in contact with researchers. Furthermore, these professors are often good and even excellent teachers, eager to share their enthusiasm of the subject and their research with the students.

Good teaching is essential to the health of the department. Professors who provide it make an important contribution. A number of professors in the Department who have limited involvement in research receive very good and even excellent teaching ratings from students. Such professors could be asked to do an extra course/term (2 extra courses/year). This request should not be seen as punishment for not doing much research but a rationalization and realization that each member of the staff has different talents, some are best at teaching, others at research and some at administration. Ideally, each person's talents should be used to the fullest extent.

Response: The chairman agrees with the goal of providing an environment in which each faculty member contributes to his fullest in the areas in which he has established talents. The election of an academic career implies a commitment to a lifetime involved in the teaching process. Although research is a very effective method of educating scientists and maintaining current awareness in one's field, this Chairman does not

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take the view that it is an absolute requirement for all faculty through their entire professional life. Where a faculty member has chosen not to engage in research it is expected that contributions in other areas important to the university will increase.

The Chairman considers that his obligation is to foster an efficient and excellent instructional and research organization. In 1988-3 the Chairman organized teaching assignments to:

- recognize the time commitment of some faculty to graduate teaching and research. Professors who were judged to carry a heavy load in this area were expected to teach no more than two full time equivalent courses per year. Some relief from excessive grading requirements was offered to faculty with heavy research commitments who teach large enrollment first year courses.

- recognize the teaching talents of those who are only slightly active or inactive in research as judged by their published works by assigning greater teaching responsibility spanning all three semesters of the year.

CONCLUSIONS

The review process provided an opportunity for a comprehensive assessment of the Department's current strengths and weaknesses. As well it provided an efficient format for the ongoing debate of alternate strategies for improvement of the undergraduate, graduate and research components of the Department. Many of the recommendations made by the review committee were distilled from presentations made by Department members during the review. For this reason implementation of most of the recommendations of the review has been rapid.

The Department wishes to thank the university for its investment in this review process. It has had a significant positive influence on the future development of the Department.

SIMON FRASER UNIVERSITY

DEPARTMENT OF CHEMISTRY

FIVE YEAR PLAN

1989 - 1993

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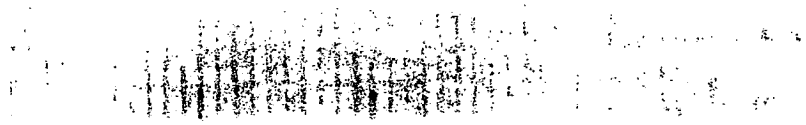

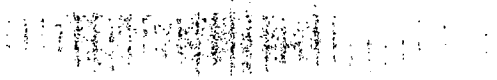

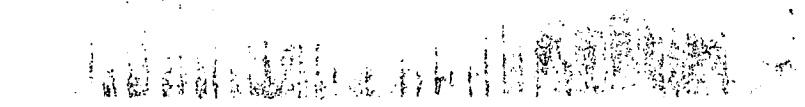

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EXECUTIVE SUMMARY

This Report contains the mission statement of the Department of Chemistry developed during an internal review in the Spring of 1987. This is followed by an analysis of the strengths and weakness of the Department identified during an external review held in 1988. Finally, a five year plan for the further development of teaching and research programs and resource planning is presented.

The present undergraduate programs in chemistry and biochemistry produce graduates that consistently place in the top 2% of all North American students taking the MCAT examinations. Our goal in the next five years is to double the number of excellent undergraduates attracted to and graduating from our majors and honors programs. The Department will further improve the attractiveness and quality of its undergraduate programs by: a) reorganization of undergraduate general chemistry and organic chemistry to present the concepts of organic chemistry earlier in the curriculum; b) upgrade of equipment in undergraduate laboratories; c) further development of curriculum utilizing computational methods; d) development of additional advanced biochemistry laboratories; and e) continued expansion of offerings into the summer semester in support of the Co-Op program. Key to our success to date and in the future are: a) maintenance of a very active high-school liaison program; b) maintenance of a program of quality assessment to ensure continued teaching excellence; and c) support of the Co-Op program. Operating budgets for the Department are 86% below 1982 levels based on increases in enrollments and running costs. In spite of the adverse economic conditions encountered during the recent past the Department has maintained excellent quality in its programs and increased research funding by 81% during the same period.

Undergraduate laboratories are under particular stress due to an increase of 82% in enrollments since 1982. Laboratory instructors and technical staff are overburdened. One additional laboratory instructor and two additional technical assistants are required to meet present demands and those anticipated from addition of advanced biochemistry laboratories. These positions as well as an additional secretarial position are justified by comparison with sister science Departments within the University and chemistry Departments in neighboring universities. An additional position is required to maintain the newly created computer resources laboratory. Approximately $175,000 per year is required to continue the upgrading of equipment in undergraduate teaching laboratories begun in 1987 and to fund new biochemistry and computing laboratories. The Department is 25-30% short of space but, this will drop to less than 20% after the IMBB building is occupied.

A most significant requirement for chemistry in terms of resource allocation is the upgrading of the ventilation in the undergraduate organic laboratories. The standard of ventilation in these laboratories predates the construction of the University. Conversion of experiments to micro-scale (~$200,000, part of the $175,000 above) coupled with movement of these

laboratories into properly ventilated facilities in the IMBB building are required to completely solve current problems of air quality in these laboratories.

The Department has set as a goal expansion of its graduate program from a current enrollment of 50 students to 80 students within the next five years. To achieve this the Department must increase its external grant support by ~11% per year. Since 1982 the Department has increased external funding at a 10% compounded rate. The dollar amounts of requests for funding to external agencies accelerated in 1988 to more than double the 1986/1987 averages. It is anticipated that the current rate of funding of applications will allow the projected growth of the graduate program.

Chemistry is central to several rapidly advancing research fronts. Most forecasts predict increased research activity in biotechnology and materials science. To position the Department at the forefront in the key basic aspects of biotechnologically related research we propose to concentrate appointments in biochemistry and organic chemistry. The overall thrust is to attract a group of faculty capable of probing the molecular basis for important biochemical processes and interfacing with those involved in the exploitation of knowledge gained in these basic research endeavors. To place the Department at the forefront of key areas of materials science in which we have a competitive position we recommend appointment of additional faculty in theoretical organic, inorganic, polymer and electrochemistry.

Developments in nuclear science are linked to the federal initiative to build a kaon factory at TRIUMF. Should this project proceed we envision expansion of this group to exploit the scientific opportunities accruing from this facility.

The highest priority for the Department is the expansion of its excellent program in biochemistry. During the next five years addition of four faculty positions in this area is anticipated. Two of these are to be funded from the IMBB initiative and two from Departmental requests. It is anticipated that by the end of the term of this plan this group will increase from 4 to 8 members and include new expertise in membrane biochemistry, nucleic acid chemistry, immunochemistry and protein biochemistry.

A high priority for the Department is addition of a senior organic chemist. This appointment and a further junior appointment in this area near the end of the plan term are fully justified on the basis of the undergraduate teaching requirements in this area and the ability of this area to attract a significant proportion of graduate students (40% at present). A senior appointment will provide a nucleus of organic chemists which will interact with both the biochemistry group and the emerging materials science design group.

The appointment of senior faculty early in the planning period would benefit the Department by: a) increasing its ability to attract the best young faculty in what is expected to be a very competitive next decade; b) increasing its ability to attract funding for big ticket capital equipment which would be of use to younger faculty; and c) increasing its ability to attract the very best graduate

students. Addition of a faculty position in the area of inorganic chemistry would ensure the continued development of this group in both synthetic and mechanistic inorganic chemistry. This combination is essential to maintenance of present group capabilities to design organometallics for use in opticoelectronic devices. In support of this initiative the Department plans to add one member in the important area of polymer chemistry. Currently SFU is the only University west of Thunder Bay that offers training in this important area, and our single polymer chemist is retiring in 1989. It is recommended that the Department attract an electrochemist to this group. The Department is considering combination of expertise in this important area with requirements in biochemistry by seeking applicants with expertise in biosensors. Much research equipment is obsolete and new faculty appointees require set up funding. An annual allocation of $300,000 is required to meet these needs of which the Department expects to obtain $150,000 annually from external sources.

I. PRESENT AND FUTURE ENVIRONMENT

The Department is located in a region that has historically depended on resource industries to provide an economic base. Higher education in disciplines not directly impacting on resource development has been viewed as a cultural endeavor but not necessary for economic progress.

Technological development is projected to be the engine that drives the economy of this region in the coming decades. As examples of regional economic expansion centered around stellar University systems proliferate, education in disciplines central to the development of new technologies can expect to receive attention from astute governments. Because of its excellent record in science education and research and as a Pacific rim University, SFU can expect to participate in the remarkable economic development predicted for this region. SFU's undeniable role in this endeavor is to supply the highly trained manpower and research base for the development of this region's exportable technologies. As a core scientific discipline, chemistry can be expected to be near the center of this technological development.

II. DEPARTMENTAL MISSION

The mission of the Chemistry Department is to support excellence in teaching and research in chemistry, biochemistry and nuclear science. The mission is carried out through delivery of its programs of undergraduate and graduate teaching and research.

1. Undergraduate Program

Majors and Honors Programs

The B.Sc. majors and honors programs in chemistry and biochemistry provide students with the intellectual underpinnings in the core areas of inorganic, organic, physical, biochemistry and nuclear science, as well as the appropriate background in the cognate areas of math, physics and biosciences. In addition, students are introduced to broader concepts through courses outside the Faculty of Science.

The programs are structured to instill in students an appreciation of the excitement and fulfillment in the pursuit of the chemical sciences. We consider the development, in students, of an appreciation for the scientific method a primary goal. Development of chemical problem solving and laboratory skills as well as written and oral communication of scientific findings and conclusions are a high priority.

Service Programs

The Department has a major commitment to serve the chemical education needs of students from biosciences, physics, kinesiology and engineering science. We also provide science electives for students from other

faculties. Students who enter University without a background in chemical concepts can currently take a semester program which then allows them to enter the general chemistry program. Due to enrollment pressures the continued offering of this service make-up program is under review. The development of the regional college system in British Columbia is expected to remove our mandate to offer these courses.

2. Graduate Program

The graduate teaching and research are key to the mission of the Department. Major emphasis has been on single-investigator-driven basic research in the forefront fields of chemistry, biochemistry and nuclear science. However, several major initiatives in interdisciplinary research are underway, and this approach is increasing in prominence. A number of projects now also involve collaborations with private enterprise (e.g., Phero Tech Inc., Moli Energy, B. C. Salmon Farmers Association, ABI Biotechnologies, Chem-Biomed, Merck Frosst, etc.).

M.Sc. Degree

The goal of our M.Sc. program is to introduce students to advanced research practice and methods through development of a research proposal and its execution. Communication skills are developed during the preparation and defense of a thesis describing the research.

Ph.D. Degree

The Ph.D. program is structured to produce mature research scientists with expertise in chemistry and biochemistry. Candidates are required to contribute significantly to a new body of knowledge through the development of an independent research program. Communication skills are developed through preparation and defense of research proposals and a thesis.

3. Research

Research is of fundamental importance to the Department. Our goal is to promote excellence in research in the chemical sciences. In support of this mission:

- We maintain experimental facilities and technical support which are at the forefront of the field.

- We provide a stimulating environment conducive to the generation of new ideas through a Departmental seminar program, participation in named corporate lectureships and an annual graduate student poster competition.

- We support travel of faculty and students to scientific meetings to present original research.

- We participate in national professional activities and in the international peer review process for selection of award winners, funding proposals and manuscripts.

- We participate in research relevant to the needs of society by participating in projects with industry, government labs and with other universities.

III. DISTINCTIVE FEATURES

1.Breadth and Interdisciplinary Nature of the Department

Modern research in chemistry is very interdisciplinary in nature and overlaps strongly with physics on the one hand and with biological sciences and molecular biology on the other. The breadth represented by the SFU chemistry Department is unique in western Canada. We have specialists with interests ranging from nuclear science to genetic engineering. Students have access to faculty with research expertise in many forefront areas including organometallics, X-ray crystallography, polymer science, gas phase reaction kinetics, organic synthesis and stereochemistry, photochemistry of inorganic and organic compounds, solid-state and surface studies and catalysis, biochemistry and nuclear science. This breadth is a distinctive strength which ideally positions us to respond to the challenges of interdisciplinary research which are emerging at the research fronts.

Faculty in Chemistry are members, along with physicists, in the Energy Research Institute, while the Chemical Ecology Research Group represents an excellent example of interdisciplinary research between chemists and biologists. The members of the TRIUMF research program are engaged in research which in many universities would fall under the label of physics. To develop capabilities in the area of biotechnology, the Department has fostered the development of the biochemistry program and the Institute of Molecular Biology and Biochemistry which have strong interactions with biosciences.

2. Pheromone Research Program

The pheromone research program is the strongest research program in the Faculty of Science in terms of the number of active research participants, level of productivity and external research grant support. It is an excellent example of applied interdisciplinary research involving faculty both from bioscience and chemistry. The pheromone research program has introduced new technologies to combat insect pests in the B.C. forestry and agricultural industries.

The members of the Chemical Ecology Research Group (CERG) have established themselves nationally and internationally. In recognition of this national stature, CERG has recently been named an Associate NRC Laboratory, and its members as Associate Members of the Biotechnology Institute in Saskatoon.

3. Biochemistry and the Institute of Molecular Biology and Biochemistry

A scientific revolution is taking place at the interface between biochemistry and molecular biology. As a result the demand for courses and research training in this area has greatly increased in the past decade. Funding agencies in the U.S. and Canada have recognized the demand by funnelling more resources into the area for training and research.

Because of its interdisciplinary nature, the SFU biochemistry program and its graduate counterpart, the Institute of Molecular Biology and Biochemistry are ideally positioned to participate in this revolution. The bridge to organic chemistry on the one hand and to more biological aspects of molecular biology on the other has not been difficult to build given the high priority the University attaches to this most important initiative in the Faculty. The development of the Institute of Biochemistry and Molecular Biology has benefitted the Departments of Chemistry and Bioscience by providing new appointments in the Institute's key areas. Future IMBB funded appointments will complement the anticipated appointments chemistry plans in the area of biochemistry

4. The Nuclear Science Program

The nuclear science program within the Department is strengthened because of the University's proximity to TRIUMF. This major national and international research facility is unique in Canada, and the nuclear science component in Chemistry is stronger at SFU than at UBC, while it is non-existent at U. Victoria.

TRIUMF represents a center of excellence for research and graduate teaching in Nuclear Science. Current research programs carried on by faculty in the Department range from the applications of muons in the study of chemical and physical systems to the investigation of nuclear reaction mechanisms and nuclear spectroscopy.

5. Co-Op Education Program

The Co-Op Education Program is a distinctive feature. Chemistry was the first experimental science Department at SFU to adopt a Co-Op education program.

6. Community Relations Programs

The Department maintains one of the most active high-school liaison programs at SFU. We are more active in this area in the Province than sister departments at the other two universities. Chemistry has taken the initiative in introducing a number of key programs including:

i) The Enrichment Program - first introduced in Science by M.L. Heit and L.K. Peterson.

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ii) The McTaggart-Cowan Entrance Scholarship - L.K. Peterson and E. J. Wells.

iii) The "Stinks and Bangs " Lecture - K.N. Slessor & D. Sutton. This has also become an important feature of all open houses.

iv) The "Chemistry in the 80's" annual symposium, which attracts 100 high school and community college teaches and top students each year. Faculty from other Departments have given generously of their time to this activity (D. Baillie, R. Mathewes, S. Nelson, L. Palmer, H. Weinberg).

IV. CURRENT UNDERGRADUATE PROGRAMS

1. Program Content and Structure

The core content of the degree program is dictated by the Chemical Institute of Canada accreditation requirements. These include a first year of general chemistry (with high school Chem 12, Math 12 and Physics 12 as prerequisites) and an additional minimum of a full year in lecture and laboratory work in each of organic, inorganic, physical and analytical chemistry. Approximately two years of math and physics are also required. Further upper level courses are required to meet a minimum of 1,000 hours of instruction in the discipline. A comparison of the SFU and UBC programs with the majority of chemistry programs across the country show them to be very similar. At SFU, the upper level elective courses reflect the breadth of the Department, allowing students options in nuclear science and biochemistry as well as in the core areas.

The first year program presents much of the material in the B.C. high school curriculum in much greater depth and introduces new topics on atomic structure, chemical bonding, thermodynamics and kinetics. This program is structured to allow students with a wide variety of high school backgrounds to develop knowledge of the fundamental concepts of chemistry for further study in the discipline or for study in other areas of science.

Courses at all levels are accompanied by tutorials. This structure effectively doubles the contact hours taught by the Department during the first two years compared to Departments that do not use the tutorial system. This large investment is constantly reviewed from the standpoint of its effectiveness in producing outstanding graduates who are conversant in their discipline. At its most recent review of the Department's tutorial system in the Fall of 1988, the faculty reaffirmed their belief that the tutorial system is effectively used in providing opportunities for discussion of important concepts.

The second and subsequent years include comparable emphasis on the fundamentals of organic chemistry, including mechanisms of reactions and synthesis; inorganic reactions including transition metal chemistry; principles of physical chemistry including quantum and statistical mechanics, thermodynamics, equilibria and chemical kinetics; instrumental methods of analysis and principles important in biochemistry and nuclear science.

Laboratory courses provide experience in synthesis and characterization of inorganic and organic compounds by spectroscopic methods. Experimental physical chemistry includes electrochemical methods and computerized data acquisition and analysis. Laboratories in biochemistry involve characterization and study of proteins and nucleic acids.

The biochemistry and nuclear science programs utilize courses in the introductory cores of chemistry and other Departments. The main body of these programs are made up of 300 and 400 level courses that introduce the advanced concepts pertinent to these fields.

V. RESOURCE INVENTORY - UNDERGRADUATE PROGRAM

1. Faculty Complement

The breadth of the undergraduate program covering all the key areas of chemistry and including biochemistry and nuclear science, is a strength. However, there has historically been an imbalance in the faculty complement between physical chemistry (9) on the one hand (with an additional 4 faculty in nuclear) , and inorganic (5) , organic (5) and biochemistry (4) on the other.

Since physical chemistry is not currently an area that attracts significant student interest, upper division teaching requirements are low in comparison to other sub-disciplines. Although faculty with expertise in physical chemistry carry most of the first year teaching load, there is still an imbalance in faculty complement. This imbalance will be addressed as new faculty are hired to replace retiring faculty over the next 10 years.

There are two professional/administrative staff. Dr. Ken Stuart is the Departmental Assistant/Laboratory Coordinator (see Resorurce Planning) and Dr. Alan Tracey is the Director of NMR Services. Each of these individuals provides a distinctly different and key service to the Department.

2. Laboratory Personnel

Laboratory Instructor Support

Chemistry currently has five full-time equivalent laboratory instructors: Evelyn Palmer (freshman chemistry) , Mel Heit (lower level) , Lee Hanlan (half-time, freshman and inorganic) , Shirley Black (organic) , Andy Yim (biochemistry) and J.C. Brodovitch (half-time, physical, analytical and nuclear). During the past six years the enrollments in our lower division laboratory courses has skyrocketed. Current staffing levels are below acceptable levels and some staff are clearly overworked.

Enrollments in Lab Courses Offered in Fall Semesters

COURSE	82-3	83-3	84-3	85-3	86-3	87-3	88-3
BICH 311	21	17	20	20	14	32	25
BICH 412	12	11	18	20	20	16	20
CHEM 106	86	100	91	76	73	51	54
CHEM 115	179	254	264	260	301	360	350
CHEM 118+119	47	61	57	86	78	80	75
CHEM 218	3	22	28	28	29	39	25
CHEM 256	65	90	107	118	160	148	170
CHEM 336	7	8	3	8	8	17	17
CHEM 356	37	24	30	35	46	36	27
CHEM 366	10	5	5	9	5	9	17
CHEM 416	0	13	7	8	8	0	8
TOTALS	431	555	564	635	639	788	786

Lower Level Lab Course Sections

LAB COURSES	81-2	81-3	82-1	88-2	88-3	89-1	
CHEM 106	1	3	2	1	2	2	
CHEM 115	1	4	2	1	6	2	
CHEM 117	1	-	-	-	-	-	
CHEM 118	-	2	2	1	3	4	
CHEM 119	-	-	-	1	3	4	
CHEM 218	-	1	1	1	2	2	
CHEM 256	1	4	3	2	6	5	
TOTALS	4	14	10 = 28	7	22	19	= 48

% increase in the number of sections = 71.4%

An increase in funding for personnel in support of our service undergraduate laboratories is important if the quality of our offerings is to be maintained. The current formula of financing allows each class to be met, taught and graded. There are no allocations for development and upgrading of laboratory experiments. If funding of development is not forthcoming, introduction of new experimental techniques will, at best, be delayed. Even in this circumstance we will loose our edge in offering superior educational opportunities to the province's youth.

Safety in undergraduate laboratories is also a key factor that must be taken into account in determining the appropriate ratio of students to laboratory personnel in the experimental sciences.

Teaching Assistantship Support

The present low level of T.A. support in chemistry is a major impediment to higher quality teaching in the first two years of the program. Teaching assistants provide direct instruction of students in laboratory techniques and underlying theory. In addition, they are crucial in the grading of weekly laboratory reports each week. Teaching Assistants also play a major role in grading problem sets and examinations in the high enrollment lecture courses.

The Department's FTE increase during the past six years was heavily skewed toward the first two years. Increased enrollment in the first year general and second year organic laboratories over the period resulted in 71% more sections. To compound the problem, salaries of teaching assistants have risen 43% during the period, so we are able to retain the services of 10% less teaching assistants in 1989 compared with 1981.

To fill part of the void, faculty now teach most tutorials and participate directly in upper level laboratory courses. In addition, each year the Department spends $30,000 to $40,000 in sabbatical and sessional replacement monies to fulfill its T.A. requirements.

It is easy to calculate that to fund the lower level laboratories at 1981 levels while paying current T.A rates would require a T.A. budget in 1988/89 of {$141,500 X 1.43 + (10 X $3,665) => } $239,000.

FTE Enrollments (Annualised)

82/83	83/84	84/85	85/86	86/87	87/88
234	239	282	280	296	~315

Teaching Assistantship Support for Undergraduate Laboratories

	1980-81	1988/89	%Change
T.A. Budget	$141,500	$183,000	+29
Base units*	275	250	-10
FTE Enrollment	250	~315	+26
Number of lower level lab sect	28	48	+71
	T.A. Stipend		
GTA1 (5BU)	$2,315	$3,355	+45
GTA2 (5BU)	$2,867	$3,975	+41
Average	$2,567	$3,665	+43

*Base units available using average cost/BU.

One can see that for the first two years of our program there is a real justification for either an additional laboratory instructor or additional T.A. funds.

Technical Staff Support

In support of the front-line instructors there are four technical support staff: Eva Derton, Tony Parsad, Edna Cheah and Sharon Hope. During the cutbacks of the early 1980's the Department was required to cut its technical staff in support of its teaching laboratories from 5 to 4. In the ensuing years the workload in these laboratories has increased by ~70% (above).

There are three additional research/teaching technicians. Ms. Marcie Tracey operates the high-field NMR and provides graduate and undergraduate instruction on the Departmental NMR instruments. Greg Owen operates the Departmental mass spectrometer for all research groups and provides service to undergraduate laboratories. Paul Saunders is resopnsible for all infrared, ultraviolet and electron spin resonance spectrometers and provides instruction on these to graduates and undergraduates.

3. Equipment for Undergraduate Laboratories

While the emphasis on laboratory course work is a major strength, the maintenance of adequate laboratory equipment a very major hurdle. There is a considerable inventory of equipment still in use which dates back to 1965-1970. Much of this equipment is now unserviceable. There is an urgent need for a major injection of new money to replace this obsolete equipment. The recent review of the Department pointed to this problem as one of significance that should be addressed. Yearly replacements of aging and obsolete undergraduate teaching equipment are funded as part of the capital budget. In 1988-89 the Department spent $79.2K of its $129K in capital allocation on replacement of equipment for undergraduate laboratories. This was a larger proportion than other science departments spent on this endeavor. Among the high priority equipment purchased this year and highlighted by the review committee were items for the advanced analytical laboratory and for development of computer interfaced experiments in advanced physical chemistry.

4. Undergraduate Laboratory Space

While the 39% increase in FTE enrollment over the period 1982 to 1988 followed a national trend, the enrollment increase in Departmental service courses was in the 95-160% range. This has resulted in capacity use of existing laboratories (below).

Laboratory Enrollments 1982-1988

Course	82-3	83-3	84-3	85-3	86-3	87-3	88-3	
Chem 115	179	254	264	260	301	360	350	+ 95%
Chem 256	65	90	107	118	160	148	170	+160%

We cannot accommodate more students in these laboratories in the Fall because we lack the physical capacity if laboratories are restricted to normal

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working hours. Even in the Spring (89-1) we turned away 46 students from 300 and 400 level laboratory courses because of space restrictions. These students will be encouraged to enroll in the courses they require for degree completion in other semesters. Scheduling laboratories outside normal working hours requires additional resources for technical support staff and equipment.

5. Study Space for Undergraduates

Study space for undergraduates in the Faculty of Science is at a premium. Additional lounges and study space are recommended, and the very wide corridors running south through the science complex should be examined as possible locations for desk space.

The Department has committed two-thirds of one trailer to undergraduates as a common room for the Chemistry Student Union (CSU). This is woefully inadequate. Other Departments have SU common rooms in the building, and appropriate space is requested for the CSU.

VI. STRENGTHS AND WEAKNESSES OF THE UNDERGRADUATE PROGRAM

1. Strength - High Quality

The Department has a demonstrable record of producing graduates with excellent training.

- SFU students have scored amongst the highest grades in North America in recent years on the chemistry portion of the MCAT examination.

- B.Sc. graduates from our program successfully pursued Ph.D. degrees at prestigious schools such as Stanford and M.I.T.

- Our graduates successfully compete for jobs in a variety of industries including analytical, plastics, polymer, paint, fine chemical and research-based companies such as Moli Energy and Phero Tech., RCMP laboratories, the AECL Radioisotope Laboratory at TRIUMF as well as in the mining and pulp and paper industries. A substantial number of graduates also enjoy successful careers in teaching.

Our success in the area of undergraduate education is attributed to a high level of **commitment to excellence in teaching (2 Master Teacher Awards since 1985)** coupled with the tutorial system that allows contact between the professor and small groups of students at all levels. The Department is one of very few in the University where undergraduate counseling and advising is performed by faculty rather than by staff.

There is an active Chemistry Student Union and an active CIC Student Chapter which is supported and encouraged by faculty. Our undergraduates hosted a Second Annual Western Undergraduate Student CIC Conference in May 1988. This conference featured four plenary lectures, and 21 poster and oral presentations by the 32 attending students.

The Department hosts an Annual Awards Ceremony at which the achievements of our undergraduates are recognized through a number of private and government funded awards.

2. Area for Improvement-Higher Undergraduate Discipline

Profile

Undergraduate Population Statistics and Trends

The Department has historically attracted a small number of declared majors to the discipline, although a high proportion of these subsequently complete a degree. In 1987 the number of declared majors (Chemistry and Biochemistry) rose to 191 compared with 133 in 1985/86. This increase was larger than at most other Canadian universities.

Unergraduate Populations 85/86

UNIVERSITY	DECLARED MAJORS, HONS		DEGREES AWARDED	
	85/86	86/87	85/86	86/87
UBC	204	228	55	67
SFU	133	191	23	29
Victoria	87	83	22	20
Alberta	56	54	11	8
Calgary	172	68	21	11
Saskatchewan	72	92	17	20
Manitoba	42	42	12	12
Guelph	168	170	48	26
McMaster	200	176	82	77
Queen's	169	166	35	32
Toronto	214	205	35	28
Western	310	298	66	55
York	176	161	29	23
McGill	128	98	27	28
Montreal	263	229	43	60
Dalhousie	139	127	41	31

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SFU Degrees Awarded

	1982	1983	1984	1985	1986	1987	1988
Chemistry	9	8	9	9	6	5	6
Biochemist	16	6	13	11	16	12	16
Total	25	14	22	20	22	17	22

There is room to increase the number of declared majors and thereafter the number of B.Sc. graduates in chemistry. **Our goal is to double the number of majors and honors students attracted to our programs within the next five years.** To achieve this we will, among other actions described below, place our very best teachers in lower division classes and provide them with adequate support to allow them to carry out effective teaching without time commitments that erode ongoing research.

3. Analytical Chemistry

Area for Improvement

An area covered in the undergraduate curriculum, but where there is a shortfall in faculty expertise, is analytical chemistry. The Department has been historically divided on the importance of the role of analytical chemistry in teaching and research. UBC has established a strong presence in analytical chemistry and given this, and our current breadth of research and teaching interests, a major development of this area would appear unjustified. Two of our faculty, Drs. D'Auria and Peterson, have developed research projects in analytical chemistry and are team teaching the 400 level course on instrumental methods in analytical chemistry.

4. The Biochemistry Program

Strong Chemical Base

The Biochemistry program has a strong base in chemical concepts. Our belief that there are good pedagogic reasons for this are supported by discussions with industrial biochemists (Merck Frosst and Genentec) who unequivocally support the view that a rigorous base in physical and organic chemistry is essential to the development of scientists who can significantly contribute in forefront areas such as biotechnology.

Areas for Improvement - Faculty Complement and Curriculum Revision

As was pointed out in the 1984 external review of biochemistry, a weakness in the program lies in the fact that the present curriculum requires addition of courses centered around protein and nucleic acid biochemistry.

A major weakness is the small number of biochemistry and organic faculty. This has been exacerbated in the former by the loss of Professor Gresser to Merck-Frosst. Our plan is to strengthen these areas, and the closely allied area of bio-organic chemistry.

5. Nuclear Science

The nuclear science minor is a potentially strong area. Although these courses have not attracted the enrollments we had hoped, the possible development of a kaon factory at TRIUMF will result in increased funding to this facility. This will give TRIUMF an opportunity to expand its staff which will, in turn, yield opportunities for increased instruction in Nuclear Science through joint and cross appointments. Student interest in this area is expected to increase in the future.

6. The Co-Op Education Program

Chemistry continues to lead within the Faculty of Science in the percentage of its students that participate in this program. While U. Victoria has a Co-Op program UBC does not. Our close physical proximity to companies in the lower mainland area gives us a distinct edge over U. Victoria.

Chemistry/Biochemistry Co-Op Education Placements

	86-1	86-2	86-3	87-1	87-2	87-3	88-1	88-2	88-3
Placements	11	15	10	12	24	15	19	35	17

Chemistry/Biochemistry Co-Op Companies
(Vancouver companies unless stated)

Summer Semester 1987

Advanced Chemicals, Langley
Diachem
Vangeochem
E.P.S.
SFU Research Laboratories
C.I.L.
AECL Chalk River, Ontario
Can Test Ltd.,
Circuit Graphics, Burnaby
I.S.L., Burnaby
Forintek
Sando Industries, Ladner
Quesnel River Pulp
CanCor
B.C. Cancer Res. Center
Dow Chemical

Summer Semester 1988

Advanced Chemicals, LangleyAECL, B.C. Hydro, Surrey
Can Test Ltd., Vancouver
Diachem, Richmond
McMillan, Bloedel
McGill University Montreal Biotechnology
Morrow Engineering, North Vancouver
Pulp & Paper Research Institute
Stuart Plastics, Burnaby
Simon Fraser University
Vangeochem
University of Toronto
Pinawa, Manitoba
Borden Chemicals, Vancouver
Chatterton Petrochemical, Delta
DOW, Fort Saskatchewan, Alberta
Dept. of National Defence, Ralston, Alta
Moli Energy Ltd., Burnaby
National Research Council, Ottawa
Pacific Biological Station, Vancouver
Reichhold Chemicals, Port Moody
Synphar, Edmonton
TRIUMF
Waring, Port Alberni
Comcor, New Westminster

Area for Improvement - Increased Summer Upper Level Course Offerings

A recognized weakness in our Co-Op participation has been the limited upper division course offerings in summer semesters. This deficiency has been substantially addressed with the summer offering of key upper division courses in organic and biochemistry. Increased staff requirements are funded from our sessional budget which has grown since sabbatical replacement funds were made available. During the next five years we envision steady growth in this program as a factor in drawing good students to SFU, and in terms of the numbers of students opting for this program. While we do not expect additional faculty will be required to specifically service this program, increasing shortfall in support staff cannot continue uncorrected.

7. Laboratory Courses in Chemistry

Rigorous Structure

A major strength of the Chemistry program lies in the separation of lecture and laboratory components. This places considerable emphasis on the observation, recording and interpretation of experimental data. The demands placed on students are far greater in our program than in those where lecture

and lab are combined. Moreover, the preparation of weekly laboratory reports assists the students in development of technical writing skills.

VII.CHANGES IN CURRICULUM WITHIN FIVE YEARS

To maintain excellence in its undergraduate program the Department continually reviews its offerings. During consideration of how to better deliver its first year program, the Department concentrated on two principal criticisms of these offerings by students: namely that a) they have previously seen a significant amount of the material and b) that the first year courses are too demanding. Although it seemed that both these criticisms could not be valid, the Department has accepted them as recognizable areas for improvement and has addressed both of them.

1. Lower Division Streaming

To provide courses tailored more closely to student backgrounds and career goals, beginning in 1987-3 the Department offered two streams of its first year courses. One is aimed at those students whose probable career choice will be one of the physical sciences, while the second was developed for those who are likely to choose a career in the life sciences. The concepts taught are basically the same, but in the former a more rigorous mathematical approach is taken.

2. Resequencing

To introduce different and exciting material at the freshman level which students are capable of mastering and as a result of recommendations made by the external reviewer, beginning in 1990-3 the Department will implement a lower division sequence in which the core organic course is given in the second semester of the first year rather than in the first semester of the second year. In the new sequence a new student will enroll in a first semester of general chemistry equivalent to that presently given. In the second semester he will have the option to enroll in introductory chemistry which he can continue in his third semester. Alternatively the second semester of general chemistry can be taken in the third semester. The ability to enroll in organic chemistry early in their academic career is seen as a distinct advantage to students for whom biochemistry and molecular biology are career paths.

Resequencing will require instruction of larger numbers of students in the parallel introductory organic laboratory courses. It is estimated that if the University is limited to its current size, facilities for approximately 500 organic chemistry laboratory enrollees (current 115 + 356 and 357 fall enrollments) will be required each Fall.

The ventilation is clearly inadequate in the current laboratory in which undergraduate organic chemistry is taught The Review Committee external member, Professor Tony Durst of the University of Ottawa, stated frankly that "The present facilities predate the construction of the University.....the situation requires immediate action." The Department proposes to partially remedy this

severe problem by initial reduction of the scale of the organic chemistry laboratory experiments by introduction of microscale exercises. Since most research techniques involve use of very small amounts of rare chemicals, students who learn micro techniques as undergraduates will have a distinct advantage in subsequent chemical studies. This conversion is therefore seen as pedagogically innovative. It is also environmentally sound and economically justifiable.

The second component of the remedy is a proposed move of this laboratory into new and properly ventilated facilities in the proposed IMBB building. This has been requested, and we understand that adequate ventilated space for an undergraduate organic chemistry laboratory is a high priority for inclusion in this building. We earnestly request that this remain a high priority as plans for this structure are finalized.

This remedy will also solve another problem, namely that we have to turn away students from laboratory courses because they are filled to capacity.

3. Upper Level Chemistry

In the last several years a number of major changes have occurred in the upper division chemistry undergraduate curriculum. The core undergraduate courses in physical chemistry, Chem 261, 361 and 362 have been revised, and a new course in kinetics (Chem 363) has been introduced. These revisions involved a rearrangement of the groupings in which concepts important in physical chemistry are presented.

Senior level organic chemistry courses have been restructured to better reflect the development of modern organic chemistry. Recommendations of an additional organic course at the 300 level were favorably received by the external review committee and the Department. This is expected to serve as a central discipline course emphasizing spectroscopic techniques.

The senior level analytical chemistry course is undergoing a major revision so that students will receive a more systematic introduction to advanced analytical techniques. Techniques expected to emerge as important are atomic absorption, x-ray fluorescence spectroscopy, HPLC, GLPC, ultraviolet and fluorescence spectroscopy and electrochemical techniques such as use of ion selective electrodes.

4. Biochemistry Program

Biochemistry remains the highest priority area for development. A revision of the present undergraduate curriculum is overdue. The present small contingent of biochemists allow only the very essential service courses in metabolism and enzymology to be offered on a regular basis. These courses are taught by Chemistry faculty R.J. Cushley, W.R. Richards, R.B. Cornell and T.H. Borgford. We currently also require two sessional appointees to fulfill minimal biochemistry offerings. New lecture and laboratory courses in nucleic acid chemistry, protein biochemistry, immunochemistry and membrane

biochemistry have been identified as highest priority for development. The offering of these courses will require additional faculty.

Development of New Biochemistry Laboratories

The development of new biochemistry laboratory courses is essential to ensure the continued development of a first class biochemistry program at the undergraduate level.

Protein Structure and Function

This laboratory course is designed to familiarize students with current methodologies for the purification, characterization and manipulation of proteins. Proteins will be isolated from both native tissue sources (beef and chicken muscle) and recombinant DNA sources (*Escherichia coli* and yeast) using standard techniques for the homogenization of tissues (Waring blender, French press, sonication) and standard techniques for the fractionation of subcellular components (centrifugation, column chromatography, HPLC). Proteins will be physically characterized by electrophoretic methods (SDS-PAGE, isoelectric focussing) and amino acid analysis (involves HPLC). A function description of the purified proteins will involve simple kinetic (catalytic) methods (fluorescence and absorbance spectroscopy).

Nucleic Acid Biochemistry

This course is designed to familiarize students with current techniques for the isolation and manipulation of nucleic acids. It will involve the purification of DNA and RNA from tissues (homogenization, ultra-centrifugation methods, microcentrifuge methods, column chromatography). Nucleic acids will be characterized by electrophoretic and spectroscopic methods (fluorescence and absorbance spectroscopy). DNA will be sequenced by the procedures of Maxim and Gilbert (chemical) and by the dideoxy method of Sanger (enzymatic) (involves polyacrylamide gel electrophoresis; requirement for gel drier and X-ray cassettes). The interaction of nucleic acids with specific drugs and proteins will also be studied.

Biomembranes

The objectives of this laboratory course are to instruct students in current methodologies for the purification and characterization of cellular membrane components. Students will use techniques for the homogenization of tissues (Waring blenders, sonicators) , extraction and quantitation of membrane lipids (solvent extraction methods: distillation of solvents, rotary evaporation, separator funnels, etc.) , and techniques for the separation and identification of individual components (column chromatography, thin-layer chromatography). Model membrane systems will be reconstituted and characterized by simple spectroscopic and calorimetric methods (fluorimetry, scanning density calorimetry).

Immunochemistry

This course will demonstrate methods for the production and purification of antibodies and the value of these proteins in science and medicine. Antibodies will be produced classically from immunized rabbits and methods will be demonstrated which are relevant to the production of monoclonal antibodies. Antibodies will be used in the detection of antigens at extremely low concentrations by the methods of radio immuno assay (RIA) and microplate assays using conjugated antibodies which have been prepared in the laboratory.

5. Nuclear Science

Major changes in the nuclear science offerings will be outside the undergraduate curriculum. Beginning in 1990 it is planned to offer a self-financing eight week Summer Nuclear Science Workshop that will train participating professionals in the techniques of radiopharmaceutical synthesis. This is an advanced technology in which British Columbia has an adaptive advantage due to the proximity of nuclear scientists and organic chemists. This important initiative is co-sponsored by the Department and TRIUMF and is spearheaded by Professor John D'Auria and Dr. Tom Ruth, a senior research scientist at TRIUMF. In recognition of Dr. Ruth's contributions to this venture he has been appointed an Adjunct Professor in the Department effective January 1, 1989.

6. Computer Laboratories in Chemistry

A revolution is taking place in the application of computational techniques to chemical problems. The Department is the Canadian leader in the introduction of these methods to the undergraduate curriculum. The new modules available to our undergraduates involve computerized structural analysis for development of organic synthetic processes, spectral analysis and simulation, molecular and reaction modelling and quantum mechanical calculations.

Development of our undergraduate computer lab has made it possible to integrate these computational techniques as well as data analysis in our third and fourth year courses. The impact of this laboratory on the teaching of chemistry can be expected to expand to biochemistry as more sophisticated graphics facilities become available for modelling biomolecules. This facility, together with a local area network and satellite facilities in individual laboratories will have a major impact on the teaching of chemistry and biochemistry at all levels. As of early 1989 the facility consists of 14 IBM PC and AT clones networked to a SUN 3/50 file server, a Roland printer and a HP plotter. The cost of the present equipment and software was $80,000.

7. Service for Non-science Students

The Department has historically offered a sequence of courses (Science and Society, The Origins of Life, etc.) which are intended as science electives for non-science students. These courses require considerable breadth in the faculty member's interests and demand a very special commitment from the instructor. Only a limited number of faculty have shown an interest in these courses (S. Aronoff, J. Walkley) but they have certainly been successful in their endeavor.

These courses generally attract a mature upper-level clientele. The sophistication of the students and the level of work required justifies renumbering as 300-level courses. This would be coincident with limiting their use by science students to use as general electives and not as electives towards the 44 hr 300/400 level requirement.

The Department considers these courses to be an important aspect of its mandate and will, within its resources, continue to sponsor their development and offering.

8. Continuing Studies Activities.

The Department's contributions in offering credit or non-credit courses in the evening, downtown or through DISC have been limited to 00X offerings. To the limited extent that these courses have been offered through Continuing Studies they have been quite successful. A future area of development which may relate to continuing studies is the Summer Workshop in Nuclear Science

VIII. GRADUATE PROGRAMS

1. M.Sc Program Structure and Plans for Improvement

High Quality

The Department graduates 3-5 high quality M.Sc. students each year. Unlike many other Canadian schools the SFU Chemistry M.Sc. is not considered a failed Ph.D. Our students compete successfully for positions in other graduate schools (eg., Toronto) and private industry. The average time to complete an M.Sc. in the Department is slightly over 3 years which is ~25% longer than at many other Canadian universities. It was determined during the recent Department Review that high course and cumulative examination requirements were the major contributing factors for lengthy M.Sc. completion times.

Our M.Sc. students currently: a) complete four courses of three credit units each; b) formulate and defend a cumulative examination on their proposed research; c) complete a suitable research project, and d) prepare and defend a thesis describing the results of their work.

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Area for Improvement - Emphasis on Research and Communication

The Department has surveyed M.Sc. requirements at other Canadian universities and determined that these requirements are unduly structured and excessive. The Department has approved an alternative program structure that decreases reliance on structured courses and will recommend to the University the necessary formal changes to its M.Sc. program. These include the replacement of the cumulative examination (Cum I) by a research report seminar course (805) in which students would normally enroll in their fourth semester. Students would be required to make written and oral reports on their research progress in Chem 805. Another seminar course, Chem 801, also requiring a student presentation would replace one of the formal lecture courses. Thus, two lecture courses, Chem 801, Chem 805 and a successful thesis examination would be required of M.Sc. graduates. The strengths of the new structure are seen in the early introduction of students to their research projects and an emphasis on research and communication skills.

2. Ph.D. Program Structure and Plans for Improvement

Good Quality

The Department graduates 5-7 Ph.D. research chemists each year. Within the group of students graduating since 1980 several have won prestigious postdoctoral fellowships in national competitions. Our graduates also compete well for positions in industry and government research laboratories. After postdoctoral studies, a few have gained academic positions in Canada (Ottawa) and the U.S. (University of California at Riverside). The Department considers that there is room for improvement in the area of producing Ph.D. graduates that are recognized as clearly outstanding.

Area for Improvement - Emphasis on Research and Communication

The length of time for completion of the Ph.D. degree is similar to the national average.Ph.D. degree requirements in the Department are: a) completion of seven lecture courses; b) preparation and oral defense of three cumulative examination papers; c) execution of a major original research project; and d) preparation and defense of a thesis describing the project. The seven course requirement for the Ph.D. is on the high side for this degree. To keep the M.Sc. and Ph.D. degree requirements consistent, the Department has approved in principle the substitution of student seminar courses (Chem 801, 802 and 805) for the three cumulative examinations. Each of the seminar courses would be given credit so only four lecture courses would be required. A group of three or four staff members could be assigned on a yearly basis so that reasonably consistent assessments would be made.

Consistent with the proposed changes to the M.Sc. program the goal of these revisions is to emphasize the research aspects of the Ph.D. degree and provide a program that hones the communication skills of the candidates. The

increasing importance of interdisciplinary research makes good communication and interpersonal skills important in graduate education.

It is recognized that introduction of these proposals will decrease the demand for graduate courses and decrease the frequency of offering and variety of courses available to graduate students. To counteract this, each sub-discipline will offer one key course in their area on a regular basis to ensure that students in all areas can meet their course requirements within a reasonable time period.

3. Seminar Program

The Department sponsors an excellent seminar program featuring internationally known scientists. This integral part of our graduate teaching and research program also attracts faculty and students from UBC and local colleges.

IX RESOURCE INVENTORY - GRADUATE PROGRAM

1. Graduate Student Support

The Department accepts about a dozen new graduate students per year. This results in a slowly growing graduate student population that currently numbers 58 of which 60% are visa students. Attraction of a significantly greater number of high quality Canadian graduate students is a goal of the Department.

Science graduate students receive most support from three sources, graduate scholarships, research grants and teaching assistantships. In successful science graduate programs, students do not take time away from experimental research to earn income to see them through graduate school. It is certainly the common practice in chemistry across Canada to provide full support for graduate students. During the last decade, the proportion of graduate student support derived from research grants and external fellowships has increased relative to that from teaching assistantships and internal scholarships.

The change which has occurred in the profile of graduate student support has placed faculty grantees in less competitive positions *vis a vis* faculty in universities where graduate research has a higher priority. Continuance of the present trend at SFU will seriously affect our ability to attract new graduate students.

The chemistry external review committee recommended that the Department pressure the administration to ensure that NSERC and other scholarship holders find SFU attractive and competitive not only in research but also from the financial point of view. The Department considers a joint effort by the University and the Department appropriate in this area. In an effort to make the yearly stipends competitive with other universities in B.C. and in the remainder of Canada, the Department now offers both M.Sc. and Ph.D. students $600 supplements (derived from NSERC operating grants) to their teaching

assistantship stipends. Additional University scholarships to major scholarship holders at competitive or higher levels would be effective in attracting more students of excellent quality, and the Department recommends this be a continuing priority of the Dean of Graduate Studies.

The Department recognizes that the driving formula for allocation of teaching assistantship funds is not the need for graduate student support. However, this important support component should be maintained at levels that enable the University to "pay an honest day's wages for an honest day's work." The funding erosion that occurred in this area during the last several years has spread more work among fewer T.A.s. In this Department graduate students now put in far more hours than the contracted time to complete their assigned tasks. This effectively negates any benefit to graduate research that this program is considered to have. The Department recommends that the University reconsider the present formulas driving teaching assistantship allocations.

2. Nonsalary University Support of Graduate Studies

The University supports graduate studies in the Department by the provision of approximately 15% of the operating budget for acquisition of supplies directly used by graduate students. This amounts to ~15-20% of the cost of supplies spent in support of this activity. The remaining cost is borne by external research grants. The Department also receives salary support for 2 technical personnel who operate major installations in mass and nmr spectroscopy as well as for a director of nmr services. By comparison the UBC chemistry Department which services three times the graduate population is catered to by over a dozen technical personnel in equivalent capacities.

The Chemistry Review committee recommended that the administration ensure that the graduate research program at SFU receive at least a competitive amount of University support compared to UBC or the University of Victoria.

3. Research Space

A detailed inventory of space (Appendix) and an analysis of the space entitlement shows that there is a shortfall of space of 16,500 sq. ft. within the Department. Of this, the most crucial shortfall is 14,300 sq. ft. of graduate research laboratory space. There is also a shortfall of 1,700 sq. ft. of office space and 500 sq. ft. of undergraduate lab space.

Amongst the most pressing needs for graduate research space are those of the biochemists. Dr. Cornell currently has 4 research personnel working in the space allocation of 2. There are also major shortfalls in bio-organic chemistry. Dr. Pinto has 10 researchers working in the space allocation of 4. The inorganic chemists are likewise crowded. Dr. Hill is working with 4 researchers in the space allocation for 2 1/2. While there have been major reallocations of space to accommodate new faculty, nevertheless it is the newer

members of the Department who are in most need of additional research space. This problem will become worse as we appoint additional new faculty.

4. Fumehood Facilities

Evolving sources of concern are health and safety in the laboratories. Of particular concern is access to fumehoods for graduate students and other researchers conducting synthetic chemistry. Over the last two decades there has been a growing awareness throughout the chemical fraternity of the toxicity and carcinogenic character of many commonly used chemicals, and the need to perform most synthetic chemistry in fumehoods. At SFU these hazards are made all the more acute by crowding in our synthetic laboratories.

In response to a report from the Department alerting the University to the critical shortage of fumehood facilities in Chemistry, a number of fumehoods will be installed in 1988 and 1989 in those laboratories involved in synthetic research. This will ease the problems of inadequate ventilation, and allow the existing laboratory space to be used more effectively. Due to the costs involved in these building modifications the only laboratories for which this remedial action is targeted are those located on the south side of the building.

The proposed fumehoods are estimated to cost $600,000, and are to be located in the following laboratories.

1988	Y. L. Chow	6 fumehoods	C7041
1988	R. K. Pomeroy	4 fumehoods	C6005
1988	D. Sutton/L. K. Peterson/R. H. Hill	5 fumehoods	C6016
1989	A. C. Oehlschlager	10 fumehoods	C7030/2

5. Graduate Student Office Space

Another safety-related consideration is the location of desk-space for graduate students. It has been common practice to accommodate graduate student desks in experimental laboratories. While in some cases this is acceptable, in synthetic laboratories where large quantities of toxic and carcinogenic materials are handled this practice is dubious at best. Moreover, the fire hazard in such laboratories suggests that using them as a substitute for office space is not to be recommended.

The removal of student desks and study areas from the experimental laboratories would increase safety practice and standards and free up more serviced experimental lab space for lab work. This ideal rearrangement is blocked by the lack of suitable office space within the chemistry complex.

6. Major Facilities

400 MHz NMR SPECTROMETER with liquid helium cooled superconducting magnet. This facility is operated by Ms. M. Tracey as a Departmental service. Purchased in 1981 at a cost of $450,000, this facility has had a dramatic impact on the research programs in inorganic, organic and

biochemistry Since its installation over half of the published work emanating from the Department has utilized this instrument in an intimate way. The machine is characterized by its high resolution sensitivity and its capability to perform complex pulsed experiments (e. g. , NOE and 2D experiments).

This facility is operated on a fully saturated seven x 24 hour day basis. The Department is upgrading this instrument in 1989 using funds from Special Projects ($40,000) , capital ($40,414) , contingency ($50,000) , special internal funds ($80,000). A 1989 NSERC equipment grant $150,000 application for this upgrade was unsuccessful and equivalent funds are being sought from other sources to allow this crucial purchase to proceed. We have requested $810,000 from the B. C. Science and Technology Research Fund for 1989 to enable acquisition of a 500 MHz instrument. The importance of this technique in biochemical research coupled with the increase in faculty in this area dictate that two high field instruments will be required in the 1990's.

250 MHz BROAD-BAND DEUTERIUM NMR SPECTROMETER This dedicated facility is operated by Dr. Cushley's research group for their research on ^{2}H nmr of membrane systems. Dr. Cushley was awarded funds for an upgrade to the computer driving and processing data from this spectrometer in the 1989 NSERC competition ($29,392).

100 MHz NMR SPECTROMETER This is a user-operated (graduate students and post-docs) service machine which is essential to all the synthetic groups in the Department. It is of recent vintage and will not be replaced over the five year term of this plan. The requirement for NMR spectra in the undergraduate teaching laboratories makes the addition of one new instrument in this class mandatory ($115,000).

60 MHz SOLID-STATE NMR SPECTROMETER This dedicated facility is used by Dr. Gay's group to measure the nmr spectra of solids which is a very specialized branch of nmr spectroscopy in which we have recognized expertise. The present machine is, in part, home-built. A replacement magnet requested in the 1989 NSERC competition ($97,123) was not funded.

NONIUS CAD-4 X-RAY DIFFRACTOMETER with a Microvax computer for data reduction and analysis. This facility is operated by Dr. Einstein's group in collaboration with other research groups in this and other Departments.

GC-FT IR SPECTROMETER This Departmental facility is operated by Mr. Greg Owen and is available to all research groups. It finds specific application in Dr. Hill's research and in the work of the pheromone group. Dr. Hill's research group has expanded to the point that an additional FT-IR instrument was required and this was funded in the 1989 NSERC Equipment competition ($32,935).

GC-MASS SPECTROMETER This Departmental facility is also operated by Mr. Greg Owen for the benefit of all research groups. It is the only mass spectrometer in the University and provides an essential service. The process of

seeking funding for an upgraded instrument with increased mass measurement capability has begun with a 1989 NSERC equipment application for $312,000.

SPECTROSCOPIC SUITE This facility is maintained by Paul Saunders for the Department. It contains several research quality infrared (1) , ultraviolet (2) , fluorescence (1) and electron spin resonance spectrometers (1). All spectrometers except the infrared and electron spin resonance spectrometers are of sufficiently recent vintage to permit their use during the next five years.

COMPUTER RESOURCES LABORATORY This laboratory is now one of the best in Canada for teaching computer methods in chemistry at the undergraduate level. It is intended to expand this facility to include capabilities that would allow it to be a resource for graduate research and courses. Indeed, the first graduate course using entirely computer mounted experiments was given in 89-1. Graduate students currently use this facility for data analysis, spectral simulation and modelling of reaction pathways and molecular structures. Additional funding is required to acquire 3D graphics capability and in-house high speed computing. In 1989 the Department awarded $40,414 from NSERC for a high quality graphics facility to be used by graduate and undergraduate research students.

NUCLEAR LABORATORY Equipment associated with the undergraduate nuclear science laboratory is also used in the research programs of nuclear scientists in the Department. This includes radiation detectors, and multichannel analyzers. Additional equipment is required for these laboratories to provide computer interfaced experiments.

CONTROLLED ENVIRONMENT CHAMBERS Several controlled environment chambers used in biochemistry and by the pheromone research group for growing plants and insects under controlled environmental conditions are nearing the end of their useful lives and need to be replaced.

CENTRIFUGES Several ultracentrifuges are used in the research and teaching laboratories essential to the Biochemistry Program. Several of these machines have reached the end of their useful lives and replacements must be sought in the near future.

TRIUMF Beyond the confines of the Department the TRIUMF facility represents a very major Departmental and University resource.

7. Library Resources

The holdings of monographs and journals are not keeping abreast of developments in many fields of chemistry and this is a cause for major concern, both from the standpoint of senior undergraduate and graduate teaching and research.

Another area of concern is the computer catalogue which is considered inefficient and cumbersome, while the microfiche are now out of date and less than useful.

Desk space surrounding the bound journals and the monographs quite inadequate, Library policy should restrict access to the journal and monograph areas to those who need to use these facilities.

Greater emphasis on data base access should be assumed by the library as it reduces its acquisition rate.

X. NEW GRADUATE PROGRAM INITIATIVES

1. Institute in Molecular Biology and Biochemistry

Consistent with the 1984 External Review of Biochemistry, the initial thrust of IMBB is envisioned to be in graduate research. The introduction of the graduate teaching program in Biotechnology requires addition of faculty with specific expertise and additional funding to be recommended by the IMBB.

The present faculty who will form the core of the proposed Institute are:

Chemistry	Biosciences
T. H. Borgford	D. Baillie
W. R. Richards	M. Smith
R. Cornell (Associate Member)	A. Beckenbach
M. Gresser (On leave)	B. Honda

It is envisaged that three biochemists will be added to the complement of faculty resident in Chemistry. The focus of interests of the new faculty wil be in the areas of protein biochemistry, immunochemistry and nucleic acid chemistry. This will allow the addition of new graduate courses and the development of research programs in these areas.

Other faculty from Chemistry who have graduate teaching and research interests in this area are:

B. M. Pinto	Conformational Studies and Antibody-AntigenInteractionNSERC Oper. $27K/yr. NSERC Strat. (Biotechnology) $63K/yr.
A. C. Oehlschlager	Enzymes in Organic Synthesis NSERC Strategic (Biotechnology) $56K/yr.

The IMBB members resident in chemistry desire to have the Department maintain biochemistry as a high priority for future faculty appointments. These IMBB members were not in favor of the Institute becoming a separate Department in the near future. In light of these attitudes the Chemistry Review Committee recommended that appointments funded by the IMBB allocation be continued to be distributed between the Departments. Hiring of new faculty for the Institute should emphasize scholars who are likely, by virtue of background and personality, to become involved in interdisciplinary research. The Department agrees with this approach and has fostered initiatives to strengthen ties between IMBB and non-IMBB members with common research interests:

1) It has fostered joint requests for funding of major equipment such as NMR and molecular graphics facilities which are crucial to research of IMBB and non-IMBB members.

2) It has fostered the formation of a Molecular Recognition Group involving IMBB and non-IMBB members to facilitate fund raising by the Development Office.

2. Nuclear Science Institute

The formation of a Nuclear Science Institute is proposed. It will function to promote research and graduate teaching in Nuclear Science, to oversee the Nuclear Science Minor and to promote the offering of workshops in Nuclear Science.

Nuclear science and radioactivity are subjects which are of high intrinsic interest to scientists and the lay public. Knowledge of these subjects is becoming more important in industry and medicine where radioisotopes find wide application. The general public wishes to be informed on matters relating to the safety of nuclear power reactors and the anticipated effects of nuclear weapons.

The teaching programs will include an expansion of the Nuclear Science Minor in the undergraduate B. Sc. program, as well as mounting of short courses and workshops. Recognized clientele include those from industry, public health and safety Departments, hospitals, high schools, community colleges and the public.

The Institute would amplify the research and graduate teaching activities in Nuclear Science by facilitating the organization of seminars and discussion groups.

The establishment of an Institute would create a Regional Centre of Excellence at SFU in Nuclear Science which would highlight to the outside world the strength of our research programs in Nuclear Science. This would serve to attract more graduate students in this area.

SFU has a strong complement of faculty in Chemistry and Physics with research and teaching interests which span the range from the more esoteric aspects of nuclear structure to the practical application of radioisotopes and nuclear techniques in chemistry, physics, archaeology, biology and earth sciences. The major research contributors in Chemistry will be:

R. G. Korteling J. M. D'Auria	Nuclear Reaction Studies Studies of Short-lived Nuclei; ISOL and Radioactive Ion Beams
P. W. Percival	Muon Spin Rotation and its Applications in Chemistry
C. H. W. Jones	Mossbauer Spectroscopy; Chemical Effects of Nuclear Processes

TRIUMF appointees who now have an affiliation with the Department include:

K. P. Jackson	Nuclear Structure Studies
T. Ruth	Production of Radioisotopes for Medical and Other Applications

The major research contributors in Physics would be:

A. S. Arrott, D. H. Boal, O. Hausser, D. Huntley, I. Thorsen, K.Viswanathan, K. Hicks

The major research contributors in Associated Departments would be:

E. Nelson- Archaeology
M. Roberts - Geography
G. Lister- Biosciences
R. Harrop- Math

The addition of new faculty is not envisaged at this point. The development of TRIUMF as a kaon factory would have a considerable significance for this Institute. It would certainly provide the opportunity for expanded staff at TRIUMF and cross appointments at SFU in conjunction with Chemistry and Physics. Expansion of the current course offerings in this area could be achieved through this mechanism.

3. Environmental Toxicology

There is increasing interest by the public and all branches of government in improving methods of disposal of toxic materials and in monitoring their levels in the environment. The Department has a long standing in development of an advanced program in this area. Due to the interdisciplinary nature of the problems of environmental toxicoloty the Department envisions developments in this area only in collaboration with other Departments in the University. To our knowledge the Deparment of Biological Sciences has the most fully developed plans to offer an advanced degree in this area.

XI. RESEARCH INTERESTS OF FACULTY

1. Current Research Interests

The breadth of graduate teaching and research programs within the Department is apparent from the tables in the Appendix There are a number of first-class research programs indicative of the excellence of the Department.

i) The chemical aspects of the pheromone research program are conducted in the laboratories of K. N. Slessor and A. C. Oehlschlager. This program has clearly established an international reputation for first-class basic

science in this field. This research is also of immediate practical importance to the forestry and agricultural industries of B. C. and of Canada.

ii) B. M. Pinto has built a first class team to study the factors influencing the conformation of organic molecules and the application of this fundamental knowledge to understanding antibody-antigen interactions. This group is one of the few groups to successfully compete to the last round in the National Centers of Excellence Competition. As of the date of this report the outcome of this evaluation is not known.

iii) R. J. Cushley is internationally recognized for his contributions to the factors that influence the ordering of molecules in membranes and the application of this knowledge in understanding the mechanism of atherosclerosis. He is a member of IMBB.

iv) P. W. Percival has developed the use of muons in the study of diverse phenomena such as diffusion in solids and the structure of free radicals. The recent discovery of Level Crossing Resonance Spectroscopy by the team at TRIUMF has established it as an exciting forefront tool in free radical chemistry.

v) F. W. B. Einstein, R. K. Pomeroy and D. Sutton have established international reputations in the fundamental study of bonding and structure in organometallic complexes. This work has important implications in the rational application of such complexes as industrial catalysts and in determining their role in nitrogen fixation.

vi) Y. L. Chow is a world authority in the chemistry of nitrosamines and their possible role as carcinogens.

vii) J. M. D'Auria, K. P. Jackson and R. G. Korteling are an internationally recognized TRIUMF team conducting research into the mechanisms of intermediate energy nuclear reactions, decay of short-lived radioactive nuclei and the production of radioactive isotope beams.

viii) I. D. Gay is a pioneering authority in the theory and use of solid-state nmr spectroscopy in the study of conformations of molecules existing in the solid state or adsorbed on solids. His work has important implications in understanding metal oxide catalysts.

ix) B. L. Funt, who is retiring in 1989, is a recognized authority in the synthesis and study of electrically conducting polymers. He has been an active member of the Energy Research Institute.

x) G. L. Malli has an international reputation in relativistic quantum mechanics.

One key to attaining excellence lies in the appointment of first-class faculty. New faculty who have been hired over the last thirteen years and are serving as centers for growth in the graduate teaching and research programs are:

Biochemistry:	R. B. Cornell (URF)	Membrane Enzymology
	T. H. Borgford (IMBB)	Site-directed Mutagenesis
	M. Gresser (On Leave)	Enzymology
Bio-Organic:	B. M. Pinto	Organic Conformational Analysis
		Antibody - Antigen interactions
Inorganic:	R. K. Pomeroy	Organometallics
	R. H. Hill (URF)	Photochemistry of Organometallics
Physical/Nuclear:	P. W. Percival	Muonium Chemistry

The Department is justifiably proud of the recent appointments Drs. Pinto, Cornell, Hill and Borgford. These faculty are rapidly establishing themselves as first class researchers and teachers.

The primary key to maintaining excellence lies in the ability of the Department to retain the services of its brightest stars. We were unfortunate to loose one of ours, Dr. Michael Gresser, to Merck-Frosst Canada, where he is currently Director of Biochemical Research. Although the door at SFU will remain open until late 1989, the competition for the services of stellar individuals is keen.

In addition to these strong research programs in inorganic, organic, biochemistry and nuclear chemistry, a number of initiatives are underway which will serve as catalysts for growth in research productivity in forefront areas:

i) The Institute of Molecular Biology and Biochemistry will serve as a major catalyst for growth in graduate teaching and research. Within Chemistry, this is expected to lead to two or three new faculty in protein biochemistry and nucleic acid chemistry.

The Institute is expected to foster development of research programs of those faculty with biochemical research expertise.

ii) Developments at TRIUMF and creation of the proposed Institute of Nuclear Science could lead to an increase in emphasis of the nuclear science related programs. The proposal to convert TRIUMF into a kaon factory is expected to be viewed favorably by the federal government. This development would involve capital expenditures of $400 million over four years and see the current operating budget of TRIUMF of $30 million grow to $80 million, that of a very major international facility.

While kaon research is not an area of immediate relevance to the SFU Chemistry Department, the injection of such major capital and operating monies will clearly benefit all areas of research in nuclear science, and will provide the

base for the continuing growth and development of TRIUMF over the next two decades.

A second, lower-cost, proposal is for an On-Line Isotope Separator (ISOL) at TRIUMF, and this could lead to the development of active research programs using the radioisotope beams available. An ISOL facility could lead to interactions with solid-state physics as well as with other groups in Chemistry.

2. External Research Grant Support

In 1988 the Department garnered $1,673,537 in research funds from external agencies (Appendix). The bulk of external research grant support is from NSERC in the form of operating, project and strategic grants. With the increasing emphasis on biochemistry funding from the B. C. Health Care Foundation ($132,501) and the B. C. Heart Foundation ($46,450) are becoming significant sources of funding. Our expertise in natural products chemistry has been recognized by the receipt of $210,650 in IDRC grants in the Department in the last two years.

The current level of external research grant support is very good indeed, and shows a significant increase over previous years. Recent grants of particular note are:

		$ for 1988
Borgford	B. C. Health Care	35,000
Chow	NSERC Operating	45,119
	NSERC Strategic	46,380
Cornell	NSERC Operating	25,000
	B. C. Health Care	35,000
Cushley	NSERC Operating	46,000
	B. C. Heart Foundation	29,450
	B. C. Health Care	25,000
Gresser	NSERC Operating	41,520
	MRC	39,000
Hill	NSERC Operating	22,000
Korteling	NSERC Infrastructure	107,000
Percival	NSERC Operating	66,000
Pinto	NSERC Operating	27,000
	NSERC Strategic	63,000
Pomeroy	NSERC Operating	32,256
Sutton	NSERC Operating	30,000

Dr. Oehlschlager attracts major research support (>$200K/yr) from several sources.

3. Assessment of Quality of Research

The only Nobel Prizes to be awarded to Canadian physical scientists during the past several decades have been in chemistry. It is arguable, therefore, that the standards against which Canadian chemical research is gauged are extremely high. Overall the research activities in the Department may be described as good with high recognition in selected areas. Two of our faculty, M. Pinto and A. C. Oehlschlager have received **national awards** for their work at SFU. The latter and Y. L. Chow have won **University Research Professorships. Nine faculty are Fellows of the Chemical Institute of Canada,** which is the largest professional scientific society in Canada.

Since the implementation of the peer review system in Canadian science and engineering in the early 1970's it was considered a safe approximation to use NSERC operating grants as an index of research quality. As Canadian science moves to the year 2000 this measure is increasingly inaccurate except for the most basic research. The number of agencies supplying peer reviewed research funds has increased dramatically. The proportion of research funding provided by NSERC operating grants to faculty in the Department has decreased from ~80% in 1978 to less than 40% in 1988.

Because of the interdisciplinary nature of the research in chemistry faculty receive their operating or project research grant support from 5 different NSERC grant selection committees:

Selection Committee	Number of Grants
Cell Biology	4
Chemistry	13
Physics	1
Sub-atomic Physics	4
Interdisciplinary	1

The philosophies adopted by these grant committees differ as do the average grants. The average operating grant obtained by faculty from all of these committees was ~$33,000 in 1988. When operating grants from MRC, B. C. Health and NSERC Strategic are added, faculty in Chemistry garner average operating funds in excess of $60,000 per annum and this by any measure is very good.

A criticism of the Department has been that the average NSERC operating grant of faculty funded from the Chemistry Grant Selection Committee is only ~80% of the national average and the Department has no faculty member commands a grant in the top 10% of grantees in this group (~$70,000). It was pointed out in the recent external review that the Department would increase its stature in the community of academic chemists by the acquisition of two or three academics that are either in this stellar category or show high probability of reaching it. The recently announced NSERC operating grants to Drs. Pinto (to ~$38K) , Pomeroy (to ~$42K) and Oehlschlager (to ~$59K)

showed increases in the 30-40% range. These were certainly the highest increases in the Faculty of Science and suggest rapid progress toward recognition for excelence in research of mainline chemists within the Department.

The average NSERC operating grant of faculty funded from cell biology and sub-atomic physics are well above the national averages for grants in these disciplines and these represent areas of strength.

A measure of the commitment to research and success in the peer review process is the steady increase in funding awarded to the faculty over the past six years. From 1982 to 1988 external funding to chemistry faculty increased 81% which is a 10% compounded rate. Over 90% of these funds were awarded in the peer review system as opposed to contract work. Sister science Departments experienced funding rate increases of 1/3 to 1/2 the rate earned in Chemistry during this period.

Other measures of quality include:

i) number of research publications in refereed journals:

1984	1985	1986	1987	1988*
(71)	(79)	(82)	(103)	(105)

*3. 75/faculty

ii) conference and seminar papers presented by faculty at national and international meetings:

1984	1985	1986	1987	1988*
(37)	(35)	(28)	(46)	(56)

*2. 0/faculty

iii) invitations to serve on national bodies and the receipt of national awards:

1984	1985	1986	1987	1988*
(7)	(8)	(12)	(16)	(14)

*0. 5/faculty

iv) the positions taken up by our M. Sc. and Ph. D. graduates when they leave SFU (see Appendix).

XI. RESOURCE PLANNING

1. New Faculty Appointments

The divisions described below are based on a purely classical view of chemistry as a discipline. By the turn of the century these will be blurred by the formation of research groups that approach research from a problem rather than a discipline orientation. Thus, physical chemists, inorganic chemists, electrochemists and theoretical organic chemists are reasonably expected to form shifting alliances to tackle problems in molecular design and properties of new materials. Biochemists, organic, inorganic, nuclear and physical chemists can also be expected to form alliances to tackle problems in biotechnology. The appointments recommended below are selected from among the many specialities available to maximize these anticipated interactions and to build on present strengths.

Biochemistry Highest Priority

The 1988 review of the Department identified biochemistry as the highest priority area for new appointments. As a key component of the revolution in molecular biology and biotechnology, this is a crucially important area in which the Department currently has an excellent reputation Our current strengths are in lipid modifying enzymes (R. Cornell) , enzymology of chlorophyll biosynthesis (W. Richards) , protein-membrane interactions (R. Cushley) and study of protein structure through site directed mutagenesis (T. Borgford). We plan to build on these strengths by adding biochemists with expertise in the study of the principal cell constituents. We envision several appointments during the next five years in the following order of priority: a senior protein biochemist to replace Dr. Gresser (Chemistry) ; b) an appointee with expertise in nucleic acid biochemistry (IMBB) ; c) an appointee with expertise in protein/nucleic acid interactions (IMBB) ; d) an appointee with expertise in membrane biochemistry (Chemistry) and d) an appointee with expertise in immunochemistry (Chemistry). These appointments will provide the impetus for continued development of Biochemistry and the IMBB. Set up costs for Chemistry sponsored appointments are expected to be $100,000 each.

Impact of Present NSERC URF Appointments

Dr. Rosemary Cornell has expertise in the area of membrane biochemistry and will be competing for a tenure-track position in this area in the next two years.

Organic Chemistry

The 1988 review of Chemistry identified the appointment of an organic chemist of outstanding reputation as the appointment most likely to benefit the Department. This review recognized the organic group at SFU as having the highest visibility and respect amongst the chemical community in Canada. The

continued development of Mario Pinto and the appointment of a senior level organic chemist would, in the view of the review committee, bring SFU to the point where it could reasonably claim an excellent graduate program in organic/bioorganic chemistry.

The research expertise of our current organic faculty are in the areas of photochemical transformations (Y. L. Chow) , chemistry of pheromones and other natural products (C. Oehlschlager, K. Slessor and E. Kiehlmann) and conformational analysis and carbohydrate chemistry (M. Pinto).

The Department is well equipped for frontline organic research and could reasonably expect to be competitive in its search for an outstanding organic chemist. It has recently committed substantial internal funding ($200,000 over two years) to the upgrade of its high field nuclear magnetic resonance spectrometer, which would certainly be required equipment for an organic chemist.

Set-up requirements would be in the range of $150,000-200,000. The Department would allocate a significant portion of its capital and renovation budget to minimize the financial impact of this authorization on the University. It would be ideal if this appointment could be linked to a Shrum Chair appointment.

Laboratory space of 2000 square feet would be required. This is expected to be available from the increased efficiency of use of existing laboratories due to installation of hooded work areas and from space vacated by Chemistry faculty moving to the IMBB building. The appointment of an organic chemist of significant stature is viewed by the Department as strategically important in its development in the next decade. As retirements occur in the next decade the University will, as a matter of policy, only approve junior appointments. Junior faculty in Chemistry will require very expensive capital items such as nuclear magnetic resonance spectrometers and mass spectrometers to conduct frontline research. It is generally expected that such items would be obtained from NSERC in national competitions. Without co-applicants with stellar reputations junior faculty would not be expected to be competitive for large ticket items. The teaching demands on organic faculty completely justify the addition of a second organic faculty member within the next five years. The Department recommends the second appointment be at the junior level. The teaching of present organic chemistry courses requires the hiring of part-time sessional lecturers on a continuing basis. Newly proposed courses cannot be offered due to faculty constraints. An additional burden will fall on organic chemistry faculty with the implementation of the new altered sequence of freshman instruction wherein organic chemistry is introduced in the second semester of the first year rather than in the first semester of the second year. The organic group has 40% of all graduate students within the Department, yet is quite small (6 of 27 with 3 of the 6 supervising graduate students). Two members (Unrau and Chow) are within a few years of retirement, and a third (Oehlschlager) has accepted a 5 year mandate as Chairman. Organic chemistry interfaces directly and closely with biochemistry. The addition of a highly reputable organic chemist within the Department would strengthen

the IMBB initiative by providing expertise in synthetic and/or mechanistic organic chemistry.

Inorganic/Organometallic Chemistry

The 1988 Review identified the inorganic group as an emerging strength. It was considered that the research profile of this group would increase substantially in the next few years. The review recommended that the Department solidify its commitment to this area by the appointment of one additional member.

This group has two synthetic inorganic chemists with expertise in transition metal chemistry (Drs. Pomeroy and Sutton) and a structural chemist (Dr. Einstein). The availability of other inorganic chemists to teach inorganic chemistry has been curtailed by requirements in other areas. Dr. Peterson's commitments to teach advanced analytical chemistry have removed him from full-time teaching of inorganic chemistry. Dr. Sutton's lecturing abilities are required in the freshman-level courses, and he has agreed to fill the void left by Professor Jones. These requirements have left the instructional capabilities in inorganic chemistry seriously depleted. Development of this group is important if the Department is to build on its existing inorganic core courses and expand offerings into materials science. There is an emerging group in inorganic chemistry with expertise in the important area of chemical vapor deposition. This group (Jones, Hill and Pomeroy) have expertise in the design and fabrication of molecules that deposit thin metallic films on existing surfaces. This technology is key to the development of new electrooptical materials. It is anticipated that the addition of one additional faculty member to this group would provide the impetus for continued development of this initiative.

Impact of Present NSERC URF Appointment

Dr. Ross Hill has expertise in the area of mechanistic inorganic chemistry. He is developing his expertise in chemical vapor deposition and will be competing for a tenure-track position in this area in the next two years.

Physical Chemistry

Five of the nine faculty remaining in late 1989 (Professor Funt retires) in this sub-discipline are active in chemical research (Bell, Gay, Malli, Voigt and Percival). Three others are active in chemically related research, such as computer-assisted instruction (S. Lower) , effect of large scale testing on the teaching of chemistry at the high school level (A. Sherwood) , and the history of Canadian chemistry (J. Walkley). Expertise in chemical research is varied and no central theme emerges. Dr. Bell is expert in photochemical processes of small organic compounds. Dr. Gay is well known for his work on solid-state NMR of catalytic surfaces, and collaborates with organic and inorganic chemists on a regular basis. Dr. Malli is a recognized expert in quantum mechanics and is credited with the significant developments in relativistic quantum mechanics. Dr. Voigt has an established reputation and expertise in the investigation of the photophysical processes of large organic molecules similar to chlorophylls.

Dr. Percival is internationally recognized as an authority on the chemistry of muonium, a cyclotron-generated isotope of hydrogen. It was the view of the 1988 Review of Chemistry that because of higher teaching demands in other sub-disciplines, addition of faculty in the area of physical chemistry must concentrate future appointments in areas projected for growth. This is undeniably in the area of materials science. Initial efforts were made to replace Professor Funt, whose teaching and research efforts are in the area of polymer chemistry. These efforts entailed the nomination of a excellent young polymer chemist to NSERC as a URF. Unfortunately this nominee was not awarded a URF and we must endeavor to fill the void left by the retirement of Professor Funt by appointment . We consider this a very important area to continue to offer courses and graduate training. It is crucial to the development of a pure research group with expertise in the molecular design of materials. The Department requests a CFL position in 1989-1990 in polymer chemistry.

Analytical Chemistry

The 1988 External Review of the Department identified Analytical Chemistry as an area that should be developed within the Department. The development of Analytical Chemistry at UBC suggests that this area should only be strengthened if the new appointee has strong research ties to established groups in the Department. Accordingly, it is recommended that an electrochemist be sought to fill the void in this area. An appointee with expertise in this area would be a logical participant in the development of a materials science research group. Set-up costs are estimated at $75,000 for this appointment.

2. Future Directions of Development in Chemistry and Biochemistry

The retirement pattern in Chemistry will also impinge on the areas of research and graduate teaching activity. Within the next seven years the following faculty will reach retirement age:

B. L. Funt (Physical Polymers) 1989
A. M. Unrau (Organic) 1991
E. M. Voigt (Physical Spectroscopy) 1993
Y. L. Chow (Organic Photochemistry) 1994

Specific Areas to be Strengthened

Biochemistry:	Protein Biochemistry - Gresser Replacement Nucleic Acid Chemistry (IMBB Funded) Protein and Nucleic Acid Biochemistry (MBB Funded) Membrane Biochemistry - Rosemary Cornell (?) Structural Biochemistry
Inorganic Chemistry:	Physical Inorganic - Ross Hill (?)
Organic Chemistry:	Synthetic Organic (Senior) Theoretical Organic
Physical:	Polymer
Analytical:	Electrochemistry

Projected Faculty Complement 1989-1994
Retirements and Resignations With No Replacements Other Than Current URF'S

Area	1988	1989	1990	1991	1992	1993	1994	1994
Biochemistry	4	-1		+1				5
				+1				
Inorganic	4			+1				5
Organic	6			-1			-1	4
Physical	10	-1				-1		8
Nuclear	3							3
Analytical	0							
	27	26	26	27	27	26	25	25

Retirements Replaced With Current URF'S and Additional Faculty According to 1988 Review

Area	1988	1989	1990	1991	1992	1993	1994	1994
Biochemistry	4	+2#	+1@	+1RC	+1			8
		-1						
Inorganic	4			+1RH				5
Organic	6		+1	-1	+1		-1	6
Physical	10	-1	+1		- 1			9
Nuclear	3							3
Analytical	0			+1				1
	27	27	30	32	34	32	32	32

1, Chem; 1,IMBB @ IMBB

Detailed Replacement Schedule by Area and Year

Area	1988	1989	1990	1991	1992	1993	1994
Bich	4	+ Protein Biochem + Nucl Acid Biochem@	+ Protein & Nucl Acid Biochem@	+ Membrane Biochem	+ Struct Biochem		
Inorg	4			+ Inorganic Photochem			
Org	6	+ Synthetic Org		- Bio-organic		+ Org	- Org Photo
Phys	10	- Polymer	+ Polymer			- Spectro	
Nucl	3						
Anal	0			+ Electrochemistry			

3. Support Staff

In comparison with our sister University Chemistry Departments we are understaffed in every category.

The Department has only one person, Dr. Ken Stuart, to act as both laboratory coordinator and Departmental assistant. The myriad of assignments borne by Dr. Stuart range from maintaining Departmental accounts ($2. 5 million/yr) to overseeing the safe operation of all Departmental laboratories. Dr. Stuart plays a pivotal role in the operation of the Department.

Laboratory Instructors, Technicians and Secretarial Support 1987/1988*

	Lab Inst.	Lab Tech.	Oth	Sec/ Admin	TOTAL	Staff/ Fac.	Sec. / Fac.	Graduates M. Sc./Ph.D.	B.Sc.
UBC	25	7	10	11	53	0.85	0.17	29	65
SFU	5	4	5	4	18	0.62	0.13	7	34
U Vic	13	4	3	5.5	25.5	1.04	0.22	3	28

*CCUCC

T. A. and Laboratory Instructor Support of Undergraduate Laboratories

As outlined under the section on graduate teaching and research there is an urgent need to increase the T. A. support to the Department by ~30% or to add an additional laboratory instructor. This is required for proper laboratory instruction and for tutorials and grading in the first two years of our program.

Undergraduate Laboratory Technical Support

Some 70 support staff positions were eliminated across the University during the cutbacks of the early 1980's. In the ensuing years the enrollment has substantially increased, forcing the extra workload on fewer shoulders. This is demonstrably true in the Department's undergraduate laboratories, where the workload is directly related to the enrollments. Here, the total undergraduate enrollment has increased 60% since 1982, while the technical staff in support of undergraduate laboratories decreased from 5 to 4. The present technical staff are stretched to the limit. Each year we have been forced to hire additional temporary technical support to maintain minimum safety margins in the Fall and Spring semesters. Increasing numbers of stress-related sick leaves are requested by staff. The University is certainly cognizant of the risk inherent in having overworked technical staff overseeing student work with hazardous chemicals.

The reinstatement of one technical staff position and the addition of a second position is justified by the present enrollments and projected development of further advanced biochemistry laboratories. Our immediate needs are in the area of reagent preparation for lower level courses and

development of experiments in advanced inorganic and analytical chemistry laboratories. Also, the development of new biochemistry laboratory courses will require additional technical support staff. The immediate addition of one technical support staff position followed by a second within two years is recommended.

Computer Laboratory Resource Person

The continued success of the Chemistry Computer Laboratory will rely in major part on the presence of a Resource Person to coordinate the purchase, installation and servicing of equipment, implementation of software and to assist faculty and students in the use of computers in their work. It is realistic to expect a full-time position at the Grade 10 Technical Support Staff position to oversee this $200,000 facility.

Secretarial Staff

The Department currently has 4. 0 secretarial staff positions servicing 29 faculty (including URF's). Bev Ward is secretary to the Chair, Penny Snell is responsible for all undergraduate matters, Nancy Milliken is responsible for all graduate matters and Lucy Arratia-Perez has primary responsibility for manuscript and report preparation. We currently operate with a faculty to secretary ratio of >7:1, which is double the accepted range of 3-5:1 for professional:secretary ratios. The current situation places chemistry faculty at a disadvantage with respect to the execution of quality teaching and research. It has also led to a situation wherein chemistry had seven secretarial candidates come and leave during November 1987 to January 1989.

Arguments for an additional position are based on actual work performed and projected:

1) The increase in undergraduate enrollment requires the preparation of more teaching materials in larger quantities. All course outlines, problem sets, exams, workbooks and laboratory manuals associated with teaching both undergraduate and graduate students are the responsibility of the office staff. Because of the shortage of office staff many faculty presently prepare and photocopy their own teaching materials.

2) The preparation of promotional material and correspondence associated with the selection of graduate students, scholarship correspondence, and undergraduate and graduate record keeping are the responsibility of the office staff. Because of the shortage of office staff we now have faculty performing the record keeping duties.

3) The increase in the number of faculty active in writing research proposals (Percival, Pinto, Hill, Cornell and Borgford) has caused an increase in workload. In 1982 there were 14 proposals prepared, resulting in $467,066 in funds. In 1988 there were 35 proposals prepared, requesting $2,354,457 in funds. Even though 1988 was a year when less than ten faculty were required to request NSERC operating grant renewal, requests for external funding were

generated at twice the rate experienced in 1987. The rate of proposal formulation is expected to increase slightly if no secretarial support is forthcoming but substantially with more support. In many instances proposals are completely prepared by the faculty because insufficient staff time is available.

4) The faculty of the Department report at meetings and publish comprehensive accounts of the work carried out in its laboratories. The increase in the number of graduate students and postdoctoral research fellows in the Department increased research productivity. In 1982 approximately 342 manuscript pages were processed, while in 1987 this figure rose to approximately 679. Viewed from the standpoint of published papers, the Department published over 100 research papers in 1988, which is a 50% increase compared to 1984. Numbers of papers presented at scientific meetings have increased by similar amounts (56 in 1988) during the last four years.

Most faculty prepare their own manuscripts for publication. There are not enough support staff even to get expeditious printing of manuscripts. Similarly, abstracts for meetings are often prepared in final form by faculty rather than by secretarial staff.

5) Preparation of correspondence concerned with refereeing proposals and manuscripts is a function for which the office staff is responsible. Again, because of the shortage of staff faculty can be found preparing the final drafts of these documents.

6) The Department conducts the most active Community Liaison Program in the Faculty of Science. In addition to participation in Enrichment, Science Day and Futures it runs a program in Science in the 80's and organizes an Annual Awards Day in which parents come to the University to take part in the achievements of their offspring. Given sufficient secretarial support the Department plans to offer summer Saturday workshops for high-school teachers during the summer of 1989.

7) The Department conducts an active seminar program and organizes an annual poster competition for its graduate students. Both of these activities require secretarial support.

8) Preparation of all curriculum vitae updates for funding proposals as well as salary, promotion and tenure considerations are the responsibility of the office staff.

9) Special projects which will cause a heavy load on office staff in the coming year are the search for a replacement for Mike Gresser and recruitment of additional positions requested above.

The execution of secretarial jobs by faculty directly affects the idea generation and instructional time available to faculty. The University loses research productivity and teaching effectiveness by this practice.

There are just 3 secretarial staff in the General Office and this is not sufficient to meet our needs. The appointment of one new full time secretarial position is immediately required. Additional positions should be allocated on a formula basis.

The Department requests equity with its sister Departments and asks the University to provide secretarial staff on a formula basis throughout the University to academic and administrative Departments.

Present Situation:
29 Faculty
5 Lab Instructors
57 Graduate Students
25 PDF and Research Associates
3 Secretaries in General Office and
1 Chairman's Secretary.

This is lowest ratio of secretarial support to faculty and active researchers in the Faculty of Science.

Comparison of Secretarial Support in Experimental Departments in the Faculty of Science

Department	Fac/Sec	1987FTE/Sec	1987Grant$/Sec
Chemistry	7.2 (5.8) *	80 (64) *	287,583 (230,067) *
Biosciences	4.9	74	249,949
Physics	6.7	67	372,810

(*) = Effect of adding 1. secretarial position to Chemistry

4. Capital Equipment Requirements

Over the last 15 years the University has failed to fully recognize the need to establish the appropriate funding to:

i) service, maintain and upgrade major experimental facilities;

ii) replace obsolete equipment - both minor equipment and major facilities;

iii) provide new equipment in new experimental areas where new techniques have developed;

iv) provide equipment for new faculty.

In a typical year the Department obtains approximately 20% of its Capital request. Even if one assumes the average lifetime of equipment is 15 years, the growth in requirements due to enrollment increases coupled with low allocations has caused a crisis in this area. This has led to the following problems.

i) Teaching laboratories are attempting to function with large inventories of obsolete equipment, some of which dates back to 1965-70.

ii) Several major facilities purchased in large measure with major equipment grants through Debenture Funding, NSERC, etc. and which were

once state of the art, are fast becoming obsolete and should be upgraded or replaced over the next 5 years.

iii) Maintenance contracts have not been taken out on any of our major pieces of equipment because of the cost involved. However, this means we are living on borrowed time, and as equipment breakdown becomes more common major costs will be incurred.

iv) New technological advances are leading to rapid changes in experimental methods and equipment. If research programs are to remain at the forefront, new state of the art equipment must be purchased on an ongoing basis.

v) New faculty who will be appointed over the next 5 years will bring with them demands for new equipment and facilities.

Equipment for the Teaching Laboratories

Acquisition of equipment for undergraduate laboratories is a very high priority for the next five years. For the first and second year laboratories alone we have identified amongst the lower-cost, general-use equipment some $145,000 worth of equipment which should be replaced immediately (see below).

If some of the specialized higher-cost equipment is included (i. r. spectrometers, analytical gas chromatographs, etc.) and if equipment for the upper level laboratory courses is considered, the replacement cost will be several times this figure.

Obsolete Equipment in Introductory Lab Courses

Equipment	Courses	#	Year of Purchase	Unit Price	Replacement
Spectrophotometers	115, 118,	20	1965	1,500	30,000
(Spectronic 20's)	119, 218	5	1970		
Balances		16	1965	1,900	38,000
Analytical	106, 115	4	1970		
Top loading	115	5	1970	350	1,750
pH Meters					
Corning 5's	118,119,	14	1965	600	10,800
1L's	218	4	1970		
U. V. -Visible Spectrophotometer	218	1	1965	20,000	20,000
Gas-Chromatograph	218	1	1970	20,000	20,000
Spectropolarimeter	256	1	1969	4,000	4,000
Recorders	218, 256	4	1969	1,650	6,600
Ice Machines	115, 106	2	1970	3,000	6,000
General lab equipment including heaters, stirrers and variacs			1969-70		8,000
Total Replacement Cost					$145,150

The cost of conversion of the organic laboratories to miniaturized experiments coupled with resequencing teaching requirements (500 students per semester in laboratory sessions of 72 students each) is approximately $226,000. This includes the following items:

500	Micro Kits	@ $ 176	= $ 88,000
5	Balances(0. 1mg)	@ $ 1,600	= $ 8,000
62	Stirrer, Hot Plates	@ $ 200	= $ 12,400
48	Pipetters (5-1000 microL)	@ $ 100	= $ 4,800
2	FT Infrared Spectrometers	@ $27,000	= $ 54,000
4	Refractometers	@ $ 4,000	= $ 16,000
1	Gas Chromatograph	@ $19,000	= $ 19,000
2	G. C auto injector	@ $12,000	= $ 24,000
			$ 226,200

The estimated cost savings in reduced cost of chemicals will be $25K per year not including the skyrocketing cost of disposal.

In addition to this there is also much obsolete instrumentation in the upper level laboratory courses in need of replacement.

Analytical Chemistry	$ 100,000
Computer Laboratory	$ 100,000
Organic Chemistry	$ 25,000
Physical Chemistry	$ 50,000
Inorganic Chemistry	$ 25,000

A time-frame of 5 years for these purchases is reasonable.

5. Development of New Laboratories in Computational Chemistry

The Computer Laboratory in Chemistry is the focal point for applications of microcomputers in teaching. This facility, will expand to several locations throughout the Department, all linked through a Local Area Network. These satellite locations will serve the undergraduate laboratories and students with computer applications related to their lecture courses and research. Initially, the emphasis will be on serving students in the 300 and 400 level programs.

It is expected that if the Department is to remain at the forefront of the application of microcomputers in teaching over the next five years this facility will need to be expanded to a total of 20 microcomputers with a laser printer and a graphics station, and to add a graduate computing research facility. In-house high-speed computing will be required as we introduce biomolecule modelling, the computer simulation of experiments not otherwise readily performed in the laboratory, and analysis of 2D nmr data.

The capital cost of these improvements is estimated to be $100,000 over five years. We have received $40,414 of this amount from NSERC, and hope to raise the difference from University and private sources. The acquisition of a Grade 10 Technical Support staff member to oversee the facility is required.

6. Requirements for Research Equipment

It is realistic to anticipate total equipment requirements in Chemistry over the next 5 years to be approximately $2. 5 million. The Department expects to obtain $100,00 to $200,000 per year from external agencies to upgrade some of its research equipment. This will leave a shortfall of $1.5 million which we hope can be supplied by the University.

The Department submitted requests for $844,500 worth of capital equipment in 1988. This is roughly equivalent to what was requested by the Department in the previous four years. We obtained $114,000 in equipment in the 1988-89 competition, which is also roughly equivalent to the sum obtained in the previous four years.

NSERC Grant Applications - 1988

Major Equipment Applications

A. C. Oehlschlager	Departmental Mass Spectrometer ($312,000)
A. S. Tracey	New Console upgrade for 400 MHz NMR Spectrometer ($150,000)

Minor Equipment Applications

T. J. Borgford	Fermenter (20 L). ($39,295)
Y. L. Chow	Capillary Gas Chromatograph ($21,785. 08)
R. J. Cushley	NMR Data System ($35,691, awarded, $29K)
I. D. Gay	Magnet for Solid State NMR ($97,123)
R. H. Hill, D. Sutton	FT-IR spectrophotometer ($32,935, awarded)
A. C. Oehlschlager	Gas Chromatograph ($18,380)
L. K. Peterson	Atomic Absorption Spectrometer ($45,000)
B. M. Pinto	Molecular Graphics Facility ($40,414, awarded)
R. K. Pomeroy	Rocking Autoclave ($11,600, awarded)
W. R. Richards	HPLC System ($18,926. 30)
S. Tracey	Molybdenum - 95 NMR Probe ($20,352)
J. D.'Auria, G. Roy, U. Alberta	ECR Ion Source (~70K)

Major Facilities

Facility	Operator	Purchase Date	Replacement Value $	Anticipated Future (1-7 years) Expenditures
400 MHz NMR.	Tracey	1981	450,000	Immediate Replacement of Computer* $200,000
250 MHz NMR	R. Cushley group	1983-86	180,000	Replacement in 5-7 yrs $200,000 ($35,691. 70*)
100 MHz NMR	Users	1984-86	180,000	Second installation $130,000
60 MHz NMR solid-state spectrometer	D. Gay	1975	150,000	Complete replacement needed $150,000 2 years ($97,123*)
FT-IR	G. Owen	1984	180,000	Additional Instrument Immediately Required for Inorganic Research ($50,000)
GC-mass	G. Owen	1979-83	200,000	Complete replacement spectrometer in 2 years, $312,000 (higher mass machine*)
X-ray Diffractometer group	F. Einstein	1981-85	280,000	New graphics terminals $50,000
Spectroscopic Suite	P. Saunders	1967-83	200,000	Replacement i. r. and u. v. machines $120,000
Microcomputer Laboratory	R. Korteling	1986	55,000	A $150,000 facility. Graphics within 3 yrs.
Nuclear Lab	J. Brodovitch	1967-80	80,000	New multi-channel analyzers etc. $50,000
Environmental Chambers	Pheromone Group and Biochemistry	1970-80	100,000	On going servicing and replacement $15,000 per annum
Centrifuges	Biochemistry	1968-80	220,000	Replacement over 5-7 years$200,000

*Requested in 1989 NSERC Equipment Competition.

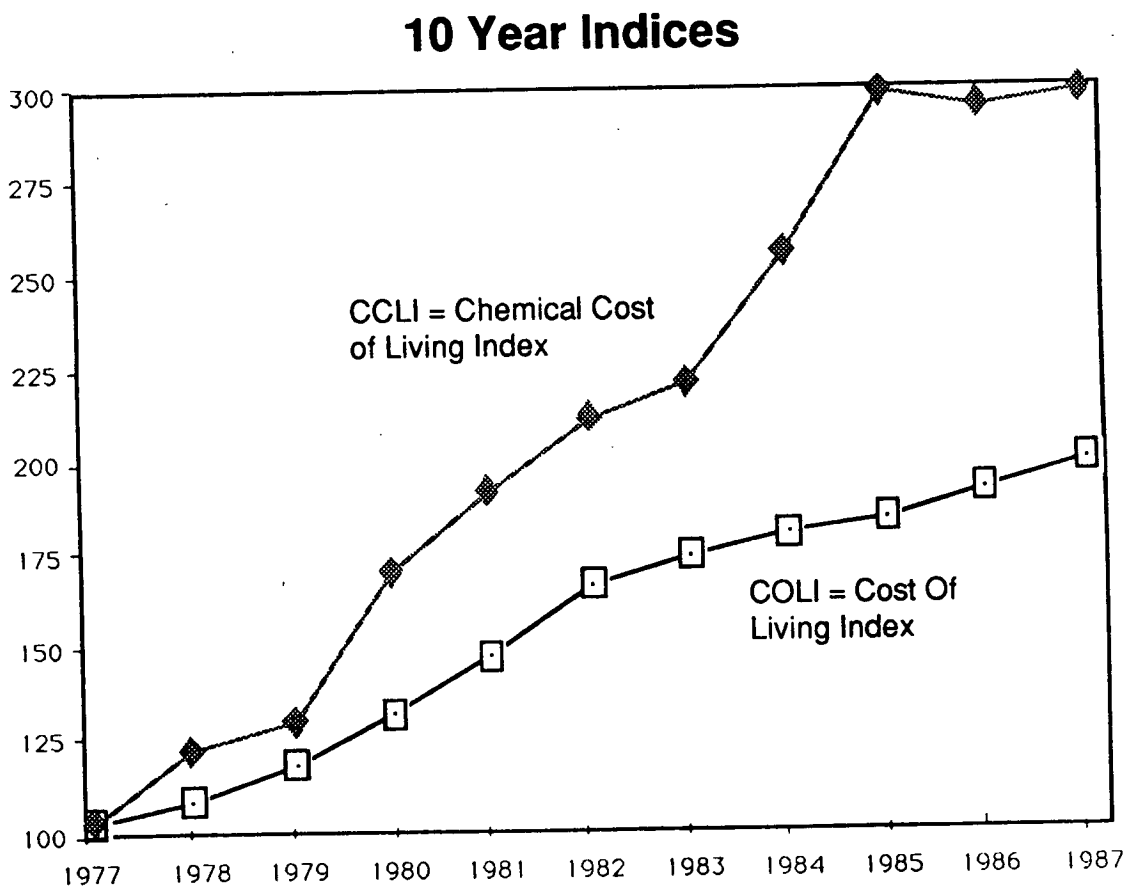
Research Equipment for New Faculty

The new faculty will require start-up funds and new equipment. A minimum of $75,000 start-up costs per appointment is realistic.

7. Operating Fund Requirements

Between 1982 and 1988 the operating funds to the Department declined from $316,595 to $312,202, which represents a decrease of 1. 5%. During this time undergraduate enrollment increased from 243 (FTE) to 315 (FTE) , or 30% and the graduate enrollment increased from 33 to 57, or 73%. Our ability to provide materials and supplies in support of these instructional activities has been further eroded by inflation in the cost of chemical supplies that has been far in excess of the Cost of Living Index (see below).

CHEMICAL COST OF LIVING INDEX VS COST OF LIVING INDEX



Data compiled by the Committee of Canadian University Chemistry Chairmen
Costs of common laboratory chemicals, glassware, and equipement.

During the 1982 to 1988 period the cost of common chemical reagents and equipment used in most undergraduate and graduate laboratories increased by 43%, compared with an increase in the Cost of Living Index of 21%. Based only on our undergraduate enrollment increase and the increase in the chemical cost of living index our operating grant is 86% less than the 1982 funding level. While we recognize that the entire University was required to adjust its spending patterns during the last six years, we doubt that the adjustment to a higher efficiency operation has been as dramatic as it has been in Chemistry. We recommend that the administration examine very carefully the efficiency of University units when additional resources are made available for "catch-up". Chemistry's record is clear. During the period between 1982 and 1988 we suffered a 86% loss in revenue based on 1982 entitlements. During this time we increased our external grant funding by 81%. We doubt that any other unit can match this record of funding achievement while producing graduates that are clearly in the top 5% of all graduates in North America.

8. Space Requirements

Immediate Space Needs

There is an immediate shortfall of 16,500 sq. ft. of research and office space in the Chemistry Department. Space is now the most immediate limiting factor in the development of the Department. The immediate concerns can be ranked as follows:

i) The most urgent requirement is for the installation of new fumehoods which allow the overcrowded synthetic laboratories to be more efficiently and more safely used.

ii) Additional research spacemust be found, particularly for Drs. Pinto, Tracey, Cornell, Hill and Pomeroy. The required area for these 5 faculty alone is 6000 sq. ft.

iii) Space for new appointments in Biochemistry must be given high priority. Each new faculty member should be provided with a minimum of 1,000 sq. ft. of serviced laboratory space.

iv) New desk space for graduate students is also a high priority. This would allow space to be freed up in the experimental laboratories and thus increase safety.

v) Study space for undergraduates. The lounge space on the 9000 level should be examined as a possible area for higher-density study space for undergraduates.

Reallocations of Space (short term)

The reallocation of existing space has been actively pursued over the last 8 years. Extensive reallocations involving EMV, BLF, TNB, AGS, CHWJ,

WRR, FWBE, EJW, JW, YLC and ACO were required to free-up space for the new faculty, PWP, RKP, BMP, RHH, RBC and TB.

Further space allocations are envisaged which will lead to a more equitable distribution within the Department. These will involve making use of the room presently occupied by the neutron generator, moving the radiochemistry teaching laboratory, and the swapping of labs between individual faculty. However, such reallocations cannot solve the shortfall of research and office space of 16,500 sq. ft.

The space currently available in trailers is as follows:

1500 sq. ft. TRIUMF office space

1000 sq. ft. K. N. Slessor research space

500 sq. ft. Graduate Student Study space

300 sq. ft. Undergraduate Student Common Room

While this space is extremely valuable, it does not impinge in any major way on the current or anticipated space requirements.

9. Projected Enrollment in the M. Sc. and Ph. D. Programs

Expansion of the graduate program to achieve a graduate student to active research faculty ratio of 3:1 is desirable from the standpoint of pedagogy and development of the Department. Given the projected faculty complement in five years this would mean ~80 graduate students. The projected areas of growth are (in decreasing order) biochemistry, bio-organic chemistry, inorganic chemistry and nuclear science.

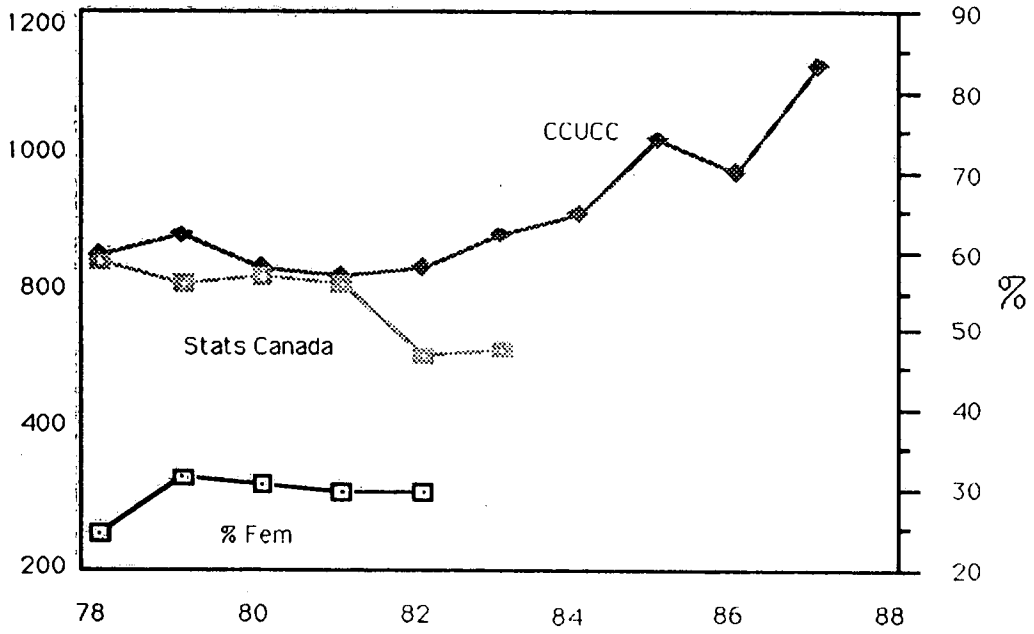
Projected Graduate Enrollments by Area

	Org	Biochem	Inorg	Phys	Nucl	Total
Current Program	18	8	8	9	3	46
5 Year Projection	25	25	15	10	5	80

Attainment of this goal primarily depends on the success of faculty in competition for research grants. During the last six years the external funding garnered by faculty has increased at a 10% compounded annual rate. This is nearly the rate [(11+COL) %] required to sustain the 11% per annum growth in our graduate program that is considered desirable. Given the activity in fund requests that has been evident in the Department in 1988 (15 equipment NSERC applications vs a yearly average of 3-4) , and the fact that we are adding new faculty who are attracting funding in excess of 20% compounded rates, this goal is achievable. The Department must assume that that the University will not redress the shortfalls in either T. A. allocations or space.

If NSERC reinstates the 33% rule we may face a problem in the short term in that there is a restricted pool of Canadian graduates on which we can draw. However, the number of B. Sc. 's in Chemistry graduating from Canadian universities has been increasing and this is a very positive sign.

B. Sc. Awarded



A major source of very high quality international graduate students is mainland China. There are currently 15 Chinese students enrolled in our M. Sc. and Ph. D. programs. University funding of scholarships for the Chinese students would further develop this international collaboration. There is a significant shortfall in research space at the present time. An additional 30 graduate students will require 6000 sq. ft. more research space and 1200 sq. ft. of office space. Approximately 8200 sq. ft. of laboratory space will be vacated by IMBB members when they move into the new IMBB building in 1991. All office space vacated (~650 sq. ft.) will be required for faculty and instructors. Since 25 of the projected 80 students are associated with these faculty the graduate enrollment competing for space in chemistry will be increased only from 50 to 55. Thus, it is not envisioned that space considerations will be a major factor limiting growth of our graduate program, providing faculty and students are satisfied with the current shortfall conditions.

10.CHEMISTRY DEPARTMENT FIVE YEAR PLAN COST PROJECTIONS

	1988	1989	1990	1991	1992	1993	1994	
PERSONNEL								
NEW FACULTY	1	2	2	3	2	1		
RETIREMENTS AND RESIGNATIONS		2		1		1	1	
TOTAL FACULTY INCL RC, RH in 1991	27	27	29	31	33	33	32	
GRADUATE STUDENTS	47	52	56	62	68	74	80	
TEACHING ASSISTANTSHIP SUPPORT 1.05/YR		183000	192150	201758	211845	222438	233560	
SCHOLARSHIP AND GRANT SUPPORT		441000	513450	616643	726555	843162	1014440	
POST DOCTORAL FELLOWS 25 x 25000 X 1.05/YR		625000	656250	689063	723516	759691	797676	
MATERIALS AT 300/MONTH		277200	291600	313200	334800	356400	378000	
TOTAL EXTERNAL SUPPORT REQUIRED		1343200	1461300	1618905	1784870	1959254	2190116	
SPACE REQUIRED								
RECOVERED FROM IMBB MEMBER REALLOCATION								
RECOVERED FROM IMBB BUILDING					-8981			
OFFICE SHORTFALL	1600	1900	2380	2710	560	800	920	
RESEARCH LAB SHORTFALL	12600	14320	15100	15320	6269	8269	9269	
UNDERGRADUATE LAB SHORTFALL	493	493	542	597	-644	-708	-779	
TOTAL SHORTFALL	14693	16713	18022	18627	6185	8361	9410	
SHORTFALL AS FRACTION OF ALLOCATION	0.29	0.33	0.36	0.37	0.12	0.17	0.19	
SECRETARY	4	4	5	5	5	5	5	
LABORATORY INSTRUCTORS	5	6	6	6	6	6	6	
LABORATORY TECHNICIANS	4	5	5	6	6	6	6	
COMPUTER RESOURCE PERSON	1	1	1	1	1	1	1	
EQUIPMENT FOR UNDERGRADUATE LABS								
LOWER LEVEL	23700	29000	29000	29000	29000	29000	29000	
ORGANIC MICRO		113000	113000					
UPPER LEVEL								
ANALYTICAL	35000	20000	20000	20000	20000	20000	20000	
BIOCHEMISTRY	4000	40000	40000	40000	40000	40000	40000	
COMPUTING	30000	20000	20000	20000	20000	20000	20000	
INORGANIC	0	5000	5000	5000	5000	5000	5000	
ORGANIC	3500	5000	5000	5000	5000	5000	5000	
PHYSICAL	13000	10000	10000	10000	10000	10000	10000	
TOTAL UNDERGRADUATE EQUIPMENT	109200	242000	242000	129000	129000	129000	129000	1000000
RESEARCH EQUIPMENT								
NSERC, MRC, BCHCRF, BCSC	125360	200000	150000	150000	150000	150000	150000	950000
UNIVERSITY								
NEW FACULTY	125067	200000	200000	175000	200000	100000	10000	885000
EXISTING FACULTY	174000	100000	100000	100000	100000	100000	100000	600000
TOTAL RESEARCH EQUIPMENT	424427	500000	450000	425000	450000	350000	260000	2435000

Appendix

DEPARTMENT OF CHEMISTRY

AREAS OF GRADUATE TEACHING AND RESEARCH

PHYSICAL	Gas Phase Kinetics	T. N. Bell, A. G. Sherwood
	Polymers	B. L. Funt
	Spectroscopy	E. M. Voigt, I. D. Gay
	Surface Studies & Heterogeneous Catalysis	I. D. Gay
	Solid State NMR	
	Theoretical Studies	G. L. Malli
INORGANIC	Photoinorganic Chemistry	R. H. Hill
	Transition Metal Chemistry	R. K. Pomeroy, D. Sutton,
	Organometallics	L. K. Peterson
	X-ray Crystallography	F. W. B. Einstein
	Main Group Chemistry	C. H. W. Jones
ORGANIC	Isolation Characterization and Synthesis of Pheromones	A. C. Oehlschlager K. N. Slessor
	Photochemistry of Nitrosamines	Y. L. Chow
	Phytochemistry	E. Kiehlmann
	NMR Conformational Studies	B. M. Pinto
BIOCHEMISTRY	Chlorophyll Biosynthesis	W. R. Richards
	NMR Studies of Model Membrane Systems	R. J. Cushley
	Site-Directed Mutagenesis	T. H. Borgford
	Antibody-Antigen Interactions	B. M. Pinto
	Structure and Function of Membranes	R. B. Cornell
	NMR Studies of Vanadium Biochemistry	A. Tracey M. J. Gresser
	Enzymes in Organic Synthesis	A. C. Oehlschlager
NUCLEAR	Intermediate Energy Nuclear Reactions	R. G. Korteling K. P. Jackson
	Nuclear Spectroscopy	J. D'Auria
	Muonium Chemistry	P. W. Percival
	Mossbauer Spectroscopy	C. H. W. Jones

FACULTY BY RANK, AREA OF INTEREST AND YEAR OF ATTAINMENT OF 65

NAME	RANK	AREA OF INTEREST	YEAR
Bell, T. N.	Professor	Physical Chemistry	1997
Borgford, T. H.	Assistant Prof	Biochemistry	2020
Chow, Y. L.	Professor	Organic Chemistry	1994
Cornell, R. B.	Asst. Prof. (NSERC URF)	Biochemistry	2018
Cushley, R. J.	Professor	Organic & Biochemistry	2001
D'Auria, J. M.	Professor	Nuclear & Radiochemistry	2004
Einstein, F. W. B.	Professor	Inorganic Chemistry	2005
Funt, B. L.	Professor	Physical Chemistry	1989
Gay, I. D.	Professor	Physical Chemistry	2004
Gresser, M. J.	Assoc. Prof (on leave)	Biochemistry	
Hill, R. H.	Asst. Prof. (NSERC URF)	Inorganic Chemistry	2023
Jones, C. H. W	Professor, Dean of Science	Nuclear/Radiochem/Inor	2006
Kiehlmann, E.	Associate Prof	Organic Chemistry	2002
Korteling, R. G.	Professor	Nuclear & Radiochem.	2002
Lower, S. K.	Associate Prof	Physical	1998
Malli, G. L.	Professor	Physical & Theoretical	2003
Oehlschlager, A. C.	Professor	Organic & Bioorg. Chem.	2005
Percival, P. W.	Professor	Nuclear Chemistry	2013
Peterson, L. K.	Associate Prof	Inorganic Chemistry	2000
Pinto, B. M.	Assistant Prof	Organic/Bioorg. Chem	2017
Pomeroy, R. K	Associate Prof	Inorganic Chemistry	2010
Richards, W. R.	Associate Prof	Biochemistry	2003
Sherwood, A. G.	Associate Prof	Physical Chemistry	1995
Slessor, K. N.	Professor	Organic & Biochemistry	2003
Sutton, D.	Professor	Inorganic Chemistry	2002
Unrau, A. M.	Professor	Organic & Biochem.	1991
Voigt, E. M.	Professor	Physical Chemistry	1993
Walkley, J.	Professor	Physical Chemistry	1996
Wells, E. J.	Associate Prof	Physical Chemistry	2001
Tracey, A. S.	Director, NMR Services	Applications of NMR in Biochem.	

EXTERNAL RESEARCH GRANTS JANUARY - DECEMBER 1988

GRANTEE	TYPE	AMOUNT
Bell, T. N.	NSERC Operating	13,000
Borgford, T. H.	BC Health Care	35,000
Chow, Y. L.	NSERC Operating	45,119
	NSERC Strategic	46,380
Cornell, R. B.	NSERC Operating	25,000
	BC Health Care	35,000
Cushley, R. J.	NSERC Operating	46,000
	BC Heart Foundation	29,450
	BC Health Care	25,000
D'Auria, J. M.	NSERC Project	20,000
(with L. K. Peterson)	B. C. Salmon Farmers (7,590)	3,795
Einstein, F. W. B.	NSERC Infrastructure	29,760
Funt, B. L.	NSERC Operating	22,000
	NSERC Strategic	35,600
Gay, I. D.	NSERC Operating	24,134
Gresser, M. J.	NSERC Operating	41,520
	Medical Research Council	39,000
	B. C. Health Equipment Grant	37,501
Hill, R. H.	NSERC Operating	22,000
Jones, C. H. W.	NSERC Operating	29,134
Jackson, K. P.	NSERC Project	40,000
Korteling, R. G.	NSERC Project	107,000
Malli, G. L	NSERC Operating	25,426
Oehlschlager, A. C.	NSERC Operating	46,465
	NSERC Strategic	56,200
	I. D. R. C.	142,750
(with J. H. Borden, M.	NSERC Strategic (99,079)	49,539
Winston and K. N. Slessor)	NSERC Strategic (75,000)	37,000
Percival, P. W.	NSERC Operating	66,000
Peterson, L. K.	Skana-Photo Lab	5,450
(with J. D'Auria)	B. C. Salmon Farming (7,590)	3,795
Pinto, B. M.	NSERC Operating	27,000
	NSERC Travel Grant	2,350
	NSERC Strategic	63,000
	NSERC Travel Grant	2,500
Pomeroy, R. K.	NSERC Operating	32,640
Richards, W. R.	NSERC Operating	19,300
Sherwood, A. G. (with G. Ivany and co-worker)	SSHRC Operating (75,000)	25,000
Slessor, K. N.	NSERC Operating	14,400
	DSS Forestry	7,800
(with J. H. Borden, M. Winston and C. Oehlschlager)	NSERC Strategic (99,079)	49,539
	NSERC Strategic (75,000)	37,000

Sutton, D.	NSERC Operating	30,000
Tracey, A. S.	NSERC Operating	19,200
	BC Heart	17,000
	CDN. Job Dev.	11,000
Voigt, E. M. (with K. E. Riechhoff)	NSERC Team (27,000)	27,000
	SUBTOTAL	**$1,541,591**
	Department NSERC Gen, URF, etc)	136,750
	Contract Overheads	6,540
	TOTAL	**$1,673,537**

DEPARTMENT OF CHEMISTRY SPACE INVENTORY 1989-1

ENTITLEMENT	OFFICE	RESEARCH TEACHING	SQ. FT.
Academic			
1) Chairman	1 x 180		180
2) Faculty	29 x 120		3,480
		29 x 500	14,500
3) Res. Assoc. /PDFs	25 x 90		2,250
		25 x 375	9,375
4) Lab. Instructors	6 x 90		540
5) Graduate Students	52 x 40		2,080
		52 x 250	13,000
Support Staff			
6) Administrative/Prof.	2 x 120		240
		1 x 375	375
7) Dept. Technicians	7 x 90		630
8) Sec. to Chairman	1 x 120		120
9) Sec. /Clerical*	3. 5 x 90		315
Office Support			
10) Seminar/Conference	29 x 20		580
11) Office Support			400
Student Space			
12) Student Union			80
13) Student Common Room			250
Teaching Labs.			
14) Undergrad. Lab.	2832 weekly student contact hrs. x 6. 5 sq. ft. per WSCH		18,408
TOTAL ENTITLEMENT			66,803

*Includes 0. 5 Sec. position (SFU/TRIUMF)

SUMMARY OF SPACE INVENTORY FOR CHEMISTRY
(In Sq. Ft.)

	ENTITLEMENT	INVENTORY	SHORTFALL
I) Office Space	11,145	9,425	1,720
II) Research Space	37,250	22,930	14,320
III) Undergrad. Lab.	18,408	17,915	493
TOTALS	66,803	50,270	16,533

FACULTY WITH MAJOR RESEARCH SPACE SHORTAGES

	Current Entitlement sq. ft.	Allocated sq. ft.
R. B. Cornell	1,250	600
R. K. Pomeroy	2,000	1,100
B. M. Pinto	2,500	900
R. H. Hill	1,000	600
Y. L. Chow	2,500	1,500
A. C. Oehlschlager	4,000	2,500
R. J. Cushley	2,000	1,300
K. N. Slessor	1,200	700

GRADUATE STUDENT POPULATIONS 1987/88

	Population					Degrees Awarded	
	Total	Ph.D.	M.Sc.	Cdn.	For.	Ph.D.	M.Sc.
U. B. C.	183	126	57	80	103	17	12
S. F. U.	50	31	19	22	28	2	5
U. Vic.	43	30	13	16	27	3	0
Calgary	44	24	20	16	28	4	3
Alberta	44	24	20	16	28	4	3
Saskatchewan	33	17	16	16	17	4	0
Manitoba	38	21	17	22	16	6	3
Guelph/Waterloo	120	71	49	97	23	11	15
McMaster	49	29	20	39	10	7	3
Queen's	63	19	44	50	13	8	7
Toronto	126	78	48	118	8	16	20
Western	62	38	24	43	19	6	0
York	29	18	11	22	7	4	1
McGill	124	101	23	98	26	18	1
Montreal	135	57	78	128	7	19	18
Dalhousie	29	22	7	12	17	10	4

NEW GRADUATE STUDENT ENROLLEES

Year	Arrivals
1989 (4 admitted (2 recommended for admission as of Feb. 6/89)	
1988	8 (+ 1 spec. student)
1987	12
1986	8
1985	10
1984	12
1983	11
1981	13

GRADUATE ENROLLMENTS 1982 TO 1988

1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
33(1)	43(0)	45(0)	48(1)	48(1)	51(0)	57(0) (+ 1 special student)

(part-time in parentheses)

GRADUATE STUDENTS BY AREA OF RESEARCH 1988-1989

Biochemistry	15
Organic	21
Inorganic	13
Physical	4
Nuclear	5
	58

GRADUATE STUDENTS BY CITIZENSHIP 1988-1989

Canadian	19
NLI	34*
LI	4
Diplomatic	1
	58

*Of these 16 are from mainland China.

GRADUATE STUDENT SUPERVISORY COMMITTEES

* Degree awarded

Student	Program	1st Sem.	Sr. Supervisor	Committee Members
Akber, Syed F.	Ph.D	89-1	R.J. Cushley	
Aksela, Maija K.	M.Sc	88-3	A.C. Oehlschlager Special Student	
Andrews, John S.	M.Sc	86-3	B.M. Pinto (organic)	R.J. Cushley M.J. Gresser
Bhattacharjee, R.	Ph.D.	88-1	W.R. Richards (biochemistry)	R.B. Cornell A.C. Oehlschlager
Cackette, Mike R.	M.Sc.	84-3	J.M. D'Auria (physical)	I.D. Gay L.K. Peterson H.P. Blok
Chana, Ravinder S.	Ph.D.	82-3	R.J. Cushley (biochemistry)	K.N. Slessor A.S. Tracey
Cheng, Xianen	Ph.D.	85-2	Y.L. Chow (organic)	B.M. Pinto W.R. Richards
Craig, Marcia M.	Ph.D.	83-3	M.J. Gresser (biochemistry)	K.N. Slessor R.B. Cornell
Davis, Harry B.	Ph.D.	84-3	R.K. Pomeroy (inorganic)	F.W.B. Einstein A.C. Oehlschlager
Dodd, Dharmpal S.	M.Sc.	87-3	A.C. Oehlschlager (organic)	A.M. Unrau R.B. Cornell
Dombsky, Marik	Ph.D.	85-1	J.M. D'Auria (nuclear)	I.D. Gay C.H.W. Jones
Fenske, David B.	Ph.D.	81-3	R.J. Cushley (biochemistry)	W.R. Richards I.D. Gay
Fischer, Traugott P.	Ph.D.	87-3	R.J. Cushley (biochemistry)	W.R. Richards B.M. Pinto
Gardner, Suzanne P.	M.Sc.	87-3	J.M. D'Auria (nuclear)	Thomas J. Ruth D. Sutton
Gu, Jian-Hua	Ph.D.	88-1	B.M. Pinto (organic)	I.D. Gay D. Sutton
Hansen, Valerie M.	M.Sc.	85-3	R.K. Pomeroy (organometallic)	F.W.B. Einstein Y.L. Chow
He, Yingtian	M.Sc.	87-1	I.D. Gay (physical)	C.H.W. Jones F.W.B. Einstein
Hundle, Bhupinder S.	Ph.D.	82-3	W.R. Richards (biochemistry)	M.J. Gresser B.L. Funt
Hutzinger, Michael W	.M.Sc.	85-3	A.C. Oehlschlager (organic)	R.K. Pomeroy B.M. Pinto
Johansson, Carl I.	M.Sc.	89-1	Y.L. Chow (organic)	
Johnston, Victor J.	Ph.D.	85-3	Einstein/Pomeroy (inorganic)	B.M. Pinto
Juzkow, Victor J.	Ph.D.	87-3	I.D. Gay (physical)	D.P. Wilkinson E.J. Wells
Kovacs, Phillip E.*	M.Sc.	85-1	C.H.W. Jones (phys./inorganic)	B.L. Funt E.J. Wells
Leon-Lai, Chui Har	M.Sc.	87-3	M.J. Gresser (biochemistry)	W.R. Richards R.B. Cornell
Leung, Ronald Y-N.	Ph.D.	83-3	B.M. Pinto (organic)	M.J. Gresser A.S. Tracey

Leung, S-Keung Sam	Ph.D.	85-3	P.W. Percival (nuclear)	C.H.W. Jones	
Li, Huali*	Ph.D.	83-1	Y.L. Chow (organic)	E.J. Wells	
Liu, Susana	M.Sc.	87-1	Gresser/Tracey (biochemistry)	D. Sutton	
Liu, Xiaoyun	Ph.D.	84-3	Y.L. Chow (organic)	R.J. Cushley	
Lowen, Stephen V.*	Ph.D.	82-3	B.L. Funt (physical)	K.N. Slessor	
Ma, Andrew K.Y.	Ph.D.	85-1	R.K. Pomeroy (inorganic)	R.K. Pomeroy	
Male, Jonathan	Ph.D.	88-3	R.K. Pomeroy (inorganic)	A.C. Oehlschlager	
May, Robert G.	M.Sc.	87-3	A.C. Oehlschlager (organic)	C.H.W. Jones	
Mehta, Seema	M.Sc.	89-1	B.M. Pinto (organic)	I.D. Gay	
McLeod, Ronald G.	M.Sc.	86-3	B.M. Pinto (organic)	D. Sutton	
Ouyang, Xinxin	Ph.D.	88-1	Y.L. Chow (organic)	K.N. Slessor	
Palmer, Bentley J.	M.Sc.	88-1	R. Hill (inorganic)	B.M. Pinto	
Ramos, Agustin F.	Ph.D.	88-2	R. Pomeroy/Einstein (inorganic)	Y.L. Chow	
Reimer, Kerry B.	M.Sc.	85-3	B.M. Pinto (organic)	R.H. Hill	
Samiel, Armine	M.Sc.	89-1	A.C. Oehlschlager (bioorganic)	A.S. Tracey	
Sharma, Sunaina	Ph.D.	82-3	A.C. Oehlschlager (organic)	R.H. Hill	
Shipley, John A.	M.Sc.	85-3	R.K. Pomeroy (inorganic)	D Sutton	
Singer, Robert D.	Ph.D.	86-3	A.C. Oehlschlager (organic)	A. G. Sherwood	
Snajdarova, Iva	M.Sc.	87-3	W.R. Richards (biochemistry)	A. C. Oehlschlager	
Trigo-Gonzalez, G.R.	M.Sc.	88-3	T.J. Borgford (biochemistry)	I. D. Gay	
Vanderwel, Desiree	Ph.D.	83-3	A.C. Oehlschlager (organic)	R.K. Pomeroy	
				K.N. Slessor	
Varma, Vikram	M.Sc.	87-3	B.M. Pinto (organic)	R.K. Pomeroy	
Xia, Wenjia	M.Sc.	89-1	R.H.Hill (inorganic)	K.N. Slessor	
Yan, Xiaoqian	Ph.D.	85-3	D. Sutton (inorganic)	M.J. Gresser	
Yang, Mengsu	M.Sc.	86-3	Y.L. Chow (organic)	D. Sutton	
Yu, Dake	Ph.D.	85-2	P.W. Percival (nuclear)	M.J. Gresser	
Yue, Jun-Shi	Ph.D.	84-3	R.J. Cushley (biochemistry)	K.N. Slessor	
Zhao, Dachuan	Ph.D.	83-3	Y.L. Chow (organic)	R.K. Pomeroy	
Zhong, Qi	Ph.D.	87-3	R.B. Cornell	R.J. Cushley	
				B.M. Pinto	
				B.M. Pinto	
				R.B. Cornell	
				K.N. Slessor	
				J.H. Borden	
				B.L. Funt	
				I.D. Gay	
				A.S. Tracey	
				L.K. Peterson	
				C.H.W. Jones	
				A.C. Oehlschlager	
				R.H. Hill	
				T.N. Bell	
				R.G. Korteling	
				A.C. Oehlschlager	
				B.L.Funt	
				B.M. Pinto	
				T.N. Bell	
				A.C. Oehlschlager	

Zhou, Xuemin	Ph.D.	87-1	(biochemistry) Y.L. Chow (organic)	M.J. Gresser A.S. Tracey M.J. Gresser
Zhuang, Jun-Ming	Ph.D.	85-3	D. Sutton (inorganic)	F.W.B. Einstein A.C. Oehlschlager

GRADUATES IN CHEMISTRY

NAME	DEGREE	# SEMESTERS IN PROGRAM	CURRENT POSITION
1983			
J. W. Wong	Ph. D.	11	Private Business
C. Barrientos-Penna	Ph. D.	10	Res. Assoc., U. Alberta
S. B. Hinchigeri	Ph. D.	14	Faculty member, India
1984			
Y. M. A. Naguib	Ph. D.	19	PDF, U. S. A.
A. F. H. Nour-Eldeen	M. Sc.	7	Egypt
J. G. J. O. Millar	Ph. D.	13	Assistant Professor U. C. Riverside
Romines III	M. Sc.	16	W. H. Burroughs Welcome, USA
G. E. Soto-Garrido	Ph. D.	16	Faculty member, Chile
1985			
S. Beharry	Ph. D.	13	PDF, U. B. C.
M. Dombsky	M. Sc.	12	Ph. D. program, SFU
P. P. M. Hoang	Ph. D.	18	Reichhold Chemicals, Van.
A. A. Kandil	Ph. D.	16	PDF, U. S. A.
S. K. Leung	M. Sc.	9	Ph. D. program, SFU
S. H. C. Liang	Ph. D.	21	PDF, Queen's Univ.
Y. I. Parmar	Ph. D.	18	PDF, U. B. C.
V. A. Salas-Reyes	Ph. D.	18	Faculty member, Chile
Y. Y. Shu	M. Sc.	7	Ph. D. program, U. S. A.
W. D. Treleaven	Ph. D.	23	PDF, S. F. U.
1986			
A. P. Acuna-Johnson	M. Sc.	10	Director Pharmaceutical Sciences U. of Valparieso, Chile
M. Craig	M. Sc.	9	Ph. D. program, SFU
B. D. Johnston	Ph. D.	20	PDF, SFU
A. H. Klahn-Oliva	Ph. D.	12	Faculty member, Chile
L. R. Martin	Ph. D.	15	Instructor, Fraser Valley College, NSERC PDF, U. B. C.
M. K. K. Phoon	M. Sc.	9	Pharmacy, U. B. C.
J. L. Thewalt	Ph. D.	20	NSERC PDF, U.B.C.
K.G. Tyers	Ph.D.	16	Private Business

1987			
G.H. Fritzke	M.Sc.	13	Chatterton Petrochemical
A. Ramos	M.Sc.	8	Ph.D. program, SFU
R. Alex	Ph.D.	15	NSERC PDF, U.B.C.
E. Bramhall	M.Sc.	9	Ph.D. program, SUNY
Z. Wu	Ph.D.	14	PDF, Purdue University
T. Kastelic	M.Sc.	8	Potential Medical School
K. Doherty	M.Sc.	11	Chemist, Merck Frosst
E. Peters	M.Sc.	10	Ph.D. program, Waterloo
1988			
R. Fong	M.Sc.		Moli Energy Limited
S. Holdcroft	Ph.D.		NSERC PDF, U. Toronto
M. Hutzinger	M.Sc.		Ph.D. program, SFU
J. LaFontaine	M.Sc.		Phero Tech Inc.
H. Li	Ph.D.		PDF, SFU
K. Reimer	M.Sc.		Ph.D. program, SFU