DEPARTMENT OF CHEMISTRY

Preface

The Strategic Plan presented in this document is a product of the efforts of the full faculty and staff of the Department of Chemistry. The first sections of this document are informative and include a description of the Department (mission, vision, and goals) and a review of programs and support relationships that the Department either contributes to or relies on for success. A strategic review (beginning on page 4) follows these introductory sections which addresses strategic issues, strengths, weaknesses, challenges, and opportunities in the Department. In Section 3 (beginning on page 8) a series of Strategic Initiatives and Recommendations is proposed which directly address the five stated goals (see page 2) of the Department. In Section 4 a series of assessment mechanisms is proposed that will allow us to gauge the progress and success of the implementation of initiatives described in Section 3. Finally, the document concludes (beginning on page 16) by summarizing the barriers to realization of our stated goals, and the anticipated impact on students, faculty, and staff of the Chemistry Department community as these goals are realized.

SECTION 1 Description of the Department of Chemistry

1.1 Mission, vision, and goals

The Gustavus Adolphus College Department of Chemistry serves as a cooperative group of faculty and staff that support students interested in the study of chemistry. Over the past five years, an average of 24 students have graduated with a major from the Department of Chemistry annually. The Department also offers courses that serve students in the form of general education and allied programs. The Department engages a significant number of students in collaborative scientific research, both as part of and outside of formal course work.

Mission Statement

The mission of the Gustavus Adolphus College Department of Chemistry is to promote and support the development of students into lifelong voracious learners who are distinguished by:

- a high degree of intellectual curiosity,
- a fundamentally sound knowledge of chemistry,

- an ability to use the scientific method effectively as a core epistemology,
- an understanding of the place of chemistry within natural science, and
- comprehension of the relationship of natural science to the environment and the rest of human culture.

Vision Statement

The Department of Chemistry seeks to provide a stimulating intellectual environment by cultivating a highly engaged community of scholars. Central to our approach is the pursuit of scholarship through both independent and collaborative student-faculty research. We aim to challenge students to pursue an understanding of the natural world through study of and research in chemistry in order to develop scientifically-minded citizens and competent experimental scientists. We aspire for our students to appreciate interdisciplinary perspectives and problem-solving approaches, and to communicate effectively with a variety of audiences. Overall, we aim to value and support the development of whole persons for all members of our learning community.

In order to achieve this vision, the Department of Chemistry sets forth five goals.

Goal One: To provide a curriculum in which all students gain an appropriate depth and breadth of knowledge (content competency), understanding, and comprehension of chemistry.

Goal Two: To foster an appreciation of interdisciplinary approaches to problem solving.

Goal Three: To foster the development of greater laboratory independence and experimental competence.

Goal Four: To cohesively integrate the development of communication skills throughout the chemistry curriculum.

Goal Five: To foster a department-wide culture of excellence, professional development, and healthy life/career balance.

1.2 Programs

The Department of Chemistry enjoys mutually supportive relationships with the Department of Biology and interdisciplinary programs in Biochemistry and Molecular Biology (BMB) and Environmental Studies (ES). Shared equipment, space, and faculty

with the Biology Department are integral to our courses and research. Support for BMB and ES includes shared faculty, equipment, space, financial resources and mutually beneficial course offerings. The Department of Chemistry offers courses (i.e. CHE-107, CHE-141, CHE-251, CHE-258, and/or CHE-371) that support majors in many departments and programs, including Biology, Biochemistry and Molecular Biology, Environmental Studies, Geology, Nursing, Health and Exercise Science, and Education. The Biochemistry and Molecular Biology program and the Physics, Math and Computer Sciences, and Education Departments offer courses that support majors and minors within the Department of Chemistry. The Department of Chemistry works closely with directors, chairs, and/or liaisons to maintain the relationships between the Department of Chemistry and these programs.

The Department of Chemistry is an active participant in the First Term Seminar (FTS) program. At least one section of FTS has been offered by the Department of Chemistry almost every year the program has been in place. We plan to continue this tradition, contingent on adequate faculty staffing.

1.3 Support relationships

The Department of Chemistry relies on partnerships with and support from other programs and offices.

The Advising Office works with students and academic advisors to ensure students meet the aims and requirements of the program in which they are enrolled.

We rely on Gustavus Technology Services to support the technology in our classrooms and computers in our laboratories. In addition, they provide Internet and web support. Our partnership with GTS includes a part-time staff member to assist with and ensure that chemistry-specific software applications are installed on teaching laboratory computers. This part-time staff member also responds to occasional general computer hardware service needs.

We are partners with the Office of Institutional Advancement. The Alumni Relations Office provides us with alumni contact information for distribution of our department newsletter and alumni surveys, and we provide them with updates on alumni professional developments. We work closely with the office of Corporate and Foundation Relations as we seek external funding for research, curricular development, instrument acquisition, and programmatic development.

We benefit from a relationship with the Office of Marketing and Communication that helps us publicize the work we do through stories on the campus web site, in the *Yellow Sheet*, in the *Gustavus Quarterly*, and in the media at large.

We partner with the Library to ensure completeness and quality of the library collection related to the chemical sciences, including current scholarly texts, relevant periodical subscriptions (such as the ACS Journal package, a key component enhancing our curriculum), significant reference sources (such as the *Encyclopedia of Reagents for Organic Synthesis*), access to interlibrary loan programs (such as Minitex), and access to essential literature databases (including SciFinder Scholar, the largest scientific database and an essential tool for teaching and research in modern chemistry). Such access is necessary for the maintenance of American Chemical Society approval of our "Chemistry ACS" major that is pursued by graduate-school-bound students as well as by others. The Library and staff provide important support to our students in the access and use of chemical information for scholarly pursuits. This support is critical to the teaching of students in the classroom and the mentoring of the students in the research lab.

As do all departments on this campus, we benefit from faculty development and student/faculty research programming and support through the John S. Kendall Center for Engaged Learning.

We partner with the Office of Diversity Development and Multicultural Programs to better support and encourage racially underrepresented students who are pursing the study of chemistry at Gustavus.

SECTION 2 Strategic Review

Strategic issues

Several influences impact the Department's ability to effectively fulfill its mission.

Changes within chemistry as a discipline have prompted the American Chemical Society's Committee on Professional Training (CPT) to revise degree guidelines. The increased emphasis on interdisciplinary solutions to challenges in materials science, nanotechnology, and the development of environmentally responsible methods, for example, have led to more flexible guidelines on both program structure and laboratory curriculum recommendations.

Interdisciplinary collaborations (i.e. those that draw expertise from disciplines that are usually considered to be separate in the types of questions that they address) can produce numerous benefits. Some problems cannot be effectively addressed by a single, traditional discipline due to their complexity. Such problems, though they can be of great importance, have often been neglected by the traditional disciplines, where the ability to address them is literally made impossible by the lack of appropriate knowledge and expertise. Interdisciplinary collaborations, in their best manifestations, can combine the methodologies and insights from disparate disciplines to provide innovative solutions to such complex problems.

Research experiences are increasingly important for undergraduate students. Advances in information technology have changed both the rate at which scientific discoveries are reported and the way scientific information is accessed. Commensurate with this increase in research expectation and productivity is the increased cost and complexity of instrumentation required to conduct research of significance.

Gustavus is experiencing the national trend of increased interest in science-intensive programs. Other colleges have recognized and responded to this trend and have either renovated or constructed new science buildings to address both the changes outlined in the CPT guidelines and the growing size of the programs relative to the campus as a whole. St. Olaf College, for example has recently opened a new building that houses all of their natural sciences departments and psychology. In the last ten years, Luther College, the University of St. Thomas, Wittenberg University, and the College of Wooster have all built additional space for the natural sciences and renovated existing space.

Strengths

The Department of Chemistry and its students have benefited from the energy and expertise of both tenure-line employees and support staff. In the past decade, 71% of our chemistry and biochemistry graduates started graduate (42%) or professional (29%) school within a few years of graduation. Additionally, for the five-year period of 2001-2005, Gustavus Adolphus College ranked 9th as a source of graduates completing their Ph.D. in chemistry among the approximately 250 liberal arts colleges.[1] Specifically, we see our strengths as:

- rigorous laboratory experience for students at all levels,
- rigorous curriculum that conforms to the ACS guidelines,

[1] National Science Foundation WebCASPAR database

- broad range of faculty specialization,
- vigorous student/faculty collaborative research program,
- specific commitment to general education and First Term Seminar,
- dedicated mentoring of both majors and non-majors,
- engaging course offerings for January Term,
- strong synergy with the Biochemistry and Molecular Biology program, and
- a regular, well-attended invited speaker seminar program.

Weaknesses

The Department of Chemistry has struggled to accomplish recognized goals. These struggles have highlighted several weaknesses in our program, including:

- inadequate writing instruction, due to delayed engagement in disciplinary-specific writing and the lack of a coordinated writing development plan which spans the entire curriculum,
- inadequate oral communication instruction,
- limited pedagogical variety in introductory courses,
- limited support of Curriculum II,
- inability to develop research-like experiences in introductory laboratories,
- few course offerings for interdisciplinary topics (i.e. materials science, etc),
- lack of an adequate, sustainable process for the acquisition and maintenance of modern equipment/instrumentation, and
- inadequate attention to scientific and information literacy.

Challenges

Since the last ten-year self-study, all but one member of our department, including support staff, are new. This new faculty/staff configuration has developed a new vision, laid out in this document, that builds upon earlier contributions. In addition to the need

for cultivation of leadership skills among such a significant portion of our department, large and ever-increasing class sizes present a constant challenge.

Nearly one-third of each incoming class enrolls in Principles of Chemistry (CHE-107), our first course in the four-course sequence that is heavily used by both students interested in disciplinary-specific training, and those interested in other disciplines (c.f. §1.2 Programs). On average, 226 students enrolled in Principles of Chemistry during each of the last five years. The average section enrolled 45 students, the largest section being 57 students. The next three semesters in the sequence, Organic Chemistry I (CHE-141), Organic Chemistry II (CHE-251), and Inorganic Chemistry I (CHE-258) also enroll relatively high numbers of students. Average enrollment in each section of Organic Chemistry I, for example, has been 49 over the same five- year period with the largest section enrolling 76 students. Enrollment in Organic Chemistry II has become particularly concerning with an average enrollment of 89 students in each section, the largest section enrolling 112 students. The fourth course in the core sequence, Inorganic Chemistry I, enrolls an average of 77 students in each section, with the largest class size of 94. On average, then, students moving through the chemistry program would have class sizes of 45, 49, 89, and 77 students on a campus that advertises an average class size of 15 students.

Focusing solely on average course size, however, provides an incomplete picture of enrollment dynamics. Enrollment in Principles of Chemistry has risen 15% from 188 students in 2004 to 217 in 2008. Organic Chemistry I has increased enrollment 28%, while Organic Chemistry II has increased by 37% for the same time period. The fact that these percentage changes are increasing, rather than constant, as the sequence of courses progresses demonstrates that the retention, and therefore class size, from course to course is increasing independent of the total Gustavus enrollment. While this is a very positive development from the standpoint of retention of majors and enthusiasm for chemistry on campus, this surge in enrollments has created significant challenges in the Department as well.

The increased enrollments in chemistry have also affected how we participate in the Writing Across the Curriculum (WAC) program. Our first course in physical chemistry (Kinetics and Thermodynamics, CHE-371), for example, has enrolled an average of 33 students per section for the last five years. This course was, until 2004, our primary WRITD (writing in the discipline) course taken by many students in the fall of their third year. Currently, only a subset of our advanced 300-level courses enroll fewer than 20 people. Because WRITD-designated courses must have 20 students or fewer, our students are not experiencing intensive discipline-specific writing until second semester junior year or later.

The increased enrollments in chemistry have begun to affect the Department's participation in The First Term Seminar (FTS) program. We were, for instance, unable to offer a FTS course during Fall Semester 2008 due to lack of sufficient faculty time.

The increased enrollments in chemistry also present a budgetary problem. The cost of commodities used in the classroom and in teaching and research labs continues to rise, as is the number of students we need to accommodate. However, the Department budget remains the same. Advances in science and technology occur everyday. For the Chemistry Department to remain on the forefront of top-notch scholarship and research, funding must increase.

Over the years, budget cuts in the Library have forced members in the Department to lose access to journals and databases to which we were previously subscribed. These changes affect available course material and limit research projects that can be done. Showcasing that textbooks are not the only source of information and encouraging exploration of the rapidly changing scientific community is hindered.

Given the current curricular needs, there are insufficient human resources to participate more fully in general education programs and offer Curriculum II courses. Effective ways to decrease class size include limiting enrollment for each section, reducing the number of course offerings (so that more sections of high-enrolling courses can be offered), and increasing the number of faculty. In order to continue serving a high portion of the student body, while still meeting ACS guidelines, our preference is to increase the size of our faculty. The development and offering of research-like introductory laboratory experiences and the ability to provide more courses on interdisciplinary topics requires, in addition to increased human resources, more physical space as well as reconfiguration of the current facilities. The lack of a sustainable model for funding the acquisition and maintenance of essential equipment presents both a financial and human resource challenge.

Opportunities

In the last few years, several opportunities have arisen that fund the development of curriculum, augment student/faculty collaborative research, and facilitate interdisciplinarity. Among these are the Howard Hughes Medical Institute (HHMI) award, a Merck/AAAS interdisciplinary research grant, and the National Science Foundation's (NSF) Course Curriculum and Laboratory Improvement award (CCLI). In addition to these programmatic awards, several faculty members have benefited from competitive extramural funding sources to support individual research. Beyond funding opportunities, we have recently become a member of the Midstates Consortium for Math

and Science. We also benefit from memberships in the Midwestern Association of Chemistry Teachers in Liberal Arts Colleges, the Council on Undergraduate Research, and the Midwestern Undergraduate Computational Chemistry Consortium.

Other opportunities that allow for the growth of interdisciplinary programs include the recent establishment of the Johnson Center for Environmental Studies, the Neuroscience program, and new hires in the Biology, Geology, and Physics Departments. In a broader sense, there are several opportunities for faculty development available through the John S. Kendall Center for Engaged Learning. Faculty members also have the opportunity to collaborate with colleagues at other campuses.

SECTION 3 Strategic Initiatives and Recommendations

Goal One: To provide a curriculum in which all students gain an appropriate depth and breadth of knowledge (content competency), understanding, and comprehension of chemistry.

Strategic Initiatives

1.1 Ensure that appropriate and adequate chemical content is an integral part of all departmental course offerings.

1.2 Foster the development of chemical understanding and comprehension among students throughout the chemistry curriculum.

1.3 Contribute to the general education of liberal arts students, so as to contribute to their becoming knowledgeable citizen scientists.

1.4 Continue to develop the laboratory curriculum to provide opportunities for students to develop an understanding of chemistry through hypothesis-driven experimentation and analysis.

Goal Two: To foster an appreciation of interdisciplinary approaches to problem solving.

Strategic Initiatives

2.1 Expand the curriculum to embrace topics which highlight overlap(s) among more traditional academic disciplines.

2.2 Foster the development of a comprehensive view of the role of chemistry within the natural sciences, as well as the broader relationship between the natural sciences and human culture.

2.3 Establish a culture of inquisitiveness which spans traditional divisions among the natural sciences.

Goal Three: To foster the development of greater laboratory independence and experimental competence.

Strategic Initiatives

3.1 Use an "outcome oriented" laboratory curriculum to develop skills consistent with the demands on 21st century chemists.

3.2 Provide research-like experiences early in the laboratory curriculum.

3.3 Increase the number of laboratory exercises which highlight overlap among the traditional sub-disciplines of chemistry.

3.4 Modify the laboratory curriculum to allow for more student/faculty collaborative research.

Goal Four: To cohesively integrate the development of communication skills throughout the chemistry curriculum.

Strategic Initiatives

4.1 Initiate and execute a comprehensive plan that coordinates—at all levels of the chemistry curriculum—the development of effective writing skills.

4.2 Develop and implement a comprehensive plan that coordinates—at all levels of the chemistry curriculum—the enhancement of effective oral communication skills.

4.3 Develop a comprehensive scientific literacy plan to effectively teach students to use, critically evaluate, and assess the reliability of sources available in both the scientific literature and public media.

Goal Five: To foster a department-wide culture of excellence, professional development, and healthy life/career balance.

Strategic Initiatives

5.1 Encourage, support, and reward faculty excellence in teaching, advising, and collaborative student/faculty research.

5.2 Encourage, support, and reward scholarly work which contributes to the greater body of scientific knowledge.

5.3 Foster an environment in which established faculty and staff provide a model of healthy life/career balance for new faculty and staff, as well as for students.

Recommendations

- Develop a strategy to introduce and familiarize all chemistry students with the use and evaluation of scientific and science-related literature. This instruction will begin with a coordinated sequence of activities in the chemistry core (CHE-107, CHE-141, CHE-251, CHE-258). Addresses Goals 1, 2 & 4.

- Develop a strategy for all chemistry students to appreciate and develop their skills with a variety of written and oral communication styles. This instruction will begin with a coordinated sequence of activities in the chemistry core (CHE-107, CHE-141, CHE-251, CHE-258). Addresses Goals 4 & 5.

- Partner with the Writing Center, Library, and faculty in Communication Studies to enhance and unify instruction and evaluation of scientific literacy and communication skills across the chemistry curriculum. Addresses Goal 4.

- Partner with the Writing Center and Writing Across the Curriculum to setup workshops and training sessions for faculty involved in WRIT-I/WRIT-D course instruction. Addresses Goal 4.

- Further enhance our relationship with the Library through lengthening the term of the departmental Library Liaison from one year to 3-4 years. This change would improve continuity.

- Support efforts to centralize tutoring services across campus by recommending tutors, providing any needed resources, and being involved in the training process. Addresses Goal 4.

- Adopt a sustainable departmental model for instrument acquisition, maintenance, and repair. Develop a modern complement of chemical instrumentation and infrastructure to serve the laboratory curriculum and student/faculty collaborative research. Addresses Goals 1, 2, 3 & 5.

- Redesign the laboratory curriculum to focus on the development of basic and advanced laboratory competencies, to integrate different sub-disciplinary areas, to provide research-like experiences early in a student's career, and to promote environmental awareness. This instruction will require additional resources and a coordinated effort across the Department. Addresses Goals 1, 2 & 3.

- Generate and support on-campus extracurricular opportunities that help build a community of scholars, such as journal club, research meetings, chemistry seminar, retreats and Gustavus symposia. Provide support to allow more students and faculty to attend and/or present their research at regional and national professional meetings. Addresses Goals 1, 2, 3, 4 & 5.

- Continue our consistent support of the Nobel Conference by canceling labs and classes during conference activities and encouraging students to attend as many of the events as possible. Increase support by coordinating theme-related hands-on experiences and other activities within the department. Addresses Goal 2.

- Increase support of student/faculty research, recognizing this activity as both a significant and valued teaching-learning relationship and central to the scholarly work of the faculty. Addresses Goals 1, 2, 3, 4 & 5.

- Maintain and enhance support of existing interdisciplinary programs in BMB and ES. Develop synergistic relationships with existing programs, such as neuroscience, physics, math and computer science, and/or geology that may lead to the involvement of chemistry in existing ID programs and/or the creation of new ID programs. New involvement in ID programs will be limited to one or two so that we can offer these relationships appropriate support. Addresses Goals 2 & 5.

- Continue and expand our course offerings in general education, including First Term Seminar (FTS), January Interim Experience (IEX), Curriculum II and courses with the Natural Science Perspective (NASP) designation within Curriculum I. We will focus on increasing the number of courses with interdisciplinary themes, including areas outside of the natural sciences (e.g. History, Political Science). Addresses Goals 1, 2, 3 & 5.

- Conduct a feasibility study to assess space needs that will support the continued teaching and learning of an evolving science. This includes medium-term planning for a new building and/or major addition/renovation of the current space, and short-term planning for how to adapt the space we currently have to better

suit our needs. Throughout the process, environmental impact will be considered as we plan for the future. Addresses Goals 1, 2, 3 & 5.

- Continue to offer an appropriate breadth and depth of courses for students within the chemistry major, related majors (e.g. biology) and pre-professional programs (e.g. pre-medicine). Addresses Goals 1, 2 & 3.

- Identify and articulate content and skill competencies for each course and laboratory offered in chemistry. Addresses Goals 1, 2, 3 & 4.

- Continue to develop an integrated, rigorous curriculum that reflects the development of content competencies throughout the chemistry major. Addresses Goals 1 & 3.

- Incorporate innovative pedagogies and active learning environments in and outside the classroom to ensure opportunities for students to practice and develop critical thinking, problem solving, integration and synthesis of complex course material. Addresses Goal 1.

- Create a departmental faculty/staff development plan that includes support for new and established faculty and instructors, visiting faculty, and professional staff. Addresses Goals 2 & 5.

- Develop a plan to effectively use new and existing support systems and programs so that more faculty time is spent doing work expected of the faculty. Addresses Goal 5.

- Develop a mechanism and establish resources to foster collaboration and coordination of efforts in teaching, research, and other work across the Department. Addresses Goals 1, 2, 3, 4 & 5.

- Develop an acceptable, and realistic, accounting method for faculty full-time equivalent (FTE), which includes proper consideration of teaching, collaborative student/faculty research, administrative tasks, student advising, etc. Addresses Goal 5.

SECTION 4 Assessment

Goal One: To provide a curriculum in which all students gain an appropriate depth and breadth of knowledge (content competency), understanding, and comprehension of chemistry.

In order to demonstrate that we have achieved Goal 1, we will develop an assessment program that may include:

- monitoring the number of courses the Department of Chemistry contributes to general education on a yearly basis.
- documenting examination questions and/or assignments, and correlated student outcomes, which are reflective of basic competencies within each course.
- documenting examination questions and/or assignments, and correlated student outcomes, which are reflective of the depth of student comprehension within each course.
- implementing an exit exam for senior chemistry majors which reflects content competency, understanding and comprehension of chemistry as a whole.
- developing longitudinal survey tools to track Gustavus students/graduates who take any chemistry course, which will allow faculty to track the impact of chemistry courses on chemistry majors and non-majors alike.

Goal Two: To foster an appreciation of interdisciplinary approaches to problem solving.

In order to demonstrate that we have achieved Goal 2, we will develop an assessment program that may include:

- developing longitudinal survey tools to track the number and success of chemistry majors pursuing an interdisciplinary career track.
- surveying graduating seniors to obtain feedback on student interest and participation in interdisciplinary courses.
- working with members of other departments to assess how chemistry students approach coursework and/or problem solving in other disciplines.

- maintaining a list of interdisciplinary courses offered by the Department of Chemistry in conjunction with other departments/programs.

- monitoring our level of active support other departments/programs on campus.

Goal Three: To foster the development of greater laboratory independence and experimental competence.

To foster the development of independence and greater laboratory competence.

In order to demonstrate that we have achieved Goal 3, we will develop an assessment program that may include:

- a laboratory practicum, allowing the Department to track student outcomes as they relate to specific curricular changes and providing a basis for continued evolution of the laboratory curriculum.

- tracking the number of students pursuing and/or engaged in non-course related research opportunities.

- monitoring the number of student-designed, research-like projects within the laboratory curriculum.

- monitoring the number of laboratory projects which span traditional chemical sub-disciplines and/or are interdisciplinary in nature.

- developing and using of longitudinal survey tools containing questions related to student perception of laboratory competency, understanding and comprehension gained from a Gustavus education.

Goal Four: To cohesively integrate the development of communication skills throughout the chemistry curriculum.

In order to demonstrate that we have achieved Goal 4, we will develop an assessment program that may include:

- documenting curriculum changes, and correlated student outcomes, which are reflective of communication and literacy activities within each course.

- monitoring the number of students who present course and/or research materials in non-classroom environments (e.g. professional meetings).

- requiring communication portfolios of all department graduates (which may include class assignments, research papers/presentations, literature assignments, etc.), in order to assess student impact of any changes implemented.

- using evaluations of the communication portfolios described above as a basis for implementing further curricular changes.

Goal Five: To foster a department-wide culture of excellence, professional development, and healthy life/career balance.

In order to demonstrate that we have achieved Goal 5, we will develop an assessment program that may include:

- establishing reliable funding that supports professional development of our faculty in research, teaching, and skill development endeavors.

- monitoring class sizes at all levels within the curriculum.

- monitoring the number of students conducting on-campus research during the academic year and summer.

- monitoring the number of student and/or faculty presentations of research at regional, national and international professional meetings.

- monitoring student access to functional equipment and instrumentation within courses and research.

- monitoring faculty workloads and changes in workloads according to the realistic FTE accounting method described in recommendations above.

- monitoring and evaluating staff workloads and changes in workloads.

SECTION 5 Conclusion

5.1 Barriers

The Challenges described in Section 2 begin to outline the barriers that will impede our accomplishment of the Goals described in Section 3. Chief among these are the interrelated issues of high course enrollments, limited faculty time (and FTEs), limited budget, and space.

High course enrollments

One of the most significant barriers the Department of Chemistry has been experiencing is large and ever-increasing enrollments. As the number of students taking chemistry courses has increased, we have had to allow some course sections to grow larger (primarily lecture sections) and have had to offer additional laboratory sections (which are limited in size by the space of rooms). The increase in the size of our classes and the number of laboratory sections creates a barrier which prevents us from moving forward in several significant ways:

- The types of experiments we can have students do as well as our ability to develop innovative laboratory experiences is limited by our budget, which has not increased to match our enrollment growth.
- The types of experiments we can have students do is, in some cases, limited by the number of students enrolled per lab section.
- The types of pedagogical approaches we can use in our classrooms, particularly in our core courses (CHE-107, CHE-141, CHE-251, CHE-258), are limited by class sizes.
- Our ability to teach writing in our courses is at times limited by section size.
- Faculty find themselves overwhelmed with the administrative details of running large class sections, which can limit their time for research activities (including our highly valued student/faculty research collaborations), advising, and mentoring students. This is especially true in the core courses (CHE-107, CHE-141, CHE-251, CHE-258), which may be one of the times students need such faculty interaction the most.
- Staffing large numbers of lab sections limits our ability to offer general education and interdisciplinary courses.

Limited faculty time

A number of factors have converged to create a situation in which faculty have limited time for the planning and development required to achieve the goals described above. Increases in FTEs have not kept pace with increases in enrollments, so staffing our large number of courses/labs leaves little flexibility in teaching assignments. The demands of teaching large class sections and having large numbers of academic advisees can

consume large amounts of time. Limited faculty time creates barriers to progress in several significant ways:

- It is challenging for faculty to find time to spend on program development and curricular innovations.
- Staffing inflexibility limits our ability to offer general education and interdisciplinary courses.
- Limited number of FTEs often forces us to increase class section sizes rather than offer additional sections.
- Faculty who are teaching large classes are less able to develop relationships with students in those courses.
- Faculty sometimes lack the time to fully engage with students in the research laboratory.
- Writing instruction is limited by the time faculty have to effectively assess and provide meaningful, formative feedback on student writing.
- Faculty struggle to find time to seek external funding to support curricular development, instrument/equipment acquisition, and research.
- It can be a challenge for faculty to find the time to manage programmatic grants, once obtained.

Limited budget

Although our course enrollments have increased significantly over the last five years, our department budget has not increased to accommodate the additional laboratory reagents, supplies, and equipment required to teach these students. This, coupled with the rising price tags on these items and shipping, creates a significant barrier to progress in laboratory development. It is difficult to keep up with the cost of running our laboratory program, much less develop innovative new laboratory experiments and courses.

Space

We have been operating under ever tightening space constrictions for some time now. This creates barriers to progress in several ways:

- Inflexible, poorly designed, or too-small teaching spaces can limit pedagogical approaches in classrooms and laboratories.

- We will soon find ourselves with no space for offices and research laboratories for expanding our faculty and staff.

5.2 Impact

If we accomplish the goals that have been identified, there are some obvious impacts. For example, intentional focus on developing writing skills throughout our curriculum will result in students with stronger writing skills. There are other, broader impacts that will come from accomplishing our goals. Among these are:

- Students of the Liberal Arts benefit from an understanding of the scientific method as a core epistemology. The Department of Chemistry will more clearly define itself as an important part of the liberal arts experience.

- Students who engage in the scientific method learn to see the world as a laboratory in which they can make observations and draw conclusions that inform their decisions. Chemistry majors and non-majors alike will develop skills that will help them engage in civic discourse as scientifically-minded citizens.

- The Department of Chemistry will cultivate an atmosphere of "pervasive collaboration." Many questions of significance require larger perspective than a single (sub-) discipline can effectively provide. When students and faculty collaborate to form a community of scholars, they create an effective multidisciplinary model for answering intractable questions. The free flow of ideas across multiple levels of expertise facilitates the communication of significant ideas to multiple audiences. The collaborative relationships that develop encourage an intellectual playground wherein we may explore bold and innovative changes in how chemistry is taught. Developing flexible curriculum and laboratories provide mechanisms whereby changes in the discipline can easily be incorporated.

- Gustavus will continue to cultivate a reputation for being a leader in the training of students in the sciences. In the last decade, three Chemistry Department graduates have received Barry M. Goldwater Scholarships and another three received honorable mentions. In the last 20 years, NSF Graduate Research Fellowships have been awarded to ten students and 17 have been named honorable mentions. In the last decade, we have had two Glenn T. Seaborg Award winners.