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# 2013 Department of Chemistry: Detailed Self-Study

**Section One – Program Background and Overview**

**I. Brief Program Overview**

<u>Description of Program</u>

There are two undergraduate degree programs offered by the Department of Chemistry, i.e. Bachelor of Arts (B.A.) and Bachelor of Science (B.S.). Within these two programs are five degree tracks, two are offered through the B.A. and three in the B.S. program.

The two degree tracks in the B.A. program are the (a) Chemistry and Secondary Education and (b) Preprofessional Chemistry. The Chemistry and Secondary Education track is designed specifically for students interested in teaching chemistry at the secondary education level. This degree track is a collaborative effort between the Department of Chemistry and the College of Education and Health Professions (COEHP) where students take their content area courses in the Department of Chemistry and their education courses in the COEHP.

The Preprofessional Chemistry track, also offered through the B.A. program, is structured for those students interested in pursuing careers in the health profession. The Preprofessional Chemistry track is flexible so that students may satisfy the program electives by taking some upper-division chemistry, math, biology, or other science classes to fulfill the area. Students may also request to take other upper division courses relevant to the major or needs which may be approved by the chair. Since students in this track are interested in preprofessional careers, they are required to take three biology courses, i.e. Principles of Biology, Contemporary Issues of Biology, and Cell Biology. Moreover, the students are encouraged to take upper-division biology courses, such as Genetics, to help satisfy the program electives. Consequently, this track also satisfies the required pre-requisites to enter pre-professional schools.

The three B.S. degree tracks are the Applied Chemistry, Forensic Chemistry, and ACS Professional Chemistry tracks. The B.S. degree tracks are more rigorous than those in the B.A. program. These tracks require more chemistry and mathematics courses which are not compulsory in the B.A. program. The B.S. Applied Chemistry track is designed specifically for students who wish to enter the chemical industry or government as an entry level chemist.

The Forensic Chemistry track is intended for students with an interest in working as a forensic chemist in a private, state, or federal laboratory. The Forensic Chemistry track is not as flexible as the B.A. program tracks. However, students may satisfy the program electives by taking some upper-division chemistry, mathematics, biology, or other science classes relevant to the major or needs. Since students in this track are interested in careers related to forensics, they are advised to take upper-division courses in Criminal Justice. Completion of this degree track also prepares students for post-graduate studies in forensic chemistry.

Lastly, the B.S. ACS Professional Chemistry track satisfies the requirements for certification by the American Chemical Society (ACS) through its Committee on Professional Training (CPT) which is the national certifying/approval agency for chemistry. This track follows the guidelines set forth by the ACS and is designed for students who wish to pursue graduate studies in the discipline. Additionally, it provides the breadth and depth of laboratory experience to give graduates a wide choice of career options. Since the B.S. ACS Professional Chemistry track follows the ACS CPT guidelines, it is the most rigorous and least flexible among the degrees offered by the department. Regardless, students who complete the ACS Professional Chemistry degree track have a broader range of options and are prepared for graduate and professional school or work in the chemical industry.

In each of the degree tracks students have the opportunity to take the Independent Study course, excluding the Chemistry and Secondary Education track, and they conduct research under the mentorship and guidance of a faculty member. In addition to the specified degrees offered, students in the B.A. Preprofessional Chemistry and B.S. Applied Chemistry tracks may take education courses as part of the UTeach program. This opportunity allows students to explore teaching as a career in the STEM while pursuing their major field of interest. In summary, the selected degree track – irrespective of the program, will be reflective of the experience desired by the student.

The baccalaureate degree programs in chemistry are designed to offer students a solid background in the five primary areas of chemistry, i.e. analytical, biochemistry, inorganic, organic, and physical chemistry, as well as exposure to applied chemistry, synthesis, spectroscopy, and chemical analysis. In conjunction, the department is equipped with modern chemical instrumentation that is used for teaching and independent study research.

To deliver in-depth courses in each of the primary sub-disciplines, the Department of Chemistry is staffed with eight full-time tenured/tenure-track faculty, four part-time instructors, and a full-time chemical stockroom manager who also teaches the introductory laboratory courses for non-science majors. The eight full-time faculty members have terminal degrees in one of the five primary areas of chemistry. More importantly, all full-time faculty members are involved in research and serve as mentors to engage and train our students.

Program Mission and Its Relation to CSU Mission

The mission of the Department of Chemistry parallels that of the university. Specifically, the mission of the department is to:

- provide students with a thorough undergraduate education in chemistry which will enable them to compete in a global society
- prepare students for graduate and/or professional schools
- prepare students for teaching careers in chemistry in Georgia and beyond
- prepare students for research/technical careers in the chemical industry in the region and beyond
- promote chemical education in the local community and beyond
- provide service to our geographic region in the chemical sciences through university-community partnerships

Graduates are expected to apply quantitative interpretation, think independently, and apply skills and knowledge of chemistry to real-world problems. The programs are specifically designed to provide significant outcomes in terms of the relevance of the program to student's need, the ability of students thinking across disciplines, the impact of technology on the program of study, and the understanding of the relation of the program to diversity, multiculturalism and international perspectives. Hence, the degree programs offer an undergraduate chemistry education that provides a quality and comprehensive learning experience. Hence, through the learning objectives listed below, graduates from the chemistry programs will be able to:

- demonstrate knowledge of the diverse areas of chemistry, both theoretical and practical
- effectively communicate the rapidly changing field of chemical knowledge
- estimate and interpret chemical information in the context of the day-to-day events
- demonstrate skills in quantitative and qualitative problem-solving related to the chemical sciences
- demonstrate knowledge of chemical instrumentation and its theoretical basis, including the operation of microprocessor controlled instruments
- integrate the usage of information technology in chemistry
- think independently and apply chemical knowledge to a problem
- demonstrate knowledge of safety methodologies used in the chemical laboratory
- enter into employment in the chemical industry or graduate or professional schools

In summary, the degree tracks in the chemistry programs are strategically designed and structured to accomplish the mission of the department and thereby satisfying that of the university.

Stakeholder's Satisfaction with the Program

The stakeholders in our programs are our current students, graduates, those who accept our graduates into graduate and professional schools, and those who employ our graduates. By word of mouth and close interaction with our students, we find that our current students are quite satisfied with the program. This is because the faculty members are able to provide one-on-one attention with regard to teaching and research. As a result, the current students recognize the devotion and commitment the faculty members have to help them succeed in reaching their goals.

In regards to our graduates, the department conducted an alumni survey in 2011 in an effort to determine how our graduates are doing and what they thought about the program during their tenure. The results of our departmental alumni survey administered in 2011 to graduates reveal their satisfaction of the programs. The questions in Table I.A relate to the satisfaction of our graduates with the program. Each response is rated on a scale of 1-5 where 1 is strongly agree and 5 indicates strongly disagree. The complete survey can be found in Appendix I.

**Table I-1**. Selected Alumni Survey Questions

| **Question** | **Average** |
|---|---|
| My undergraduate study of chemistry has proved useful to my career because it provided me with the skills to succeed in graduate or professional school. | 1.9 |
| My undergraduate study of chemistry has proved useful to my career because it provided me with the skills to become a secondary teacher. | 1.4 |
| It helped me develop my critical thinking skills as a scientist. | 1.6 |
| Please rate your response to this statement: "I am glad I majored in chemistry at CSU." | 1.8 |
| It provided me with an understanding of the fundamental concepts of analytical chemistry. | 1.8 |
| It provided me with an understanding of the fundamental concepts of inorganic chemistry. | 1.7 |
| It provided me with an understanding of the fundamental concepts of physical chemistry. | 2.0 |
| It provided me with an understanding of the fundamental concepts of organic chemistry. | 1.7 |
| It provided me with an understanding of the fundamental concepts of biochemistry. | 2.0 |

As for as graduate and/or professional schools being satisfied with our graduates, we have received by e-mail correspondence from several graduate coordinators that our students perform as well, if not better, than their cohorts. Consequently, we often receive notices from them inviting us to send more students to their graduate programs. The chemistry faculty members believe strongly that we provide an excellent foundation for students to pursue graduate or professional studies. This is evident in how our students perform in these programs after leaving CSU and their attitude about the training they received.

Since 2006, six of our chemistry graduates have completed graduate programs in chemistry. Institutions where our graduates continued and completed graduate degrees are Auburn University, Georgia Institute of Technology, George Mason University, Georgia State University, Louisiana State University, Virginia Polytechnic and State University, University of Alabama at Huntsville, and University of Tennessee. Currently, there are four graduates pursuing graduate degrees in chemistry at the following universities: Auburn University, Georgia Institute of Technology, and the University of New Hampshire. The feedback that we have received from these universities on those who have completed the graduate degree, as well as those currently pursuing a graduate degree has been very good.

The department has also been successful with its graduates entering the chemical industry as entry level chemist. According to our alumni survey conducted in 2011, when asked "What is the nature of the field in which you are currently employed," a wide range of responses was noted. Nonetheless, companies where our graduates are employed are as follows: Cott Beverages in Columbus, GA; SiO2 Medical Products in Auburn, AL; High Performance Polymer Engineering (HPPE) in Columbus, GA; JVL Laboratories in Columbus, GA; and Columbus Regional GBI Crime Lab. Also, the department has produced five graduates who elected to complete the B.A. Chemistry and Secondary Education track. All five currently teach at the secondary level, four in Columbus, GA and one in Montgomery, AL.

Relationship of Program Needs to Student and Societal Demands

The majority of the students who enter the chemistry programs do so with the intention of pursuing careers medicine, dentistry, or pharmacy. Consequently, they choose the B.A. Preprofessional Chemistry track since it is designed for such. However, once they are in the program and see the latitude that the various tracks offer, most of them elect to change their career path. Only a small percentage of our majors begin with the intent of pursuing an advance degree in chemistry. A goal that was set during the last CPR in 2006 was to obtain ACS certification of the B.S. degree track. The rationale was to provide a more rigorous curriculum which will enable students to get into graduate school in chemistry. In April 2013, the department was awarded ACS approval of the B.S. Professional track by the Committee on Professional Training. As a result, students who satisfy the requirements for the ACS Professional track will receive a certificate with the signature of the president of the ACS. This is to validate completion of a rigorous chemistry degree that is endorsed by the ACS.

Moreover, in the last CPR report the B.S. Forensic Chemistry and Applied Chemistry tracks did not exist. However, due to growing interest in the field of industry and state needs within the Georgia Bureau of Investigation, the chemistry faculty convened in 2007 and proposed two new tracks to address that interest and need. As a result, the Applied Chemistry track was developed and offered in 2008 and in 2010, the Forensic Chemistry track was offered in the Bachelor of Science program.

Additionally, each year the faculty members convene to discuss each degree track and determine if any modifications are needed to improve the curricula. For example, during the 2012-2013 academic year, it was determined that an introductory course in statistics (STAT 1127) be included in each degree track, irrespective of the program, i.e. B.A. or B.S. We believe this course would enhance the students' comprehension of data analysis and could be used for graduate or professional school, as well as, on the job as an entry level chemist or forensic chemist. However, this year we elected to change some program course requirements. In the 2013-2014 academic year, the faculty in the department convened and elected to require two introductory courses in biology, i.e. Principles of Biology (BIOL 1215K) and Contemporary Issues in Biology (BIOL 1225), be included in the B.A. program as courses "Related to the Major." We believe these changes will help students be better prepared to take the medical college admissions test (MCAT) and other standardized examinations required to enter preprofessional schools of dentistry or pharmacy.

Lastly, in the previous academic school year, the College of Letters and Sciences submitted a proposal to substantively change the existing Master of Science in Environmental Science studies to Master of Science in Natural Sciences (with tracks in Biology, Geology, and Environmental Science). The prospectus has been sent to BOR and awaits final approval. Currently, Biology, Earth and Space Sciences, and Environmental Science will offer degrees in this program; however, the chemistry faculty members have expressed a strong interest in being part of this newly structured graduate program and see it as a way to bridge the gap in the discipline for students who may not be quite ready to pursue the terminal degree. More importantly, current employment data suggests that the best degree to get in chemistry right now in terms of employability in industry is the Masters degree. The data indicates that there is too much competition for employment at the bachelors level and Ph.D.s are too specialized and expensive.

**Section Two – Indicators of Program Quality**

**II A. Quality of Faculty**

<u>Appropriateness of Faculty Credentials</u>
*Assessment of Indicator: Very Strong*

In the previous CPR conducted in the former Department of Chemistry and Geology, the following recommendations were suggested to improve the quality of chemistry faculty in the department:

a. engage the faculty members in a more active role in college-wide activities and community outreach programs
b. hire an additional faculty member
c. hire a stockroom manager
d. hire a qualified female faculty member to increase gender diversity

In order to deal with the increase in the number of students taking introductory chemistry courses, the department hired one additional faculty member and replaced another who had retired at the end of the previous academic year. In 2010, the department hired a stockroom manager who also teaches some of the introductory lab classes for non-science and nursing majors. Coincidentally, the stockroom manager who was hired is female thereby helping to address the issue of gender diversity. Nonetheless, the department currently has eight full-time tenure-track faculty members (including the department chair) who have a terminal degree in one of the primary sub-disciplines of chemistry, i.e. analytical, biochemistry, inorganic, organic, and physical chemistry. Also, among the eight faculty in the department, the department has one faculty member in a one year temporary position and conducted a faculty search to replace the female who left after the end of the spring 2012 term. The full-time faculty members are listed in Appendix II-a.

Use of Part-Time Faculty

*Assessment of Indicator: Very Strong*

Currently, the department has very strong and committed part-time faculty members. Among the six part-time faculty members, two have a Ph.D. degree, one is ABD, one has a M.S. in Science Education, and the remaining two have a M.S. degree in chemistry. Three of the six part-timers received their bachelor's degree from CSU. It may be noted that we do not want or allow part-time faculty to teach program required courses in the major. They primarily teach the introductory lecture courses and laboratory courses for non-science majors. However, they are allowed to help teach the first part of the sequence of the introductory laboratory course for majors. Due to one faculty member receiving the Fulbright Award and going on sabbatical in August 2013, a replacement was hired to occupy a one year temporary position. The replacement faculty was hired to teach introductory lecture and lab courses for non-science and nursing majors. The part-time faculty members are listed in Appendix II-b.

Diversity of Faculty

*Assessment of Indicator: Satisfactory*

In our continued effort to deal with gender diversity, in 2011 the department replaced one faculty member, who had previously retired, with a female. The female faculty member remained in the department for two academic years and at the end of the 2013 academic year that faculty member elected to leave CSU to work at another university. As a result, all of the full-time tenure-track positions are held by male faculty members; however, three of the six part-time faculty members are female. However, the department is very diverse in regards to ethnicity/nationality. Faculty members in the department are from the following countries:

**Table II-A1.** Demographics of the faculty in the department.

| **Full time Tenure- track** | **Part-Time** |
|---|---|
| United States (3) | United States (4) |
| Ethiopia (2) | Burma (1) |
| India (3) | Nigeria(1) |

In addition to gender and ethnic diversity, the faculty members of the Department of Chemistry represent the various sub-divisions in the discipline. Faculty members' specialty areas are in analytical, organic, inorganic, physical and biochemistry. Moreover, the faculty members in the department have earned their degrees from universities around the world, which enhances the cultural diversity in our program.

**Table II-A2.** A List of Full-time faculty and their gender.

| **Full-time Faculty** | | | | | | |
|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Male | 8 | 8 | 8 | 7 | 7 | 8 |
| Female | 0 | 0 | 0 | 1 | 1 | 1 |
| African American | 1 | 1 | 1 | 1 | 1 | 1 |
| European American | 1 | 1 | 0 | 0 | 0 | 2 |
| Hispanic American | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 6 | 6 | 7 | 7 | 7 | 5 |
| **Total** | **8** | **8** | **8** | **8** | **8** | **8** |

Each part-time faculty teach one lecture and lab per semester or several lab sections (three credit-hour lecture and one credit-hour lab)

**Table II-A3.** A List of Part-time faculty and their gender and ethnicity

| **Part-time Faculty** | | | | | | |
|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Male | 1 | 1 | 1 | 1 | 2 | 2 |
| Female | 0 | 0 | 1 | 1 | 1 | 2 |
| African American | 0 | 0 | 0 | 0 | 0 | 0 |
| European American | 0 | 0 | 0 | 1 | 2 | 3 |
| Hispanic American | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 1 | 1 | 1 | 1 | 1 | 1 |
| **Total** | **1** | **1** | **2** | **2** | **3** | **4** |

<u>Opportunities for Faculty Development</u>
*Assessment of Indicator: Above Average*

Over the past five years the department has had a change in several faculty positions and gone through a restructuring of department, i.e. separating the chemistry program from the other disciplines in the former Department of Chemistry and Geology, to establish an autonomous Department of Chemistry. Nonetheless, the faculty members in the department have consistently received support for research through Faculty Development Grants. The faculty members have received approximately $134,608 in support for faculty development. This funding was received from the Provost/VPAA Faculty Development budget, the College of Letters and Sciences, the Center for International Education and the Department of Chemistry to support research, i.e. purchase of materials and equipment, travel to professional meetings, and international travel for site visits.

Faculty members are also provided support to routinely attend scientific conferences where they present their research findings. The conferences that are regularly attended are, Georgia Academy of Sciences, Southeast Regional Meeting of the American Chemical Society, and the National American Chemical Society meeting. Each year the faculty members in the department attend one, if not all, of these professional conferences.

Faculty members may apply for semester- or year-long sabbaticals. In spring 2013, Dr. Zewdu Gebeyehu was the recipient of the Fulbright Award and received a one-year sabbatical to fulfill the obligations of the award during the 2013- 2014 academic year. This allowed him to spend one year teaching and conducting research at his alma mater, Addis Ababa University in Ethiopia during the 2013-2014 academic year.

As it relates to faculty development, a goal was set during the last CPR in 2006 to reduce the contact hours of the faculty so as to align with the maximum recommended number (12) by the American Chemical Society for certification. Reducing the teaching load also provides time for faculty to engage in research and mentoring. Additionally, an initiative proposed in the COLS in 2010 is to strive for workload equity among faculty members in the department. The goal is to reduce course load or contact hours for productive faculty who are actively involved in research and mentoring of undergraduate and graduate students. Those faculty members mentoring an abnormally high number of undergraduates and graduate research or applying for and obtaining external funding will also be considered for a one course load reduction. Lastly, non-tenured faculty members in their first and second year will be considered for a course load lower than 12 to provide them with time to write proposals for external funding and enable them to get acclimated to the department and university for conducting research.

<u>Program Improvement Plans</u>

In order for the faculty to remain productive as scholars in the discipline, teaching loads must be reduced to 21 to 24 contact hours for an academic year. Faculty in their first year will be given 21 contact hours in the first year and all other faculty will maintain 24 contact hours. Over the past five years the number of full-time faculty has remained constant while the number of student credit hours generated has increased. From fall 2008 to fall 2013, student credit hours (SCH) generated increased by 21.2% (2300 SCH to 2920 SCH) while the total number of full-time tenure-track faculty remained constant. Although the number of part-time faculty increased from one the three, they are not sufficient to keep up with the increase in students. By increasing lecture size and utilizing part-time faculty in Survey of Chemistry and Principles of Chemistry laboratories, we have been able to handle the increases.

Unfortunately, we were only able to provide the faculty members who were in their first year with a one course reduced teaching load for half of the year. We need to reduce the teaching loads for full-time tenure-track faculty in their first year to nine contact hours. This reduced teaching load will enable them to become acclimated to the department, college, and university. Meanwhile, they will be able to set up their research laboratory to mentor students. We also need to reduce the teaching loads for the full-time tenured faculty involved in research and grant writing, as well as those mentoring a large number of undergraduate and graduate students in research, and/or have an external grant.

- Hire two full-time tenure-track faculty members. Currently, the department does not have a forensic chemist so some courses (Forensic Chemistry 1 & 2) are not offered. Moreover, there is only one biochemist in the department. With the addition of one more biochemist, we will be able to offer more courses in the sub-discipline and pursue offering another degree track which is certified by the ACS. Hence, two additional full-time tenure-track faculty members, i.e. one in biochemistry and one in forensics chemistry, are needed to help lower course teaching loads and teach upper-division courses not yet offered, such as advanced biochemistry and Forensics Chemistry 1 & 2 with their co-requisite labs. More importantly, it is well documented that by offering a B.S. degree with a concentration in biochemistry will attract more students to the university and thereby increasing the number of majors by a factor of 2 or three, i.e. the number of majors in the discipline will double or triple.

- The department proposes to hire a permanent full-time lecturer to teach Survey of Chemistry lecture and lab classes. This will enable the department to fill the void resulting from having to hire part-time help while a faculty member is out on sabbatical. Two of the lecturers currently holding these positions are temporary and their term of employment ends in May 2014. Concurrently, there are 4 part-time faculty members where only one is stable; however, one continued to teach an online course after resigning from a permanent full-time tenure-track position. That faculty member is not expected to continue teaching our online course after the 2013-2014 academic term. Another who is listed as ABD is completing the Ph.D. and is not expected to remain after the conclusion of the 2013-2014 academic year. Finally, a third faculty member holding a full-time temporary position was hired to assist because one full-time tenured faculty member is on sabbatical for a year. Since the faculty on sabbatical will return for the next academic year, the temporary faculty member will not return. Therefore, it is very important to secure a permanent full-time lecturer and maintain the 3 part-time faculty members in order to lower the teaching loads for the full-time tenure-track faculty. More importantly, this will allow our tenure-track faculty to concentrate and devote more time to our undergraduate majors, and pursue research and grant writing activities.

- Increase financial support for faculty to attend professional meetings and workshops. The departmental "Standards of Excellence" was revised each year over the past five years. As a result, the requirements for tenure, promotion, and merit-pay increases require that faculty engage in more scholarly work. However, at the current level the funding support is not sufficient for faculty to attend conferences to collaborate with colleagues and learn about new research opportunities.

- In 2012 the COLS proposed to modify the Master in Environmental Science to make it more inclusive. It was proposed that the college offer a Master of Science in Natural Sciences with degrees offered in biology, environmental science, and geology. The intent of the Department of Chemistry is to participate in this program by offering a degree track in chemistry to enhance the overall productivity and scholarly activity of the faculty in chemistry. However, in order to support graduate students as teaching assistants, the department will need initial startup funds to pay for tuition and provide stipends for the first cohort of students.

**II B. Quality of the Teaching**

Indicators of Good Teaching
*Assessment of Indicator: Above Average*

The Social Research Center provided summary data of course evaluations. All Chemistry courses combined yields an average score of 4.28 out of 5 with the highest value scored for the statement “The instructor is well prepared.” and “This course was academically challenging. = 4.50 and the lowest for “I have progressed in my ability to think critically, to solve problems and/or to make decisions” = 4.11. The 1000-level chemistry courses for science majors averaged the lowest scores with an average of 4.01 and the 4000- and 5000-level courses averaged the highest at 4.75. The highest average score was for a full-time faculty member at 4.73, and the lowest was for a full-time faculty member at 3.33. The numbers reported support the assessment of above average and that there is room for improvement for all faculty members.

Consequently, the faculty members in the chemistry department have utilized a variety of teaching methods including the use of the Mastering Chemistry online homework and peer leaders in the Principles of Chemistry 1 and 2 lecture and lab courses.

Indicators of Good Advising
*Assessment of Indicator: Below Average*

To improve the quality of advising, the faculty members in the Department of Chemistry elected to allow the Center for Academic Excellence advise all freshmen and sophomores in the major. With faculty advising only juniors and seniors, each advisor is assigned not more than 15 advisees. Consequently, the faculty members are able to spend more time with each student ensuring that they have been properly advised and remain on track.

Departmental Reward System
*Assessment of Indicator: Below Average*

During every spring semester the department chair conducts the annual performance evaluation. One of the criterion by which faculty members are assessed is teaching. The performance evaluation is based upon the Departmental Standards of Excellence, which are developed by the faculty and approved by the chair of the department and dean of the college. Consequently, recommendations for merit pay raises and for promotion and tenure are based on the evaluation. Unfortunately, merit pay raises have been non-existent for the past six years.

Program Improvement Plans

- Currently, the department chair conducts classroom visits to evaluate the quality of teaching of only non-tenured faculty and tenured faculty ask each other to evaluate their teaching, but it is not structured. To improve the quality of teaching, the department will develop a peer classroom evaluation instrument that will be used for all faculty members in the department. The goal is to improve teaching effectiveness by assessing classroom instruction more systematically and rigorously using peer evaluations. Peer faculty classroom evaluations will be submitted to the department chair for review. Hence, a new assessment tool will be developed and used for peer evaluation.

- The current Automatic Advisor Assignment shifts the advisors each year so the students never remain with the same advisor. Consequently, the faculty and student never get to know one another well enough to develop an advisor-student relationship. The department chair will work with the Registrar to develop a system that will allow students to remain with the same advisor once they are juniors and seniors. Moreover, the department will develop an advising evaluation form that students will complete and submit to the chair for review.

- With the acquisition of DegreeWorks and MAPWorks, faculty will be able to better engage in advising. DegreeWorks will enable faculty to track student progress and provide accurate advice on what courses they need to complete the degree track. Meanwhile, MapWorks will reveal students strengths and talents, as well as identify areas that need further development. Hence, it will enable faculty to formulate a plan to provide services and support specific to each advisee.

- With the use a Qualtrics, the stress of advising incoming freshman will be eliminated by pre-registering students before they arrive for orientation. This will also ensure that students are taking the correct courses.

- We will develop a "Learning Community" for freshman chemistry majors. All incoming freshman majoring in chemistry will take the same lecture and lab sections of the Principles of Chemistry 1 and 2. We will do the same for the Organic Chemistry sequence of courses. We believe the learning community will allow the chemistry majors to establish camaraderie early thereby lending support to one another as needed. As a result, this will lead to an increase in the retention and graduation rates in the major.

- We will develop and make available the first part of Survey of Chemistry lecture and lab as online classes. Currently, only Survey of Chemistry 2 and its co-requisite lab are offered online. We will develop the first part (Survey of Chemistry 1 and its co-requisite lab) to complete the sequence being offered online. There is an increase in demand for these courses and offering them online will help meet the demand. Moreover, these online courses will be used to support the DN3 program as well as the "Academic Partnership" program.

**II C. Quality of Research and Scholarship**

Opportunity for Student Research Projects
*Assessment of Indicator: Very Strong*

All students in the B.S. ACS Professional Chemistry track are required to conduct an independent senior research project under the guidance of a faculty member. Moreover, students in this track are required to give two oral presentations, i.e. one in the first semester for part 1 that is normally offered in the fall term and another in the second semester for part 2 that is offered in the spring. Students in the Applied Chemistry and Preprofessional Chemistry Tracks may also conduct research through the Independent Study course for 1, 2, or 3 credit hours. The pre-requisite for Independent Study is completion of one semester of organic chemistry or approval from the department chair.

Nonetheless, students are encouraged to apply for the grant provided by the Office of the Provost, i.e. Student Research and Creative Endeavors (SRACE) to help support the project by paying for chemicals and supplies. Students are also encouraged to present their findings at professional meetings. Nearly all students present their research findings at CSU Tower Day, Georgia Academy of Sciences, and the Southeast Regional Meeting of the American Chemical Society (SERMACS). Some students also present their research at the ACS national meetings. When the national meeting of the ACS is within driving distance, students are encouraged to participate. Finally, all Honors students are required to present their honors research projects at CSU Tower Day and before their advisory committee.

Faculty Publications, Presentations and Grants
*Assessment of Indicator: Above Average*

Over the past five years the chemistry faculty members have actively engaged in scholarly research which resulted in peer-reviewed publications and conference presentations. They have authored or co-authored over 16 professional papers and given 54 professional talks at various scientific meetings. The faculty members have also served as reviewers of textbooks and professional journals in the discipline.

The faculty members have also actively sought funding, internal, as well as external to support their research efforts. Over the previous five years, faculty members have received approximately $135,000 in faculty development funds and over $622,000 from external sources such as the National Science Foundation, Congressionally Directed Funds, and the University System of Georgia Teacher Quality Grant program. Since the department has gone through several changes in the personnel, no record is available for the scholarly accomplishments of those faculty members who are no longer with CSU. A list of faculty publications, grant awards, and presentations of the faculty at various scientific meetings over the past five years are listed in Appendix II-c.

Program Improvement Plans

- Chemistry faculty will be encouraged to aggressively seek funding from external agencies to support research, students, and travel to conferences.
- Chemistry faculty will be encouraged to apply for University Faculty Development Grants.
- Chemistry majors will be encouraged to apply for SRACE grants to support their undergraduate research projects and travel to scientific conferences to present their findings.
- Chemistry majors will be encouraged to attend local, regional, and national conferences, such as the Georgia Academy of Sciences, Georgia Undergraduate Research Conference, and the local, regional, and national American Chemical Society meetings.
- In 2012, Columbus State University was selected to partner with the Gulf Coast Ecosystem Studies Unit. We will leverage this partnership to pursue grants to support faculty and student research and travel to professional meetings to present results.
- Columbus State University is in the initial stages of establishing collaborations with the John B. Amos Cancer Center. Faculty will be encouraged to develop collaborative projects that could lead to funding research.
- The chemistry faculty will be encouraged to establish new collaborative research projects with colleagues across the country and continue those already formed.
- Improve faculty shared lab space to increase productivity and professional growth.
- For faculty who have externally funded grants, reduce their teaching loads to 9 contact hours per semester (not to include Independent Study)

**II D. Quality of Service**

Activities to Enhance Program, Department, College, Institution, Community and/or Region
*Assessment of Indicator: Very Strong*

There are 47 University, Institutional, and Elected Committees. The chemistry faculty members hold seats in 23% of the committees. This is indicative of the faculty in the Department of Chemistry being engaged throughout the life of the campus. Nevertheless, over the past two years there has been a change of faculty, i.e. three new faculty started in fall 2012 and one in 2013. Consequently, the new faculty members have not had enough time to get any substantial committee assignment. Faculty members in the Department of Chemistry serve in a number of capacities at the university and beyond. The faculty members in the department occupy seats in a number of committees on campus. Some of the committees that the chemistry faculty members serve on are presented in Table II D and a complete listing of specific committee assignments of the faculty are presented in Appendix II-d.

Table II D. Faculty Committee Seats and Community Service over the past five years.

| **COLS and Columbus State University** | **Columbus Community and beyond** |
|---|---|
| Faculty Senate | Science Olympiad |

| | |
|---|---|
| International Education Committee | Columbus Regional Science Fair |
| Quality Enhancement Program | National American Chemical Society |
| Sustainability Committee and Master Plan Committee | American Chemical Society Local Section Executive Board |
| Chairs' Assembly | Georgia Academy of Science |
| Admissions Committee | High Performance Polymer Engineering |
| Scholastic Honors | Eastman Kodak Company |
| Publication Committee | |
| Technology Utilization Committee | |
| Diversity Council | |
| Diversity Committee (Senate) | |
| General Education, General Education Reform and Core Curriculum Committees | |
| College Curriculum Committee | |
| Tower Day | |
| Institutional Review Committee | |
| Salary Study Committee | |
| Strategic Planning Committee | |
| Member Electrochemical Society | |
| Faculty Development Committee | |

Chemistry faculty members serve in various capacities in many of the committees and organizations listed above. In addition, faculty members are active at the department level with recruiting and developing a departmental brochure, upgrading our departmental webpage, improving the curriculum, revising standards of excellence, developing a colloquium, monitoring equipment needs, and working with the Chemical Hygiene Plan. The Chemical Hygiene Plan can be found in Appendix II-e. The chemistry faculty also serve as advisor to the American Chemical Society Student Chapter organization. One faculty member has served as a member of the ACS General Chemistry Committee. Faculty also meet and welcome potential majors at Discovery Day. More importantly, all faculty strive to maintain contact and communication with our alumni through e-mail.

Program Improvement Plans

Faculty members will be encouraged to strategically prioritize service activities that will enhance the chemistry program, College of Letters and Sciences, University, students, and community. Since the department has had a change in full-time tenure-track faculty, a new brochure will be developed and the department web-page will be updated. The department also proposes to develop a Facebook page to maintain better contact with alumni and current students. Faculty members will increase their presence at local and regional high schools in an effort to recruit. The department has developed an External Advisory Committee and plan to strengthen the interaction of the committee by having at least one meeting per year. Lastly, faculty will be encouraged to remain active in campus events and university committees.

**II. E. Quality of Faculty and Student Achievements**

*Assessment of Indicator: Very Strong*

Faculty Honors

Faculty in the Department of Chemistry has been recognized for outstanding achievement at the university as well as at the state and national levels. Among the greatest accomplishments on campus is that of Drs. Floyd Jackson and Anil Banerjee who were the recipients of the "Educator of the Year Award" in 2010 and 2012, respectively. The awards that the faculty members have received is a testament to the efforts put in to deliver quality programs for our students. In addition, the awards received by our students are a demonstration of the training they receive from a committed faculty. Other notable accomplishments by the faculty are presented in Appendix II-f.

Student Honors
The students in the department have distinguished themselves by achieving numerous awards on campus as well as at regional, state, and national conferences. Among the greatest accomplishments on campus is that of Ms. Claire Eunhye Cho who was the recipient in 2012 of the "Faculty Cup Award" which is the highest award a student can achieve. The awards received by the students are presented in Appendix II-g.

Achievements (Licensure, Certification, Admission to Graduate School, Job offers, etc.)
We have been able to follow the career paths for 33 of our 51 students who graduated between summer and 2008 to spring 2013. This information is summarized in the table below.
**Table II-E1.** A list of graduates and the career path taken after leaving CSU.

| Occupation | Number of Graduates |
|---|---|
| Graduate School | 16 |
| Medical School | 3 |
| Teacher | 4 |
| Pharmacy School | 1 |
| Dental School | 1 |
| Laboratory Technicians | 7 |
| Military | 1 |

We remain in contact with over two thirds of our graduates. The list above reveals that the majority of the students who complete the Bachelor's degree from our programs continue to pursue graduate studies. Nonetheless, those who enter the work force perform very well in their respective positions.

**II. F. Quality of Curriculum**

*Assessment of Indicator: Very Strong*

Relationship between Program's Curriculum and Its Outcomes
*Assessment of Indicator: Very Strong*

In the last CPR conducted in 2007, it was determined that the department was not prepared to apply for certification of its Bachelor of Science program through the American Chemical Society's Committee on Professional Training (ACS CPT) for a number of reasons. Consequently, the recommendation was that the curricula be thoroughly reviewed and refined so as to align it with the requirements to that of an ACS certified program. According to ACS guidelines, the curriculum of an approved program provides both a broad background in chemical principles and in-depth study of chemistry or chemistry-related areas that build on this background. The guidelines divide the chemistry curriculum for the certified major into three categories: the introductory chemistry experience, foundation course work that provides breadth and rigorous in-depth course work that builds on the foundation.

Moreover, an approved program uses effective pedagogy in classroom and laboratory course work where instructors teach their courses in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles. Hence, faculty members incorporate pedagogies that have been shown to be effective in undergraduate chemistry education across the country. Examples include problem- or inquiry-based learning, peer-led instruction, group learning, learning communities or networks, writing throughout the curriculum, and technology-aided instruction. Except for learning communities, we have included each of these pedagogies into our curriculum. The department also participates in the "Learning Communities" arranged by the Department of Basic Studies.

In 2010, we submitted a pre-application to the ACS CPT to determine if our program was ready for a thorough evaluation to become certified. After their review was complete, we were asked to submit a full application. A full application was submitted in June of 2012 and the department was notified in May 2013 indicating that the department was in compliance and had satisfied all of the requirements for certification by the ACS. ACS Certification is indicative that our curriculum is rigorous as it is designed according to national standards. The ACS Guidelines and supplemental material are available online at the link below and is presented in Appendix II-h.

https://www.acs.org/content/acs/en/about/governance/committees/training/acs-guidelines-supplements.html.

Moreover, having an ACS certified program requires that we review and submit a short report each year about the curriculum and a full report every five years. The result was that we refined our program outcomes and aligned them with national standards.

Each year the chemistry faculty convened to discuss the curriculum to determine if any part needed to be refined. In 2009, the faculty proposed to offer a Bachelor of Science with a concentration in Forensics. Former Provost Levi indicated that she was very much in support of this new degree track and offered to provide funding to hire a forensic chemist. As a result, the track was developed and placed in the catalog. Unfortunately, there was a change in the upper-administration at the dean and provost levels. Moreover, the financial situation at the university reached a critical juncture so we have not been able to hire a faculty to teach the specific forensics chemistry courses for the track. In addition to adding a track to the B.S. program, the other tracks in both programs have undergone refinement each year so as to eliminate unnecessary courses and include courses that would better assist the students in their career paths. Additional information regarding the design of various tracks in chemistry are found online at the link below and in Appendix II-I through Appendix II-n

https://www.acs.org/content/dam/acsorg/about/governance/committees/training/acsapproved/degreeprogram/degree-tracks.pdf

<u>Incorporation of Technology</u>
*Assessment of Indicator: Satisfactory*

The faculty have developed a fully online 1000-level lecture and lab course of a two part sequence for non-science majors. In addition, at least 66 percent of the faculty members utilize D2L to post supplemental material including power-point lecture notes. At least three of the faculty members have incorporated the use of Clickers/Response Cards in their classes and all faculty members use Mastering Chemistry online homework to supplement their teaching in the Principles of Chemistry 1 and 2 courses.

In the upper division courses, the lab components include the use of modern chemical instrumentation, such as NMR, FTIR, UV-Vis spectrometers, HPLC, GC, and GCMS. Since the last CPR, the department has acquired several major pieces of state-of-the-art equipment that is widely used in the discipline for analysis and characterization. Some of this equipment includes a Nuclear Magnetic Resonance Spectrometer (NMR), Gas Chromatography-Mass Spectrometer (GCMS), Mastercycler (PCR cloning), Refrigerator-Shaker, Microwave Chemical Reactor, Gel-Permeation Chromatography (GPC), and an Elemental Analyzer (CHNS Analyzer).

<u>Utilization of Multidisciplinary Approaches</u>
*Assessment of Indicator: Above Average*

Chemistry is considered the "central science" so the courses offered are inherently multi-disciplinary. In addition to the standard general education core requirements, students majoring in chemistry are required to take various math (including calculus and statistics) and physics courses. Students in the Bachelor of Arts program are required to take three biology courses (*Principles of Biology, BIOL 1215K; Contemporary Issues in Biology, BIOL 1225K*, and *Cell Biology, BIOL 3215K*). This is to augment their efforts to get into medical, dental, or pharmacy school. However, students in the Bachelor of Science program are encouraged to take at least two biology courses. Additionally, Bachelor of Arts students must take sequence of foreign language courses. Discipline-specific writing and oral communication is integrated throughout the curriculum. In addition to the required composition classes in area A, all chemistry courses, 2000 level and higher require students to write formal laboratory reports.

Moreover, students get practice writing following the standard format for professional papers and presentations in their Independent Study and Senior Seminar courses as outlined in the ACS CPT guidelines for "Preparing a Research Report" located online at and in Appendix II-o.

https://www.acs.org/content/dam/acsorg/about/governance/committees/training/acsapproved/degreeprogram/preparing-a-research-report.pdf.

Students also gain practice and confidence in presenting scientific research in senior-level classes, Independent Study, Senior Seminar 1 and 2, and at scientific conferences. Finally, the department follows closely the outline presented by the ACS CPT for developing student skills. The outline is presented in Appendix II-p.

Utilization of Multicultural Perspectives
*Assessment of Indicator: Above Average*

Over the past five years the Department of Chemistry has developed two different study abroad courses. In fall 2010, the first course, Environmental Chemistry, was developed and offered during the following spring semester in Ethiopia. The course was offered as a 5000 level Selected Topics course. The course was offered over an eleven day period which included spring break. In order for students to gain a global perspective with regard to environmental problems, they visited polluted rivers and eroded archeological sites. Additionally, the students met with local citizens and shared their knowledge about various environmental issues throughout the region. Lastly, students were able to attend lectures on various environmental concerns from professors at the local university, i.e. University of Addis Ababa in Ethiopia.

In fall 2012, the chemistry faculty began working on the development of the second study abroad course. During the fall 2012 term a proposal was submitted to the Curriculum Committee to develop a new selected topics course at the 3000 level and was approved. In spring 2014, the second study abroad course (Chemistry and Industry in India) was offered in Bangalore, India. Again, the course was offered during spring break as before. Two different levels of the course were offered as Selected Topics, i.e. CHEM 3555 and CHEM 5555. In this course, students visited various chemical industry plants in Bangalore to get a better understanding of the development and process of chemicals in India. Students also visited a research institution to learn about research projects at the graduate level.

Program Improvement Plans
There are several initiatives that have been proposed by the faculty and are in the planning stages. First, the faculty who teach Principles of Chemistry are planning to use the "Learning Catalytics" by Pearson. This tool will allow faculty to take roll, assign in-class participation, post quizzes, and engage students in thought provoking interactive activities during class.

- We plan to develop and make available the first part of Survey of Chemistry lecture and lab as online classes. Currently, only part two of the sequence is offered online. Moreover, we plan to develop a one credit hour online course in Chemical Hygiene/Chemical Safety. This course will be required for each degree program irrespective of the track.

- The department also has plans to develop "Learning Community" sections for Principles of Chemistry and Organic Chemistry classes. In doing so, we will be able to keep our majors together and they will get to know one another earlier.

- We are also proposing to add another track (Biochemistry) to the B.S. program. We believe that adding a biochemistry track will attract more students into the major because it is appropriate for those students who wish to pursue medicine, dentistry, and/or pharmacy. We believe that a good number of the students not enrolling in to CSU will do so as opposed to going elsewhere because of their interest in biochemistry.

- Last year the Departments of Biology and Earth and Space Sciences proposed a Master of Science in Natural Sciences. The chemistry faculty have expressed a strong interest in developing a track in chemistry for this masters' program. We believe a track in chemistry would serve graduates of our program and other programs in the region who are interested in pursuing graduate studies in chemistry.

- Lastly, over the past several years, we have developed one lower division course (Consumer Chemistry for non-science Majors) and 10 new upper division courses to give students a broader perspective of the discipline, thereby, providing more electives.

  1. Selected Topics in Chemistry, CHEM 3555
  2. Biochemistry 2 Lab, CHEM 3346
  3. Survey of Physical Chemistry, CHEM 4115
  4. Survey of Physical Chemistry Lab, CHEM 4315
  5. Forensic Chemistry I, CHEM 4181
  6. Forensic Chemistry II, CHEM 4182
  7. Forensic Chemistry I Lab, CHEM 4381L
  8. Forensic Chemistry II Lab, CHEM 4382L
  9. Advanced Organic Chemistry, CHEM 5110
  10. Catalysis, CHEM 5116

Our plan is to offer these courses on a rotating basis to give the students broader perspective on various chemical topics.

**II. G. Quality of Facilities and Equipment**

*Assessment of Indicator: Below Average*

<u>Availability of Classroom and Laboratory Space</u>
*Assessment of Indicator: Below Average*

Classrooms are assigned by a computer software program entitled, "Optimizer." This program is designed to compile information such as preferred building, course enrollment, and specific technology requirement requests to assign rooms for all courses being offered; however, the software has its limitations and errors often occur. Nonetheless, faculty may request reassignment when inappropriate rooms are assigned.

In regards to available classrooms for lecture classes, there is only one large lecture room on campus, i.e. Stanley Hall, room 203, which is able to hold 244 students. This room is needed for two chemistry courses, Survey of Chemistry and Principles of Chemistry which normally have class sizes between 110 and 140. However, this room is also heavily utilized by faculty in Department of Biology and Department of Earth and Space Sciences in their core courses. In addition, a number of other chemistry classes that are offered require several mid-sized rooms, such as Stanley 205, 207, 209, and 211, with seating capacities in the range of 58-105. Unfortunately, none of these rooms, including room 203, are adequate for conducting chemical demonstrations in class.

All chemistry laboratory classes are conducted in LeNoir Hall. In order to remain in compliance with the guidelines of the American Chemical Society's Committee on Professional Training, the labs are set up for a maximum of 24 students per lab. During a given semester we offer 11 to 12 sections of Survey of Chemistry 1 & 2 lab, 13 sections of Principles of Chemistry 1 & 2 lab, and 4 sections of organic chemistry lab. LeNoir Hall, room 307 is used for Survey of Chemistry 1 and 2 Labs, room 309 is used for Principles of Chemistry 1 and 2 Labs, and room 310 is use for organic chemistry 1 and 2 labs. It is common to offer multiple sections of the same lab course simultaneously. However, we are limited to the number of students who may take the courses due to available lab room space since we can only offer one lab section of each sequence during any given time segment.

Rooms 103, 205, 206, and 209 in LeNoir Hall are less heavily occupied. However, these rooms are only used for upper-division lab classes and faculty guided research by undergraduates. The majority of the faculty members in the department do not have personal space for mentoring students in research. Consequently, faculty and students have to conduct research during times when the labs are not in use by the structured classes. Nonetheless, over the past five years there has been an increase in research productivity among the faculty and students in the department. In order to continue with the scholarly output of the faculty, we will require additional space. Currently assigned space in the department is found in Appendix I-q.

Availability of Equipment

In the last CPR report, it was recommended that we increase the library resources, seek funding for the acquisition of a nuclear magnetic resonance (NMR) spectroscopy instrument, use lab fee money to maintain glassware and the purchase of smaller instruments, and increase lab space.

We were able to achieve all but one of the recommendations, i.e. increase the available space. Some logistical rearrangements were made in the department to address the space issue as it relates to available offices in LeNoir Hall. For example, we converted the old "Darkroom" into an office since it had not been used for its intended purpose for 15 or more years. We also made some changes in the labs, but this was only to accommodate the addition of newly acquired equipment.

In regards to the equipment in the department, over the past five years we have acquired a number of very important pieces that aided in the department in obtaining ACS Certification. The first and most important piece is the 60 MHz Nuclear Magnetic Resonance Spectrometer which was acquired through funding from the National Science Foundation's Course Curriculum and Laboratory Improvement (CCLI) grant program. The department also obtained other vital pieces of equipment, i.e. High Performance Liquid Chromatography (HPLC), Graphite Furnace Atomic Absorption Spectrophotometer, Fourier Transform Infrared Spectrometer, and a Carbon Hydrogen Nitrogen and Sulfur Elemental Analyzer, through funding from a Congressionally Directed Fund grant.

Moreover, from our close work with the director at the GBI Crime Lab in Columbus, we acquired five second generation Gas Chromatography Mass Spectrometers (GCMS), one Gas Chromatography (GC), and two High Performance Liquid Chromatography (HPLC) instruments through the state surplus/transfer program. The department also acquired a working third generation model GCMS through a donation from a private company. Although these acquisitions have proven to be vital for research and the training of our students, the equipment is older and requires substantial funding to keep them operating properly. Nonetheless, these acquisitions demonstrate our success in working to develop university and community partnerships. Through departmental lab fee funds and university faculty development grants, the department has also acquired other crucial pieces of equipment. A complete listing of the equipment/instruments in the department is presented in Appendix II-r.

As is evident from the extensive list of current equipment, the department is fairly well equipped with state-of-the-art instrumentation that is used for teaching and research. However, the equipment requires substantial financial support to keep them functioning properly. Routine maintenance checks are critical to the upkeep of the equipment. More importantly, the equipment is getting older and will need to be replaced periodically so as to keep the labs equipped with modern instrumentation.

Program Improvement Plans

A. Classroom and Laboratory Space

There are several improvements needed for the chemistry program to continue to progress. The improvement requests are:

- Since many different departments wish to use Stanley 203 because of its large seating capacity, additional (at least two) large rooms of similar seating capacity are needed.
- Four large laboratory classrooms are needed to be able to offer multiple lab sections of Survey of Chemistry, Principles of Chemistry, and Organic Chemistry simultaneously. The fourth lab is to allow for Biochemistry, Inorganic, and Quantitative Analysis labs to be offered unhindered.
- Four small labs or one large lab is needed for students to conduct research. Faculty members need dedicated research space so students conducting senior research are not limited to working in labs where classes are taught and so that faculty members can have dedicated space for their projects to mentor students.
- The ACS Committee on Professional Training recommended that the university develop a five year budget plan for "Major Capital Equipment" to replace older equipment with newer up to date models.

- The department desperately needs financial support to pay for maintenance contracts. The department currently pays out approximately $30,000 per year on service contracts.
- Purchase a higher power 300 MHz NMR instrument and sustainable support for its operation and maintenance for student research. The current 60 MHz NMR is primarily used as a teaching tool for the introductory undergraduate organic chemistry lab.

**Section Three – Indicators of Program Productivity**

**III A. Enrollment in Program for Past 5 Years**
*Assessment of Indicator: Satisfactory*

The number of chemistry majors has increased between 15 and 20 % over the past five years. When the Forensic Chemistry track was initially offered there was great interest in the track; however, the department has lost a number of majors after discovering the courses in the Forensics Chemistry track are not being offered because we do not have a forensic chemist in the department. Unfortunately, the faculty in the department all have full teaching loads and are unable to devote time to develop and offer the chemistry courses in the track. A list of enrollment over the past five years is presented in Appendix III-a.

**III B. Degrees Awarded Over Past 5 Years**
*Assessment of Indicator: Satisfactory*

A vast majority of our students enter the B.A. program with the intent to pursue pre-professional careers. However, at some point many elect to switch to one of the tracks in the B.S. program. The numbers reveal that there is a gradual increase in the number of majors graduating from the programs. In fall 2013 the degree tracks were refined as outlined in section IIF. Over the past five years we have alternated some of our 3000 level requirements and our 5000 level course offerings so as to allow students the opportunity to acquire enough electives in area H. We also modified the requirements such that students may take some area H electives of 3000 level or higher courses in biology, mathematics, physics, and engineering. This will enable them to take courses which are tailored more closely to their career interest. For example, students interested in pursuing medical school are advised to take BIOL 3215 and BIOL 3216, i.e. Cell Biology and Genetics, respectively. On the other hand, students interested in pursuing graduate studies in chemistry are advised to take MATH 3107 (Differential Equations) or other upper division math courses such as Introduction to Linear Algebra (MATH 2115).

Finally, the guidelines set forth by the American Chemical Society's Committee on Professional Training indicates on page 3 section 2.4 that the average number of graduates per year over a five year period is 2 for a program to be acceptable for approval. Fortunately, we are well in compliance of this minimum requirement. A list of the degrees awarded over the past five years is presented in Appendix III-b.

**III C. Comparison with CSU and University System of Georgia Programs**
*Assessment of Indicator: Below Average*

In comparison with other USG programs, we are below average in the number of students we graduate each year (7 for CSU and an average of 9.8 for USG peer institutions listed below). However, these numbers need to be normalized based on the number of students in each program. Our average of 7 graduates per 100 students enrolled per year is slightly below the average of 9 students per 100 enrolled per year at these peer institutions. We believe the improvement plan listed in section IIID will improve retention and progression toward graduation. A comparative list of baccalaureate degrees awarded over the past five years is presented in Appendix III-c.

**III D. Retention Rates**
*Assessment of Indicator: Above Average*

Retention rates in chemistry are slightly higher than that of the university's over the evaluation period. Data regarding the Retention Rates is presented in Appendix III-d. Nonetheless, we are not satisfied with our current rate and have initiated several program improvement initiatives which are listed below.

**Chemistry Initiatives for Retention, Progression and Graduation Improvements**

1. Develop "Learning Community" (LC) sections for Principles of Chemistry and Organic Chemistry. The LCs will be reserved for chemistry majors.
2. Create and offer a variety additional upper-division courses to allow more opportunities for students to complete the program without having to wait an additional year for a course to be offered.
3. Assist students in securing positions in summer intern programs.
4. Allow students to get course credit for Independent Study through summer internships.
5. Seek and acquire external funding to provide departmental scholarships for juniors and seniors conducting independent research or internship research.
6. Utilize peer leaders to improve student performance in introductory classes and classes with large enrollments.
7. Work closely with the Advising Center for Excellence (ACE) to help them understand our degree programs better. This in turn will help improve advising and keep students on track when they reach the faculty as juniors.
8. Pre-register new freshmen during orientation in order to ensure that students are off to the best possible start with appropriate schedules that maximize degree progress.
9. Develop a B.S. Degree Track in Biochemistry and use it to recruit more students into the major who would otherwise not attend CSU.
10. Submit a proposal to offer a degree track in chemistry in the Master of Science in Natural Sciences program to increase our research productivity. Also, it will provide us with teaching assistants to help tutor introductory courses for science majors and coordinate introductory lab courses and courses with large enrollments.
11. Expand Study Abroad opportunities in the department.
12. Offer separate group advising meetings for freshman/sophomores and juniors/seniors in order to ensure that our students are on track and to inform them of opportunities in research and international field courses.

**III E. Student Learning Indicators (using a variety of data sources)**

*Assessment of Indicator: Satisfactory (compared to the national and peer averages)*

The best indicator of student learning is our seniors' scores on Educational Testing Service's (ETS) Major Field Test (MFT) in Chemistry. The Chemistry MFT assesses students' knowledge and understanding of concepts, theories, and practice in each of the four major sub disciplines: Physical Chemistry (1), Organic Chemistry (2), Inorganic Chemistry (3), and Analytical Chemistry (4). It also includes questions that assess Analytical Skills (scientific reasoning and data analysis). The test is administered every fall and spring semester to students who have applied for graduation, and the exams are scored in annual cohorts. ETS reports for each student an overall score, scores for each of the four sub-areas, and various "assessment indicators" including Analytical Reasoning. The data presented in Appendix III-f to Appendix III-ee shows those CSU students from 2011-2013 performed similarly to students nationwide and to students at 9 peer institutions listed below.

Over the past five times the MFT was administered to our seniors, the scores indicate that our students perform within the same range and near the regional average. The 2011 cohort performed similarly on a newly revised version of the test. Furthermore, our current seniors and recent graduates rated highly the quality of preparation towards career and/or graduate studies. Fifteen out of 20 current seniors indicated that the quality of preparation was good or very good with an average rating of 4.10/5, and 28 out of 37 recent graduates rated quality of preparation as good or very good with an average of 4.05/5.

**III F. Graduation Rate of Program**

*Assessment of Indicator: Below Average*

The graduation rate for the Chemistry Programs varies each year in a manner similar to the number of graduates per year. In 2009 the graduation rate was 30.8%, then increased to 45.5% in 2010 and then fell to 37.5% in 2011. In 2012, the graduation rate fell to 26.1 and rebound to 30.8 in 2013. Hence, the only observable trend is that the graduation rate is holding constant, if not slightly increasing. However, to improve the rate of graduation for students earning a baccalaureate degree in chemistry, the department has developed several initiatives which are outlined in section III D. The Graduation Rates of the Program are presented in Appendix III-ff.

**III G. Cost Effectiveness of Instructional Delivery**

*Assessment of Indicator: Very Strong*

The data in the table below shows that instruction in chemistry has remained reasonably constant over the past five years despite having a slight increase in the number credit hours generated in the department. This consistency is due to faculty teaching larger section of introductory level courses. Consequently, the lecture class size was increased so the number of sections of the lab increased. The increase in the number of lab sections has only been possible with the use of upper level student teaching assistants employed to help with preparing the laboratory activities (prepping the lab) and grading lab reports for introductory lab classes. However, in order to improve in this area the department will need additional faculty members to accommodate the increase in students enrolled. Nonetheless, the department is seeking ways to implement techniques to improve student learning outcomes while increasing the class sizes which may work in opposition to student learning.

*Instructional Cost – Chemistry,*

| | Fiscal Year | | | | |
|---|---|---|---|---|---|
| **Chemistry** | **2010** | **2011** | **2012** | **2013** | **2014** |
| State Funds | $898,005 | $830,768 | $852,252 | $899,480 | $900,208 |
| Grant Funds | $149,491 | $206,786 | $32,370 | $32,763 | |
| *Total* | *$1,047,496* | *$1,037,554* | *$884,622* | *$932,243* | *$900,208* |

| Total Instructional Costs per Credit Hour and Headcount at CSU | | | | | |
|---|---|---|---|---|---|
| **Fiscal Year** | **Instructional Costs** | **Total Credit Hours Generated** | **Total Headcount** | **Cost per Credit Hour** | **Cost per Headcount** |
| 2008 | $31,868,466.00 | 164,732 | 7,590 | $193 | $4,199 |
| 2009 | $31,193,232.00 | 171,280 | 7,953 | $182 | $3,922 |
| 2010 | $34,596,532.00 | 178,470 | 8,179 | $194 | $4,230 |
| 2011 | $37,092,885.00 | 178,078 | 8,298 | $208 | $4,470 |
| 2012 | $39,203,981.00 | | | | |
| 2013 | $41,445,383.00 | | | | |

**Section Four – Program Viability**

**IV. A. Summary of Program's Viability**

Reference Supporting information previously presented in this report

The Chemistry Program at CSU is thriving and very viable. After the last CPR, the faculty convened to determine the direction we should go with the program and we decided that the program needed to be approved by the American Chemical Society (ACS) if we were going to offer competitive degrees for our students. As a result, we began an aggressive approach to with regard to grant writing to acquire the required equipment for approval.

Meanwhile, the faculty remained active in their respective sub-disciplines by publishing their research finding in respectable peer-reviewed journals.

In 2010, the faculty in the department prepared a pre-application to submit to the ACS to determine if the program was ready to be approved by the Committee on Professional Training (CPT). In April 2013, the chemistry program was awarded certification by the American Chemical Society, which is the national agency for our discipline. With certification comes assurance that we deliver nationally competitive degrees which allow our students to enter into graduate and/or professional school or work-force as entry level chemist. Prior to obtaining certification, our students have consistently been admitted into graduate programs to pursue the masters and/or terminal degree in chemistry. They have also obtained entry level positions in the chemical industry throughout the region. Coincidentally, the number of students selecting Chemistry as their major is slowly growing and is expected to double in the next few years. This is due to our plan to offer a B.S. degree track in Biochemistry which we plan to pursue certification by the ACS.

Our program encourages Chemistry majors to grow as professional scientists by conducting research in our independent study courses where they are allowed present their research findings at local, regional, and national scientific meetings. In 2011, our graduates were surveyed and asked to rate the quality of the program by indicating if they were glad they majored in chemistry at CSU. Out of 44 respondents and a rating from 1 to 5 (1 for strongly agree), an average rating of 1.68 which indicates that our graduates are very much satisfied with the program and how it has enabled them to progress in their careers.

The program has gone through several changes in the faculty since the last CPR. Nonetheless, we have a strong, talented, and committed team in the department. We are innovative in course preparations and look for opportunity to improve in our course delivery to increase student success for our majors as well as for non-majors. The faculty members are very active professionally and we encourage our students to follow our lead in applying for university grants, presenting their research, and publishing their findings. We have added new courses in the area of senior electives when needed and faculty expertise is available, e.g. Survey of Physical Chemistry and lab, Biochemistry 2 and lab, Advanced Organic Chemistry, Catalysis, and Electrochemistry. We continue to develop new study abroad courses due to student demand and faculty desire. We have offered two study abroad courses, i.e. Environmental Chemistry in Ethiopia and Chemistry and Industry in India.

Our faculty members are actively involved in service at all levels at the university. As a result, they are recognized by their colleagues and our students at the Annual University Scholastic Honors Convocation and College of Letters and Sciences Alumni awards ceremonies. Our students are also recognized at local, regional and national conferences with awards for their research and service.

The number of students being accepted into graduate programs is a testament to the rigor of our program and that our students are well prepared to succeed well beyond CSU.
The Department of Chemistry not only prepares our majors for success beyond CSU, but we also serve our campus in preparing students to succeed in the CSU Nursing and Health Sciences Programs (Survey of Chemistry and Principles of Chemistry) as well as provide Area D lab sciences for a large number of CSU students with nearly 600 seats each year. We also serve numerous students in the Biology and Earth and Space Sciences (ESS) departments. A portion of the MCAT now includes biochemistry. As a result, all biology majors and anyone else preparing for medical school will take our biochemistry course. Therefore, we anticipate a huge increase in the number of students taking biochemistry. Additionally, we have experienced a dramatic increase in the number of students taking our Quantitative Chemical Analysis course. This is partly due to this course being a program requirement for the Environmental Science degree offered by the ESS department.

In regards to our facilities and equipment, the value of the equipment in the department has increased from an estimated value of $100,000 to nearly $600,000 over the past five years. This is due to the aggressive approach the faculty members have made to become more active in research and training our students. A demonstration of the scholarly activity is noted in the numerous publications and presentations the faculty members have given over the past five years. This also reveals that faculty routinely travel to scientific conferences and are strongly supported for faculty development which is a direct effort of encouragement for them to remain active in their respective sub-disciplines.

In summary, the Department of Chemistry is an important part of CSU which offers a variety of strategically designed and competitive degrees. The chemistry program is the central science and students in all other science disciplines are required to take our courses. Additionally, the courses in chemistry are used to train and prepare students for careers as professional chemist, medical doctors, nurses, dentists, veterinarians, pharmacists, and more.

Summarize recommendations for the future of the program

There are several important recommendations which outline the future of the chemistry program. The recommendations are as follows:

1. maintain certification approval by the ACS- By maintaining this certification students are guaranteed a nationally competitive degree.

2. develop and seek ACS certification for a B.S. degree track in biochemistry- This will attract students to the university and major who we believe would otherwise go elsewhere to specialize in the sub-discipline.

3. offer a degree track in the Master of Science in Natural Sciences- This will enhance the overall productivity and scholarly activity of the faculty in chemistry. Additionally, this will provide help via graduate students with the lab classes and training for graduate students in the program thereby developing a pipeline of well-trained chemist to enter the work force or continue their studies for the terminal degree.

4. develop a one credit hour course in Chemical Hygiene/Chemical Safety- In each laboratory class, safety is covered on the first day of class and pointed out during the course of the term; however, the impact would be enormous for us to develop and offer this course as a requirement for chemistry majors. This course will be required for all degree tracks in the BA and BS programs.

5. develop a five year budget plan for "Major Capital Equipment"- This recommendation was made by the ACS Committee on Professional Training in an effort to establish a plan to keep the equipment in the labs modern. As a result, older outdated equipment will be replaced with newer models.

6. hire two full-time tenure-track faculty members- The new faculty will teach the forensics chemistry courses and other upper division courses in biochemistry while pursuing an ACS certified degree track in biochemistry. Two additional full-time tenure-track faculty members will also help lower course teaching loads and teach upper-division courses.

7. hire a permanent full-time lecturer- The full-time lecturer will teach Survey of Chemistry lecture and lab classes. This will enable the department to fill the void resulting from having to hire multiple part-time employees and will allow our tenure-track faculty to devote more time to our undergraduate majors to ensure their graduation.

Timetable for Program Change

| Action | Timeline |
|---|---|
| Maintain ACS Certification of Program | Ongoing |
| Develop an ACS certified B.S. degree track in biochemistry | Develop committee and begin August 2014 |
| Submit Proposal to ACS for certified B.S. degree track in biochemistry | Spring 2015 |
| Develop a degree track in the Master of Science in Natural | Develop and submit proposal to program director: August 2014 – December 2014 |
| Develop a one credit hour course in Chemical Hygiene/Chemical Safety | January 2015 – May 2015 |
| Offer a one credit hour online course in Chemical Hygiene/Chemical Safety | August 2015 |
| Submit course proposal for a one credit hour course in Chemical Hygiene/Chemical Safety | August 2015 – December 2015 |
| Develop a five year budget plan for “Major Capital Equipment” | Ongoing |
| Submit request to hire one full-time tenure-track faculty for forensics | Summer 2015 |
| Conduct search for two full-time tenure-track faculty members to teach the forensic chemistry and biochemistry courses | Fall 2015 |
| Submit request to hire one permanent non-tenure track full-time lecturer faculty. | Summer 2016 |
| Newly hired full-time tenure-track faculty member teach Forensic Chemistry and Biochemistry | August 2016 |
| Conduct search for permanent full-time lecturer to teach Survey of Chemistry lecture and lab classes | Fall 2016 |
| Hire Permanent full-time lecturer to teach Survey of Chemistry | Fall 2017 |

**IV. B. Summary of Program Improvement Plan**

Reference recommendations previously made in this report

Program improvement plans are as follows:

- develop a “Learning Community” for freshman chemistry majors- All incoming freshman majoring in chemistry will take the same lecture and lab sections of the Principles of Chemistry 1 and 2. We will do the same for the Organic Chemistry sequence of courses. We believe the learning community will allow the majors to establish camaraderie early thereby lending support to one another as needed. As a result, this will lead to an increase in the retention and graduation rates in the major.

- develop online classes for Survey of Chemistry 1 lecture and lab- Currently, only Survey of Chemistry 2 and its co-requisite lab are offered online. We will develop the first part (Survey of Chemistry 1 and its co-requisite lab) to complete the sequence being offered online. There is an increase in demand for these courses and offering them online will help meet the demand. Moreover, these online courses will be used to support the Degree-in- Three (DN3) as well as the “Academic-Partnership” programs.

- develop a new assessment tool for faculty peer evaluation of teaching- The department will develop a peer classroom evaluation instrument that will be used for all faculty members in the department. The goal is to improve teaching effectiveness by assessing classroom instruction more systematically and rigorously using peer evaluations. Peer faculty classroom evaluations will be submitted to the department chair for review.

- work with the Registrar to revise the advising system- The department chair will develop a system that will allow students to remain with the same faculty advisor once they are juniors and seniors. Moreover, the department will develop an advising evaluation form that students will complete and submit to the chair after an advising session. The advising evaluation instrument will be used to assess faculty performance in this area.

- use Qualtrics to assist with advising- The stress of advising incoming freshman will be eliminated by pre-registering students before they arrive for orientation. This will also ensure that students are taking the correct courses.
- encourage faculty to aggressively seek funding for research- Funding from external agencies as well as internal will support faculty and students research. It will also help defray the cost associated with travel to scientific conferences.

- provide a reduced teaching load to faculty who have externally funded grants- A reduced teaching load will enable faculty to complete the project in the allotted time and apply for additional funding.

- encourage more chemistry majors to apply for SRACE grants- The SRACE grants are used to support undergraduate research projects and travel to scientific conferences to present their research before their peers.

- repair and upgrade the lighting in lecture halls- The lighting in several large lecture halls, e.g. Stanley Hall, room 203, is too dim.

- build additional large lecture rooms- Additional large lecture halls are needed to satisfy the demand for Stanley 203.

- build additional laboratory classrooms- Currently, only one section of Survey of Chemistry, Principles of Chemistry, and Organic Chemistry can be offered at a time. Additional laboratory classrooms will allow the department to offer multiple sections simultaneously.

- build additional research labs- Currently, faculty and their students use the structured teaching labs to conduct research and it is extremely difficult to proceed with an experiment when one must stop due to a class needing the area.

- Purchase a higher power 300 MHz NMR instrument and sustainable support for its operation and maintenance- The current 60 MHz NMR is primarily used as a teaching tool for the introductory undergraduate organic chemistry lab. A larger and more powerful instrument is needed for students and faculty research to acquire publishable data.

<u>Specify initiatives/actions to be implemented</u>

Things we can do immediately

- Develop a “Learning Community” for freshman chemistry majors.
- Develop online classes for Survey of Chemistry 1 lecture and lab.
- Develop a new assessment tool for faculty peer evaluation of teaching.
- Work with the Registrar to revise the advising system.
- Use Qualtrics to assist with advising.
- Encourage faculty to aggressively seek funding for research.
- Provide a reduced teaching load to faculty who obtain externally funded grants.
- Encourage more chemistry majors to apply for SRACE grants.
- Repair the lighting in lecture halls.

Things that will require funding

1. Build additional large lecture rooms.
2. Build additional laboratory classrooms.
3. Build additional research labs.
4. Purchase a higher power 300 MHz NMR instrument and sustainable support for its operation and maintenance.

Timetable for Program Change

| **Action** | **Timeline** |
|---|---|
| Develop freshman chemistry Learning Community majors. | August 2014 – March 2015 |
| Require all freshman chemistry majors to sign-up for the same lecture and lab section. | Spring 2015 (Early Registration) |
| Develop Online Survey of Chemistry 1 and Survey of Chemistry 1 Lab classes | August 2014 – May 2015 |
| Offer Survey of Chemistry 1 and Survey of Chemistry 1 Lab online classes | Summer 2015 |
| Develop an assessment Instrument for Peer evaluation | Fall 2014 – Spring 2015 |
| Use newly developed assessment Instrument for Peer evaluation | Fall 2015 |
| Chair work with the Registrar to revise Advising | Fall 2014 |
| Use of Qualtrics | Summer 2014 |
| Encourage Chemistry faculty to seek External and internal Funding | Fall 2014 |
| Offer reduced teaching loads to faculty who have externally funded grants. | Fall 2014 |
| encourage chemistry majors to apply for SRACE grants | Fall 2014 |
| repair the lighting in lecture halls | Fall 2014 |
| Form departmental building and space allocation committee | Fall 2014 |
| Build Additional Large Lecture Classrooms | Summer 2016 (Contingent upon funding) |
| Build Additional Laboratory Classrooms | Summer 2016 (Contingent upon funding) |
| Build Additional Research Laboratory | Summer 2016 (Contingent upon funding) |
| Write Course Curriculum and Laboratory Improvement Grant Proposal for higher powered NMR Equipment | Summer 2015 |
| Submit Proposal to NSF | Fall 2015 |
| Purchase a 300 MHz NMR | Summer 2016 |

Address any new or reallocated resources to implement improvement plan

Now that the department offers a degree which is certified by the American Chemical Society (ACS), the university was asked to develop a five year plan to purchase "Major Capital Equipment". This is to enable faculty and students to conduct cutting edge research on up-to-date modern equipment. The university is currently involved in various building projects, one of which is to renovate and expand LeNoir Hall so as to provide additional research and teaching lab space. Currently, faculty share space which is designed for structured laboratory classes. When the building projects are complete, each faculty will have their own research space for mentoring and training students. Added space will also position the department to participate in the M.S. in Natural Sciences program, which in turn will provide graduate students to help as lab assistants for undergraduate lab courses.

The Department of Chemistry has met and/or exceeded every request made by the administration. We were asked to get the program certified, and the faculty united and responded. We have been asked to provide additional seats in our introductory courses, and we now offer at least two additional lab sections, which amounts to nearly 50 seats. However, we are limited in this area because we are only able to offer one section at a time as opposed to offering multiple lab sections simultaneously. Moreover, we developed an online class for Survey of Chemistry 2 which offers an unlimited number of seats for nursing majors and students in other health related programs.

The faculty members in the department have always been professional active despite having rather heavy teaching loads, i.e. 15 contact hours or more. Moreover, the faculty members in the department were able to acquire quality equipment to sustain their research activities. Again, we have done well to creatively meet the demands placed on the department in the past five years. However, it is time to reward the faculty in the department for their willingness to step-up and meet each new challenge and demand. We have reached the threshold of a new era in the department and it is increasingly difficult for us to continue with the same facilities if we are serious about going to the next level as a department and for the faculty grow professionally as individuals. Program improvements will require strong support and dedicated financial commitment at all levels for us to deliver quality programs which are competitive.

## Appendix I

### Department of Chemistry Alumni Survey

*Please help us assess and improve our program. We are conducting a survey of all CSU Chemistry alumni as part of a department self-study. We would appreciate your assistance. Please take a few minutes to respond to the following questions and return the survey in the enclosed prepaid envelope by* ***September 30, 2011****. Thank you!*

**1. Did you graduate from CSU with a bachelor's degree in chemistry? ______ Yes ______ No**

**2. If yes, what year did you graduate? _________________**

**3. What was the salary range of your first full-time job following graduation? (Check one)**

___Less than $20,000 ___$40,000 to $70,000 ___over $100,000
___$20,000 to $40,000 ___$70,00 to $100,000

**4. What is the salary range of your current job? (Check one)**

___Less than $20,000 ___$40,000 to $70,000 ___over $100,000
___$20,000 to $40,000 ___$70,000 to $100,000

**5. What degrees or credentials have you earned? (Check all that apply)**

___Bachelor's
___Certification
___Professional Licensure
___Master's
___Doctorate
___Other ______________________________________________________________________________________

**6. If you continue formal education, what degree or other credentials do you plan to attain? (Check all that apply)**

___Bachelor's
___Certification
___Professional Licensure
___Master's
___Doctorate
___Other ______________________________________________________________________________________

**7. What is the nature of the field in which you are currently employed? (Check one)**

___education
___lab technician
___government (city, state, federal, including military)
___law
___medicine
___pharmaceutical sales
___manufacturing business
___service business
___other ______________________________________

**8. My undergraduate study of chemistry has proved <u>useful to my career</u> because it provided me with the skills to succeed in graduate or professional school. (Check one)**

___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree
___Question is not applicable

9. **My undergraduate study of chemistry has proved <u>useful to my career</u> because it provided me with the skills to become a secondary teacher. (Check one)**

___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree
___Question is not applicable to my career

10. **Please assess each of the following statements about your undergraduate studies in chemistry at CSU.**

**a. It provided me with an understanding of the fundamental concepts of <u>analytical</u> chemistry. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree

**b. It provided me with an understanding of the fundamental concepts of <u>inorganic</u> chemistry. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly disagree

**c. It provided me with an understanding of the fundamental concepts of <u>physical</u> chemistry. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree

**d. It provided me with an understanding of the fundamental concepts of <u>organic</u> chemistry. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree

**e. It provided me with an understanding of the fundamental concepts of <u>biochemistry</u>. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree

**f. It helped me develop the ability to understand a problem and conduct independent research. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree

___Strongly Disagree

**g. It helped me develop the ability to write objectively clear laboratory reports. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree

**h. It helped me develop my critical thinking skills as a scientist. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree

**i. It helped me develop my ability to read and understand difficult scientific chemistry-related material. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree

**j. It helped me develop my ability to use a variety of applications on the computer. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree

**10. My undergraduate study of chemistry has enriched my life <u>beyond my career</u> by:**

**a. Enhancing my understanding of industrial, environmental, or government labs where I have visited or plan to visit on business or for pleasure**. **(Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree
___Question is not applicable to my personal life

**b. Providing me with the tools to investigate, study, or experiment to solve problems. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree
___Question is not applicable to my personal life

**c. Helping me develop my curiosity regarding how and why chemical processes occur in general. (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly Disagree
___Question is not applicable to my personal life

**11. Please rate your response to this statement: "I am glad I majored in chemistry at CSU." (Check one)**
___Strongly agree
___Agree
___Neutral
___Disagree
___Strongly disagree

**12. What influenced you to major in chemistry? (Check all that apply)**
___Liked my 1211/11212 teacher and that teacher encouraged me
___Always liked chemistry/science
___Felt chemistry was what I was best at
___Felt it was a good preparation for professional/graduate school
___Felt it would provide a solid background for most anything in life
___Just wanted to – no particular reason
___Other ______________________________________________________________________________

**13. What is the most valuable aspect of having been a chemistry major?**
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

**14. The Department of Chemistry has discussed adding a master's degree in chemistry. Would you be interested in enrolling in a master's degree program in chemistry at CSU? (Check one)**
___Extremely Interested
___Interested
___Not Interested

**15. If the Department added a master's degree in chemistry, which emphasis area would interest you the most? (Check one)**
___Analytical
___Biochemistry
___Inorganic
___Organic
___Physical
___Other _____________________________________________________________________________

**16. If you would like to receive an e-newsletter (with alumni news) about the Department of Chemistry, please provide your email address. (Please print neatly.)**

______________________________________________________________________________________

**17. Is there anything (or any person) in particular that you would like to learn about in the e-newsletter?**

______________________________________________________________________________________

______________________________________________________________________________________

______________________________________________________________________________________

**We are planning on starting work on a Department of Chemistry Facebook page! Check us out soon on Facebook under Columbus State University Department of Chemistry.**

Thank you for responding to this survey and for returning it by **September 30, 2011** in the prepaid envelope.

Sincerely,

Dr. Floyd R. Jackson, Professor and Chair
Department of Chemistry
jackson_floyd@columbusstate.edu
706-569-2075

## Appendix II

**a.** List of Full-Time Faculty with Rank, Education, and Research Interest.

| Name | Rank & yr | Education | Research Interest |
|---|---|---|---|
| Samuel M. Abegaz | Associate Professor, 2008 | Ph.D., Ghent University, Belgium, 2000 | Determination of Toxic Heavy Metals in Air, Soil, and Water Matrices |
| Anil C. Banerjee | Professor, 2005 | Ph.D., Indian Institute of Technology, India, 1972 | 1. Chemical Education - Inquiry Learning in Chemistry, Research Methods in Chemical Education; 2.Preparation and Characterization of Palladium Catalysts |
| Rajeev B. Dabke | Associate Professor, 2002 | Ph.D. University of Pune, Pune, India, 1992 | Designing New Electrochemistry Lab Experiments for Undergraduates |
| Zewdu Gebeyehu | Professor, 2002 | Ph.D., Philipps University, Germany, 1991 | Synthesis and Characterization of Transition Metal Complexes Which Exhibit Nonlinear Optical Application Properties |
| Daniel W. Holley, | Assistant Professor, 2012 | Ph.D., University of Tennessee, Knoxville, TN 2009 | Polymer Chemistry – The Characterization of Polystyrenes Synthesized by Microwave-Assisted, Nitroxide-Mediated Emulsion Polymerization |
| Floyd R. Jackson | Professor and Chair, 1997 | Ph.D., Howard University, Washington, DC, 1991 | (1) Synthesis and Characterization of Novel First Row Polynuclear Schiff-Base Metal Complexes; (2) Synthesis and Characterization of Cobalt(III) Complexes Containing Nitrogen Containing Heterocycles. |
| Kenneth Smith | Assistant Professor, 2012-2014 | Ph.D., University of Memphis, 1999 | The Synthesis of Cytotoxic Monastrol and Its Multicyclic Derivatives |
| Samrat Thapa | One Year Temporary Lecturer, 2013-2014 | Ph.D., University of Arkansas at Fayetteville, AK 2013 | Quantification of Thrombomodulin Methionine Oxidation in Cigarette Smokers |
| Jonathan M. Meyers | Assistant Professor, 2014 | Ph.D., Indiana University, Bloomington, IN, 2012 | Cellular uptake of polyphenols in a bacterial protein expression systems and development of synthetic methodologies for the total synthesis of insulin and insulin-like peptides |
| Renat R. Khatmullin | Assistant Professor, 2014 | Ph.D., Bowling Green University, Bowling Green, OH, 2013 | Kinetics and Mechanism of Singlet Oxygen Production in Heterogeneous Biomimetic Media |
| Nin Dingra | Assistant professor: 2011-2013 | Ph.D. The University of South Carolina, Columbia SC, 2011 | Biochemistry 1 & 2<br>Biochemistry 1 & 2 Lab<br>Survey of Chemistry 1 & 2<br>Survey of Chemistry 1 & 2 lab |

***Note**: Dr. Samrat Thapa's position concluded on May 16, 2014. However, over the previous academic year the department successfully conducted a search for a permanent faculty member to teach biochemistry. The new biochemistry faculty member (Dr. Jonathan Meyers) will begin August 1, 2014. Also, Dr. Kenneth Smith is being replaced by Dr. Renat Khatmullin who is an organic chemist. Dr. Khatmullin will also begin August 1, 2014.*

# Appendix II

**b.** List of Part-time Faculty

| Name | Rank | Education | Courses Taught |
|---|---|---|---|
| Oge Anazia | Lecturer/Stockroom Manager, 2010-2014 | M.S. Western Kentucky University, 2009 | Survey of Chemistry 1<br>Survey of Chemistry 1 Lab |
| Hunter W. Champion | Lecturer | Virginia Polytechnic and State University, ABD | Survey of Chemistry 1<br>Principles of Chemistry 1 Lab |
| Jaima Dewey | One Year Temporary Lecturer/Stockroom Manager | M.S. in Biochemistry, George Mason University, Fairfax, Virginia2013 | Survey of Chemistry 1 & 2<br>Survey of Chemistry 1 & 2 Lab |
| Nin Dingra | Lecturer, 2013-present | Ph.D. The University of South Carolina, Columbia SC, 2011 | Survey of Chemistry 2<br>Survey of Chemistry 2 lab |
| Jaimie M. Gonzalez | Lecturer, 2013 | M.Ed.: Secondary Education with a Concentration in Chemistry, Columbus State University 2012 | Survey of Chemistry 1<br>Survey of Chemistry 1 Lab |
| James O. Schreck | Senior Lecturer | Ph.D. Texas A&M University 1964 | Survey of Chemistry 2<br>Survey of Chemistry 2 lab |
| Alicia M. Anderson | Lecturer, 2014 | M.S. Environmental Science, Columbus State University 2012 | Survey of Chemistry 1<br>Survey of Chemistry 1 Lab |

# Appendix II

**c**. Faculty Publications, Presentations, Reviewer of Journals, and Grant Awards

**Publications**

1. Abera BELAY, Solomon W.K., Geremew BULTOSSA, Nuru ADGABA, **Samuel Melaku Abegaz** "Physicochemical Properties of the Harenna Forest Honey, Bale, Ethiopia". *Food Chemistry* 141 (2013), 3386-3392.
2. **Samuel Melaku Abegaz**, N. Green and V. Morris "Seasonal spatial and temporal distribution of daytime inhalation-level particulate matter in Washington, DC". *Academy Journal. Vol 2, No 1, (2011).*
3. Hui Liu, D. Raghavan, **Samuel Melaku Abegaz**, and J. Stubbs III. "Biological response of osteoblast-like UMR-106 cells to the modified PHBV matrix--Effects of porosity and collagen dip coating". *Journal of Biomedical Materials Research Part A*, *Vol.92, No.3 (1 Mar 2010): 922-930.*
4. Helping Students Visualize the Electrolysis of Water by Using Acid-Base Indicators to Create Colorful Designs, **Rajeev B. Dabke**, James O. Schreck, Jacqueline McGuire, Eunhye Claire Cho *The Chemical Educator 2013, 18,* 287–289.
5. Determining the Transference Number of $H^+$(aq) by a Modified Moving Boundary Method: A Directed Study for the Undergraduate Physical Chemistry Laboratory **Rajeev B. Dabke, Zewdu Gebeyehu**, Jonathan Padelford *Journal of Chemical Education 2012,* 89, 1600-1603.
6. Analysis of Ascorbic Acid in Supplement Tablets from the Mole Ratios of the Electrolytic Products: An Experiment for the Undergraduate Laboratory, **Rajeev B Dabke, Zewdu Gebeyehu**, Nicole Ippolito *The Chemical Educator 2012,* 17, 152-156.
7. Using Mole Ratios of Electrolytic Products of Water for Analysis of Household Vinegar: An Experiment for the Undergraduate Physical Chemistry Laboratory, **Rajeev B. Dabke and Zewdu Gebeyehu**, *Journal of Chemical Education 2012,* 89 (9), 1198-1200.
8. Coulometric Analysis Experiment for the Undergraduate Chemistry Laboratory, **Rajeev B Dabke, Zewdu Gebeyehu**, Ryan Thor *Journal of Chemical Education 2011,* 88 (12), *1707–1710.*
9. Analysis of Household Products: Coulometric Titration Experiment in the Undergraduate Laboratory, **Rajeev B Dabke, Zewdu Gebeyehu**, Mary Petermann, Napoleon Johnson, Jr., and Krutik Patel *The Chemical Educator 2011,* 16, 160-163.
10. A Versatile Apparatus for a Laboratory Demonstration of Anodic and Cathodic Reactions, **Rajeev B. Dabke** and Josue Scott, *The Chemical Educator 2010,* 15, 36-38. *(DOI 10.1007/s00897102258a)*
11. Using Magnets, Paper Clips, and Ball Bearings to Explore the Shapes of Molecules **Rajeev B Dabke and Zewdu Gebeyehu** *Journal of College Science Teaching 2010,* 40(2), 70-73.
12. **Banerjee, A.C.** Teaching Science using Guided Inquiry Experiments: A Professional Development Model for High School Science Teachers. In: B. Wojnowski & S. Koba (Eds), *Exemplary Science: Best Practices in Professional Development*, 2nd edition. NSTA Press: Arlington, 2013.
13. **Banerjee, A.C.** (2011). *Research-based Resources to Teach Chemistry: Chem Demos, Guided Inquiry Labs, Professional Development & Teaching Strategies*. LAP LAMBERT Academic Publishing AG & Co. KG: Saarbrucken, Germany.
14. **Banerjee, A.C.** (2010).Teaching Science using Guided Inquiry as the Central Theme: A Professional Development Model for High School Science Teachers. *The Science Educator, 19(2), 1-9.*
15. **Holley, D.**, Ruppel, M., Mays, J., Urban, V. & Baskaran, D. "Polystyrene Nanoparticles with Tunable Interfaces and Softness." *Polymer* 55, 58–65 (2014).
16. Mutz, M., **Holley, D.**, Baskaran, D., Mays, J. & Dadmun, M. "Impact of nanoparticle size and shape on selective surface segregation in polymer nanocomposites." *Polymer* 53, 5087–5096 (2012).

## Appendix II

**Presentations**

17. Conference Attendance, Author and Presenter, "Characterization of the the physicochemical properties of the Harenna forest honey in Bale, Ethiopia", *Georgia Academy of Science,* Valdosta, GA, U.S.A. (March 29-30, 2013). *Poster presentation.*
18. Conference Attendance, Author and Presenter, "Characterization of the the physicochemical properties of the Harenna forest honey in Bale, Ethiopia", *American Chemical Society 245th National Meeting,* New Orleans, Louisiana, U.S.A. (April 7-11, 2013). *Poster presentation.*
19. Conference Attendance and Author, "Investigation of toxic heavy metals in the Chattahoochee river water using graphite furnace atomic absorption spectroscopy", *American Chemical Society 243$^{rd}$ National Meeting,* New Orleans, Louisiana, U.S.A. (April 7-11, 2013). *Poster.*
20. Conference Attendance and Author, "Determination of lead in commercial wine samples: A comparison between graphite furnace atomic absorption spectroscopy and potentiometric stripping techniques", *American Chemical Society 243$^{rd}$ National Meeting,* New Orleans, Louisiana, U.S.A. (April 7-11, 2013). *Poster.*
21. Conference Attendance and Author, "Mentoring undergraduates-For Current and Would be Mentors", *Georgia Undergraduate Research Conference,* Columbus, GA, February 1, 2013. *Oral presentation*.
22. Conference Attendance and Author, "Characterization of the physicochemical properties of the Harenna forest honey in Bale, Ethiopia". *SERMACS,* Raleigh, NC, November 15-17, 2012. *Poster Presentation.*
23. Conference Attendance, Author and Presenter, "Atmospheric chemical measurements and trend in Columbus, GA", *Georgia Academy of Science,* Kennesaw, GA, U.S.A. (March 23-24, 2012). *Poster presentation.*
24. Conference Attendance and Author, *"*Atmospheric chemical measurements and trend in Columbus, GA", *American Chemical Society 243$^{rd}$ National Meeting,* San Diego, CA, U.S.A. (March 25-29, 2012). *Poster presentation.*
25. Conference Attendance and Author, "*Undergraduate research", Leading undergraduate Research Program, Athens, GA, April 20, 2012. Oral presentation, Invited.*
26. Conference Attendance, Author and Presenter, "Determination of Heavy Metals in Wet Deposition and Ambient Air Samples in Columbus, GA ", Georgia Academy of Science, Kennesaw State University, Atlanta, GA, U.S.A. (March 23, 2012 - March 24, 2012). *Poster presentation.*
27. Workshop, Presenter, "Developing Undergraduate Research Across the Disciplines" April 20, 2012, Athens, GA. *Invited, Oral presentation.*
28. Conference Attendance, Author and Presenter, "Determination of Heavy Metals in Wet Deposition and Ambient Air Samples in Columbus, GA ", ACS, San Diego, CA, U.S.A. (March 24, 2012 - March 29, 2012). *Poster presentation.*
29. Conference Attendance, Author and Presenter, " Assessment of Heavy Metals in Lake Walter F. George in Alabama and Georgia", ACS, Richmond, VA, GA, U.S.A. (October 25 - 29, 2011). *Poster presentation.*
30. Conference Attendance, Author and Presenter, "Determination of trace elements in Tinishu Akaki River, Ethiopia, using ICP-MS", PITTCON, Atlanta, GA, U.S.A. (March 16, 2011 - March 17, 2011). *Oral presentation.*
31. Seminar, Author and Presenter, "Determination of Mercury in Biological and Environmental Materials - Comparison of Pyrolysis & Microwave Acid Digestion Techniques," Addis Ababa University. (July 12, 2010). *Invited, Oral presentation.*
32. Conference Attendance, Author and Presenter, "Toxic Heavy Metals in Soils of Children's Environment in Columbus, GA, and Phenix City, AL", CSU, New Orleans,, Lousiana, U.S.A.. (November 29, 2010 - December 4, 2010). *Poster presentation.*
33. Conference Attendance, "37th Annual Conference: National Organization for the Professional Advancement of Black Chemists and Chemical Engineers," NOBCChE. (March 29, 2010 - April 2, 2010).

34. Conference Attendance, Author and Presenter, Georgia Academy of Science, "Determination of mercury in biological and environmental materials," Columbus State University, Columbus, GA. (March 27, 2010). *Oral presentation.*

35. Conference Attendance, Author and Presenter, NOAA office of Education 5th education and science forum, "Comparison of pyrolysis and microwave acid digestion techniques for the determination of mercury in biological and environmental materials," The NOAA Center for Atmospheric Sciences, Washington, DC. (November 12, 2009). *First prize winner poster, Poster presentation.*

36. Conference Attendance, Author and Presenter, SERMACS 2009, "Comparison of pyrolysis and microwave acid digestion reduction-aeration techniques for determination of mercury in biological and environmental materials," CSU, San Juan, Puerto Rico. (October 21, 2009). *Oral presentation.*

37. Conference Attendance, Author and Presenter, "Seasonal variation of heavy metals in ambient air and precipitation at a single site in Washington, DC.," UGA, Athens, GA. (September 2, 2009). *Invited*, *Oral presentation.*

38. Seminar, Author and Presenter, "Seasonal variation of heavy metals in ambient air and precipitation at a single site in Washington, DC," Mekelle University, Ethiopia, Mekelle, Ethiopia. (July 16, 2009). *Invited*, *Oral presentation.*

39. Seminar, "Method development for the speciation of chromium in river and industrial wastewater by GFAAS, College of Science, Columbus State University, Columbus, GA." (November 20, 2008). *Oral presentation.*

40. Conference Attendance, Author and Presenter, SERMACS, "Method development for the speciation of chromium in river and industrial wastewater by GFAAS," ACS, Nashville, TN, U.S.A. (November 12-15, 2008). *Oral presentation.*

41. Conference Attendance, Author and Presenter, "Seasonal variation of heavy metals in ambient air and precipitation at a single site in Washington, DC." 232nd American Chemical Society National Meeting and Exposition", ACS, San Francisco, CA, USA. (September 10-14, 2006). *Poster presentation.*

42. Conference Attendance, Author and Presenter, Workshop on Chromium Speciation in Industry, Environment, Occupational Health and Food, with Legislative Aspects. Jozef Stefan Institute, Ljubljana, Slovenia, May 3-4, 2004. *Oral Presentation.*

43. Conference Attendance, Author and Presenter, *“*Multi-element analysis of Tinishu Akaki River Sediment, Ethiopia, by ICP-MS after microwave acid digestion”, EuroanalysisXIII, European Conference on Analytical Chemistry, Salamanca, Spain, September 5-10, 2004. *Poster presentation.*

44. Presented a paper “Combining Chemistry with Art: Employing Acid-Base Indicators to Illustrate the Electrolysis of Water” at ChemEd 2013 at the University of Waterloo, Waterloo, Canada on August 1, 2013.

45. Presented a paper “Electrolysis of Water: A Demonstration for Middle, High School, and First Year Undergraduate Students” at 245th ACS National Meeting, Spring 2013, New Orleans, April 7-April 11, 2013.

46. Presented a paper “Electrolytic Chemical Reactions: Demonstrations for High School and Undergraduate Chemistry Laboratory” at BCCE 2012 (Biennial Conference on Chemical Education), Pennsylvania State University, University Park, PA, July 29-August 2, 2012)

47. Presented a paper “Using Mole Ratios of Electrolytic Products of Water: A Modified Coulometric Analysis Experiment in the Undergraduate Laboratory” at 243rd ACS National Meeting, Spring 2012, San Diego, CA, March 25-29, 2012.

48. Presented a paper “Development of Undergraduate Curriculum in the Area of Experimental Physical Chemistry” at the Math and Science Learning Center, Columbus State University, Columbus, GA 31907, February 14, 2012

49. Presented a paper “Development of Electrochemistry Experiments for Undergraduate Students” at the Department of Earth and Space Sciences at the Fall Seminar Series, Columbus State University, Columbus, GA 31907, November 10, 2011

50. Presented a paper “Experiment on the coulometric analysis in the undergraduate laboratory” at 242nd ACS National Meeting, Denver, CO, August 28 – September 1, 2011.

51. Presented a paper "Chemistry for Visually Impaired Community: Developing Periodic Table of Elements Using Touch Screen Tablet PC" at the ACS National Meeting, San Francisco, CA (March 25, 2010)
52. Presented a paper "Improving Electrochemistry Experience in High School and Undergraduate Laboratories" at SERMACS, San Juan, Puerto Rico (October 21, 2009)
53. Anderson , M & Banerjee, A. (2013). Preparation and Characterization of Palladium catalysts over alumina and silica supports(Paper to be presented at American Chemical Society National Meeting, New Orleans, April 8-11)
54. Richardson, L. & Banerjee, A. (2013). Preparation and Characterization of Ruthenium catalysts over alumina and silica supports(Paper to be presented at American Chemical Society National Meeting, New Orleans, April 8-11)
55. Boykin, M. & Banerjee, A. (2013). Preparation and Characterization of Platinum catalysts over alumina and silica supports(Paper to be presented at American Chemical Society National Meeting, New Orleans, April 8-11)
56. Banerjee, A. (2013). Project Guided Inquiry (Paper to be presented at American Chemical Society National Meeting, New Orleans, April 8-11)
57. Banerjee, A. C. (2012). Project Guided Inquiry (Paper presented in the Division of Chemical Education, American Chemical Society, San Diego, March 26).
58. Banerjee, A. C. (2011). Sumposium on *21st Century Skills: An International Perspective* ( Paper presented at the Annual International Conference of National Association for Research in Science Teaching, Orlando, FL 3-6 April)
59. Banerjee, A. C. (2011). Project Guided Inquiry: Effect of Guided Inquiry and Traditional Instruction on Student Understanding of Chemistry Concepts and Science as Inquiry in High Schools ( Paper presented at the Annual International Conference of National Association for Research in Science Teaching, Orlando, FL 3-6 April)
60. Banerjee, A.C. (2010). Effect of guided inquiry and traditional instruction on student understanding of chemistry concepts and science inquiry in high schools (Paper presented at the 21st Biennial Conference in Chemical Education, Denton, TX , 1-4 August
61. Banerjee, A.C. (2010). Effect of guided inquiry labs on student understanding of chemistry content and science inquiry (Paper presented in the Division of Chemical Education, American Chemical Society national meeting, San Francisco, March 21-25).
62. Banerjee, A. C. (2009). Does inquiry teaching improve student content knowledge, inquiry skills and views of scientific inquiry? (paper presented at the Division of Chemical Education, American Chemical Society national meeting, Washington DC, August 16-20).
63. Banerjee, A. C. (2009) Guided inquiry labs in chemistry to teach concepts, inquiry skills and nature of science (paper presented at the Division of Chemical Education, American Chemical Society national meeting, Washington DC, August 16-20).
64. Banerjee, A.C. (2008). A professional development program in chemistry for high school teachers (presented at the American Chemical Society National Meeting, Philadelphia, August 17-21).
65. *American Physical Society 2013 National Meeting*, "Dispersion of Soft Nanoparticles in a Chemically Identical Polymer Matrix" Ratnaweera, D.; Baskaran, D.; Holley, D.W.; Ruppel, M.; Mays, J.; Urban, V.; Dadmun, M. March, 2013.
66. *US Department of Energy Nuclear Regulatory Commission and NIST*, "Oxidative Attack of HDPE Pipe by Nonchlorine Biocides in Power Plant Cooling Water Systems" Whelton, A.J.; Holley, D.W.; September, 2012.
67. Southeast Undergraduate Research Conference - 2014, "Microemulsion polymerization of linear polystyrene encapsulated with polymethyl methacrylate-net-polyethylene glycol dimethacrylate" Scanlon, C.; Holley, D.W., January 2014.
68. *Southeast Regional American Chemical Society Annual Meeting – 2013*, "Microemulsion polymerization of linear polystyrene encapsulated with polymethyl methacrylate-net-polyethylene glycol dimethacrylate" Scanlon, C.; Holley, D.W., November 2013.
69. *Georgia Academy of Sciences Annual Meeting – 2013* "Synthesis and Characterization of Polystyrene Nanoparticles" Blackmon, M.B.; Holley, D.W., April 2013.

70. *University Committee on Undergraduate Research Conference*, “Biocide Attack of HDPE Pipe in Power Facility Cooling Water Systems” Prado E.; Navarro, L.; Holley, D.W.; Holley, H.; Whelton, A.J. October 2012.

**Reviewer of Journals**

1. Environmental Monitoring and Assessment, Reviewer, Journal Article, International, December 1, 2009 - Present.
2. Particulology, Reviewer, Journal Article, International, January 1, 2007 - Present.
3. Bulletin of the Chemical Society of Ethiopia, Reviewer, Journal Article, International, January 2006 - Present.
4. Chemosphere, Reviewer, Journal Article, International, January 2005 - Present.
5. Journal of Applied Catalysis A., Reviewer, Journal Article, International, 2012-Present.
6. International Journal of Science Education
7. Journal of Chemical Education , American Chemical Society
8. Physical Chemistry Atkins, dePaula 9th Ed. W. H. Freeman Chapter 4-6 Reviewed (Physical transformations, Simple mixtures, and Equilibrium) 2009
9. General Chemistry Flat World Knowledge Chapters 1-3, 6 (Measurements, Atomic Structure, Periodic Table, Bonding) 2009
10. Is covalent bonding a one electron phenomenon? Analysis of simple potential model of molecular structure. Bacskay, G. B.; Eek, W.; Nordholm, S. *The Chemical EducatorJournal article review* 2009

**Grants** (**Internal**)

1. Rajeev Dabke, Samuel Abegaz and *Houbin Fang: “A Faculty Center Fellowship Award ($3,500.00):* Hands-on Learning for Enhancing Chemistry and Mathematics Classroom and Laboratory Experience. September, 2013. *Funded.*
2. Abegaz, Samuel, “Determination of toxic heavy metals in commercial wine samples”. University Grant. Sponsored by CSU, $1,370.00. September, 2013. *Funded.*
3. Samuel Melaku Abegaz, “Determination of Heavy Metals in Wet Deposition and Ambient Air Samples in Columbus, GA.” Sponsored by CSU, Columbus State University, $2,060.65. (September 9, 2011 – April 1, 2012). *Funded.*
4. Samuel Melaku Abegaz, “Faculty Development Seminar to Morocco, Africa”. International Curriculum Development Grant. Sponsored by Center for International Education ($2000.00) and College of Letters and Sciences ($2820.00), Columbus State University, Total $4,820.00. (June 8-18, 2012). *Funded.*
5. Samuel Melaku Abegaz, Technology Fee Grant, Sponsored by CSU, Columbus State University, $6,200.00 (March 2012). *Funded.*
6. Samuel Melaku Abegaz, “Investigation of toxic heavy metals in atmospheric wet deposition samples using graphite furnace atomic absorption spectroscopy” Sponsored by CSU, Columbus State University, $4552.00. (June 8-August 6, 2011). *Funded.*
7. Samuel Melaku Abegaz, Assessment of trace elements in Lake Walter F. George in Alabama and Georgia. Sponsored by CSU, $3, 664.00. (January 24 – April 31, 2011). *Funded.*
8. Samuel Melaku Abegaz (Principal), Jackson, Floyd R. (Co-Principal), "Technology Fee Grant," Sponsored by CSU, Columbus State University, $32,500.00. (March 1, 2010 - Present). *Funded.*
9. Samuel Melaku Abegaz, "Determination of Toxic Heavy Metals in Atmospheric Wet Precipitation Samples in Columbus, GA," Sponsored by College of Letters and Science, Columbus State University, $4,000.00. (February 1, 2010 - December 31, 2010). *Funded*
10. Samuel Melaku Abegaz, "Aquisition of inductively coupled plasma mass spectrometry for analysis of trace elements in environmental samples in Columbus, Georgia: Major Research Instrumentation External Grant," Sponsored by Provost Office, CSU, Columbus State University, $2,000.00. (June 5, 2010 - July 31, 2010). *Funded.*

11. Samuel Melaku Abegaz, "Environmental Issues in Sub-Saharan Africa: Challenges and Prospects for Sustainable Development: Study Abroad Program," Sponsored by Center for International Education, CSU, Columbus State University, $3,800.00. (March 5, 2010 - March 14, 2010). *Funded.*
12. Samuel Melaku Abegaz, "Faculty Professional Development Grant." Sponsor: College of Letters and Sciences, Columbus State University, $4,000.00. Submitted: January 14, 2010. *Funded.*
13. Samuel Melaku Abegaz (PI) and Wakoko, Florence (Co-PI). "Environmental Issues in Sub Saharan Africa: Challenges and Prospects for Sustainable Development" Study abroad program. Sponsor: Columbus State University, $5000.00. Submitted: January 11, 2010. *Funded.*
14. Samuel Melaku Abegaz, "Faculty Professional Development Grant," Sponsored by College of Letters and Sciences, Columbus State University, $1,000.00. (September 23, 2009 - October 24, 2009). *Funded.*
15. Samuel Melaku Abegaz, Sponsored by College of Sciences, CSU, Columbus State University, $585.00. (March 22, 2009 - March 26, 2009). *Funded.*
16. Samuel Melaku Abegaz (PI), "Faculty Development Grant," Sponsored by College of Science, Columbus State University, $100.00. (November 12, 2008 - November 15, 2008). *Funded.*
17. Samuel Melaku Abegaz (PI), "Investigation of toxic heavy metals in soils of children's environment in Columbus, GA: undergraduate research," Columbus State University, $3,851.62. (March 1, 2009 - August 1, 2009). *Funded.*
18. Samuel Melaku Abegaz (PI), "Investigation of toxic heavy metals in soils of children's environment in Columbus, GA: undergraduate research," Columbus State University, $4,500.00. (December 18, 2008 - August 1, 2009). *Funded.*
19. Samuel Melaku Abegaz (PI), Ahmadibeni, Yousef (Co-Principal), "STEM Mini-Grant," Sponsored by College of Science, Columbus State University, $4,970.00. (January 2, 2009 - June 30, 2010). *Funded.*
20. Dabke, R. B, Development of High School Chemistry Learning Community Spring 2009 $4995.00
21. Dabke, R. B, Presenting a Research Poster at the Southeastern Regional Meeting of the American Chemical Society, at San Juan, Puerto Rico (October 21-24, 2009) $1315.00
22. Dabke, R. B, Presenting a Paper in Oral and Poster Sessions at the American Chemical Society's Spring 2010 National Meeting at San Francisco, CA (March 21-25, 2010) $1448.00
23. Dabke, R. B, Attending 215th Electrochemical Society Meeting at San Francisco, CA May 24-29, 2009 (for a Short Course in Electrochemical Measurements) $1130.00
24. Dabke, R. B, Research grant: Hands-on Learning for Enhancing Chemistry and Mathematics Classroom and Laboratory Experience (Fall 2013) $3500.00
25. Dabke, R. B, Presenting a chemical education paper at BCCE 2012 (Summer 2012) $1265.00
26. Dabke, R. B, "Development of Undergraduate Curriculum in the Area of Experimental Physical Chemistry (Fall 2011) $2815.00
27. Holley, D.W.,The Characterization of Polystyrenes Synthesized by Microwave-assisted, Nitroxide-mediated Emulsion Polymerization" in the amount of $4,000.
28. Holley, D.W., "The Synthesis and Characterization of a Novel Polymeric Nanoparticle Morphology: Encapsulated Chains with an Immiscible Crosslinked Shell" in the amount of $1, 080.

**Grants** (**External**)

1. Banerjee, A. C., 2014-2015: PI and project director of Federal Teacher Quality Grant "Professional Development of High School Teachers on Implementation of Common Core Literacy with Laboratory Instruction and Student Assessment ( sub award by Teacher Quality Office, University of Georgia) : $35,970

2. Banerjee, A. C., 2013-2014: PI and project director of Federal Teacher Quality Grant "Project Guided Inquiry" ( sub award by Teacher Quality Office, University of Georgia) : $35,000

3. Banerjee, A. C., 2012: PI and project director of Federal Teacher Quality Grant "Project Guided Inquiry" ( sub award by Teacher Quality Office, University of Georgia) : $32, 298

4. Banerjee, A. C., 2007-2009: PI and project director of Federal Teacher Quality Grant: "Development inquiry teaching strategies and labs to improve student learning of chemistry and physical science in middle and high schools" ( sub-award by Teacher Quality Office, University of Georgia): $94,000
5. Banerjee, A. C., 2008: Chemistry equipment grant award from Micromeritics Corporation, Georgia to improve laboratory teaching and research in heterogeneous catalysis: an equipment worth $30,000

6. Banerjee, A. C., 2006-June 2007: PI and project director of Federal Teacher Quality Grant "Inquiry teaching to implement Georgia Performance Standards in chemistry and physical science" ( sub award by Teacher Quality Office, University of Georgia): $45,364

7. **Joseph K. Rugutt, P.I.; Floyd R. Jackson, Co-P.I., 2009 – 2011: National Science Foundation; Course Curriculum and Laboratory Improvement Grant; "Integration of Fourier Transform Nuclear Magnetic Resonance Spectroscopy into the Chemistry Curriculum." $200,000**

8. Floyd R. Jackson; 2010: P.I. Congressionally-Directed Grant Award; "Equipment for a Science, Technology, Engineering, and Mat (STEM) Program," $150,000

d. **Faculty Committee Assignments**

**Abegaz, S.**

1. Colloquium Committee, **Chair**, Volunteered, April 2013 – Present.
2. Departmental Personnel Committee, Committee Member, appointed, August 2013 - Present.
3. Lead Faculty: Lead Faculty for Principles of Chemistry I lab (CHEM 1211 L), appointed, August 2013-Present.
4. Chemical Safety and Hygiene, Committee Member, appointed, April 2011 – August 2013.
5. Instrumentation Committee, **Chair**, appointed, February 24, 2010 - Present.
6. Departmental Curriculum Committee, **Chair**, appointed, August 2012 – Present.
7. Organic Chemistry faculty search committee, **Chair**, appointed, October 2012 – March 2012.
8. ACS accreditation committee, Committee Member, appointed, August 2009 – March 2013.
9. Biochemistry Faculty Search, Committee Member, appointed, December 20, 2010 - May 1, 2011.
10. Lecturer/Stock room manager search committee, Committee Member, August 2009 – August 2010.
11. Physics faculty search committee, Committee Member, appointed, October 2008 – March 2009.
12. Pre-tenure Committee, Committee Member for Dr. Fred Gordon, selected, since June 2013.
13. Post-Tenure Committee, Committee Member, College of Letters and Sciences, appointed, since August 2013.
14. Thesis Committee, Committee Member for Jennifer Collins, elected, August 15, 2010 - Present.
15. Annual Fund Drive, Committee Member, appointed, August 2009 –August 2013.
16. Grant Committee, Committee Member, appointed, October 2008 - 2010.
17. Student Research and Creative Endeavors (SRACE) committee, **Chair**, elected, since fall 2013.
18. IPC Committee, Interdisciplinary Program Council (IPC), committee member, appointed, since fall 2013.
19. Scholarship subcommittee, **Chair**, volunteer, since September 2013.
20. Student Research and Creative Endeavors (SRACE) committee, Committee Member. (August 1, 2011 – June 2013.
21. Sustainability Committee, Committee Member, volunteer, August 1, 2011 - Present.
22. International Education Committee, Committee Member. (August 16, 2010 - Present).
23. African Studies Committee, Committee Member. (January 1, 2009 - Present).
24. African Students Organization at CSU, Faculty Advisor. (September 2008 - Present).
25. Undergraduate Research and Experiential Learning, Committee Member. (September 2009 - August 2011).
26. Study abroad Subcommittee, Committee member. (August 2011 – present)
27. International Student Recruitment Subcommittee, Committee member. (August 2011 – present).

28. ***Conference organizer:*** Georgia Undergraduate Research Conference, Committee Member, Columbus State University, Columbus, GA, Since April 2012.
29. ***Conference organizer:*** Southeast Model African Union Conference, Committee Member, Columbus State University, Columbus, GA, Since August, 2013.
30. ***Honors Thesis Advising:*** I served as thesis advisor and Chair of the oral defense committee for my honor thesis student, Samantha Worthy. The title of her research was Assessment of Heavy metals in Lake Walter F. George in Alabama and Georgia. She defended her thesis successfully on the 26th of April 2013.
31. ***Mastering CSU:*** I conducted demos during the Mastering CSU event, Columbus State University, January 15, 2013.
32. ***Science Fair:*** I served as a judge during the science fair event at Columbus Regional Science and Engineering Fair, February 5, 2013.
33. ***Science Olympiad:*** I am serving as an event supervisor for the chemistry division of the Science Olympiad, since February 2009.
34. ***National Chemistry Week:*** chemistry demonstrations for local secondary school and CSU students, since 2009
35. Member, Executive Board, Auburn Local Chapter, American Chemical Society (2013-----)
36. Member, ACS DivCHED International Affairs Committee ( 2011-2014)
37. Adviser, Columbus State University ACS Student chapter ( 2008--)
38. ACS Georgia Government Affairs Federal Level Committee, ACS Office of Public Affairs (2012---2013)
39. ACS Exam Institute General Chemistry Exam Committee ( 2011-2012 and 204-2015)
40. American Chemical Society DivCHED Long Range Planning Committee ( 2010-2011)
41. Chair, Biochemistry Faculty Search Committee( 2013-2014)
42. Chair, Organic Chemistry Faculty Search Committee( 2013-2014)
43. Member, Dean of COLS Search Committee ( 2013-2014)
44. Chair, Faculty Development Committee (2012-2013)
45. General Education Committee( 2011-2013)
46. Member, Distance Learning Committee ( 2011-2012)
47. UTEACH Steering Committee ( 2011-)
48. Chemistry Department Tenure &Promotion Committee ( 2011-2014)
49. Chair, Post Tenure Committee, College of Letters &Sciences ( 2010-2011)
50. Science Education Faculty Search Committee (2010-11) Chair, Search Committee, Director of the Faculty Center for the Enhancement of Teaching & Learning ( 2010)
51. Member, Post Tenure Committee , College of Letters &Sciences ( 2009-2010)
52. Chair, Faculty Development Committee( 2009-2010)

**Banerjee, A.C.**

53. Chair, Biochemistry Faculty Search Committee( 2013-2014)
54. Chair, Organic Chemistry Faculty Search Committee( 2013-2014)
55. Member, Dean of COLS Search Committee ( 2013-2014)
56. Chair, Faculty Development Committee (2012-2013)
57. General Education Committee( 2011-2013)
58. Member, Distance Learning Committee ( 2011-2012)
59. UTEACH Steering Committee ( 2011-)
60. Chemistry Department Tenure &Promotion Committee ( 2011-2014)
61. Chair, Post Tenure Committee, College of Letters &Sciences ( 2010-2011)
62. Science Education Faculty Search Committee (2010-11)
63. Chair, Search Committee, Director of the Faculty Center for the Enhancement of Teaching & Learning ( 2010)
64. Member, Post Tenure Committee , College of Letters &Sciences ( 2009-2010)
65. Chair, Faculty Development Committee( 2009-2010)
66. Member, Executive Board, Auburn Local Chapter, American Chemical Society (2013-----)

67. Member, ACS DivCHED International Affairs Committee ( 2011-2014)
68. Adviser, Columbus State University ACS Student chapter ( 2008--)
69. ACS Georgia Government Affairs Federal Level Committee, ACS Office of Public Affairs (2012---2013)
70. ACS Exam Institute General Chemistry Exam Committee ( 2011-2012 and 204-2015)
71. American Chemical Society DivCHED Long Range Planning Committee ( 2010-2011)
72. Director, Regional Science Olympiad (2008-2009)

**Dabke, R.**

73. Assistant Chair of the Department 2009-2010
74. COLS Personnel Committee, Chair 2012-13
75. COLS Personnel Committee 2010-2011
76. COLS Personnel Committee 2011-2012
77. Faculty Handbook advisory Committee 2009-2011
78. General Education Assessment Committee 2013-
79. Departmental Chemical Hygiene Plan and Safety Committee member 2013-2015
80. Departmental Biochemistry Search Committee, Chair 2009
81. Departmental Organic Chemistry Search Committee
82. Departmental Pre-tenure Review Committee
83. Departmental Personnel Committee

**Holley, D.W.**

84. Chemistry Department - Biochemistry Search Committee Member – Fall 2013 – Present.
85. Chemistry Department - Organic Chemistry Search Committee Member – Fall 2013 – Present.
86. Chemistry Department – Instrument Committee Member – Fall 2012 – Present.
87. University Honors Committee – Fall 2013 – Present

**Jackson, F.**

88. Pre-professional Committee
89. USG Curriculum Advisory Committee for Chemistry
90. Chairs' Assembly
91. Dean's Administrative Counsel
92. Pre-Engineering Advisory Committee
93. Environmental Science Advisory Committee
94. CSU Diversity Team and Committee (fall 2009 – present)
95. Academic Vice President for Enrollment Management Search Committee (fall 2010 – spring 2011)
96. Director of Institutional Research and Assessment Search Committee (fall 2010 – spring 2011)
97. Math Chair Search Committee (fall 2010 – spring 2011)
98. Associate Provost for Research, Graduate Study, and Economic Development search Committee (fall 2009 – spring 2010)
99. College of Letters and Sciences Dean of the Search Committee (fall 2009 – 2010)
100. Provost and Vice President for Academic Affairs Search Committee (fall 2009 – 2010) Honors Scholarship Committee (2010 - 2012)

**Appendix II**

**e. Chemical Hygiene Plan**

## Columbus State University

## College of Letters and Sciences

## Department of Chemistry

# Chemical Hygiene Plan

**Revised by: Safety and Chemical Hygiene Plan Committee**

**Rajeev B Dabke (chair)**

**Kenneth Smith (member)**

**Oge Anazia (member)**

**August 23, 2013**

## Table of Contents Page

# 1.0 Introduction

The Department of Chemistry, Columbus State University is committed to providing a safe and healthy workplace and believes its employees have a “Right to Know” about health and safety hazards associated with their workplace by providing pertinent safety information. The development and implementation of a written Chemical Hygiene Plan (CHP) in compliance with the U.S. Occupational Safety and Health Administration (OSHA) standard, 29 CFR 1910.1450 is required in order to communicate appropriate information to employees. This Code of Federal Regulations specifies the mandatory requirements of a Chemical Hygiene Plan to protect persons from harm due to hazardous chemicals. The Standard can be viewed on the OSHA Web site at www.osha.gov.

This Chemical Hygiene Plan was prepared by the Safety and Chemical Hygiene Committee of the Chemistry Department of Columbus State University in order to promote the safe operation of the Department’s laboratories for students, faculty and staff, and to promote a culture of safety within the Department and the College of Letters and Sciences as required by the above regulation. The Plan describes proper practices and procedures to be followed by employees, students, visitors, and other personnel working in each laboratory in order to protect them from potential health hazards presented by chemicals used in the workplace, and to keep exposures below specified limits. The plan also includes requirements for training, medical consultation and examinations, hazard identification, and personal protective equipment. It is the responsibility of the faculty, administration, and supervisory personnel to know and follow the provisions of this Plan.

# 2.0 Responsibility

## *2.1 Department Chairperson*

The Department Chairperson has the responsibility and authority to see that the Chemical Hygiene Plan is written, updated, and implemented. In addition, the Department Chairperson appoints the Safety and Chemical Hygiene Committee. The Department Chairperson has the final responsibility for the safety and health of the employees, visitors, students, and other personnel in the department laboratories.

## *2.2 Safety and Chemical Hygiene Committee*

The Safety and Chemical Hygiene Committee will serve in the development and implementation of the Department's Chemical Hygiene Plan (CHP) in consultation with the Department Chair. The Chemical Hygiene Committee also provides the following:

a. Advice and assistance to faculty, staff and students with regard to the implementation of the CHP.
b. Periodical reviews and updates to the CHP.
c. Inspection of laboratories and follow-up visits to laboratories not meeting initial compliance.
d. Assurance that appropriate controls are available to protect individuals working in the laboratories.
e. Reporting of unresolved chemical safety issues to the department chair.

### *2.3 Faculty and staff*

Faculty (full time or part-time) and staff must follow the appropriate safety precautions. They must serve as good role models for their students by observing and enforcing all rules and regulations, wearing protective equipment and being advocates of safety. Faculty and staff will ensure that:

a. All personnel working in their laboratory(s) are aware of and practice appropriate precautions.
b. Rules and Standard Operating Procedures (SOPs) are enforced and discipline is maintained.
c. Emergency equipment is available and in proper working order and that everyone has been trained on its use.
d. Information and training on special or unusual hazards or equipment is provided and documented.
e. Appropriate safety plans and emergency procedures have been developed and are followed.
f. Material Safety Data Sheets (MSDSs) are readily accessible and are reviewed before unfamiliar work or work with new chemicals commences.
g. Personal protective equipment is available and used.
h. All Hazardous Waste Regulations, including waste minimization, are complied with.
i. Periodic inspections and surveys of the laboratory work area are conducted.
j. All health and safety procedures and rules are followed.

### *2.4 Students*

Students shall follow safe work practices as directed by the laboratory instructor and are required to:

a. Consult with the laboratory supervisor prior to performing work about which they are unsure or feel unsafe.
b. Plan and conduct all operations in accordance with the departmental Chemical Hygiene Plan.
c. Develop effective personal chemical hygiene habits.

## 3.0 Standard Operating Procedures (SOP)

### *3.1 General Rules*

a. Follow all safety instructions carefully. Use equipment only for its intended purpose.
b. Become thoroughly acquainted with the location and use of safety equipment such as safety showers, fire blankets, eyewash fountains, fire extinguisher, phone, and exits.

c. Understand the safety rules and procedures that apply to the work being performed. Determine potential hazards and precautions before undertaking any operation.
d. Be alert to any unsafe conditions and work practices and call attention to them immediately, so that appropriate corrections can be made as soon as possible.
e. Horseplay, practical jokes, or other behavior that might confuse, startle, or distract other workers in the laboratory is prohibited.
f. Be certain all chemicals are correctly and clearly labeled. Post warning signs when unusual hazards such as the use of carcinogens or highly toxic chemicals exist.

## *3.2 Personal Protective Equipment*

### 3.2.1 Eyes

Everyone in the laboratory, including visitors, MUST wear appropriate eye protection at all times, even when not performing a chemical operation. Regular prescription eyeglasses (with or without side shields) are not allowed as a substitution for safety glasses or splash goggles. Faculty and staff may obtain prescription safety glasses with side shields. Faculty and staff who do not obtain prescription safety glasses must wear safety glasses (for impact hazard) or goggles (splash hazard) designed to go over their prescription glasses. Whether for a structured laboratory class or research, students must wear safety goggles for impact hazard and/or for splash hazard which are designed to go over their prescription glasses. Faculty mentoring students must enforce this regulation. Full face shields with safety glasses or goggles underneath must be worn when conducting an operation that may result in a violent reaction.

### 3.2.2 Clothing

Clothing should offer protection from splashes and spills, should be easily removed in case of an accident, and should be fire resistant. Proper laboratory attire includes full-length pants and long sleeve shirts. All students and faculty working in the laboratory must wear a lab apron or a lab coat. High heeled or open toed shoes, sandals, and flip-flops will not be worn in the laboratory. Shorts, short dresses, miniskirts, tank tops, and halter-tops are also prohibited. Long hair and loose clothing should be constrained. Jewelry such as rings, bracelets, and watches should not be worn.

### 3.2.3 Gloves

Gloves are an essential part of personal protection when used correctly. Check to make sure there are no cracks, breaks, or small holes prior to use. Gloves should be removed before handling telephones, doorknobs, writing instruments, and notebooks to prevent the unintentional spread of chemicals. Gloves should be changed on a periodic basis depending on the nature of work and the chemicals used. Glove material must be appropriate for the chemicals being handled and the operation being performed. A chemical resistance chart that lists the material or materials being used should be consulted.

## *3.3 Personal Hygiene*

a. Do not prepare, store, or consume food or beverages in the laboratory.
b. Do not apply cosmetics in the laboratory.
c. Wash hands and forearms before leaving the lab even if gloves were worn. Do not use solvents to wash skin. Solvents remove the protective oils from the skin and cause drying, redness, and irritation.
d. Never wear or bring lab coats or aprons in areas where food is stored or consumed.
e. Food should not be stored in a refrigerator used for chemical storage. Refrigerators used for chemical storage should be clearly labeled "Chemicals Only - No Food." Conversely refrigerators used for food storage, which will be located outside the laboratory area, should be labeled "Food Only - No Chemicals."
f. Never pipette or siphon by mouth.

## *3.4 Housekeeping*

In the laboratory and elsewhere, keeping things clean and neat generally leads to a safer environment. When housekeeping standards fall, safety performance inevitably deteriorates. Therefore,

a. Work areas should be kept clean and free from obstructions. Keep aisles free of chairs, boxes, equipment, and waste receptacles.
b. Lab benches and floors should be cleaned regularly and kept free of clutter.
c. Access to emergency equipment, exits, control panels, and outlets should be kept clear at all times.
d. Drawers and cabinets should be closed when not in use.
e. Full hazardous waste collection containers should be removed from the laboratory.
f. Unneeded or unwanted reagents should be returned to the department stockroom.
g. Spilled chemicals should be cleaned up immediately and disposed of properly.
h. All laboratory sinks must be clean and free of debris to allow the sinks to drain without obstruction.

## *3.5 Unattended Operations*

Reactions that are left to run unattended overnight or at other times are prime sources for fire, floods, or explosions. Plan for interruptions in electrical, gas, or water service must be in place. Equipment such as power stirrers, hot plates, heating mantles, and water condensers should not run unattended without fail-safe provisions. Unattended operations must be checked regularly. Appropriate signs should be posted indicating that a laboratory operation is in progress. The sign will include any hazards associated with the operation and a telephone number of the person(s) to be contacted in an emergency.

## *3.6 Working Alone*

No student may work in a laboratory building alone. If a faculty member determines that a student can work alone in a laboratory room, arrangements should be made for frequent contact with a faculty member in the immediate area. Contact will be maintained with campus security during work outside of normal hours.

## *3.7 Security*

a. All laboratories must be locked when unattended and not in use to protect employees, students, equipment and supplies.
b. Utilize locked storage cabinets for expensive, hazardous, or sensitive items.
c. All suspicious persons or actions should be reported to Campus Police immediately at **706-568-2022**

## *3.8 Glassware*

Careful handling and storage procedures are necessary to avoid damaging glassware.

a. Damaged or broken glassware must be discarded. Place broken glass in designated containers. Broken glass collection containers should be labeled, "CAUTION - Broken Glass" to prevent injury to custodians and garbage handlers.
b. Adequate hand protection must be worn when inserting glass tubing into rubber stoppers or corks, or when placing rubber tubing on glass connections.
c. Handle glass apparatus under vacuum with extreme care to prevent implosion. Glassware under vacuum should be taped or shielded and only glassware designed for vacuum use such as Dewar flasks may be used for that purpose.
d. Clean all glassware at a laboratory sink. The use of strong oxidizer agents such as nitric, chromic, or sulfuric acid should be minimized.
e. Proper hand protection must be worn when handling broken glass.
f. Glassware or bottles used in laboratory operations may not be used to prepare or store food or beverages.

## *3.9 Systems Under Pressure.*

a. Reactions under pressure must be carried out in an apparatus that is designed to withstand the full pressure of the system.
b. All pressurized apparatus must have appropriate relief devices.

## *3.10 Compressed Gases*

a. Gas cylinders should be strapped or chained securely to a wall or bench top.
b. Gas cylinders must be capped when not in use.
c. Flammable compressed gases should be stored away from heat, oxygen, and sources of ignition.
d. The appropriate regulator must be used.
e. Gas cylinders should not be completely empty.
f. Empty gas cylinders must be labeled as such and separated from full ones.
g. Gas cylinders must be transported using gas cylinder carts specifically designed for this purpose.

## *3.11 Chemical Storage*

### 3.11.1 General

a. Every chemical container in the laboratory should have a definite storage place and must be returned to that location after each use. Containers may not be left on bench tops overnight.
b. Do not store chemicals on desks, bench tops, or in hoods that are used for chemical manipulations.
c. Storage trays or secondary containers must be used to minimize the spread of material should a container break or leak.
d. Store chemicals by hazard class, not alphabetically.
e. At the very least, acids must be separated from bases and flammables must be separated from oxidizers.
f. Chemical containers must be inspected periodically. Repair worn or faded labels. Dispose of deteriorated or unusable chemicals.
g. Chemical containers should be dated when opened. This includes stating the date received, the date opened, and the initials of the responsible faculty.
h. All volatile solvents must be stored in a cold room, e.g. petroleum ether.

### 3.11.2 Toxic Substances

a. Chemicals known to be highly toxic must be stored in safety cabinets inside chemically resistant secondary containers when not in use.
b. Only minimum working quantities should be present in the work area, which must be well ventilated.
c. Containers of suspected carcinogens or acutely toxic chemicals MUST carry a label such as the following: “CAUTION – Carcinogen” or “CAUTION - Highly Toxic.”

### 3.11.3 Peroxide Forming Chemicals

Specific chemicals that can form dangerous concentrations of peroxides on exposure to air include cyclohexene, cyclooctene, decalin (decahydronaphthalene), p-dioxane, ethyl ether anhydrous, diisopropyl ether, tetrahydrofuran, and tetralin (tetrahydronaphthalene).

a. The quantity of peroxide-forming chemicals purchased should be limited to the minimum quantity required. Unused material may not be returned to the original container.
b. Containers of peroxide-forming chemicals must be dated when opened, tested after 6 months, and disposed of before their expiration date.
c. Peroxide-forming chemicals must be stored at the lowest possible temperature consistent with their freezing point to prevent decomposition, but will not be allowed to freeze.

### 3.11.4 Mercury

a. Avoid or minimize spills of elemental mercury as much as possible. Avoid skin contact.
b. When a mercury thermometer is broken, clean up spills with a mercury spill kit.
   Ventilate area well to remove Hg vapors.

# 4.0 Labeling

All containers of hazardous chemicals must be properly labeled as described below. The use of unmarked containers of hazardous chemicals is strictly prohibited.

Each original shipment container, portable container, and stationary process container shall include the appropriate hazard warning for each chemical, or mixture as a whole, based on the method of hazard determination [OSHA 29 CFR 1910.1200(d)(2)]. Specifically, each original, incoming container shall be labeled, tagged, or marked by the manufacturer or distributor with the following minimum information:

a. Identity of the hazardous chemical(s). Identity means the trade name or chemical name as given on the Material Safety Data Sheet (MSDS).
b. The appropriate hazard warning, including health, flammability, reactivity, and preferably, personal protective equipment (PPE) data.
c. Name and address of the chemical manufacturer, importer, or other responsible party.

Labels and other forms of warnings must be legible, in English, and prominently displayed. Existing labels on incoming containers must not be removed or defaced unless the container is empty of its original materials.

Secondary containers (safety cans, plastic bottles, etc.) must be labeled with the chemical formula, chemical name (or trade name if appropriate) and hazard warnings (health, reactivity, flammability).

It is recommended that secondary containers (safety cans, bottles, etc.) containing solids and liquids be labeled with the chemical grade. Secondary containers containing solutions should be labeled with the date of preparation, solution concentration, and solvent, including water.

Containers too small to label completely should at least be labeled with the chemical formula and chemical name (or trade name, if appropriate). The container should be stored on or near a card (for example a 3”x5” card) containing information not found on the label.

Any bottle that is re-used must have the original label removed and an appropriate label placed on it.

Chemical containers, both hazardous and non-hazardous, must be inspected by the Environmental Safety office of the university to ensure that they are properly labeled. Incorrect labels must be corrected immediately.

Extremely hazardous materials such as cyanides should also be marked with a label identifying its extreme hazard. Extremely hazardous materials are considered those materials which pose an unusually high risk due to toxicity, reactivity, flammability, etc. Questions regarding the need for special labeling should be directed to the university’s Environmental Safety office at **706-507-8213**.

# 5.0 Controlling Chemical Exposures

The basic routes for a chemical to enter the body in a laboratory setting are inhalation, skin and eye contact, ingestion, and injection. The prevention of entry by these routes can be accomplished by control mechanisms such as engineering controls, personal protective equipment, and administrative controls. Each route can be minimized by a variety of control measures depending on the hazard and operation.

Employing administrative controls is the most desirable method for controlling chemical exposures and must be used whenever possible. Administrative controls include but are not limited to the following:

a. Utilizing hazard information and education.
b. Substitution of a non-hazardous or less hazardous chemical, procedure, or equipment.
c. Reducing the volumes of experiments or quantities used.

d. Controlling and minimizing individual exposure times. Rotating responsibilities.
e. Restricting access to an area where a hazardous chemical is in use.
f. Conducting operations that produce nuisance odors outside of typical hours.
g. Placing proper signs on doors to indicate the hazards within and the name and phone numbers of appropriate individuals to contact in an emergency.

## *5.1 Inhalation*

Inhalation of hazardous chemicals is the most common route of entry to the body in laboratory operations. To avoid significant inhalation exposures and limit exposure to concentrations below the normal values, there are a number of control measures that can be used. Substituting a less toxic or less volatile chemical is the most desirable measure. If substitution is not practical, ventilation will be used to reduce exposure. Dilution ventilation may be used to reduce exposure to non-hazardous nuisance vapor and odor. All hazardous chemicals should be used in a properly functioning chemical fume hood. For extremely toxic substances, the use of closed systems such as a glove box may be required. If necessary, additional personal protective equipment may be worn to limit chemical exposures. Dust masks or half-face air purifying respirators may be utilized to this end.

## *5.2 Skin and Eye Contact*

Contact with the skin is a frequent mode of chemical injury. To reduce the risk of chemicals entering the body via skin and eye contact or skin absorption, personal protective equipment such as gloves, eye protection, lab coats, aprons, appropriate shoes, and special protective equipment must be used. The laboratory instructor should consult references to determine the proper protective material for the chemicals being used.

Administrative controls to reduce skin/eye contact exposure include the following:

a. Setting up hazardous and non-hazardous areas in the laboratory.
b. Enforcing sound chemical hygiene procedures, such as no eating or drinking in the lab and washing hands after handling chemicals.

## *5.3 Ingestion*

Most of the chemicals used in the laboratory are toxic if they enter the body by ingestion. The relative toxicity of a chemical can be determined by its $LD_{50}$, which is the quantity of material that in a single dose will cause the death of 50% of test animals. It is usually expressed in grams or milligrams per kilogram of bodyweight.

Ingestion should not be a route of exposure in a laboratory setting. The best way to eliminate exposure by ingestion is to limit actual contact with all chemicals. Wear gloves and practice good hygiene measures. Food and drink should not be stored in areas where chemicals are being used or stored. Label all chemical containers, and replace worn or faded labels as soon as possible. Chemicals should not be tasted and pipetting and siphoning of liquids may not be done by the mouth. Food and beverages should not be consumed in the laboratories.

### *5.4 Injection*

Exposure to chemicals by injection seldom occurs in the chemical laboratory. However, it can inadvertently occur through injury from metal or glass contaminated with chemicals or when chemicals are handled in syringes. Attention to detail and adherence to general standard operating procedures will provide control against accidental injection exposure. Appropriate assigned boxes should be used to collect all used needles and syringes. Separate collection containers should be used to collect broken glass. Label the containers "CAUTION - Broken Glass."

## 6.0 Laboratory Safety Equipment

### *6.1 Ventilation*

Laboratory procedures must be conducted using adequate ventilation or other engineering controls, such as glove boxes and fume hoods. All laboratory fume hoods, glove boxes, and special ventilation areas must perform to measurable efficiencies. Laboratory air should be replaced continuously (8 air changes per hour). General ventilation provides only modest protection against toxic gases, aerosols, vapors and dusts. General ventilation alone should not be used for protection against toxins.

### *6.2 Chemical Fume Hoods*

Local ventilation will be used to prevent harmful fumes, mists, dusts, gases, and vapors from entering the laboratory air. The best protection is the chemical fume hood, if used properly.

Work practices for chemical fume hoods are as follows:

a. Determine if hood is working properly by checking air flow prior to use. Check the fume hood indicator light to ensure the proper airflow. Fume hood should always be operating and never turned off.
b. Set up work at least 6 inches from the face of the hood to avoid turbulence at the sash edge.

c. Separate and elevate each instrument by using blocks or rack so that air can flow easily around all apparatuses.
d. Do not clutter the hood with unnecessary bottles or equipment. Do not use the hood for storage of chemicals or other materials if it is used for chemical operations as well. Only materials in use should be in the hood.
e. Work with the sash in the lowest possible position. The sash provides a physical barrier to protect against splashes, sprays, fires, or minor explosions. Lower the sash completely when no one is working in the hood.
f. Do not dismantle or modify the physical structure of the hood or exhaust system in any way without first consulting Physical Plant personnel.
g. Do not place electrical receptacles or other spark producing equipment inside the hood.
h. Never put your head inside an operating hood to check an experiment. The plane of the sash is the barrier between contaminated and uncontaminated air.
i. Clean up spills as soon as possible.
j. Do not use a hood for evaporation of chemical wastes.
k. Heating of perchloric acid may only be performed in a perchloric acid fume hood.
l. If you suspect that your fume hood is not functioning properly, let a representative in the Physical Plant know immediately.

## *6.3 Eyewashes and Safety Showers*

All laboratories in which hazardous and corrosive chemicals are used should have direct access to eyewash stations and safety showers.

a. Employees and students who may be exposed to hazardous materials shall be instructed in the location and proper use of emergency shower and eyewash units.
b. Personal wash units (portable or squeeze bottle type eyewashes) are considered supplemental to emergency eyewash and shower equipment.
c. The eyewash units must provide flushing fluid to both eyes simultaneously.
d. Eyewash nozzles must be protected from airborne contaminants.
e. The shower (and eyewash) must be located on the same level as the hazard and the path of travel shall be free of obstructions that may inhibit the immediate use of the equipment.
f. Emergency eyewash and shower equipment should be available for immediate use, but in no instance should it take an individual longer than 10 seconds (or 50 feet) to reach the nearest facility.
g. Showers should be checked routinely to assure access is not restricted and the start chain is within reach.
h. The flow through the safety showers should be tested periodically to ensure sufficient flow (approximately 60 gallons per minute). Annual inspections must be conducted, and stickers must be placed on each unit indicating the date of testing.

### 6.4 Fire Safety Equipment

Fire safety equipment must be easily accessible to the laboratory and include a fire extinguisher (type ABC) available within 50 feet, and may include a fire blanket. Fire extinguishers must be inspected annually.

### 6.5 First Aid Kit

Each laboratory shall have a standard first aid kit inspected and stocked regularly. All laboratory personnel and students must have access to emergency equipment, fire alarm, and telephone for use in an emergency.

### 6.6 Exit and Aisles

Aisles and exit routes must not be obstructed in any way. Therefore, keep stools

pushed under or next to the bench. Keep book bags and other personal items where they will not be an obstruction hazard.

## 7.0 Material Safety Data Sheets (MSDSs)

MSDSs or other reference information for particularly hazardous substances should be kept on file in the laboratory or building where they are used. Instructional laboratories should also have MSDS copies on file for the hazardous chemicals frequently used or stored in large quantities in the laboratory. It is the responsibility of the laboratory instructor to ensure that these MSDS files are maintained and updated.

MSDSs must be reviewed before working with unfamiliar or particularly hazardous chemicals, and should be obtained prior to purchase in order to properly evaluate substances being considered for use. MSDSs contain information about safe handling and storage procedures as well as the personal protective equipment required for adequate protection. Laboratory supervisors are responsible for disseminating this information to technicians and students. Material Safety Data Sheets are also available on the Internet.

## 8.0 Information and Training

### 8.1 General

Employee information and training must occur initially during a new employee’s orientation period. Training and information distribution is a continuous process; information and training must be refreshed by the department as needed with a formal training session at least once per year. Laboratory supervisors must ensure that everyone working or studying under their supervision has been adequately trained on the chemicals, equipment, and procedures that they are using.

## 8.2 Information

All laboratory personnel should be informed of the contents of “Occupational Exposure to Hazardous Chemicals in Laboratories,” OSHA Standard 29 CFR 1910.1450, and the location and contents of the department’s Chemical Hygiene Plan.

All laboratory personnel should be informed of the OSHA Permissible Exposure Limits (PELs) and ACGIH Threshold Limit Values (TLVs).

## 8.3 Training

Training must consist of methods and observations that may be used to detect the presence or release of a hazardous chemical, the physical and health hazards of chemicals in the work area, the measures employees can take to protect themselves from exposure, personal protective equipment, work practices, and emergency procedures. Training will cover the department's Chemical Hygiene Plan.

## 8.4 Training for Students

Faculty shall provide a safe environment for learning by providing safety training to students as follows:

a. At the beginning of the term and prior to laboratory activities, class time shall be devoted to safe laboratory practices and the signing of the student Safety Consent Form (Appendix C) for all laboratory classes. The instructor should store the safety consent forms for two years.
b. Instruction in laboratory safety shall be provided to all students enrolled in laboratory classes. Students enrolling after safety instruction has taken place shall receive instruction prior to being permitted to engage in laboratory activities.
c. The extent of student safety training should be based on their course of study, the laboratory facility, university policies, the chemical hygiene plan, and the level of chemical handling and potential exposure to hazardous chemicals. The safety training should also include handling of chemicals, proper identification of hazardous waste, and material safety data sheets.
d. Safety training must include understanding the importance and content of container labels and material safety data sheets. As appropriate, the student shall also be introduced to other sources of chemical safety information.
e. Additionally, students of 1211L class are required to complete the safety workshops presented on the following websites:

http://www.usg.edu/ehs/training/hazwaste/

http://www.usg.edu/ehs/training/rtkbasic/

http://www.usg.edu/ehs/training/chemical/

# 9.0 Hazardous Chemicals and Other Hazards

## *9.1 Hazardous Chemicals*

The highly hazardous nature of some chemicals demands that special handling and disposal techniques be used. Before beginning any laboratory operation, the supervisor or instructor must review the MSDSs for each chemical with which they are unfamiliar to determine precautions and waste disposal implications and methods. All chemical purchases must be approved by the department chairperson.

## *9.2 Electrical*

a. Report all tingles, shocks, or observed potential shock hazards to the instructor (big shocks are often preceded by small ones).

b. ALL instruments must be grounded (exceptions are those with non-conductive plastic cases and controls, such as microscopes).

c. DO NOT WORK ON - OR ATTEMPT TO REPAIR - ANY INSTRUMENT WHILE IT IS PLUGGED IN!

d. Remove rings, watches, or other jewelry when working on instruments.
e. When working on the electrical components of instruments, be aware of what both hands are touching.

## *9.3 Centrifuge*

a. Do not operate centrifuges unless the cover is closed (including serofuges).
b. Keep hair, beards, neck ties, hair ribbons, or other frilly or dangling items out of the way.
c. Do not centrifuge uncovered tubes of specimens (blood, urine, sputum) or flammable liquids. Spinning creates a vacuum and volatilizes liquids.

# 10.0 Particularly Hazardous Substances

In addition to the general safety guidelines mentioned throughout this plan, special precautions are needed when handling select carcinogens, reproductive toxins, and substances of high acute toxicity.

## *10.1 Carcinogens*

A carcinogen commonly describes any agent that can initiate or speed the development of malignant or potentially malignant tumors. Carcinogens commonly used in larger volumes in the department include chlorinated hydrocarbons, benzene, and formaldehyde.

## *10.2 Reproductive Hazards*

A reproductive toxin is a chemical that affects the reproductive capabilities including chromosomal damage (mutagens) and effects on the fetus (teratogens). A mutagen affects the chromosome chains of exposed cells. The effect may be hereditary and become part of the genetic pool passed on to future generations. A teratogen (embyrotoxic or fetotoxic agent) is an agent that interferes with normal embryonic development without damage to the mother or lethal effects on the fetus. Effects are not hereditary. Few examples of substances assessed to cause reproductive toxicity are: acrylamide, ammonium dichromate, benzene, and 1- and 2-benzenedicarboxylic acid, etc.

## *10.3 Highly Toxic Chemicals*

Acutely toxic chemicals are substances falling into any of the following categories:

a. A chemical that has a median lethal dose ($LD_{50}$) of 50 mg or less per kg of body weight, when administered to albino rats weighing 200 g to 300 g each.
b. A chemical that has a median lethal dose ($LD_{50}$) of 200 mg or less per kg of body weight, when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) to the bare skin of albino rabbits weighing 2 kg to 3 kg each.
c. A chemical that has a median lethal concentration ($LC_{50}$) in air of 200 parts per million by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing 200 g to 300 g each.

## *10.4 Handling Procedures*

When handling substances that present special hazards, the procedures in the following pages should be used to minimize risk. These procedures must be followed in laboratory operations with substances believed to be highly toxic or carcinogenic, even when used in small amounts. The extent of precaution depends on the hazards of the particular substance. Factors such as physical form and volatility of the substance, type and duration of exposure, and the amount to be used should be considered. The overall objective is to minimize exposure to toxic substances by any route of exposure. The general precautions outlined elsewhere in this plan should normally be followed whenever a toxic substance is transferred from one container to another or is subject to some chemical or physical manipulation. The following procedures must also always be followed:

### *Record Keeping*

Accurate records that include the amounts of chemicals used and names of researchers or students involved should be kept as part of the laboratory notebook record of the experiment (Appendix E).

### *Storage*

Substances having high chronic toxicity should be stored in a well-ventilated area in a secondary container or tray.

### *Labels and Signs*

All containers in the high chronic toxicity category will include a warning such as: WARNING! CANCER SUSPECT AGENT. All newly purchased containers should already contain this warning, but batch containers and solutions must also be labeled. Any area used for storage should have a label identifying the special toxicity hazard that exists.

### *Designated Areas*

All experiments with and transfers of particularly hazardous substances or mixtures containing such substances must be performed in a designated area. A designated area is defined as a laboratory, a portion of a laboratory, or a facility such as an exhaust hood or glove box that is designated for the use of highly toxic substances. Its use need not be restricted if all personnel who have access to the controlled area are aware of the nature of the substances being used and the necessary precautions. Designated areas will be clearly marked with a conspicuous sign such as the following: WARNING! HIGHLY TOXIC SUBSTANCE IN USE: AUTHORIZED PERSONNEL ONLY. The working surface of the hood can be fitted with a removable liner of absorbent material. Surfaces can be protected from contamination with chemically resistant trays or plastic backed disposable paper.

### *Protective Equipment*

In some cases, the laboratory supervisor may deem it advisable to wear special protective equipment when working with particularly hazardous substances. Examples include long gloves or an apron covered by a disposable coat.

### *Decontamination*

On leaving a controlled area, remove any protective apparel, and thoroughly wash hands and arms, face, and neck. If disposable apparel or absorbent papers have been used, place these items in a closed impervious bag or container for disposal. Work surfaces will be thoroughly washed and rinsed. All equipment that is known or suspected to have been in contact with particularly hazardous substances must also be washed and rinsed.

### *Waste Disposal*

All general waste disposal procedures must be followed. Certain additional precautions must also be observed when waste materials are known to contain any amount of highly toxic substances. Volatile toxic substances must never be disposed of by evaporation in the hood. If practical, waste materials should be decontaminated as the last step in the experiment by some procedure that can reasonably be expected to convert the toxic substance to nontoxic substances. Consult Prudent Practices for Disposal of Chemicals from Laboratories (available in the department office) for specific destruction procedures. If decomposition is not feasible, the waste should be stored in closed, impervious containers such that personnel handling the containers will not be exposed to its contents. All waste containers must be labeled to indicate the contents, including constituents and approximate amounts or percentages (Appendix E), and the type of hazard that contact may pose. For instance, if a waste stream is known to contain appreciable amounts of a carcinogen, the container should be labeled: CANCER SUSPECT AGENT. The generation of acutely hazardous waste must be closely monitored. All wastes and residues that have not been chemically decontaminated should be stored and disposed by sending them to a commercial hazardous waste processing facility.

# 11.0 Medical Consultation

An opportunity to receive medical consultation must be provided under the following circumstances:

a. If an employee, i.e. faculty, staff, or student worker, develops signs or symptoms associated with a hazardous chemical to which they may have been exposed.
b. If there has been a spill, leak, explosion, or other occurrence in the work area resulting in the likelihood of a hazardous exposure.
c. If exposure monitoring reveals that a Permissible Exposure Limit (PEL) or action level is routinely violated for any OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements.

Employees subject to the above conditions may receive medical attention through Workers' Compensation. Contact campus security to fill out an injury report. In addition, employees who need to wear respirators to control chemical exposure must have a medical examination prior to wearing the respirator to ensure that they are physically able to wear one.

# 12.0 Spills and Emergency Procedures

## *12.1 Chemical Spills*

Preparations to handle a spill should be made long before it occurs. Appropriate precautions and the proper equipment can alleviate many of the potential complications associated with the spill of a hazardous material. The following principles will decrease the likelihood of a spill:

a. Substitute a less hazardous chemical, procedure, or piece of equipment such as alcohol thermometers instead of mercury thermometers.

b. Always store chemical containers with closed caps.
c. Use secondary containment whenever possible, such as trays and wash basins. Coated safety bottles should be used when possible.
d. Do not store chemicals on the floor, desks, or counter tops.
e. Check shelving; watch for overloading or overcrowding. Excess chemicals can be stored in the stockroom.
f. Practice good housekeeping. Clutter increases the likelihood of a spill or accident.
g. Minimize chemical storage in the laboratory. Purchase only the amount needed.

Anticipate chemical spills by having appropriate clean-up and safety equipment on hand. These cleanup supplies should be consistent with the hazards and quantities of substances used.

Paper towels and sponges may be used as absorbent type clean-up aids, but this should be done cautiously. Paper used to clean up oxidizers can later ignite. Appropriate gloves should be worn when cleaning toxic materials with towels. Sponges should be chemical resistant.

Commercial clean-up kits are available which have instructions, absorbents, neutralizers, and protective equipment, but these kits are usually expensive and may not cover every substance used in a particular lab. Individuals may want to assemble their own kits. These kits should be located strategically around the laboratory or department area.

If a spill does occur, the following general procedures should be followed:

a. Attend to contaminated personnel and/or student.
b. Alert personnel in adjacent areas.
c. Confine the spill, and evacuate nonessential personnel from the spill area.
d. If spilled material is flammable, extinguish flames and all other sources of ignition.
e. Maintain fume hood ventilation.
f. Secure appropriate cleanup supplies.
g. During cleanup, wear appropriate personal protection.
h. Contact the chair of the department.

When the nature of the spill constitutes a more serious hazard or involves the release of gas or fumes, the following procedures should be followed:

a. Activate the emergency alarm system.
b. Rescue injured personnel, if possible.
c. Evacuate the building; move to the designated assembly area.
d. Get the MSDS and have them available to share with security
e. Notify campus security with the details of the situation.
f. Contact the chair of the department.

## 12.2 Emergency Procedures

The following procedures are intended to limit injuries and minimize damage should an accident occur:

a. Render assistance to persons involved and remove them from exposure to further injury, if necessary.
b. Warn personnel in adjacent areas of potential hazards to their safety.
c. Render immediate first aid such as washing in safety shower and administering CPR.
d. Extinguish small fires by using a portable fire extinguisher. Turn off nearby apparatus and remove flammable materials from the area. In case of larger fires, contact University Police immediately, (**706-568-2022**).
e. Contact the chair of the department immediately.

In the case of a medical emergency, remain calm and do only what is necessary to protect life.

a. Call University Police immediately, at 706-568-2022.
b. Do not move an injured person unless they are in further danger.
c. Keep the injured person warm. If feasible, designate one person to remain with the injured person.
d. If clothing is on fire, knock the person on the ground and roll them around to smother the flames. A fire blanket should only be used as a last resort.

## 12.3 Fires and Explosions

Small fires can easily be extinguished without evacuating the building or calling the fire department. However, even a small fire can quickly become a serious problem. The first few minutes are critical to preventing a larger emergency. In the event of a minor fire, the following actions should be taken:

a. Alert other people in the laboratory and call Campus Police at **706-568-2022**.
b. Attack the fire immediately, but never attempt to fight a fire alone. A fire in a small vessel can often be suffocated by placing a larger beaker or watch glass over the top. Use the proper extinguisher, directing discharge of the extinguisher at the base of the flame:

    Class A fires - ordinary combustible solids such as paper, wood, rubber, and textiles.

    Class B fires - petroleum hydrocarbons and volatile flammable solvents.

    Class C fires - electrical equipment.

    Class D fires - combustible or reactive metals such as sodium, potassium, or magnesium, metal hydrides, or organometallics.

c. Avoid entrapment; always fight a fire from a position accessible to an exit.
d. Contact the chair of the department

If there is any doubt that the fire can be controlled locally by available personnel or equipment, the following actions should be taken:

a. Activate the emergency alarm system. Confine the fire (close hood sashes, doors between laboratories, and fire doors) to prevent further spread of the fire.
b. Assist injured personnel.
c. Evacuate the building.
d. Contact the chair of the department

## *12.4 Personal Contamination*

Chemical Spill to a Large Portion of the Body

a. Immediately flood the contaminated area with sufficient running water. Use safety shower if necessary.
b. Remove all contaminated clothing.
c. Continue to rinse with cold water for 15 minutes. Wash the chemical from the contaminated areas with water but do not apply crèmes or lotions.
d. Get medical attention promptly.

Chemicals on the Skin in a Confined Area

a. Flush the exposed skin with cold water.
b. Seek medical attention if necessary.
c. If the skin is not burned, wash the area with soap

Chemical in the Eyes

a. Flush the eyeball and inner eyelid with cold water for 15 minutes. Forcibly hold the eye open to wash thoroughly behind the eyelids.
b. Get medical attention promptly.

Smoke or Fume Inhalation

a. Remove from the contaminated air to fresh air.
b. Treat for shock.
c. Get medical attention promptly.

Chemical Ingestion

a. Administer antidote, if available.
b. Wrap in blanket to prevent shock.
c. Notify Campus Police.
d. Identify the chemical(s), and obtain the MSDS for the hospital.

### *12.5 Incident Reporting and Review*

In the event of an incident that falls under any of the categories in this section, a Laboratory Accident Report Form (Appendix D) must be filled out under the supervision of a safety or campus police officer. A copy of the incident report sheet will be forwarded to the Environmental Safety Office for review and a copy will be kept on file in the department. Depending on the nature and severity of the incident, this review will take place as soon as possible after the incident.

### *12.6 Reporting of Accidents and Exposures*

In the laboratories, students must report all accidents to the instructor immediately. All accidents involving students or faculty must be reported to the department chair and university police. This includes electrical shocks, chemical spills, bodily exposure to blood and body fluids contaminated with blood, and all other types of exposures or injuries.

The instructor, in consultation with the department chair if necessary, will evaluate the exposure, counsel the student, and treat the exposure as deemed appropriate. If deemed necessary, the student will be referred to a physician for consultation/medical treatment.

A Laboratory Accident Report Form (Appendix D) must be completed and provided to the student.

## 13.0 Laboratory Waste Management

The Department of Chemistry is in compliance with all federal, state, and local regulations pertaining to the handling, storage, and disposal of hazardous wastes. All of the hazardous waste generated in the department is sent to a commercial hazardous waste processing facility.

## References

1. OSHA SAFETY and HEALTH STANDARDS, (29 CFR 1910), United States Department of Labor, U.S. Government Printing Office.

2. POCKET GUIDE TO CHEMICAL HAZARDS. Publication No. 78-210, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health (NIOSH), Washington, D.C., 1990.

3. National Research Council, Prudent Practices in the Laboratory, Washington: National Academy Press, 1995.

4. SAFE STORAGE OF LABORATORY CHEMICALS, 2nd Edition, David A. Pipitone, John Wiley & Sons, Inc., New York, NY, 1991.

5. SAFETY IN ACADEMIC CHEMICAL CHEMISTRY LABORATORIES, 6th Edition, Committee on Chemical Safety, American Chemical Society, Washington, D.C., 1990.

6. BELLARMINE UNIVERSITY CHEMICAL HYGIENE PLAN, May 1999.

7. TENNESSEE TECH UNIVERSITY CHEMISTRY DEPARTMENT CHEMICAL HYGIENE PLAN, 2010.

8. LANSING COMMUNITY COLLEGE SCIENCE DEPARTMENT CHEMICAL HYGIENE PLAN, VERSION NUMBER 15, 2006.

9. JAMES MADISON UNIVERSITY CHEMICAL HYGIENE PLAN, 2002.

10. CHEMICAL HYGIENE PLAN AND HAZARDOUS MATERIALS SAFETY MANUAL FOR PURDUE UNIVERSITY, 2010.

11. TEXAS A&M UNIVERSITY-TEXARKANA CHEMICAL HYGIENE PLAN, 2010.

# Appendix A

**<u>Georgia Right to Know (RTK) Law</u>**

**RIGHT TO KNOW**

The Georgia Right to Know Law (Public Employee Hazardous Chemical Protection and Right to Know Act of 1988, as amended) requires that all employees be informed of:

a. the requirements of the law;
b. their right to receive information regarding hazardous chemicals faced on the job;
c. their right to have their physician receive information on the chemicals to which they may be exposed;
d. their right to receive formal training and education on hazardous chemicals;
e. what a material safety data sheet (MSDS) is, and how to use it;
f. where hazardous chemicals are used in their work area.

**Columbus State University employees are required, at the time of hire, to take the online Right to Know (RTK) Training.** The training can be accessed by visiting www.usg.edu/ehs/training/rtkbasic/ and clicking next>> in the upper right hand corner. You must complete the questionnaire at the end of the training (http://www.usg.edu/ehs/training/rtkbasic 7phtml).

Your Name____________________________ CSU ID #_____________________________

(Please print)

I have received information on The Right to Know Law, and acknowledge my responsibility to take the online questionnaire.

_____________________________________ ____________________

Employee Signature Date

**Return this Form to the Department of Chemistry**

**Columbus State University**

# Appendix B

**Definitions**
**ACGIH -** American Conference of Governmental Industrial Hygienists. An organization of professional personnel in governmental agencies or educational institutions engaged in occupational safety and health programs. ACGIH develops and publishes recommended occupational exposure limits (see "TLV") for hundreds of chemical substances and physical agents.

**Action level -** A concentration designated in 29 CFR § 1910 for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

**Acute** - Severe, often dangerous conditions in which relatively rapid changes occur.

**Acute exposure** – A single, brief exposure to toxic substances. Adverse effects on the human body are evident soon after the exposure and come quickly to a crisis.

**Auto ignition temperatur**e – The lowest temperature at which a flammable gas or vapor-air mixture will ignite from its own heat source or other contacted heat source.

**C.A.S. Numbe**r - The number assigned to chemicals or products by the Chemical Abstracts Service.
**Carcinogen** - A substance or agent capable of causing or producing cancer.

**Chemical Hygiene Officer** - An employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the CHP. This definition is not intended to place limitations on the position description or job classification that the designated individual must hold within the employer's organizational structure.

**CHP** – Chemical Hygiene Plan. A written program developed and implemented by the employer. It sets forth procedures, equipment, personal protective equipment, and work practices that

a. Are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace, and
b. Meet the requirements of CFR 29 1910.1450.

**Chronic effect** - An adverse effect on a human or animal in which symptoms develop slowly over a long period of time or recur frequently. **Compressed gas** -

a. A gas or mixture of gases in a container, having an absolute pressure exceeding 40 psi at $70^0$F ($21.1^0$C)
b. A gas or mixture of gases in a container, having an absolute pressure exceeding 104 psi at $130^0$F ($54.4^0$C) regardless of the pressure at $70^0$F ($21.1^0$C)
c. A liquid having a vapor pressure exceeding 40 psi at $100^0$F ($37.8^0$C).

**Designated area** - An area which may be used for work with “select carcinogens,” reproductive toxins or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, an area, or a device such as a laboratory hood.

**Emergency** - Any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment, which results in an uncontrolled release of a hazardous chemical into the work place.

**Employee** - An individual employed in a laboratory work place who may be exposed to hazardous chemicals in the course of his or her assignments.

**Explosive** - A chemical that causes a sudden release of pressure, gas and heat when subjected to shock, pressure, or high temperature.

**Exposure limi**t - A limit set to minimize occupational exposure to a hazardous substance. Recommended occupational exposure limits used are the American Council of Governmental Industrial Hygienists’ Threshold Limit Values (TLVs) and Occupational Safety and Health Administration Permissible Exposure Limits (PELs).

**Flashpoint** - The minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite.

**Hazardous chemical** - A chemical for which there is statistically significant evidence based on at least one study, conducted in accordance with established scientific principles, that acute or chronic health effects may occur in exposed employees. The term “health hazard” includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

**Health hazard** - Any chemical for which there is at least one scientific study that shows it may cause acute or chronic health symptoms. This includes chemicals which are carcinogens, toxic or highly toxic, irritants, corrosives, sensitizers, or chemicals that effect target organs including the lungs, kidneys, nervous system, pulmonary system, reproductive system, skin, and eyes.

**Ignition source** - Anything that provides heat, sparks, or flame sufficient to cause combustion/explosion.

**Ingestion** - The drawing of a substance into the body (stomach) through the nose, mouth, and breathing passages, in the form of a gas, vapor, fume, mist, or dust.

**Inhalation** - The drawing of a substance into the body (lungs) through the nose, mouth, and breathing passages, in the form of a gas, vapor, fume, mist, or dust.

**Irritant** - A substance which will cause an inflammatory response or reaction of the eye, skin, or respiratory system following single or multiple exposures.

**Laboratory** - A facility or room where the use of potentially hazardous chemicals, biological agents, or sources of energy (i.e. lasers, high voltage, radiation, etc.) are used for scientific experimentation, research, or education.

**$LC_{50}$** - Lethal Concentration 50. The concentration in air that causes the death of 50% of test animals. The concentration is expressed in mg/liter, $mg/m^3$.

**$LD_{50}$** - Lethal Dose 50. A single dose of material which on the basis of laboratory tests is expected to kill 50% of a group of test animals. The material may be administered by mouth (oral) or applied to the skin (dermal or cutaneous). The dose is expressed in g/kg of body weight.

**Medical consultation** - A consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

**MSDS** - Material Safety Data Sheet. Written or printed material about a chemical that specifies its hazards, safe use, and other information. It is prepared by the chemical manufacturer and is required by federal law.

**Organic peroxide** - An organic compound that contains the bivalent -O-O- structure and which may be considered a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

**OSHA** - Occupational Safety and Health Administration of the U.S. Department of Labor. OSHA is a federal agency with safety and health enforcement authority for most of U.S. industry and business.

**Oxidizer** - The Department of Transportation defines an oxidizer or oxidizing material as a substance that yields oxygen readily to stimulate the combustion (oxidation) of organic matter. Chlorate ($CLO_3$), permanganate ($MnO_4$) and nitrate ($NO_3$) compounds are examples of oxidizers.

**PEL** - Permissible Exposure Limit. An exposure limit established by OSHA's regulatory authority. PELs may be expressed as either a time weighted average (TWA) limit or a maximum concentration exposure limit.

**Protective laboratory practices and equipment** - Those laboratory procedures, practices, and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

**Reproductive toxins** - Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses' teratogenesis.

**TLV** - Threshold Limit Value. The exposure limit for a specific substance as per ACGIH. TLV is a measure of exposure to inhalation only.

**Target organ** - The specific organs or body systems that sustain hazardous effects from a toxic chemical either long or short-term. Target organs could be the liver, kidney, central nervous system, or skin.

**Toxic** - A substance which has a median lethal dose ($LD_{50}$) of 50 to 500 mg/kg for ingestion, from 200 to 1,000 mg/kg within a 24-hour period for contact and from 200 to 2,000 PPM gas or vapor for inhalation.

**Vapor pressure** - The pressure exerted by vapor, in confinement, over its liquid as it accumulates at a constant temperature.

# Appendix C

## Department of Chemistry

## Columbus State University

## Safety Consent Form

This form should be filled out after the safety instructions have been presented by the instructor and the student feels comfortable with the guidelines, rules, and precautions discussed in the laboratory and the laboratory manual. Failure to observe and follow the rules and guidelines may result in dismissal from the laboratory course.

Additionally, the students of 1211L class are required to complete the safety workshops presented on the following websites:

http://www.usg.edu/ehs/training/hazwaste/

http://www.usg.edu/ehs/training/rtkbasic/

http://www.usg.edu/ehs/training/chemical/

**Student Name**________________________________________________________________

*Print Clearly*

**Drawer Number**______________ **Lock Combination**__________________

Please read and initial the item listed below:

_______I have been informed of the appropriate safety procedures and precautions to be used in the laboratory. I have also read the "Laboratory Safety and Work Instructions" presented in the laboratory manual on pages 1 through 6 and watched the ACS safety video shown by the instructor. I agree to follow all of the rules and regulations presented in the laboratory manual and safety video. Furthermore, I agree to follow all safety rules and regulations that the instructor and/or student assistant requires. I understand that failure to follow any of the rules, i.e. written or verbal, may result in expulsion from the course.

In case of an Emergency, please notify:

**Name**_________________________________________**Phone Number**____________

*Print Clearly*

**Relation**__________________________________________________________________________

**Medical Problem(s) (***optional***)**__________________________________________________

_____________________________________________________________________________________

_____________________________________________________________________________________

**Student Signature**____________________________________________**Date**________________

**Instructor Signature**_________________________________________Date _______________

# Appendix D

**LABORATORY ACCIDENT REPORT FORM**

This form is to be filled out by the responsible faculty member, University Police and Department Chair.

**Name**:___________________________________________________ **Date**:_______________________

Student   Staff   Faculty (circle one)

**Department**:_____________________________________________**Date/Time of Incident**:_

**Campus Address**:_________________________________________Campus Telephone:___________

**Home** (Local) **Address**:______________________________**Home Phone**#:________

**Location of accident**:___________________________________________________________________

**Cause of Injury**:________________________________________________________________

**Type of Injury**:_________________________________________________________________

**Medical Facility**:___________________________________ **Ambulance Needed**?_________Y______N

**Physician**:_____________________________________________________________________________

**Witnesses**: Name / Address / Phone #

_________________________________________________________          _____________________

_________________________________________________________          _____________________

Brief description of incident (include the use of personal protective equipment, fume hood, safety shower and/or fire extinguisher):

**Name of Faculty Member/Instructor**:_____________________________________________

**Signature of Faculty Member**:__________________________________________________

# Appendix E

**CHEMICAL WASTE DISPOSAL FORM**

**Lab number**: ______________________________________ **Phone**: __________________________________

| No. | Type of Chemical Waste Identification and % Composition | Quantity Volume/gram | Classification | Disposal Date |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |
| 12 | | | | |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |
| 16 | | | | |
| 17 | | | | |
| 18 | | | | |
| 19 | | | | |
| 20 | | | | |

**Waste Generator**: _______________________________________________**Date**: ________________

# Appendix II

**f**. Faculty Honors - Honors earned by the Department of Chemistry faculty members.

1. Columbus State University Faculty center fellowship award 2013-14, **Rajeev Dabke**
2. American Chemical Society Science Coach (2013-2014), **Anil Banerjee**
3. American Chemical Society Chemistry Ambassador ( 2013----), **Anil Banerjee**
4. Educator of the Year, Columbus State University ( 2012), **Anil Banerjee**
5. Governor Teaching Fellowship, GTF, Teaching, Regional, GA, U.S.A., 2010-2011, **Samuel Abegaz**
6. Educator of the Year, Columbus State University ( 2010), **Floyd Jackson**
7. Nominee for Educator of the Year, Columbus State University ( 2010), **Anil C. Banerjee**

**g. Student Honors – Honors/Awards earned by the Department of Chemistry undergraduate students.**

1. COLS Alumni Award, Dr. Christopher Wommack, MD, 2013
2. Georgia Academy of Sciences Undergraduate Award, **Matthew B. Blackmon,** Spring 2013
3. Principles of Chemistry Award, **Prophitt, Jennifer J**., 2013
4. Excellence in Research Award, Excellence in Research Award, **Severin, Chelsea C**., 2013
5. Outstanding Chemistry Major Award, **Washington, Huirui D**., 2013
6. Outstanding Chemistry Major Award: **Cho, EunHye (Claire)**, 2012
7. Excellence in Research Award**: Anderson, Michael**, 2012
8. Outstanding Chemistry Major Award**: Anderson, Michael,** 2011
9. Excellence in Research Award**: Cho, EunHye (Claire)**, 2011
10. Principles of Chemistry Award: **Meeks, Ryan**, L., 2011
11. Columbus State University Faculty Cup, **Cho, EunHye (Claire)**, 2010
12. General chemistry Award: Patrick H. Russell, 2009

    Chemistry Award: Jane V. Skalski, 2009

Appendix II-h
ACS Guidelines and Evaluation Procedures
for Bachelor's Degree Programs

Office of Professional Training
American Chemical Society
1155 Sixteenth Street, N.W.
Washington, DC 20036
202-872-4589
cpt@acs.org
www.acs.org/cpt

# Undergraduate Professional Education in Chemistry

## ACS Guidelines and Evaluation Procedures for Bachelor's Degree Programs

Spring 2008
American Chemical Society
Committee on Professional Training

**Published by**
**American Chemical Society**
**1155 Sixteenth Street, N.W.**
**Washington, DC 20036**

The cover graphic is the 600 MHz phase-sensitive double quantum filtered COSY spectrum of cholesterol.

**Disclaimer**
The evaluation and reevaluation of undergraduate chemistry programs by the American Chemical Society (ACS) and the ACS Committee on Professional Training are undertaken with the objective of improving the standards and quality of chemistry education in America. The following ACS guidelines for evaluating and reevaluating undergraduate chemistry programs have been developed from sources believed to be reliable and to represent the most knowledgeable viewpoints available with regard to chemistry education. No warranty, guarantee, or other form of representation is made by ACS or ACS's Committee on Professional Training or by any of its members with respect to any aspect of the evaluation, reevaluation, approval, or disapproval of any undergraduate chemistry program. ACS and the ACS Committee on Professional Training hereby expressly disclaim any and all responsibility and liability with respect to the use of these guidelines for any purposes. This disclaimer applies to any liability that is or may be incurred by or on behalf of the institutions that adopt these guidelines; the faculties, students, or prospective students of those institutions; and any member of the public at large; and includes, but is not limited to, a full disclaimer as to any liability that may be incurred with respect to possible inadequate safety procedures taken by any institution.



# TABLE OF CONTENTS

# I. GUIDELINES FOR PROGRAM APPROVAL AND STUDENT CERTIFICATION

## 1. Goals of Program Approval and Student Certification

Chemistry is central to intellectual and technological advances in many areas of science. The traditional boundaries between chemistry subdisciplines are blurring, and chemistry increasingly overlaps with other sciences. Unchanged, however, is the molecular perspective which is at the heart of chemistry. Chemistry programs have the responsibility to communicate this molecular outlook to their students and to teach the skills necessary for their students to apply this perspective.

The American Chemical Society (ACS) promotes excellence in chemistry education for undergraduate students through approval of baccalaureate chemistry programs. The ACS has charged the Committee on Professional Training (CPT) with the development and administration of guidelines for this purpose. ***ACS, through CPT, approves chemistry programs*** meeting the ACS guidelines. Approved programs offer their students a broad-based and rigorous chemistry education that provides them with the intellectual, experimental, and communication skills to participate effectively as scientific professionals. Offering such a rigorous program requires an energetic and accomplished faculty, a modern and well-maintained infrastructure, and a coherent chemistry curriculum that incorporates modern pedagogical approaches. ACS recognizes that the diversity of institutions and students is a strength in higher education. Thus, these guidelines provide approved programs with opportunities to develop chemistry degree tracks that are appropriate to the educational missions of their institutions.

***ACS authorizes the chair of the ACS-approved program to certify graduating students*** who complete a bachelor's degree meeting the ACS guidelines. Graduates who attain a certified degree must often complete requirements that exceed those of the degree-granting institution, but this comprehensive undergraduate experience provides an excellent foundation for a career in the molecular sciences. A certified degree signifies that a student has completed an integrated, rigorous program which includes introductory and foundational course work in chemistry and in-depth course work in chemistry or chemistry-related fields. The certified degree also emphasizes laboratory experience and the development of professional skills needed to be an effective chemist. Certification gives a student an identity as a chemist and helps in the transition from undergraduate studies to professional studies or employment.

ACS approval publicly recognizes the excellent chemistry education opportunities provided by an institution to its students. It also provides standards for a chemistry curriculum based on broad community expectations that are useful for a department when designing its curriculum or acquiring resources. The approval process provides a mechanism for departments to evaluate their programs, identify areas of strength and opportunities for change, and leverage support from their institutions and external agencies. Faculty benefit from the commitment to professional development required of approved programs. Students benefit from taking chemistry courses from a department that meets the high standards of ACS approval, and ACS-certified graduates benefit from their broad, rigorous education in chemistry and the recognition associated with their degree.

## 2. Institutional Environment

An approved program in chemistry requires a substantial institutional commitment to an environment that supports long-term excellence. Because the approved program exists in the context of the institutional mission, it must support the needs, career goals, and interests of the institution's students. Similarly, in order to support a viable and sustainable chemistry program, the institutional environment must provide the following attributes.

**2.1 Institutional Accreditation.** The institution must be accredited by the regional accrediting body. Such accreditation ensures broad institutional support in areas such as mathematics, related sciences, and the humanities.

**2.2 Program Organization.** The administration of the approved program should rest in a chemistry department organized as an independent unit with control over an adequate budget, faculty selection and promotion, curriculum development, and assignment of teaching responsibilities. If the program is part of a larger unit, the chemistry faculty must have reasonable autonomy over these functions.





**2.3 Program Budget.** An approved undergraduate program in chemistry requires continuing and stable financial support. The institution must have the ability and will to make such a commitment at a reasonable level that is consistent with the resources of the institution and its educational mission. Adequate support enables a program to have

- a chemistry faculty with the scientific breadth to offer the educational experiences described in these guidelines,
- nonacademic staff and resources for administrative support services, stockroom administration, and instrument and equipment maintenance,
- a physical plant that meets modern safety standards with adequate waste-handling and disposal facilities,
- resources for capital equipment acquisition and replacement along with the expendable supplies required for high-quality laboratory instruction,
- modern chemical information resources,
- research resources for faculty and students,
- support for faculty and student travel to professional meetings, and
- opportunities for professional development and scholarly growth by the faculty, including sabbatical leaves.

**2.4 Minimum Number of Graduates.** Initial and continuing approval requires that the program award an average of at least two chemistry degrees per year during any five-year period. There is no required minimum number of certified graduates.

## 3. Faculty and Staff

An energetic and accomplished faculty is essential to an excellent undergraduate program. Faculty members are responsible for defining the overall goals of the undergraduate program. The faculty facilitates student learning of content knowledge and development of professional skills that constitute an undergraduate chemistry education. An approved program, therefore, has mechanisms in place to maintain the professional competence of its faculty, to provide faculty development and mentoring opportunities, and to provide regular feedback regarding faculty performance.

**3.1 Faculty.** The faculty of an approved program should have the range of educational backgrounds and expertise to provide a sustainable, robust, and engaging environment in which they educate students. The faculty of an approved program has the following attributes:

- There must be at least four full-time, permanent faculty members wholly committed to the chemistry program. Most vigorous and sustainable approved programs have a larger number.
- At least three-fourths of the chemistry faculty must hold the Ph.D. or an equivalent research degree.
- The collective expertise of the faculty should reflect the breadth of the major areas of modern chemistry.
- Because faculty members serve as important professional role models, a program should have a faculty that is diverse in gender, race, and ethnic background.

**3.2 Adjunct, Temporary, and Part-Time Faculty.** Full-time, permanent faculty should teach the courses leading to student certification in an approved chemistry program. Programs may occasionally engage highly qualified individuals outside the regular faculty when permanent faculty members are on sabbatical leaves or to deliver special courses. The Committee strongly discourages, however, excessive reliance on temporary, adjunct, or part-time faculty in an ACS-approved program and will review such situations carefully.

**3.3 Teaching Contact Hours.** Contact hours are the actual time spent in the direct supervision of students in a classroom or laboratory by faculty and instructional staff. The institution's policies about teaching contact hours should provide all faculty and instructional staff adequate time for professional development, regular curriculum assessment and improvement, contact with students outside of class, and supervision of research. The number of contact hours in classroom and in laboratory instruction for faculty and instructional staff *must not exceed 15 total hours per week*. To accommodate occasional fluctuations in instructional responsibilities, up to two individuals may have as many as 17 contact hours in one semester or quarter, provided that the average for each individual during the academic year does not exceed 15 contact hours per week. Fifteen contact hours is an upper limit, and a significantly smaller number should be the normal teaching obligation. Faculty and instructional staff in the most effective programs usually have substantially fewer contact hours, particularly when they supervise undergraduate research.





**3.4 Professional Development.** Sound policies regarding salaries, duties, promotions, sabbatical leaves, and tenure are essential. Institutional policies and practices should provide opportunity and resources for scholarly activities that allow faculty and instructional staff to stay current in both their specialties and modern pedagogy in order to teach effectively.

- The institution should provide opportunities for renewal and professional development through sabbaticals, participation in professional meetings, and other professional activities. Faculty and instructional staff should use these opportunities for improvement of instructional and research programs. Institutions should provide resources to ensure program continuity during sabbaticals and other leaves.
- The program should provide formal mechanisms by which senior faculty mentor junior faculty. Proper mentoring integrates all members of the instructional staff into the culture of their particular academic unit, institution, and the chemistry profession, ensuring the stability and vitality of the program.

**3.5 Support Staff.** A sustainable and robust program requires an adequate number of administrative personnel, stockroom staff, and technical staff, such as instrument technicians, machinists, and chemical hygiene officers. The number of support staff should be sufficient to allow faculty members to devote their time and effort to academic responsibilities and scholarly activities.

**3.6 Student Teaching Assistants.** The participation of upper-class chemistry undergraduates and graduate students in the instructional program as teaching assistants both helps them reinforce their knowledge of chemistry and provides a greater level of educational support to students in classes. If graduate or undergraduate students serve as teaching assistants, they should be properly trained for and supervised in their roles in the instructional program.

## 4. Infrastructure

A modern and comprehensive infrastructure is essential to a vigorous undergraduate program in chemistry. Program infrastructure must receive strong institutional support in order to provide sustainability through inevitable changes in faculty, leadership, and funding levels.

**4.1 Physical Plant.** An approved program should have classroom, teaching laboratory, research, office, and common space that is safe, well-equipped, modern, and properly maintained.

- Chemistry classrooms and chemistry faculty offices should be reasonably close to instructional and research laboratories. Classrooms should adhere to modern standards for lighting, ventilation, and comfort and have proper demonstration facilities, projection capabilities, and internet access.
- Laboratories should be suitable for instruction in the chemical sciences and must meet applicable government regulations. Properly functioning fume hoods, safety showers, eyewashes, first aid kits, and fire extinguishers must be readily available. Construction or renovation of laboratory facilities must conform to the regulations of the Occupational Safety and Health Administration (OSHA) and national norms. The number of students supervised by a faculty member or by a teaching assistant should not exceed 25. Many laboratories require smaller numbers for safe and effective instruction.
- Faculty and student research laboratories should have facilities appropriate for the type of work conducted in them. These facilities should permit maintaining experimental arrangements for extended periods of time during ongoing research projects.
- The program should have access to support facilities such as machine, electronic, and glass fabrication shops to support both teaching and research.

**4.2 Instrumentation.** The characterization and analysis of chemical systems requires an appropriate suite of modern chemical instrumentation and specialized laboratory apparatus to support undergraduate instructional and research missions.

- Instrumentation should be modern, high quality, and properly maintained.
- Approved programs must have a functioning NMR spectrometer that undergraduates use in instruction and research. The Committee strongly recommends an FT-NMR spectrometer.
- Throughout their curriculum, undergraduates must use additional instrumentation and specialized laboratory apparatus from most of the broad categories listed below, chosen as appropriate to the teaching and research needs of the program:





  - Optical spectroscopy (e.g., UV-vis, FT-IR, fluorescence, atomic absorption and emission, Raman, laser)
  - Mass spectrometry (e.g., MS, GC-MS)
  - Structure determination methods (e.g., NMR, X-ray diffraction)
  - Chromatography and separations (e.g., HPLC, GC, electrophoresis)
  - Electrochemistry (e.g., potentiometry, voltammetry)
  - Vacuum and inert-atmosphere systems (e.g., Schlenk line, dry box)
  - Thermal analysis (e.g., DSC, TGA)
  - Imaging and microscopy methods (e.g., electron microscopy, scanning probe microscopy)
- The program should have resources for maintenance and upkeep of this instrumentation, including knowledgeable support staff.

**4.3 Computational Capabilities and Software.** The ability to compute chemical properties and phenomena complements experimental work by providing understanding and predictive power. Students should use computing facilities and computational chemistry software in their course work and research.

**4.4 Chemical Information Resources.** The vast peer-reviewed chemical literature must be readily accessible to both faculty and students. Historically such access came through a good library providing monographs, periodicals, and facilities for database searches. Electronic access has changed the function of libraries as physical repositories. An approved program must provide students with the following minimum chemical information resources:

- An approved program must provide access to no fewer than 14 current journals chosen from the CPT recommended journal list (available from the CPT Web site) in either print or electronic form. At least three must come from the general content list, and at least one must come from each area of analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, physical chemistry, and chemistry education. In addition, the library should provide access to journal articles that are not readily available by a mechanism such as interlibrary loan or document delivery services. If primary student access is electronic, cost or impractical times for access should not limit it unduly.
- Students must have print or electronic access to *Chemical Abstracts*, including the ability to search and access full abstracts.

**4.5 Chemical Safety Resources.** The program must be conducted in a safe environment that includes

- adherence to federal and state regulations regarding hazardous waste management and laboratory safety including, but not limited to, development of a written chemical hygiene plan and maintenance of proper facilities and personnel for chemical waste disposal,
- safety information and reference materials, such as material safety data sheets (MSDS), and
- personal protective equipment readily available to all students and faculty.

## 5. Curriculum

The curriculum of an approved program provides both a broad background in chemical principles and in-depth study of chemistry or chemistry-related areas that build on this background. These guidelines divide the chemistry curriculum for the certified major into three categories: the *introductory* chemistry experience, *foundation* course work that provides breadth, and rigorous *in-depth* course work that builds on the foundation. Because chemistry is an experimental science, substantial laboratory work must be part of these experiences. Programs have the opportunity to design innovative curricula that meet the needs and interests of their particular students by defining degree tracks or concentrations requiring specified in-depth course work. The curriculum must also include experiences that develop student skills essential for their effective performance as scientific professionals.

**5.1 Pedagogy.** An approved program should use effective pedagogy in classroom and laboratory course work. Programs should teach their courses in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles. Additionally, a program should provide opportunities for faculty to maintain their knowledge of best practices in chemistry education and modern theories of learning and cognition in science. An approved program should regularly review its pedagogical approaches to ensure that it provides excellent content and builds skills that students need to be effective professionals.

Faculty should incorporate pedagogies that have been shown to be effective in undergraduate chemistry education. Examples include problem- or inquiry-based learning, peer-led instruction, group learning, learning communities or





networks, writing throughout the curriculum, and technology-aided instruction. Laboratory work provides a particularly attractive opportunity for inquiry-driven and open-ended investigations that promote independent thinking, critical thinking and reasoning, and a perspective of chemistry as a scientific process of discovery.

**5.2 Introductory or General Chemistry.** The introductory or general chemistry experience plays a vital role in educating all students. An introductory course provides a common background for students with a wide range of high school experiences. It also allows a maturation period for students, both in chemical topics and in mathematical and laboratory skills.

The purpose of introductory chemistry course work for those students pursuing a degree in chemistry is preparation for the foundation course work. This introduction ensures that students know basic chemical concepts such as stoichiometry, states of matter, atomic structure, molecular structure and bonding, thermodynamics, equilibria, and kinetics. Students need to be competent in basic laboratory skills such as safe practices, keeping a notebook, use of electronic balances and volumetric glassware, preparation of solutions, chemical measurements using pH electrodes and spectrophotometers, data analysis, and report writing.

The diversity of institutions and students requires a variety of approaches for teaching general or introductory chemistry. Offerings range from a full-year course to a one-semester course to waiving the introductory course requirement for very well-prepared students. To accommodate all these situations, these guidelines only describe the requirements and characteristics of experiences beyond the introductory level.

**5.3 Foundation Course Work.** Foundation course work provides breadth and lays the groundwork for the in-depth course work. Certified majors must have instruction *equivalent* to a one-semester course of at least three semester credit hours in each of the five major areas of chemistry: analytical chemistry, biochemistry, inorganic chemistry, organic chemistry, and physical chemistry. Programs operating on the quarter system can achieve this breadth with at least eight three-credit one-quarter courses that include the equivalent of at least one quarter of coverage of each of the five areas.

Foundation course work typically builds on the introductory chemistry experience. Textbooks for foundation course work are specialized books that serve as an introduction to each field, rather than a general chemistry textbook. Exam questions should cover concepts in greater detail than is typical in an introductory or general chemistry course. At the conclusion of a foundation course, a student should have mastered the vocabulary, concepts, and skills required to pursue in-depth study in that area.

Some areas, particularly organic and physical chemistry, have traditionally been taught as year-long courses. This practice may continue, using the first-semester course in the sequence as a foundation course and the second-semester course as an in-depth course. Integrated foundation course work may provide exposure to multiple foundation areas of chemistry or a group of topics organized by overarching themes (for example, synthesis, characterization, and reactivity) rather than by the traditional organization of chemistry subdisciplines.

Foundation courses can also be used to introduce topics that span multiple areas of chemistry. For example, the synthesis, analysis, and physical properties of small molecules give an incomplete picture of the higher order interactions in macromolecules and supramolecular systems (e.g., the physical properties of synthetic polymers, information storage and transfer by biopolymers, or aggregate properties of self-assembled systems). Students should be exposed to the principles of macromolecules across foundation areas, which could then serve as the basis for deeper exploration through in-depth course work or degree tracks.

**5.4 In-Depth Course Work.** The curriculum for the certified major must also include at a minimum the equivalent of four one-semester courses or six one-quarter courses (corresponding to at least 12 semester or 18 quarter credit hours) of in-depth course work. An in-depth course builds on prerequisite foundation course work. The goals of in-depth course work are both to integrate topics introduced in the foundation courses and to investigate these topics more thoroughly. Exams and other assignments associated with in-depth courses should require critical thinking and problem-solving skills.

The in-depth course work could be additional study in chemistry that increases a student's understanding of a traditional chemistry subdiscipline. For example, in a two-semester course sequence, the first semester could be a foundation course in a traditional chemistry subdiscipline (analytical, biochemistry, inorganic, organic, or physical) and the second an in-depth course. In-depth course work could also integrate multiple chemistry





foundation areas and therefore have those foundation courses as prerequisites.

Alternatively, in-depth course work could be a collection that supports a specialized, department-defined degree track (see Section 5.6). Although another department might teach some of these courses, they still must contain significant chemistry or chemistry-related content at a level beyond foundation course work to count as an in-depth course. The collection of in-depth course work required for a specialized degree track should provide a coherent experience in that area. Programs should be able to provide the rationale for each degree track and its requirements.

**5.5 Laboratory Experience.** The certified major must have 400 hours of laboratory experience beyond the introductory chemistry laboratory. Laboratory course work must cover at least 4 of the 5 foundation areas of chemistry and may be distributed between the foundation and in-depth levels. The laboratory experience must include synthesis of molecules; measurement of chemical properties, structures, and phenomena; hands-on experience with modern instrumentation; and computational data analysis and modeling. Students should understand the operation and theory of modern instruments and use them to solve chemical problems as part of their laboratory experience. They must have hands-on experience with a variety of instruments, including spectrometers (such as those for NMR, FT-IR, and UV-visible spectroscopy), chemical separations instruments (such as those for GC, GC-MS, and HPLC), and electrochemical instruments. Undergraduate research can serve as part of the laboratory hours and the in-depth course work if accompanied by a comprehensive written report.

**5.6 Degree Tracks or Concentrations.** A degree track used to certify graduates is a specialized, department-designed curriculum meeting the foundation, in-depth, and laboratory requirements that focuses on

- chemistry,
- a specific chemistry subdiscipline, or
- a chemistry-related multidisciplinary area.

Degree tracks offer the opportunity to incorporate emerging areas of chemistry, take advantage of faculty and local expertise, and match departmental and institutional missions. The faculty is responsible for defining these degree tracks for its program. The responsibility for student learning, consequently, resides with those who can best implement and assess it. While the ACS approves chemistry programs, it does not approve specific degree tracks developed by individual chemistry programs.

A chemistry degree track might require the second semesters of organic and physical chemistry, along with two semesters of in-depth electives or research. More specialized tracks might provide greater depth of instruction focused on a chemistry subdiscipline such as advanced organic synthesis, computational chemistry, polymer chemistry, or chemical measurement science. Examples of cross-disciplinary tracks are focused study in bioanalytical chemistry, biochemistry, biophysical chemistry, chemical education, chemical physics, environmental chemistry, forensic chemistry, green chemistry, materials science, medicinal chemistry, or other specialties.

Degree tracks might also include additional requirements determined by the department that do not count as in-depth courses. For example, a forensic chemistry degree track might require a course in the criminal justice system, although such a course would not qualify as an in-depth course because it would not have sufficient chemistry content which builds on the foundation courses.

**5.7 Cognate Courses.** Certified graduates must complete course work equivalent to two semesters of calculus and two semesters of physics with laboratory. The Committee strongly recommends a calculus-based physics curriculum and study of multivariable calculus, linear algebra, and differential equations.

**5.8 Frequency and Location of Course Offerings.** In all but the most exceptional cases, the program must teach all foundation courses annually. In rare cases, it may be possible to teach some foundation courses on a regular biennial schedule that enables all students to complete them in a planned way. Because in-depth courses determine the rigor of the undergraduate experience, the program must teach at least four semester-long or six quarter-long in-depth courses annually, exclusive of research. The frequency of the foundation and in-depth courses must allow students to complete the requirements for a chemistry degree in four years. While permanent, full-time chemistry faculty usually teach the courses in the chemistry curriculum, in some cases it may be appropriate to include courses taught by faculty outside the chemistry department. For example, a student





might obtain a foundation biochemistry experience through a course taught in a biochemistry or biology department.

**5.9 Transfer Students.** With students increasingly transferring among institutions during their undergraduate education, approved programs should be aware of the educational background of their students. Programs should provide transfer students with orientation and academic advising to assist with a successful transition to their new institution. Departments should regularly communicate with chemistry programs that are a significant source of transfer students to ensure that their chemistry curricula are coordinated.

## 6. Undergraduate Research

Undergraduate research allows students to integrate and reinforce chemistry knowledge from their formal course work, develop their scientific and professional skills, and create new scientific knowledge. A vigorous research program is also an effective means of keeping faculty current in their fields and provides a basis for acquiring modern instrumentation. Original research culminating in a comprehensive written report provides an effective means for integrating undergraduate learning experiences, and allows students to participate directly in the process of science.

Conducting undergraduate research with a faculty advisor allows the student to draw on faculty expertise and encourages a student-faculty mentor relationship. The research project should be envisioned as a component of a publication in a peer-reviewed journal. It should be well-defined, stand a reasonable chance of completion in the available time, apply and develop an understanding of in-depth concepts, use a variety of instrumentation, promote awareness of advanced safety practices, and be grounded in the primary chemical literature.

Research can satisfy up to four semester credit hours or six quarter credit hours of the in-depth course requirement for student certification and can account for up to 180 of the required 400 laboratory hours. A student using research to meet the ACS certification requirements must prepare a well-written, comprehensive, and well-documented research report including safety considerations. Although oral presentations, poster presentations, and journal article coauthorship are valuable, they do not substitute for the student writing a comprehensive report.

Research performed during the summer or performed off-campus, even though it might not receive academic credit, may count toward student certification. In such cases, the student must prepare a comprehensive written report that a faculty member of the home institution evaluates and approves.

## 7. Development of Student Skills

While formal course work provides students with an education in chemical concepts and training in laboratory practices, students should go beyond course content alone to be effective and productive scientists. They need to master a variety of skills that will allow them to become successful professionals.

**7.1 Problem-Solving Skills.** The ultimate goal of chemistry education is to provide students with the tools to solve problems. Students should be able to define problems clearly, develop testable hypotheses, design and execute experiments, analyze data using appropriate statistical methods, and draw appropriate conclusions. In this process, students should apply their understanding of all chemistry subdisciplines. Students should use appropriate laboratory skills and instrumentation to solve problems, while understanding the fundamental uncertainties in experimental measurements.

**7.2 Chemical Literature Skills.** Students should be able to use the peer-reviewed scientific literature effectively and evaluate technical articles critically. They should learn how to retrieve specific information from the chemical literature, including the use of *Chemical Abstracts* and other compilations, with online, interactive database-searching tools. Approved programs must provide instruction on the effective retrieval and use of the chemical literature. A specific course is an excellent means of imparting information-retrieval skills, though such a course usually would not qualify as an in-depth course. Integrating the use of these skills into several individual courses is also an effective approach. Both library and online exercises should be a part of such instruction on information retrieval.

**7.3 Laboratory Safety Skills.** Approved programs should promote a safety-conscious culture in which students understand the concepts of safe





laboratory practices and how to apply them. Programs should train students in the aspects of modern chemical safety appropriate to their educational level and scientific needs. A high degree of safety awareness should begin during the first laboratory course, and both classroom and laboratory discussions must stress safe practices. Students should understand responsible disposal techniques, understand and comply with safety regulations, understand and use material safety data sheets (MSDS), recognize and minimize potential chemical and physical hazards in the laboratory, and know how to handle laboratory emergencies effectively.

**7.4 Communication Skills.** Effective communication is vital to a scientist. Speech and English composition courses alone rarely give students sufficient experience in oral and written communication of technical information. The chemistry curriculum should include writing and speaking opportunities, and the chemistry faculty should evaluate them critically. Students should be able to present information in a clear and organized manner, write well-organized and concise reports in a scientifically appropriate style, and use technology such as poster preparation software, word-processing, chemical structure drawing programs, and computerized presentations in their communication.

Knowledge of one or more foreign languages is another component of communication. Even though English is the international language of science, chemistry is worldwide in scope. The study of a foreign language adds greatly to a student's education, although ACS certification does not require it.

**7.5 Team Skills.** Solving scientific problems often involves multidisciplinary teams. The ability to work in such teams is essential for a well-educated scientist. Students should be able to work effectively in a group to solve scientific problems, be effective leaders as well as effective team members, and interact productively with a diverse group of peers. Programs should incorporate team experiences in classroom and laboratory components of the chemistry curriculum.

**7.6 Ethics.** Ethics should be an intentional part of the instruction in a chemistry program. Students should conduct themselves responsibly and be aware of the role of chemistry in contemporary societal and global issues. As role models, faculty should exemplify responsible conduct in their teaching, research, and all other professional activities.

**7.7 Assessment of Student Skills.** Both dedicated courses and integration of learning opportunities throughout the curriculum can be used to develop student skills and provide a means of assessing them. Examples of the former approach are a course emphasizing technical writing and presentation, such as a senior capstone experience or a chemical literature course. The latter approach could include the conscious introduction of team projects into courses or having students make presentations related to the current literature. Undergraduate research is a highly effective means for imparting, integrating, and assessing these skills. Approved programs should have an established process by which they assess the development of student skills.

**7.8 Student Mentoring and Advising.** Effective advising and mentoring of undergraduates are central to student achievement. Successful mentors provide guidance for a student's development, networking, confidence building, and career planning. Mentoring can ease the transition for students who transfer into the chemistry major. Faculty should advise students about the many career options available to chemistry graduates and should encourage those with a strong interest in teaching or research to pursue advanced study in chemistry or related sciences. It is particularly important to encourage members of underrepresented groups to pursue chemistry as a career. Undergraduate research is an exceptional opportunity for mentoring students, especially when it is started early and maintained throughout the course of study.

## 8. Program Self-Evaluation

An approved chemistry program should regularly evaluate its curriculum and pedagogy, faculty development opportunities, and infrastructure needs relative to the program's teaching and research mission. Self-evaluation is a process for continual improvement of a program, not a static end product. The result of an effective self-evaluation is a vibrant, sustainable, and resilient program that produces a steady stream of dedicated and accomplished students, supports continual professional development and scholarly activities





of faculty, and provides a strong infrastructure to support the educational and scientific missions of the program.

## 9. Certification of Graduates

The chair of an approved program certifies those chemistry majors receiving a baccalaureate degree consistent with the guidelines described here. Students usually receive certification when they complete the baccalaureate degree. It is also possible to certify students who initially obtain a noncertified baccalaureate degree from an approved program and subsequently complete additional study in an ACS-approved undergraduate program to qualify for certification. The Office of Professional Training provides certificates for certified graduates upon request.

# II. APPROVAL PROCESS AND REVIEW PROCEDURES

## 1. Membership of the Committee

The CPT has 17 members. The ACS Board of Directors and the president of the Society with the advice of the ACS Committee on Committees jointly appoint 16 voting members. One member serves as an appointed chair and one serves as an elected vice chair. There is also one nonvoting staff secretary. The secretary communicates the results of all reviews conducted by CPT and consults with faculty and administrators about guidelines and procedures related to ACS approval. Initial appointments are usually for a three-year term, and reappointment for up to a total of nine years of service is possible. The Committee occasionally retains one or more former members or appoints individuals with special expertise as nonvoting consultants. Members of the CPT are experienced educators and scientists from all areas of the country, chosen to represent different fields of chemistry, possess different points of view, come from different types of academic and nonacademic institutions, and reflect the breadth of the chemical community.

## 2. Costs Associated with the Approval Program

The Society does not charge academic institutions for the evaluation of the chemistry program, including site visits by Visiting Associates of CPT (Section 8).

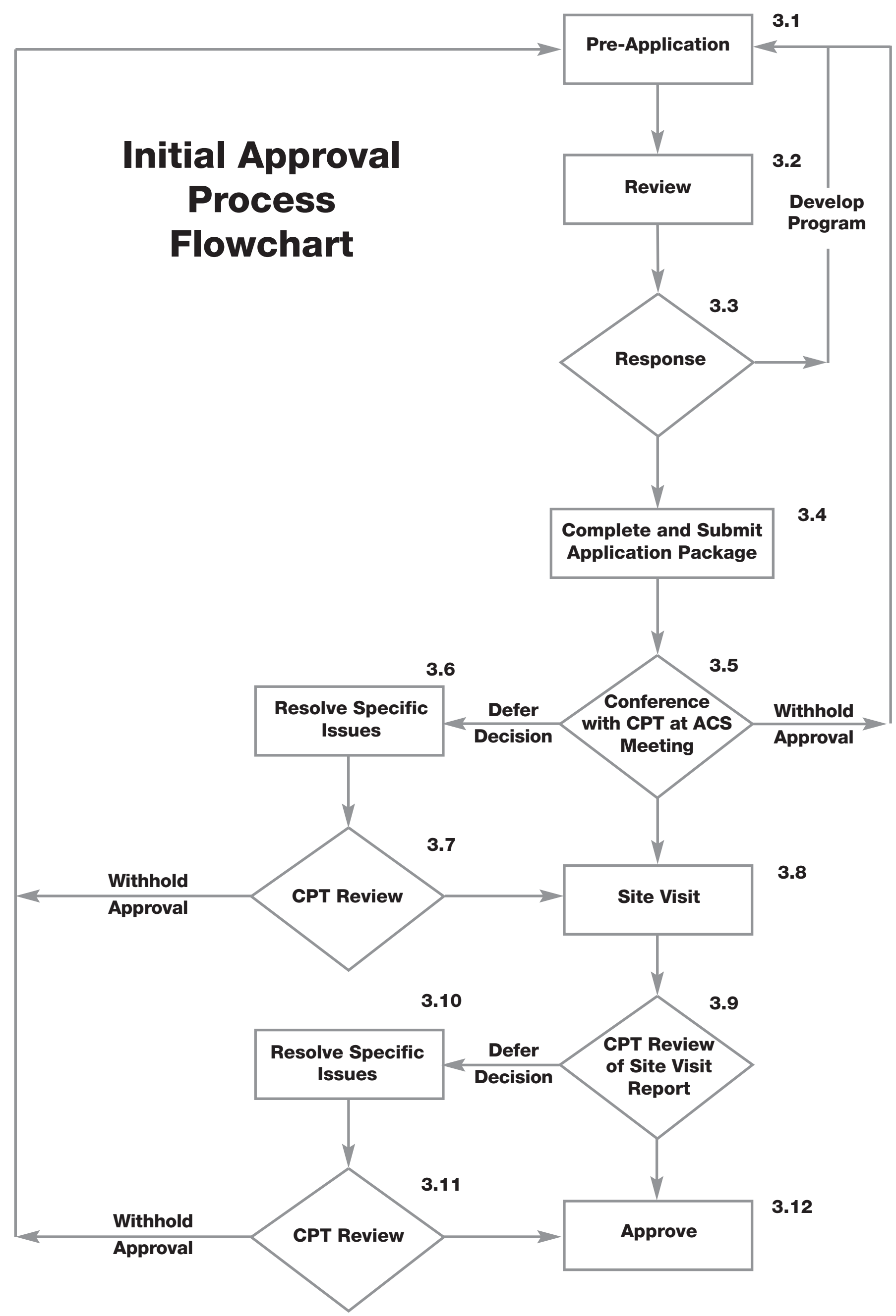
## 3. Initial Approval Process

The ACS, through CPT, establishes the recommendations and requirements for approval of bachelor's degree programs in chemistry and policies for administering the approval process. The chemistry faculty should conduct a self-study to determine the program's readiness to begin the approval process. The following flowchart summarizes the steps of the initial approval process, and the accompanying text describes each of the steps in the flowchart.

**3.1 Pre-Application.** The chemistry department completes a pre-application form, which is available at the CPT Web site, and submits it by the deadline given on the pre-application Web page.







**3.2 Review.** The Committee reviews the pre-application form within two months of the submission deadline.

**3.3 Response.** The Secretary of the Committee reports the outcome of the review to the department chair by letter. Two outcomes are possible.

1) *The applicant does not meet* the requirements for ACS approval that are covered in the pre-application form. The letter identifies the deficiencies and instructs the department to develop the program further and submit a new pre-application form after addressing the areas identified.
2) *The applicant meets* the requirements for ACS approval that are covered in the pre-application form. The Committee invites the department to submit a full application package.

**3.4 Complete and Submit Application Package.** Departments complete an extensive self-study questionnaire and provide supporting documentation including course syllabi, examinations, and student research reports. ACS staff reviews the package for completeness and assigns the applications for review by the Committee at the fall or spring ACS National Meeting following the deadline for submission of the application.

**3.5 Conference with CPT.** The chair of the chemistry program and other faculty members or administrators meet with the Committee at the fall or spring ACS National Meeting. During this conference, CPT members discuss the chemistry program and may inquire about certain aspects of the application package. The Secretary of CPT communicates the outcome of CPT's review to the chair of the department that administers the chemistry program. Three outcomes are possible.

1) *The applicant and Committee arrange a site visit* (Section 3.8) by a Visiting Associate. (Section 8)
2) *The Committee defers a decision* pending submission of additional information. (Sections 3.6, 3.7)
3) *The Committee withholds approval of the program.* The letter from the Secretary of CPT describes the areas of noncompliance. After addressing these concerns, the applicant must start the application process again with the submission of the pre-application form.





**3.6 Resolve Specific Issues.** The department must resolve the specific issues identified in the letter from the Secretary of CPT and submit a response by the deadline given in the letter.

**3.7 CPT Review.** ACS staff verifies that the information submitted by the applicant is complete and schedules the application for review at the next regular CPT meeting. Two outcomes are possible.

1) *The Committee decides to proceed with a site visit* (Section 3.8) by a Visiting Associate. (Section 8)
2) *The Committee decides to withhold approval of the program.* The Secretary of CPT reports the outcome of this review via letter to the applicant following the CPT meeting.

**3.8 Site Visit.** The Secretary of CPT reports the decision to proceed with a site visit by letter to the chair of the department that administers the chemistry program. The president (or chief administrative officer of the institution) must then invite ACS to make a site visit. One Visiting Associate (Section 8) will make the site visit, which typically lasts one to two days. The ACS pays all expenses of the site visitor. ACS staff provides the site visitor with a copy of the applicant's self-study questionnaire, background information on the chemistry faculty, and the college catalog pages for the chemistry program. The site visitor submits a written report on the site visit to the Secretary of CPT within six weeks following the visit.

**3.9 CPT Review of Site Visit Report.** CPT reviews the written report of the site visitor at the next regular meeting after it is received. Two decisions are possible.

1) *The Committee approves the chemistry program.* (Section 3.12)
2) *The Committee identifies specific issues needing resolution.* (Sections 3.10, 3.11)

**3.10 Resolve Specific Issues.** The department must resolve the specific issues identified in the letter from the Secretary of CPT and submit a response by the deadline given in the letter. This is not an iterative step and occurs only once following the site visit.

**3.11 CPT Review.** CPT reviews the department's report describing the resolution of the specific issues. Two decisions are possible after this review.

1) *The Committee approves the chemistry program.* (Section 3.12)
2) *The Committee withholds approval of the program.* The letter from the Secretary of CPT will describe the areas of noncompliance. After addressing these concerns, the applicant starts the application process again with the submission of the pre-application form.

**3.12 Approve.** The Secretary of CPT writes to the president of the institution and the chair of the department that administers the chemistry program to report this decision. The Committee will post the name of the institution on the list of ACS-approved chemistry programs on its Web site. An approved institution must satisfy the reporting requirements described in Sections 4 and 5. Failure to comply with the annual and periodic review requirements will lead to probationary action (Section 6).

## 4. Annual Review

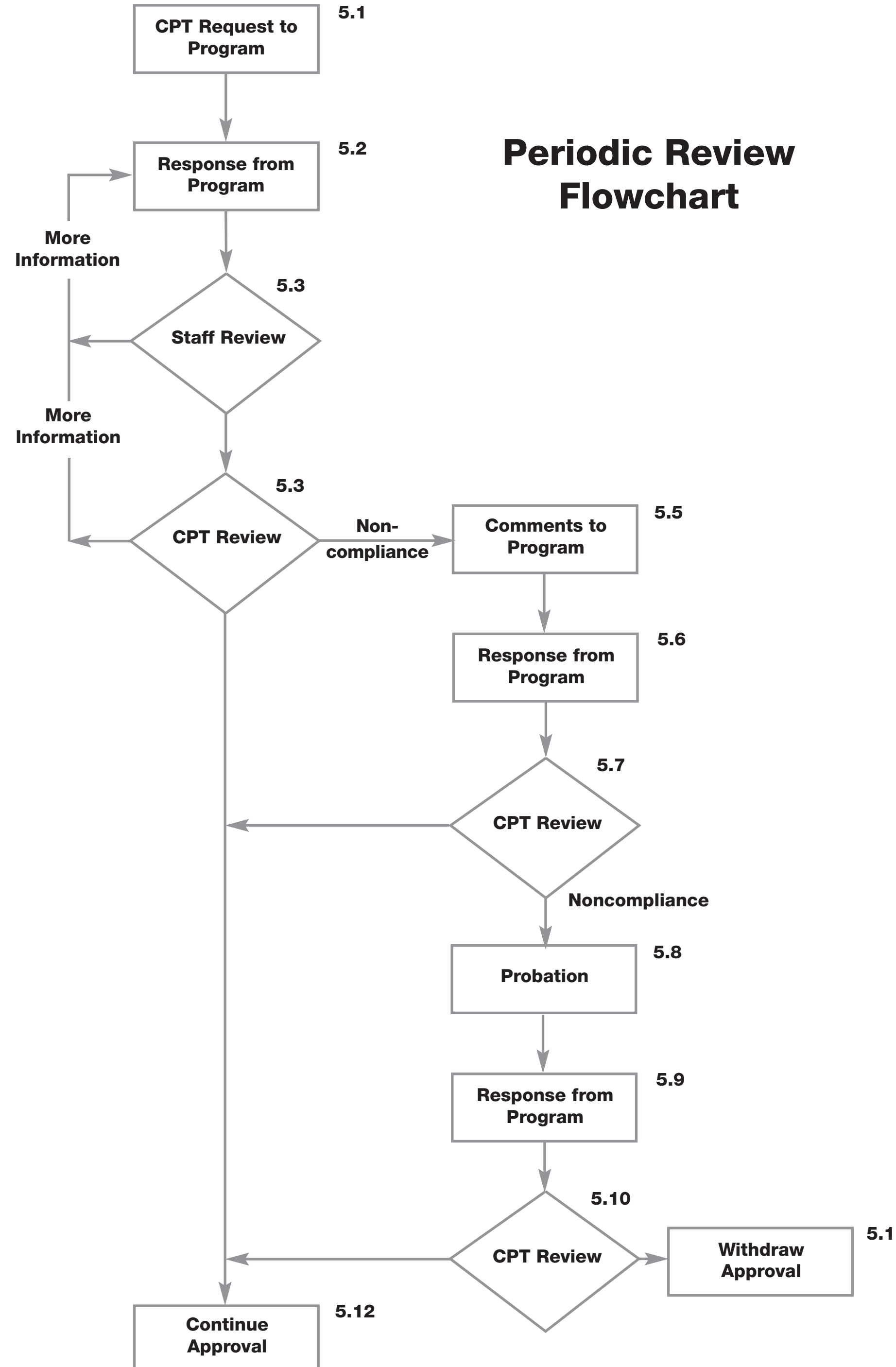
Approved institutions must report annually to the Committee on the number of degrees granted by the chemistry program, all graduates and the certification status of the baccalaureate graduates, and supplemental information on the curriculum and faculty. The Committee reviews the report for completeness and consistency with the guidelines and may request additional information from the program. The Committee summarizes and publishes the statistical information about the numbers of graduates at the various degree levels each year.

## 5. Periodic Review

To ensure compliance with the ACS guidelines, approved programs must submit a periodic report about their program using a form provided by CPT. The following flowchart summarizes the steps of the review process, and the accompanying text describes each of the steps in the flowchart.





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**5.1 Request for Periodic Report.** The Secretary of CPT contacts the chair of the department that administers the ACS-approved chemistry program with instructions for completing the periodic report. The Secretary of CPT sends a report form that includes questions on all components of the ACS guidelines for approval and a copy of the letter reporting the final outcome of the previous review. The Committee also may ask departments to provide copies of specific course syllabi, examinations, and student research reports. Departments must submit a periodic report every five years.

**5.2 Response from Program.** The department must respond by the deadline provided in the letter from the Secretary.

**5.3 Staff Review.** An ACS staff member reviews the periodic report package for completeness and corresponds with the department chair to obtain any missing information.

**5.4 CPT Review.** The Committee reviews the periodic report at one of its three yearly meetings. Three outcomes are possible.

1) *The Committee requests more information.* The CPT members may find that essential information is missing from the report package despite the staff review step and ask a staff member to obtain this information from the department.
2) *The Committee determines that the chemistry program is not in compliance* with the requirements specified in the guidelines or has not adequately addressed the recommendations in the previous periodic review. (Section 5.5)
3) *The Committee continues approval.* (Section 5.12)

**5.5 Comments to Program.** The Secretary of CPT identifies the area(s) of noncompliance in a letter to the chair of the department. The Committee establishes a reasonable time frame for response that is appropriate to the nature of the issues.

**5.6 Response from Program.** The department must report to CPT on the measures taken to address the deficiencies identified by the deadline provided in the letter from the Secretary.





**5.7 CPT Review.** The Committee reviews the department's response at the first possible meeting after receiving it. Two outcomes are possible.

1) *Continue approval.* (Section 5.12)
2) *Probation.* (Section 5.8)

**5.8 Probation.** If the department has not corrected the deficiencies identified in the correspondence from the Secretary, CPT will place the department on probation. The Secretary of CPT communicates this decision and the areas of noncompliance in a letter to the president (or chief administrative officer) of the institution and the chair of the department that administers the chemistry program. The probation decision is confidential between CPT and the institution. During probation, the institution remains on the list of ACS-approved schools, and the department chair may continue to certify graduates who have satisfied the requirements as specified in the guidelines.

**5.9 Response from Program.** The probationary period normally lasts from 12 to 18 months. The institution must provide a written report that describes how it has corrected all of the areas of noncompliance, including supporting documentation as appropriate. Either the department chair or a member of the administration may prepare the response, which must be submitted to the Secretary of CPT before the end of the probationary period.

**5.10 CPT Review.** The Committee reviews the department's response at the first possible meeting after receiving it. In some circumstances, CPT may request a site visit by a Visiting Associate (Section 8). Two outcomes are possible.

1) *Continue approval.* (Section 5.12)
2) *Withdraw approval.* (Section 5.11)

**5.11 Withdraw Approval.** If the department does not meet all of the requirements for ACS approval by the end of the probationary period, CPT withdraws approval of the chemistry program. The Secretary of CPT reports this outcome in a letter to the president of the institution (or chief administrative officer) and the chair of the department responsible for administering the chemistry program. The institution will be removed from the published list of ACS-approved schools, and the chair may no longer certify graduates. The institution may appeal this decision as described in Section 7.

**5.12 Continue Approval.** If CPT determines that the chemistry program meets all of the requirements for ACS approval and the spirit of the guidelines, the Committee continues approval of the program. The Secretary of CPT reports this outcome in a letter to the chair of the department responsible for administering the ACS-approved chemistry program with a copy to the president of the institution (or chief administrative officer). The letter may contain CPT's recommendations and suggestions for strengthening and further development of the chemistry program. The department must adequately address these recommendations as part of the next periodic review. Failure to do so may lead to a determination of noncompliance in the future. Under certain circumstances, CPT may request a shorter review cycle.

## 6. Administrative Probation

The Committee may place an ACS-approved chemistry program on probation if it does not comply with the following administrative requirements for maintaining approval:

- Submission of the periodic review report by the deadline.
- Submission of additional information requested following CPT review of a periodic report.
- Completion of an annual report by the deadline.

The chair of the department responsible for administering the chemistry program receives two warnings that the program has missed the deadline before the Secretary of CPT contacts the president (or chief administrative officer) of the institution. The Secretary of CPT notifies the president that the department does not comply with the requirements for maintaining approval and allows 30 days to correct the situation before placing the program on administrative probation. Administrative probation lasts no longer than 60 days. During administrative probation, programs retain approval and may certify graduates. The Committee withdraws approval of any program that fails to submit the required report or information within the 60-day period.





## 7. Appeal of an Adverse Decision

An institution may petition for review of an adverse decision (withholding or withdrawal of approval) if it believes that the Committee has not adhered to its own established policies and procedures or has failed to consider all of the evidence and documentation presented during the evaluation. The petition must reach the Committee within 60 days following the date of the letter advising the institution of the adverse decision. Within four months of submitting the petition, the institution must provide any additional information and documents in support of the petition. After receiving the petition and supporting information, the Committee reviews the matter at its next regular meeting, which may include a conference with representatives of the institution if desired by either the institution or the Committee. After the meeting and deliberation, the Committee reports its findings to the institution.

Every institution has the right to appeal the Committee's decision to an independent Appeals Board convened for that purpose. The Society's president and the chair of its Board of Directors will appoint an Appeals Board, consisting of three individuals who are not members of the Committee, to hear the appeal.

Any action of any Society unit is always subject to review by the Society's Board of Directors, which has full legal responsibility for all Society activities.

## 8. Visiting Associates

Visiting Associates of the Committee are experienced educators and scientists familiar with the ACS guidelines and the administrative and technical aspects of conducting a successful undergraduate program in chemistry. The Committee periodically holds meetings with Visiting Associates to brief them on guidelines policy and evaluation procedures. The Visiting Associate receives comprehensive and detailed instructions on CPT's expectations for the site visit that also are sent to the chair of the department to aid in preparation for the visit. In addition, the Associate receives confidential comments from CPT that describe aspects of the program that should receive careful attention during the site visit and in the visitor's report. Visiting Associates serve as fact-finders for CPT and do not fill the role of an external consultant who might advise the faculty on the development of the chemistry program.

In the selection of a Visiting Associate, the Committee makes every effort to eliminate any possibility of bias or conflict of interest. For example, a graduate of the institution under review or a person with a close and continuing relationship to the institution or members of the faculty would not be chosen to make a site visit. The Committee would not select an Associate who is a faculty member at an institution in the immediate geographical area.

### 9. Confidentiality

The information provided to the Committee and all related discussions and correspondence between the Committee and an institution are solely for the confidential use of the Committee. In the event that an institution appeals a Committee decision, the Committee provides the information necessary for the proper conduct of the appeal to the Appeals Board.

The Committee communicates all decisions to the department chair. In the case of approval, continued approval, report on a site visit, probation, or withdrawal of approval, the Committee also informs the principal administrative officer of the institution. These communications summarize the reasons for the decisions made by the Committee.

In its annual published reports, the Committee identifies those institutions whose programs are currently approved as meeting the ACS guidelines for undergraduate professional education in chemistry. These annual reports also summarize statistical information provided by each institution about its chemistry graduates. Otherwise, the Committee does not publish any additional information about a particular program or evaluation.





## APPENDIXES

### A. The Formal Mandate of the Committee on Professional Training

A resolution of the ACS Council established the Committee on Professional Training in 1936, and the Committee published the first edition of the guidelines for approval of undergraduate programs in 1939. In 1968, the Committee became a Joint Committee of the ACS Board and Council, reporting to both. In 1979, the Society codified the responsibilities of the CPT in ACS Bylaw III,3,(h):

(1) The SOCIETY shall sponsor an activity for the approval of undergraduate professional programs in chemistry. The Committee on Professional Training, constituted as an Other Joint Board-Council Committee under this Bylaw, shall act for the Board and Council in the formulation and implementation of the approval program with published criteria and/or guidelines, as well as published evaluation policies and procedures.

(2) The goals of the approval program shall be *inter alia*:

- a. promoting and assisting in the development of high standards of excellence in all aspects of postsecondary chemical education, and undertaking studies important to their maintenance,
- b. collecting and making available information concerning trends and developments in modern chemical education, and
- c. cooperating with SOCIETY and other professional and educational groups having mutual interests and concerns.

(3) Institutions may petition for review of adverse evaluation decisions to an established Appeals Board consisting of three members of the SOCIETY, not members of the Committee, appointed jointly by the President and the Chair of the Board.

## B. Members of the Committee on Professional Training

### CPT Members – 2008

Ruma Banerjee, *University of Michigan*
Robert A. Copeland, *GlaxoSmithKline*
Ron W. Darbeau, *McNeese State University*
Ron C. Estler, *Fort Lewis College*
Joseph S. Francisco, *Purdue University*
Cornelia D. Gillyard, *Spelman College*
Carlos G. Gutierrez, *California State University, Los Angeles (Consultant)*
Suzanne Harris, *University of Wyoming*
Scott C. Hartsel, *University of Wisconsin-Eau Claire*
John W. Kozarich, *ActivX Biosciences (Consultant)*
Cynthia K. Larive, *University of California, Riverside, Vice Chair 2007-08*
Anne B. McCoy, *Ohio State University*
Nancy S. Mills, *Trinity University*
George R. Negrete, *University of Texas at San Antonio*
Lee Y. Park, *Williams College*
Jeanne E. Pemberton, *University of Arizona, Chair 2000-02 (Consultant)*
William F. Polik, *Hope College, Chair 2006-08*
Barbara A. Sawrey, *University of California, San Diego (Consultant)*
Joel I. Shulman, *University of Cincinnati*
George S. Wilson, *University of Kansas*
Cathy A. Nelson, *American Chemical Society, Committee Secretary*

### Former CPT Members Who Participated in the Development of the Guidelines

Robert J. Angelici, *Iowa State University*
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Sally Chapman, *Barnard College, Chair 1994-96*
Norman C. Craig, *Oberlin College*
F. Fleming Crim, *University of Wisconsin-Madison, Chair 2003-05*
Royce C. Engstom, *University of Montana*
Edward N. Kresge, *Exxonmobil Chemical Company (Retired)*
Margaret V. Merritt, *Wellesley College*
Jerry R. Mohrig, *Carleton College, Chair 1997-99*
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# Degree Tracks

## Introduction

Degree tracks offer departments the opportunity to create unique student experiences through thoughtful selection of course requirements. The guidelines describe a degree track as a “specialized, department-designed curriculum meeting the foundation, in-depth, and laboratory requirements” (Section 5.6). Each student completing these basic curriculum requirements and appropriate cognate course work in an ACS-approved program becomes eligible for certification by the department chair. Programs are responsible for designing for their students one or more specialized *degree tracks* that take advantage of faculty and local expertise and match departmental and institutional missions. While a degree track can remain the broadly based exposure to all areas of chemistry that has traditionally been the curriculum for a certified major, the department can also define more specialized degree tracks.

The curriculum for each degree track should include the foundation chemistry and cognate course work along with department-specified in-depth courses and other requirements. The language used to describe the sets of courses or experiences within each degree track should reflect that used within the college or university. Consequently, the degree tracks may be described locally as *majors* or *concentrations* and the requirements for each should be included in the college catalogue. The collection of course work and experiences required for a degree track must provide students a coherent experience in that area. Programs should be able to provide a rationale for each degree track and its requirements.

It should be emphasized that ACS, through CPT, evaluates and approves the overall chemistry program of a department and not specific degree tracks. Consequently, CPT suggests that departments use the following or similar language in describing their program and certified degrees. "The chemistry program is approved by the American Chemistry Society (ACS). Students completing a baccalaureate degree that meets the ACS Guidelines will receive an 'ACS-certified degree'. The following degree tracks (majors, concentrations) include the course work and experience necessary to satisfy requirements for ACS certification." For example, if a department designs a biochemistry degree track, a student completing this degree track could say that she was awarded an "ACS-certified chemistry degree with a biochemistry emphasis (or concentration)."

## Models and Examples

Degree tracks may focus on providing a broad overview of chemistry, a specific chemistry subdiscipline, or a chemistry-related multidisciplinary area. For a *chemistry* degree track, a department might require the second semesters of organic and physical chemistry along with one or two additional in-depth electives and a research experience. Undergraduate research can be a valuable component of any degree track, and up to four credit hours of undergraduate research can counted as in-depth course work. Specialized *subdisciplinary* chemistry tracks provide greater in-depth study in a particular chemistry subdiscipline. For example, in a department with strong faculty and student interest in synthesis, an *organic synthesis* track might include the second semester of organic chemistry, an advanced synthesis course, a course in spectroscopic characterization, and a laboratory-based research project. In a department with strong expertise in polymer chemistry, a *polymer chemistry* track could require the second semesters of organic and physical chemistry, additional in-depth polymer chemistry courses, and polymer research.

C*ross-disciplinary* and *multidisciplinary* tracks provide a broader range of in-depth courses. An *environmental chemistry* degree track, for example, might require the second semester of organic chemistry, a course in the environmental chemistry of water and water pollution control, another appropriate in-depth elective, and a laboratory research project. All of the courses must have one or more foundation chemistry courses (not introductory chemistry) as a prerequisite to satisfy the in-depth requirement. A department offering such an environmental chemistry track might also include additional required courses in environmental law and statistics that would not qualify as in-depth courses because of their limited chemistry content (i.e., they do not build on the chemistry foundation courses). Similarly, a multidisciplinary polymer concentration might require courses in materials science or polymer engineering in addition to the required in-depth chemistry courses. A department could also offer a *biological chemistry* track that might be appropriate for pre-medical students. A *biological chemistry* track might include the second semester of organic chemistry, additional in-depth biochemistry and/or medicinal chemistry courses, and a laboratory research project. Courses in biology or biophysics might also be considered as in-depth courses, provided they had appropriate chemistry prerequisite and sufficient chemistry content.

The examples given are not intended to be prescriptive. There are a number of effective ways to structure the curriculum. The overall goal for a department in designing a degree track is to provide a coherent program, based on its own expertise and interests, to strengthen and develop further the chemistry education of its students provided by the foundation course experience.

Committee on Professional Training

# Analytical Chemistry Supplement

## Context

Classroom and laboratory experiences in analytical chemistry at the undergraduate level should present an integrated view of chemical, biological methods and instrumental techniques, including their theoretical basis, for solving a variety of real chemical problems. Students should receive a coherent treatment of the various steps of the analytical process, including: problem definition, selection of analytical method, sampling and sample preparation, validation of analytical method, data collection and interpretation, and reporting. The problem-oriented role of chemical analysis should be emphasized throughout the student's experience. Not only do such experiences provide an excellent introduction to the analytical process they also provide the opportunity to introduce undergraduate students to relevant societal problems requiring modern chemical analysis.

## Conceptual Topics

The student should emerge from an undergraduate program of study having been exposed to a systematic treatment of the entire sequence of steps of the analytical process, including:

Definition of Analytical Requirements

- What is the analyte?
- What is the nature of the sample?
- What information is needed (qualitative, quantitative)?
- What level(s) of analyte(s) is (are) expected?
- If quantitative analysis is desired, what is the detection threshold, and what is the required precision and accuracy?

Selection of Analytical Method

- Criteria: information content, specificity, limit of detection, interferences, dynamic range, sampling methods (gas, liquid, solid), sample preparation (solid phase extraction, digestion, etc.), accuracy, speed, ease of use, cost, temporal and spatial resolution, regulations (FDA, EPA, GLP, ISO)
- Capabilities and Limitations of Analytical Methods:
    - Chemical and Biological Reactions for Analysis and their Properties: Reaction stoichiometry, equilibrium chemistry, reaction rate, labeling (fluorescent, radiochemical), biospecific reactions (enzymes, antibodies, DNA)
    - Instrumental Methods: Instrument components and principles of their operation in the following major areas:
        - Spectroscopy (UV-vis, fluorescence, atomic absorption, ICP-AES, IR, Raman, x-ray, NMR)
        - Separations (GC, HPLC, electrophoresis, ion chromatography, affinity chromatography)
        - Mass spectrometry (including the distinction and utility of different ionization methods including EI, CI, ESI, MALDI)
        - Electrochemistry (ion selective electrodes, amperometry, voltammetry)
        - Hyphenated techniques (GC-MS, LC-MS)
        - Thermal methods (TGA, DSC)

- Signal Measurement and Processing Concepts:
    - Basic electronics, signal/noise ratio, signal transducers, signal processing (filtering, Fourier Transform)
    - Sampling and Sample Preparation
    - Sampling consistent with question being addressed, analyte concentration and separation from complex matrices, elimination or reduction of interferences, derivatization/solubilization
- Validation of Method:
    - Choice of suitable standards, instrument calibration (standard addition, internal and external standards), use of surrogates (tracers)
    - Collection and interpretation of data
    - Statistical analysis (errors, analysis of variance, hypothesis testing), accessing and employing databases
- Reporting:
    - Record-keeping, report writing, and oral presentation

## Practical Topics

The laboratory experience needs to reflect the entire "analytical process" and not focus only on the measurement step. The problems to which students are exposed should reflect the diversity of analytical problem-solving:

- Biological, materials, environmental, and chemical systems
- Major to trace components
- Various physical states of matter
- Chemical speciation
- Qualitative and quantitative analyses reflecting a range of accuracy and precision

The lab experience should provide experience in a diverse set of approaches that reflect the wide range of analytical tools available (equilibrium-based methods, kinetic-based methods, physical properties) using various families of instrumentation including spectroscopy (atomic and molecular), separations, and electrochemistry.

## Illustrative Modes of Coverage

Typically analytical chemistry is taught in a two-course sequence; an introduction to basic concepts followed by a course focused on instrumental analysis. The latter course generally has a physical chemistry pre-requisite. If such a two-course sequence is used, both courses should include laboratory work and coverage of chemical/biological and instrumental methods of analysis. A foundation course in analytical chemistry should include an introduction to both basic concepts and instrumental methods, with the goal of providing a systematic treatment of the entire sequence of steps of the analytical process. The laboratory would focus on problem solving approaches reflective of contemporary analysis requirements. An approach in which analytical chemistry is distributed throughout the curriculum is acceptable as long as the "analytical process" is taught. In such an approach, general chemistry can serve to introduce some experiences in analytical chemistry. Carefully designed courses in environmental or forensic chemistry and biochemistry may provide some components of the analytical curriculum. The choice of problems for analysis affords an opportunity for students to understand and address the application of chemistry to broad societal concerns. Examples of such problems include environmental assessment, screening for controlled substances and explosives, materials characterization, toxicology, food safety, and detection of pathogens.

While spectroscopic characterization of newly isolated or prepared substances, typically included in organic and inorganic laboratories, are important components of the undergraduate curriculum, these experiences cannot be substituted for teaching the analytical process as described.

Committee on Professional Training

# Biochemistry Supplement

## Context

In the belief that all professional chemists need to know some biochemistry, the ACS guidelines require that approved programs offer and certified majors graduate with the equivalent of three semester hours of biochemistry. Molecular aspects of biological structures, equilibria, energetics, and reactions should be covered in the required biochemistry experience for chemistry majors. Sufficient introduction to these topics should be presented so that students can obtain the flavor of modern biochemistry.

## Conceptual Topics

Three general subject areas in biochemistry, along with specific topics in each area, are appropriate for meeting the biochemistry requirement. While all three general subject areas are expected, CPT recognizes that most approved curricula will not be able to cover all of the topics for each of the three general areas.

Biological Structures and Interactions

- Fundamental building blocks (amino acids, carbohydrates, lipids nucleotides, and prosthetic groups)
- Biopolymers (nucleic acids, peptides/proteins, glycoproteins, and polysaccharides)
- Macromolecular conformations
- Membranes
- Supramolecular architecture

Biological Reactions

- Kinetics and mechanisms of biological catalysis
- Biosynthetic pathways and strategies
- Metabolic cycles and their regulation
- Organic and inorganic cofactors

Biological Equilibria and Thermodynamics

- Acid-base equilibria
- Thermodynamics of binding and recognition
- Oxidation and reduction processes
- Electron transport and bioenergetics

## Practical Topics

Some of the required topics in biochemistry may be covered in laboratory courses. The experiments that are used for this purpose should emphasize techniques of general importance to biochemistry as described in the general guidelines outlined above. Some examples are: error and statistical analysis of experimental data, spectroscopic methods, electrophoretic techniques, kinetics, chromatographic separations, bioinformatics and molecular modeling, and isolation and identification of macromolecules.

## Illustrative Modes of Coverage

Most commonly approved programs implement the requirement in one of two ways: 1) a minimally three-semester-credit-hour self-contained foundation course in biochemistry and/or 2) the first semester of a traditional two-semester biochemistry sequence. A second-semester in-depth course is expected to build upon foundation courses that cover fundamental biochemistry, chemical bonding and structure, organic chemistry, thermodynamics, and kinetics. A prerequisite of more than one semester of organic chemistry may be needed for either mode of delivery.

# Inorganic Chemistry Supplement

## Context

Inorganic chemistry plays a key role in the science of materials, catalysis, biological processes, nanotechnology, and other multi-disciplinary fields.

## Conceptual Topics

Topics that are part of the inorganic curriculum are listed below. It is recognized that many curricula will not cover all of these topics, and that some topics may be distributed among several different courses.

- Atomic Structure. Spectra and orbitals, ionization energy, electron affinity, shielding and effective nuclear charge.
- Covalent Molecular Substances. Geometries (symmetry point groups), valence bond theory (hybridization, $\sigma$, $\pi$, $\delta$bonds), molecular orbital theory (homo and hetero-nuclear diatomics, multi-centered MO, electron-deficient molecules, $\pi$ -donor and acceptor ligands).
- Main Group Elements. Synthesis, structure, physical properties, variations in bonding motifs, acid-base character, and reactivities of the elements and their compounds.
- Transition Elements and Coordination Chemistry. Ligands, coordination number, stereochemistry, bonding motifs, nomenclature; ligand field and molecular orbital theories, Jahn-Teller effects, magnetic properties, electronic spectroscopy (term symbols and spectrochemical series), thermodynamic aspects (formation constants, hydration enthalpies, chelate effect), kinetic aspects (ligand substitution, electron transfer, fluxional behavior), lanthanides and actinides.
- Organometallic Chemistry. Metal carbonyls, hydrocarbon and carbocyclic ligands, 18-electron rule (saturation and unsaturation), synthesis and properties, patterns of reactivity (substitution, oxidative-addition and reductive-elimination, insertion and de-insertion, nucleophilic attack on ligands, isomerization, stereochemical nonrigidity).
- Solid State Materials. Close packing in metals and metal compounds, metallic bonding, band theory, magnetic properties, conductivity, semiconductors, insulators, and defects.
- Special Topics. Catalysis and important industrial processes, bioinorganic chemistry, condensed materials containing chain, ring, sheet, cage, and network structures, supramolecular structures, nanoscale structures and effects, surface chemistry, environmental and atmospheric chemistry.

## Practical Topics

The goal of the inorganic laboratory is to give students experience with a range of techniques used in the synthesis and characterization of inorganic compounds and to give them experience in preparing and analyzing various classes of inorganic compounds (coordination, organometallic, and main group compounds, extended solids) and bonding/structural motifs (fluxional behavior, metal-metal multiple bonds, ligands with multiple bonding modes, 3-center bonds, hapticity). Among the techniques that are recommended for inclusion in the inorganic laboratory are the following:

- **Synthetic Methods** that make use of inert atmospheres (dry box/bag, Schlenk methods), a high temperature furnace/heated tube, a vacuum line, a high pressure autoclave, and electrochemical apparatus.

- **Purification Methods** such as column/ion exchange chromatography, sublimation, recrystallization and resolution of optically active compounds.

- **Characterization Methods** that involve measurements of magnetic susceptibility, conductivity, oxidation-reduction potentials, X-ray diffraction, IR, UV-vis, NMR (variable temperature, multinuclear, multidimensional), optical rotation, ESR, Mössbauer, and mass spectrometry.

In the ideal case, experiments should be more than a list of instructions to be followed. Instead, they should illustrate how characterization methods provide insight into fundamental electronic structure and structure-property relationships (by studying families of related compounds for instance). Instructors are encouraged to consult the chemical education literature for ideas about suitable experiments. The list below provides examples of complexes that have been described in the chemical education literature, as a starting point for development of laboratory projects.

- **Coordination Compounds** – $[Co(NH_3)_5Cl]Cl_2$, $Mn(acac)_3$, $[Co(en)_3]Cl_3$, $CrCl_2(H_2O)_4^+$, $Cr(acac)_3$, $[Cr(NH_3)_6](NO_3)_3]$, $Cu(O_2CMe)_2{\bullet}H_2O$, $[Co(en)_2Cl_2]Cl$, $[Co(\underline{o}\text{-phen})_3]Br_2$, Co(salen), $Mo_2(O_2CMe)_4$, $K_4Mo_2Cl_8$.

- **Organotransition Metal Compounds** – $(\eta^6\text{-1,3,5-}Me_3C_6H_3)Mo(CO)_3$, $Cp_2Fe_2(CO)_4$, $Ir(Cl)(CO)(PPh_3)_2$, $Cp_2Ni$, $PtCl_2$(1,5-cyclooctadiene), $[Pd(Cl)(\eta^3\text{-allyl})]_2$, $Cp_2Fe$, $Rh(Cl)(CO)(PPh_3)_2$, $Fe_3(CO)_{12}$.

- **Main Group Element Compounds** – $BH_3{:}NH_2$(t-Bu), $B(OR)_3$, $C_{60}$, $GeH_4$, $Sn(Cl)_2(R)_2$, $Ph_2PCH_2CH_2PPh_2$, $K_2S_2O_8$, $PhBCl_2$, $K(C_2B_9H_{11})$, $ICl_3$, $[I(pyridine)_2](NO_3)$, $[PCl_4][SbCl_6]$, $Me_3N{:}BF_3$, siloxane polymers.

- **Solid State Compounds** – $YBa_2Cu_3O_7$, $VO(PO_4)(H_2O)_2$, a zeolite, $CrCl_3$.

- **Bioinorganic Compounds** – $Ni(glycinate)_n^{(2-n)+}$, copper(II) tetraphenylporphyrin, $Pd(nucleoside)_2(Cl)_2$, $Cu(saccharin)_2(H_2O)_4$, $Cu(glycinate)_2$, cis-platin, cobaloxime model complexes.

- **Special Topics** – quantum dots, nanocrystals, templated synthesis of nanowires, self-assembled monolayers.

## Illustrative Modes of Coverage

The conceptual topics are usually taught in one or two courses dedicated to inorganic chemistry (one foundation and one in-depth), with the in-depth course having a physical chemistry pre-requisite in the ideal case. It is possible for course material to be spread over several courses that do not focus explicitly on inorganic chemistry, as long as a reasonable breadth and exposure to principles of inorganic chemistry are included. Examples might include courses on the synthesis of organic and inorganic compounds, polymeric and supramolecular synthesis and structures, materials chemistry and nanotechnology, catalysis, bioinorganic, organometallic, atmospheric and environmental chemistry. The inorganic laboratory experience may be offered as a course dedicated to inorganic chemistry or as part of a laboratory course that integrates inorganic practical experiences with those of the other areas of chemistry.

# Organic Chemistry Supplement

## Context

Carbon-based molecules are central to a host of chemical and biological processes because of their broad range of structure and reactivity. The millions of organic compounds alone, ranging from polymers to pharmaceuticals, make the field important for study. Yet organic chemistry is also a highly integrated discipline that impacts and is impacted by the other branches of chemistry and other sciences. Indeed organic chemistry enables a molecular understanding of physicochemical phenomena in material science, the environment, biology, and medicine. The field has reached a high level of maturity, yet progress in organic chemistry continues at a fast pace and much more remains to be discovered.

It is nearly impossible to master the breadth of organic chemistry in only an introductory course sequence, but it is important that students understand the principles and learn to apply them to gain a working knowledge and appreciation of organic structure and reactivity.

## Conceptual Topics

- The understanding that our only way to molecular knowledge is through experimentation; correlating structure with reactivity and function through wet chemical methods, spectroscopy, (notably nuclear magnetic resonance and infrared spectroscopy and x-ray crystallography) and use of computational methodology.
- Bonding and its consequences on molecular structure and reactivity.
- Interplay between electronic, steric, and orbital interactions in the behavior and properties of molecules.
- The dependence of structure and reactivity on context, the environment, whether gaseous, liquid or solid; or in solution.
- Lewis and Bronsted acid-base chemistry.
- Stereochemistry and conformational analysis.
- Addition, elimination, substitution and rearrangement mechanisms, and reactive intermediates.
- Functional groups, with particular emphasis on the centrality of the carbonyl group in organic reactions.
- Organic synthesis, including retrosynthetic analysis of target molecules.
- Synthesis and behavior of macromolecular species, including biomolecules such as proteins and polysaccharides and synthetic polymers.

## Practical Topics

The laboratory portion of the organic chemistry experience should demonstrate how organic chemical knowledge is acquired through experimentation. Laboratory skills and techniques are important, as are the skills of asking questions and answering them by the analysis of experimental data. Working in teams can be useful in the latter.

- Developing a feel for the logic of organic experimental procedures: the logic of glassware design, selecting the optimum equipment for a particular reaction or operation, why particular solvents and reaction conditions are used for a specific transformation.
- Planning and carrying out a variety of organic reactions, including safety considerations.
- Keeping a laboratory notebook as a record of what is done.
- Monitoring the progress of a reaction.
- Isolation and purification of products.
- Spectroscopic analysis of starting materials and products; deducing structures and answering questions from modern spectroscopic and computational data.
- Analysis of experimental data using statistical analysis.
- The value and limitations of computational methods.

## Illustrative Modes of Coverage

The foundation experience in organic chemistry is generally presented as a two-semester (or equivalent) sequence of courses and associated laboratories. While it is usually taught in the second year, some institutions teach part of it with success in the first year. Where a one-semester foundation course is used to support other course work such as biochemisty, the topics in that course must be carefully chosen. Some topics appropriate for the foundation course that supports biochemistry include:

- carbonyl chemistry, including nucleophilic addition, alkylation and condensation reactions
- oxidation and reduction
- nucleophilic substitution reactions
- addition and elimination
- acidity and basicity of organic compounds
- stereochemistry, as applied to the previous topics
- concepts and consequences of resonance and aromaticity
- spectroscopy at a basic level as applied to the previous topics

Since this may be the only course in organic chemistry a student may see, the lecture and laboratory must reinforce each other. It is appropriate for the primary treatment of spectroscopy, including NMR and IR spectroscopy, to be done in the laboratory setting.

# Physical Chemistry Supplement

## Context

Physical chemistry provides the fundamental concepts and organizing principles that are applied in all aspects of chemistry and related fields. It develops rigorous and detailed explanations of central, unifying concepts in chemistry and contains mathematical models that provide quantitative predictions. Physical chemistry contains the mathematical underpinning to concepts applied in analytical, inorganic, organic, and biochemistry courses, as well as more advanced topics in chemistry.

## Conceptual Topics

Physical chemistry should emphasize the connection between microscopic models and macroscopic phenomena. Courses should develop both qualitative and quantitative models of physical properties and chemical change, and students should critically apply them to deepen their understanding of chemical phenomenon. Problem solving is a key activity in learning physical chemistry. The physical chemistry course typically requires at least two semesters of calculus and two semesters of physics. Previous experience with multivariable techniques is highly desirable, and exposure to differential equations and linear algebra is very useful as well. In addition, prior chemistry courses may provide preparation for the principle areas of coverage in physical chemistry.

The core treatment of physical chemistry will typically address each of the major concepts listed in bold below. However, a two semester course cannot cover all of the topics listed for each concept, and a one semester course will require a judicious choice of topics and coverage. A broad survey of the concepts and in-depth treatment of selected topics is a common and effective approach. Because physical chemistry concepts underlie the descriptions of many phenomena, it is especially useful to include examples of current scientific interest, make connections to others areas in chemistry, and study interdisciplinary applications of physical chemistry.

- **Thermodynamics and equilibria**. Standard functions (enthalpy, entropy, Gibbs, etc.) and applications. Microscopic point of view especially for entropy. Gibbs chemical potential applied to chemical and phase equilibria. Non-ideal systems; standard states; activities; Debye-Huckel limiting law. Gibbs phase rule; phase equilibria; phase diagrams. Thermodynamics of electrochemical cells.

- **Kinetic theory of gases.** Maxwell-Boltzmann distribution. Collision frequency; effusion rate. Equipartition of energy; heat capacity. Transport processes; diffusion coefficient; viscosity.

- **Chemical kinetics**. Differential and integral expressions with emphasis on multi-step as well as single-step first-order phenomena. Relaxation processes. Microscopic reversibility. Expressing mechanisms in rate laws. Steady state approximation. Collision theory; absolute rate theory; transition state theory. Isotope effect. Molecular reaction dynamics including molecular beams, trajectories, and lasers.

- **Quantum mechanics**. Postulates and formulation of Schrodinger equations. Operators and matrix elements. Particle-in-a-box. Simple harmonic oscillator. Rigid rotor; angular momentum. Hydrogen atom; hydrogenic wave functions. Spin; Pauli principle. Approximate methods. Helium atom. Hydrogen molecule ion; hydrogen molecule, Diatomic molecules. LCAO method. Computational chemistry. Quantum chemistry applications.

- **Spectroscopy** (often interspersed with quantum mechanics to provide immediate applications). Light-matter interaction; dipole selection rules. Rotational spectra of linear molecules. Vibrational spectra. Term symbols. Electronic spectra of atoms and molecules. Magnetic spectroscopy. Raman spectroscopy; multiphoton selection rules. Lasers.

- **Statistical thermodynamics** (often associated with thermodynamics and kinetic theory). Ensembles. Standard thermodynamic functions expressed in partition functions. Partition function expressions for atoms, rigid rotors, harmonic oscillators. Einstein crystal; Debye crystal.

- **Interdisciplinary applications**. Atmospheric, biophysical, materials, and/or quantum chemistry.

## Practical Topics

The physical chemistry laboratory gives students experience in connecting quantitative models with observed chemical phenomena using physical chemistry concepts. The pedagogical goal is for students to understand the qualitative assumptions and limitations of models and the quantitative ability of the models to predict observed chemical phenomena.

Students must understand how to record good measurements, decide whether their measurements are valid, and estimate the errors in their primary experimental variables. This entails understanding the principles and use of electronic instrumentation for making measurements, as well as developing laboratory problem solving experience with these instruments. Hands-on experience with modern instrumentation for measurement of physical properties and chemical change is essential. The opportunity for students to design aspects of their own experiments is quite valuable in learning about making measurements. During their data analysis, students must develop the ability to propagate experimental measurement uncertainties into uncertainties in calculated chemical quantities. A detailed error analysis is an important feature of physical chemistry laboratory reports.

Computers should assist in the collection, analysis, and graphing of data, as well as in the writing of reports. It is important that students gain experience with spreadsheet programs and linear least squares fitting for data analysis. Computational tools such as Mathematica, Matlab, or Mathcad are useful for helping students connect models to observed phenomena, and experiments using modern computational techniques (quantum calculations, molecular modeling) play an important role.

A list follows from which a set of experiments in physical chemistry might be selected. Within the physical chemistry area itself, as well as in an integrated laboratory, it is common for individual experiments to combine several aspects of experimental methods and theoretical concepts.

- **Thermodynamics.** Heat of combustion; enthalpy of reaction in solution. Thermodynamic functions from the temperature dependence of an equilibrium constant or the emf. Study of a system in which activity coefficients play a prominent role.

- **Phase Equilibria**. Solid-liquid phase diagram. Liquid-vapor phase diagram.

- **Kinetic Theory**. Thermal conductivity of gases. Diffusion in solution. Knudsen effusion. Viscosity of gases.

- **Kinetics.** Relaxation study (first-order kinetics), possibly using lasers. Kinetic analysis of a complex reaction. Enzyme study.

- **Spectroscopy.** Analysis of a vibration-rotation spectrum; isotope effects, e.g., HCl/DCl. Analysis of a polyatomic vibrational spectrum, e.g., $SO_2$. Analysis of an electronic-vibration spectrum, e.g., $I_2$. Analysis of electronic spectra, e.g., conjugated polyene dyes. Atomic spectroscopy. Raman spectroscopy. NMR analysis of spin-spin coupling in a non-first-order case. Laser applications.

## Illustrative Modes of Coverage

A common and traditional approach for teaching physical chemistry is a two-semester lecture and laboratory course taught in the third year. The laboratory program may accompany the lectures, be separate courses, or be an intensive single semester course. The physical chemistry laboratory experience may also be integrated into a broader laboratory experience. These examples are not proscriptive, and creativity in the pedagogy and teaching of physical chemistry concepts is encouraged.

A one semester course provides both opportunities and challenges for introducing students to the topics of physical chemistry within the context of a degree track.  Often these courses provide a broad survey of the concepts and in-depth treatment of selected topics. The challenge of designing a one-semester course in physical chemistry is to determine the important principles that govern the physical and chemical behavior of matter within the context of the course emphasis. For example, a one semester class for students who are pursuing a biochemistry track might focus on quantum chemistry, thermodynamics, and kinetics with examples from biochemistry used to illustrate these concepts. An environmental degree track could use examples based on analyzing field measurements or the kinetics of air pollutants.

Given the amount of material and time-constraints of a one semester class, some of the important topics in physical chemistry could be moved into other courses.  For example discussions of enzyme kinetics could be incorporated into a course in biochemistry, kinetic modeling into an in-depth course in atmospheric chemistry, molecular orbital theory into physical organic or physical inorganic chemistry, and non-ideal solutions and electrochemistry into analytical chemistry. The choice of topics and coverage is at the discretion of the instructor and department; and discussion is encouraged within the department to ensure that important topics are not overlooked.

Independent of the focus of a one-semester physical chemistry course, students should be exposed to both microscopic and macroscopic aspects of physical chemistry, the relationship between these two approaches, and the use of quantitative models for understanding and predicting chemical phenomena.  Discussion within and among departments is encouraged as the chemistry community works to develop one semester physical chemistry courses that provide students with the necessary background and training to pursue a career in the chemical sciences.

# Preparing a Research Report

Research experience is as close to a professional problem-solving activity as anything in the curriculum. It provides exposure to research methodology and an opportunity to work closely with a faculty advisor. It usually requires the use of advanced concepts, a variety of experimental techniques, and state-of-the-art instrumentation. Ideally, undergraduate research should focus on a well-defined project that stands a reasonable chance of completion in the time available. A literature survey alone is not a satisfactory research project. Neither is repetition of established procedures. The Committee on Professional Training (CPT) strongly supports efforts by departments to establish active and vibrant undergraduate research programs, recognizing the role that research can play in developing a wide range of student skills. The 2008 guidelines allow for the use of undergraduate research both as in-depth coursework, as well as a means of meeting 180 of the 400 laboratory hours required for certification ***provided that*** a well-written, comprehensive, and well-documented research report is prepared at the end of a project (samples of such research reports must be submitted with the periodic reports.) The CPT has a separate supplement outlining the components of successful research programs and projects.

Preparation of a comprehensive written research report is an essential part of a valid research experience, and the student should be aware of this requirement at the outset of the project. Interim reports may also be required, usually at the termination of the quarter or semester. Sufficient time should be allowed for satisfactory completion of reports, taking into account that initial drafts should be critiqued by the faculty advisor and corrected by the student at each stage. It may be expected that concrete outcomes of any research project would be student presentation of research results at a professional meeting and/or co-authorship on a journal publication. However, while this is a most desirable outcome, it is not a substitute for a well-written comprehensive report, produced by the student with substantive critique and correction by the faculty mentor, which demonstrates that the student has a full grasp of the scope of the problem, the techniques/instrumental methods used, and the ramifications of the results generated (much as might be expected for a capstone paper or a B.S. thesis). It is of paramount importance that any undergraduate research project culminates in a thorough well-documented written report.

Guidelines on how to prepare a professional-style research report are not always routinely available. For this reason, the following information on report writing and format is provided to be helpful to undergraduate researchers and to faculty advisors. Much of what follows is similar to what authors would find in many 'guidelines to authors' instructions for most journal submissions.

The most comprehensive reports examined by CPT have been those student reports reviewed by more faculty than just the supervising research advisor. In some cases, departments require an approval of the report by several faculty members; in such cases, student research reports are often of high quality.

## Organization of the Research Report

Most scientific research reports, irrespective of the field, parallel the method of scientific reasoning. That is: the problem is defined, a hypothesis is created, experiments are devised to test the hypothesis, experiments are conducted, and conclusions are drawn. The exact format of scientific reports is often discipline dependent with variations in order and content. The student is encouraged to adopt the format that is most appropriate to the discipline of the research. Many journals offer a formatting template to aid the author. One example of such a framework is as follows:

- Title
- Abstract
- Introduction
- Experimental Details or Theoretical Analysis
- Results
- Discussion
- Conclusions and Summary
- References

## Title and Title Page

The title should reflect the content and emphasis of the project described in the report. It should be as short as possible and include essential key words.

The author's name (e.g., Mary B. Chung) should follow the title on a separate line, followed by the author's affiliation (e.g., Department of Chemistry, Central State College, Central, AR 76123), the date, and possibly the origin of the report (e.g., In partial fulfillment of a Senior Thesis Project under the supervision of Professor Danielle F. Green, June, 1997).

All of the above could appear on a single cover page. Acknowledgments and a table of contents can be added as preface pages if desired.

## Abstract

The abstract should concisely describe the topic, the scope, the principal findings, and the conclusions. It should be written last to reflect accurately the content of the report. The length of abstracts varies but seldom exceeds 200 words.

A primary objective of an abstract is to communicate to the reader the essence of the paper. The reader will then be the judge of whether to read the full report or not. Were the report to appear in the primary literature, the abstract would serve as a key source of indexing terms and key words to be used in information retrieval. Author abstracts are often published verbatim in Chemical Abstracts.

## Introduction

"A good introduction is a clear statement of the problem or project and the reasons for studying it." (The ACS Style Guide. American Chemical Society, Washington, DC, 2006.)

The nature of the problem and why it is of interest should be conveyed in the opening paragraphs. This section should describe clearly but briefly the background information on the problem, what has been done before (with proper literature citations), and the objectives of the current project. A clear relationship between the current project and the scope and limitations of earlier work should be made so that the reasons for the project and the approach used will be understood.

## Experimental Details, Computation Procedures, or Theoretical Analysis

This section should describe what was actually done. It is a succinct exposition of the laboratory and computational details, describing procedures, techniques, instrumentation, special precautions, and so on. It should be sufficiently detailed that other experienced researchers would be able to repeat the work and obtain comparable results.

In theoretical reports, this section would include sufficient theoretical or mathematical analysis to enable derivations and numerical results to be checked. Computer programs from the public domain should be cited. New computer programs should be described in outline form.

If the experimental section is lengthy and detailed, as in synthetic work, it can be placed at the end of the report so that it does not interrupt the conceptual flow of the report. Its placement will depend on the nature of the project and the discretion of the writer.

### Results

In this section, relevant data, observations, and findings are summarized. Tabulation of data, equations, charts, and figures can be used effectively to present results clearly and concisely. Schemes to show reaction sequences may be used here or elsewhere in the report.

### Discussion

The crux of the report is the analysis and interpretation of the results. What do the results mean? How do they relate to the objectives of the project? To what extent have they resolved the problem? Because the "Results" and "Discussion" sections are interrelated, they can often be combined as one section.

### Conclusions and Summary

A separate section outlining the main conclusions of the project is appropriate if conclusions have not already been stated in the "Discussion" section. Directions for future work are also suitably expressed here.

A lengthy report, or one in which the findings are complex, usually benefits from a paragraph summarizing the main features of the report - the objectives, the findings, and the conclusions.

The last paragraph of text in manuscripts prepared for publication is customarily dedicated to acknowledgments. However, there is no rule about this, and research reports or senior theses frequently place acknowledgments following the title page.

### References

Thoroughness and currency of literature references acknowledge foundational work, direct the reader to published procedures, results, and interpretations, and play a critical role in establishing the overall scholarship of the report. The report should include in-text citations with the citations collated at the end of the report and formatted as described in The ACS Style Guide or using a standard established by an appropriate journal. The citation process can be facilitated by using one of several available citation software programs. In a well-documented report, the majority of the references should come from the primary chemical literature, with any citation of Internet sources kept to a bare minimum.

### Preparing the Manuscript

The personal computer and word processing have made manuscript preparation and revision a great deal easier than it used to be. It is assumed that students will have access to word processing and to additional software that allows numerical data to be graphed, chemical structures to be drawn, and mathematical equations to be represented. These are essential tools of the technical writer. All manuscripts should be carefully proofread before being submitted. Preliminary drafts should be edited by the faculty advisor (and/or a supervising committee) before the report is presented in final form.

### Useful Texts

**Writing the Laboratory Notebook**, Kanare, H. M., American Chemical Society, Washington, DC, 1985.

This book describes among other things the reasons for note keeping, organizing and writing the notebook with examples, and provides photographs from laboratory notebooks of famous scientists.

**ACS Style Guide: Effective Communication of Scientific Information,** Coghill, A. M., Garson, L. R.; 3rd Edition, American Chemical Society, Washington, DC, 2006.

This volume is an invaluable writer's handbook in the field of chemistry. It contains a wealth of data on preparing any type of scientific report and is useful for both students and professional chemists. Every research laboratory should have a copy. It gives pointers on the organization of a scientific paper, correct grammar and style, and accepted formats in citing chemical names, chemical symbols, units, and references.

There are useful suggestions on constructing tables, preparing illustrations, using different fonts, and giving oral presentations. In addition, there is a brief overview of the chemical literature, the way in which it is organized and how information is disseminated and retrieved. A selected bibliography of other excellent guides and resources to technical writing is also provided. See also The Basics of Technical Communicating. Cain, B. E.; ACS Professional Reference Book American Chemical Society: Washington, DC, 1988.

**Write Like a Chemist**, Robinson, M. S., Stoller, F. L., Costanza-Robinson, M. S., Jones, J. K., Oxford University Press, Oxford, 2008.

This book addresses all aspects of scientific writing. The book provides a structured approach to writing a journal article, conference abstract, scientific poster and research proposal. The approach is designed to turn the complex process of writing into graduated, achievable tasks.

# Development of Student Skills in a Chemistry Curriculum

It is a given that all students obtaining a certified degree in chemistry should be well trained in chemical concepts and laboratory practices. However, to be effective and productive scientists, students need to master a variety of skills that go beyond course content alone. These student skills, which are enumerated in the 2008 ACS Guidelines for undergraduate chemistry programs, are described below, along with comments on how they can be imparted and assessed within a chemistry curriculum.

## Student Skills Defined

These skills, which can also be termed *process skills, soft skills, or employability skills*, share the characteristics that they are generic and transferable, are marketable and lifelong, and have wide applications that go beyond course content alone. Included in no particular order are the following:

### *Problem-Solving Skills*

Chemistry education provides students with the tools to solve problems. This means that students should be able to apply the scientific method: define a problem clearly, develop testable hypotheses, design and execute experiments, analyze data, and draw appropriate conclusions. Assessment tools in chemistry courses should reflect this expectation. Examinations should be constructed to encourage the synthesis of a variety of concepts in solving problems while discouraging rote memorization. Students should be able to integrate knowledge across chemical subdisciplines and apply this knowledge to solve problems. In the laboratory, they should understand the use of statistical methods and the fundamental uncertainties in experimental measurements.

### *Chemical Literature Skills*

Students should be able to retrieve specific information from the chemical literature and use the peer-reviewed scientific literature effectively. They should develop proficiency using Chemical Abstracts and other compilations. They should also be able to evaluate technical articles critically.

### *Laboratory Safety Skills*

A high degree of safety awareness should begin with the first laboratory course and continue throughout a student's college career. This includes understanding safety and dress rules;

knowing when to use fume hoods; the use of safety/emergency equipment; handling, storage, and disposal of chemical waste; understanding and use of material safety data sheets; awareness of OSHA requirements; and, in general, knowing how to handle laboratory emergencies effectively.

### *Communication Skills*

These skills, both written and oral, are among the most valued in chemistry graduates and least emphasized in many chemistry programs.  At the same time, they are cited by industry as among those needing improvement in new graduates.  Students should have a variety of writing experiences, not limited to laboratory reports.  They should be able to synthesize information from a variety of sources in a clear and organized manner using a scientifically appropriate style.  Equally important is the opportunity to present material orally.  For the most effective experience, students should receive critical feedback on their oral or written communications.  Students should be able to use communication technology such as computerized presentations as well as software for word processing, chemical-structure drawing, and poster preparation.

### *Team Skills*

Solving scientific problems often involves working in teams, often in multidisciplinary teams. This is especially true in industry.  Group experiences provide learning opportunities for students to appreciate how projects that capture the areas of particular expertise of the team members result in a stronger final product than would have been possible by independent work—the whole may be greater than the sum of its parts.  Students should learn to work productively with a diverse group of peers; and should be able to lead portions of an activity or be effective followers, as dictated by the situation.

### *Ethics*

Chemistry, like any discipline, has a social structure with a code of practices that govern acceptable/unacceptable behaviors.  Progress in chemistry, as in all sciences, relies on complete honesty, openness, and trustworthiness of chemists, and on reproducibility of experimental results.  Students should display high personal standards and integrity, conduct themselves responsibly, and be aware of contemporary issues related to chemistry.

## Imparting and Assessing Student Skills

There are at least three modalities for imparting and assessing student skills:  incorporation into existing courses throughout the curriculum; developing dedicated courses; and utilizing undergraduate research.

### *Using Existing Courses.*

- It goes without saying that a culture of safety should be designed into all laboratory courses and the absolute importance of ethics should be incorporated into the instruction in all aspects of a chemistry curriculum.

- Course examinations can be used to encourage and assess problem-solving skills by asking the student to go beyond knowledge to demonstrate integration and utilization of information. Unless they are very carefully constructed, multiple-choice questions may not provide for the synthesis of a variety of concepts. Instructors should look for opportunities to use a variety of pedagogical tools, such as inquiry-based learning, projects that place experimental data in the context of the chemical literature, and take-home examinations.

- The chemistry curriculum should include writing and speaking opportunities beyond simply lab reports. The experience of finding and synthesizing information from a variety of sources in a term paper, with a critical evaluation of conflicting information, is invaluable training for a chemist. Similarly, preparing and delivering a talk or poster on a chemical topic can be incorporated into existing courses. Requiring the use of the primary and secondary literature in early chemistry courses will provide the foundation for student communication skills.

- Team projects can be introduced into existing courses. Examples include cooperative learning strategies such as organizing students into problem-solving teams in lecture courses or using team strategies in laboratory situations with each member responsible for defined activities. Peer-led team learning, using trained peer leaders who have completed the course, can also be effective.

### *Developing Dedicated Courses*

- A chemical literature course can give students experience in oral and written communication of technical information beyond what may be available in general speech and English composition courses.

- A specific course in safety would have general applicability, but should not replace safety instruction specific to each laboratory course.

- A course in scientific and research ethics may be offered by the chemistry department or elsewhere in the college. A variety of resources and case studies for such a course are easily accessed on the Web.

- A capstone or seminar course for majors can provide an avenue to impart and assess student skills such as communication, chemical literature, and ethics.

### *Undergraduate Research*

- Undergraduate research is one of the most powerful opportunities for students to learn problem-solving skills. "The quest to answer a question is where the learning takes place, not the answer itself." (R. N. Zare, C&EN, July 14, 2008, p. 3)

- Similarly, undergraduate research provides a unique opportunity for experience in oral and written communication. Both a written report and an oral presentation contain the expectation that a student will use the primary and secondary literature, will understand the context for the research, and can provide enough background to convey that to a reader or audience.

- Undergraduate research also provides students the opportunity to learn from their peers and solve problems in teams.

## CPT Expectations

CPT expects that approved chemistry programs will have an established process by which they define, impart, and assess the development of student skills. The Committee will not look at individual student outcomes, but is interested in the process by which each program addresses the area of student skills.

## Appendix II

q. Currently assigned space in the Department of Chemistry.

| **Room Number** | **Function** |
|---|---|
| Lenoir Hall 103 | Research and Teaching Lab |
| Lenoir Hall 106B | Research and Teaching Lab |
| Lenoir Hall 205 | Physical Chemistry Laboratory (Primary), Research Lab |
| Lenoir Hall 205A | Instrumentation Lab |
| Lenoir Hall 206 | Research and Teaching Lab |
| Lenoir Hall 206A | Instrumentation Lab |
| Lenoir Hall 209 | Inorganic, Quantitative Analysis, and Biochemistry Lab, Instrumentation Lab |
| Lenoir Hall 210 | Office |
| Lenoir Hall 212 | Office |
| Lenoir Hall 250A | Office |
| Lenoir Hall 304 | Solvent Room |
| Lenoir Hall 305 | Biochemistry and research Lab |
| Lenoir Hall 305A | Cold Room |
| Lenoir Hall 307 | Survey of Chemistry Lab, Biochemistry Lab |
| Lenoir Hall 308 | Chemistry Stock Room |
| Lenoir Hall 309 | General Chemistry Lab |
| Lenoir Hall 309A | Chemistry Computer Simulation Lab |
| Lenoir Hall 310 | Organic Chemistry Lab |
| Lenoir Hall 310A | Organic Chemistry prep room, Organic Research |
| Lenoir Hall 311 | Office |
| Lenoir Hall 312 | Office |
| Lenoir Hall 313 | Office |
| University Hall 021 | Office |
| University Hall 022 | Office |
| Faculty Office Building 204 | Office |
| | |

## Appendix II

**r. Equipment/Instruments available in Lenoir Hall for chemistry programs.**

| Room Number | Instrument or Software/Model | Year Acquired | Funding Source |
|---|---|---|---|
| 103 | Varian Cary Fluorescence Spectrophotometer/Eclipse | 1999 | - |
| 103 | Shimadzu GC-2010 | 2005 | Dean/Faculty Development |
| 103 | Varian Cary 100 UV-Visible Spectrophotometer | 2001 | Dean/Faculty Development |
| 103 | Varian Cary 300 UV-Visible Spectrophotometer | 2010 | Congressionally Directed Funds |
| 103 | Shimadzu HPLC | 2010 | Congressionally Directed Funds |
| 103 | JASCO HPLC/PU289+ | 2005 | Dean/Faculty Development |
| 103 | Anazazi 60 MHz Nuclear Magnetic Resonance Spectrometer | 2008 | NSF Funded CCLI Grant |
| 106B | Varian Atomic Absorption Spectrophotometer | ~2000 | NSF Funded Grant |
| 106B | Shimadzu Graphite Furnace Atomic Absorption Spectrophotometer | 2010 | Congressionally Directed Funds |
| 106B | VWR 1350G Oven | 2005 | Donation Bayer Material |
| 106B | Refrigerator | 2009 | Lab Fee |
| 205 | Parr Bomb Calorimeter | 2008 | Lab Fee |
| 205 | TC12 Tubular Furnace/Mellen Company | 2005 | Donation |
| 205 | Faraday MP Potentiostat | 2006 | Lab Fee |
| 205B | Perkin Elmer Spectrum One FTIR | 2005 | Dean/Faculty Development |
| 205B | Perkin Elmer Spectrum 100 FTIR | 2009 | Dean/Faculty Development |
| 205B | Perkin Elmer Identicheck FT-NIR | 2003 | Donation Bayer Material |
| 206 | 2 Agilent GCMS | 2011 | GBI Crime Lab State/Surplus |
| 206 | Schlenck Line/Vacuum Line | 2010 | Univ. Faculty Development |
| 206 | Glove Box | - | Donation |
| 206A | 2 Agilent GCMS | 2012 | GBI Crime Lab State/Surplus |
| 206A | Thermo-Finnigan/Ion trap GCMS | 1988 | NSF Grant |
| 206A | Shimadzu Atomic Absorption/AA-6701 Flame Emission | 1988 | NSF Grant |
| 209 | Corning Automatic Collection System for Distilled Water | 2000 | - |
| 209 | Thermo Electron Corporation Precision Oven | 2006 | Lab Fee |
| 209 | Fisher Isotemp Oven/300 Series/350G | - | - |
| 209A | 6 Analytical Balances/Fisher ScientificA-250 | - | |
| 209A | 2 Magnetic Susceptibility Balances/Johnson Matthey | 1998/2005 | |
| 305 | UV spectrophotometer/Genesys10 Thermoelectron Corp. | 2005 | Lab Fee |

| | | | |
|---|---|---|---|
| 305 | Labconco Freeze Dryer | 2006 | Faculty Development |
| 305 | Ultra Centrifuge | - | - |
| 305 | Mini-Ultra Centrifuge | 2011 | Faculty Development |
| 305 | Refrigerator Shaker | 2011 | Faculty Development |
| 305 | PCR Master Cycler | 2011 | Faculty Development |
| 305 | Research Grade Gel Electrophoresis System | 2011 | Faculty Development |
| 305 | Cold Room | - | - |
| 305 | Lyophilizer | 2006 | Faculty Development |
| 309B | 12 Laptop Computers w/Assorted Chemical Software (Spartan Molecular Modeling, CHEMDRAW, CHEMLab,…etc) | 2010 | University Technology Fee |
| 310 | Agilent GCMS | 2012 | GBI Crime Lab State/Surplus |
| 310 | Hewlet Packard 5890 GCMS | 2009 | Private Donation |
| 310A | MARS Microwave Reactor | 2009 | University Technology Fee |
| 310A | Perkin Elmer FTIR Spectrometer | 2010 | Congressionally Directed Funds |

## Appendix III

a. A List of Enrollment over the Past Five Years.

| Comprehensive Program Review<br>Department of Chemistry<br>Programs: BA and BS in Chemistry<br>Quantitative Measures | | | | | | |
|---|---|---|---|---|---|---|
| **Measure** | **2008-09** | **2009-10** | **2010-11** | **2011-12** | **2012-13** | **5-Year Avg** |
| **Number of Declared Majors - Fall Semester** | | | | | | |
| BA Chemistry | | | | | | |
| Full-Time | 18 | 29 | 23 | 28 | 34 | 26 |
| Part-Time | 10 | 7 | 8 | 9 | 10 | 9 |
| *Total* | *28* | *36* | *31* | *37* | *44* | *35* |
| BS Chemistry | | | | | | |
| Full-Time | 73 | 55 | 55 | 61 | 65 | 62 |
| Part-Time | 17 | 9 | 10 | 16 | 13 | 13 |
| *Total* | *90* | *64* | *65* | *77* | *78* | *75* |
| Combined Undergraduate Programs | | | | | | |
| Full-Time | 91 | 84 | 78 | 89 | 99 | 88.2 |
| Part-Time | 27 | 16 | 18 | 25 | 23 | 22 |
| *Total* | *118* | *100* | *96* | *114* | *122* | *110* |

**b.** A list of degrees conferred over the past five years.

| **Measure** | **2008-09** | **2009-10** | **2010-11** | **2011-12** | **2012-13** | **5-Year Avg** |
|---|---|---|---|---|---|---|
| **Number of Degrees Conferred - Fiscal Year** | | | | | | |
| BA Chemistry | 1 | 2 | 1 | 4 | 3 | 2 |
| BS Chemistry | 6 | 6 | 5 | 8 | 7 | 6 |
| Combined Undergraduate Programs | *7* | *8* | *6* | *12* | *10* | 9 |

## Appendix III

c. A comparative list of baccalaureate degrees awarded over the past five years.

| Baccalaureate Degrees Awarded in Chemistry Programs at USG State Universities | | | | | | |
|---|---|---|---|---|---|---|
| **USG Institution** | **2007-08** | **2008-09** | **2009-10** | **2010-11** | **2011-12** | **5-Year Avg** |
| **Albany State University** | 12 | 5 | 4 | 8 | | 7 |
| **Armstrong Atlantic State University** | 9 | 14 | 9 | 11 | | 11 |
| **Augusta State University** | 13 | 9 | 10 | 10 | | 11 |
| **Clayton College & State University** | 0 | 0 | 0 | 0 | | 0 |
| **Columbus State University** | 2 | 7 | 8 | 6 | 12 | 7 |
| **Fort Valley State university** | 2 | 5 | 2 | 1 | | 3 |
| **Georgia College & State University** | 12 | 13 | 18 | 7 | | 13 |
| **Georgia Southwestern State University** | 6 | 2 | 6 | 8 | | 6 |
| **Kennesaw State University** | 32 | 31 | 37 | 28 | | 32 |
| **North Georgia College & State University** | 7 | 10 | 5 | 4 | | 7 |
| **Savannah State University** | 6 | 5 | 7 | 9 | | 7 |
| **Southern Polytechnic State University** | 0 | 0 | 0 | 2 | | 1 |
| **State University of West Georgia** | 26 | 20 | 20 | 21 | | 22 |
| ***Total*** | *127* | *121* | *126* | *115* | *12* | 100 |

# Appendix III

## **d.** Retention Rates by Baccalaureate Program.

**Retention Rates by Baccalaureate Program (*)**

* The cohorts below are first-time full-time undergraduate students enrolled fall semester who entered CSU in the fall or the preceding summer term.

| Major Program | Number in Fall 2007 Cohort | Fall 2007 Cohort Returning Fall 2008 | | Number in Fall 2008 Cohort | Fall 2008 Cohort Returning Fall 2009 | | Number in Fall 2009 Cohort | Fall 2009 Cohort Returning Fall 2010 | | Number in Fall 2010 Cohort | Fall 2010 Cohort Returning Fall 2011 | | Number in Fall 2011 Cohort | Fall 2011 Cohort Returning Fall 2012 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number | Rate | | Number | Rate | | Number | Rate | | Number | Rate | | Number | Rate |
| **Baccalaureate** | | | | | | | | | | | | | | | |
| Accounting | 20 | 11 | 55.0% | 19 | 15 | 78.9% | 0 | | | 0 | | | 9 | 3 | 33.3% |
| Art | 18 | 14 | 77.8% | 22 | 15 | 68.2% | 25 | 19 | 76.0% | 27 | 17 | 63.0% | 13 | 6 | 46.2% |
| Art Education | 2 | 1 | 50.0% | 2 | 1 | 50.0% | 2 | 0 | 0.0% | 6 | 4 | 66.7% | 5 | 3 | 60.0% |
| Biology | 85 | 62 | 72.9% | 99 | 70 | 70.7% | 106 | 74 | 69.8% | 88 | 61 | 69.3% | 113 | 80 | 70.8% |
| Chemistry | 13 | 12 | 92.3% | 31 | 26 | 83.9% | 10 | 7 | 70.0% | 13 | 11 | 84.6% | 24 | 19 | 79.2% |
| Communication | 13 | 8 | 61.5% | 20 | 16 | 80.0% | 13 | 12 | 92.3% | 19 | 16 | 84.2% | 24 | 17 | 70.8% |
| Computer Science | 40 | 30 | 75.0% | 51 | 28 | 54.9% | 39 | 24 | 61.5% | 33 | 26 | 78.8% | 42 | 27 | 64.3% |
| Criminal Justice | 20 | 15 | 75.0% | 19 | 11 | 57.9% | 33 | 21 | 63.6% | 33 | 19 | 57.6% | 46 | 21 | 45.7% |
| Early Childhood Education | 42 | 34 | 81.0% | 40 | 32 | 80.0% | 40 | 29 | 72.5% | 51 | 40 | 78.4% | 36 | 26 | 72.2% |
| Earth & Space Science/Geology | 2 | 1 | 50.0% | 0 | | | 3 | 1 | 33.3% | 3 | 2 | 66.7% | 4 | 2 | 50.0% |
| English Language | 15 | 12 | 80.0% | 18 | 14 | 77.8% | 27 | 23 | 85.2% | 25 | 16 | 64.0% | 25 | 19 | 76.0% |
| Exercise Science | 12 | 8 | 66.7% | 11 | 8 | 72.7% | 21 | 12 | 57.1% | 30 | 22 | 73.3% | 31 | 21 | 67.7% |
| Finance | 9 | 5 | 55.6% | 13 | 7 | 53.8% | 0 | | | 0 | | | 6 | 5 | 83.3% |
| General Business | 40 | 26 | 65.0% | 40 | 32 | 80.0% | 0 | | | 0 | | | 28 | 18 | 64.3% |
| Health & Physical Education | 4 | 3 | 75.0% | 3 | 1 | 33.3% | 6 | 4 | 66.7% | 4 | 2 | 50.0% | 5 | 2 | 40.0% |
| Health Science | 2 | 1 | 50.0% | 9 | 7 | 77.8% | 15 | 13 | 86.7% | 10 | 8 | 80.0% | 18 | 11 | 61.1% |
| History | 10 | 5 | 50.0% | 9 | 4 | 44.4% | 12 | 10 | 83.3% | 10 | 6 | 60.0% | 9 | 9 | 100.0% |
| History & Secondary Education | 7 | 6 | 85.7% | 10 | 4 | 40.0% | 9 | 6 | 66.7% | 8 | 5 | 62.5% | 9 | 5 | 55.6% |
| Information Technology | NA | | | 1 | 1 | 100.0% | 3 | 1 | 33.3% | 8 | 5 | 62.5% | 4 | 4 | 100.0% |
| Management | 21 | 15 | 71.4% | 24 | 10 | 41.7% | 2 | 2 | 100.0% | 0 | | | 12 | 6 | 50.0% |
| Management Information Systems | 6 | 4 | 66.7% | 3 | 1 | 33.3% | 0 | | | 0 | | | 3 | 1 | 33.3% |
| Marketing | 18 | 12 | 66.7% | 14 | 9 | 64.3% | 0 | | | 1 | 0 | 0.0% | 15 | 13 | 86.7% |
| Mathematics | 9 | 5 | 55.6% | 16 | 8 | 50.0% | 17 | 13 | 76.5% | 6 | 4 | 66.7% | 9 | 7 | 77.8% |
| Middle Grades Education | 5 | 2 | 40.0% | 3 | 2 | 66.7% | 7 | 6 | 85.7% | 8 | 7 | 87.5% | 8 | 5 | 62.5% |
| Modern Language & Culture | 2 | 2 | 100.0% | 0 | | | 7 | 6 | 85.7% | 4 | 4 | 100.0% | 4 | 3 | 75.0% |
| Music Performance | 14 | 12 | 85.7% | 22 | 16 | 72.7% | 28 | 22 | 78.6% | 32 | 27 | 84.4% | 24 | 15 | 62.5% |
| Music Education | 28 | 22 | 78.6% | 30 | 24 | 80.0% | 22 | 19 | 86.4% | 20 | 16 | 80.0% | 24 | 22 | 91.7% |
| Music, General | 9 | 6 | 66.7% | 8 | 5 | 62.5% | 6 | 3 | 50.0% | 8 | 6 | 75.0% | 8 | 5 | 62.5% |
| Nursing | 53 | 41 | 77.4% | 73 | 46 | 63.0% | 91 | 68 | 74.7% | 99 | 65 | 65.7% | 126 | 87 | 69.0% |
| Political Science | 9 | 4 | 44.4% | 12 | 8 | 66.7% | 20 | 14 | 70.0% | 14 | 11 | 78.6% | 14 | 9 | 64.3% |
| Pre-Business | 0 | | | 0 | | | 121 | 87 | 71.9% | 77 | 56 | 72.7% | 17 | 9 | 52.9% |
| Psychology | 34 | 24 | 70.6% | 39 | 24 | 61.5% | 43 | 31 | 72.1% | 47 | 24 | 51.1% | 59 | 40 | 67.8% |
| Sociology | 10 | 6 | 60.0% | 7 | 4 | 57.1% | 5 | 4 | 80.0% | 4 | 2 | 50.0% | 8 | 6 | 75.0% |
| Spec Ed - General Curriculum | 2 | 2 | 100.0% | 3 | 2 | 66.7% | 3 | 2 | 66.7% | 4 | 2 | 50.0% | 5 | 4 | 80.0% |
| Theatre Arts | 27 | 23 | 85.2% | 26 | 19 | 73.1% | 49 | 37 | 75.5% | 53 | 43 | 81.1% | 19 | 17 | 89.5% |
| Theatre Education | 9 | 8 | 88.9% | 17 | 13 | 76.5% | 5 | 4 | 80.0% | 0 | | | 7 | 4 | 57.1% |
| *Total Baccalaureate* | *610* | *442* | *72.5%* | *714* | *483* | *67.6%* | *790* | *574* | *72.7%* | *745* | *527* | *70.7%* | *813* | *551* | *67.8%* |

**Appendix III**

**e.** A list of peer institutions who administer the Major Field Test to a select number of in chemistry students.

| School Name | Number of Students |
|---|---|
| Albany State University, GA | 7 |
| Armstrong Atlantic State University, GA | 57 |
| Berry College, GA | 26 |
| Clayton State University, GA | 10 |
| Columbus State University, GA | 19 |
| Covenant College, GA | 5 |
| Fort Valley State University, GA | 13 |
| Mercer University, GA | 6 |
| Morehouse College, GA | 24 |
| Spelman College, GA | 37 |
| Total | 204 |

# Appendix III

**f.** A list of Comparative Data Report for Columbus State University Individual Students Total Score Distribution for Seniors from Domestic Institutions - September 2011 to May 2014

| Total Score<br><br>Range (120 - 200) | Percent Below |
|---|---|
| 175 - 200 | 99 |
| 174 | 98 |
| 173 | 98 |
| 172 | 98 |
| 171 | 98 |
| 170 | 97 |
| 169 | 95 |
| 168 | 95 |
| 167 | 94 |
| 166 | 94 |
| 165 | 94 |
| 164 | 93 |
| 163 | 92 |
| 162 | 91 |
| 161 | 89 |
| 160 | 88 |
| 159 | 87 |
| 158 | 86 |
| 157 | 86 |
| 156 | 85 |
| 155 | 83 |
| 154 | 82 |
| 153 | 81 |
| 152 | 80 |
| 151 | 79 |
| 150 | 78 |
| 149 | 76 |
| 148 | 73 |
| 147 | 71 |
| 146 | 68 |
| 145 | 65 |
| 144 | 62 |
| 143 | 58 |
| 142 | 55 |
| 141 | 51 |
| 140 | 49 |
| 139 | 46 |
| 138 | 45 |
| 137 | 42 |
| 136 | 41 |
| 135 | 38 |
| 134 | 29 |
| 133 | 27 |
| 132 | 24 |
| 131 | 20 |
| 130 | 16 |
| 129 | 14 |
| 128 | 9 |
| 127 | 8 |
| 126 | 6 |
| 125 | 5 |
| 124 | 3 |
| 120 - 123 | 1 |
| Number of Examinees | 204 |
| Mean | 141.4 |
| Median | 140 |
| Standard Deviation | 12.7 |

## Appendix III

**g.** Individual Students Subscore Distributions in Chemistry for Seniors from Domestic Institutions - September 2011 to May 2014

| Subscores [2] | Subscore Percent Below | | | | Subscores [2] |
|---|---|---|---|---|---|
| Range (20 -100) | S1 | S2 | S3 | S4 | Range (20 -100) |
| 79 - 100 | 99 | 99 | 99 | 99 | 79 - 100 |
| 78 | 99 | 98 | 99 | 97 | 78 |
| 77 | 99 | 98 | 99 | 97 | 77 |
| 76 | 99 | 98 | 99 | 97 | 76 |
| 75 | 99 | 98 | 99 | 96 | 75 |
| 74 | 97 | 98 | 99 | 96 | 74 |
| 73 | 97 | 96 | 99 | 96 | 73 |
| 72 | 97 | 96 | 98 | 96 | 72 |
| 71 | 97 | 93 | 98 | 96 | 71 |
| 70 | 96 | 93 | 98 | 96 | 70 |
| 69 | 96 | 93 | 97 | 94 | 69 |
| 68 | 96 | 91 | 97 | 94 | 68 |
| 67 | 95 | 91 | 97 | 94 | 67 |
| 66 | 95 | 90 | 95 | 94 | 66 |
| 65 | 95 | 90 | 95 | 94 | 65 |
| 64 | 92 | 90 | 95 | 94 | 64 |
| 63 | 92 | 88 | 95 | 92 | 63 |
| 62 | 92 | 88 | 92 | 92 | 62 |
| 61 | 90 | 88 | 92 | 92 | 61 |
| 60 | 90 | 84 | 92 | 91 | 60 |
| 59 | 90 | 84 | 88 | 91 | 59 |
| 58 | 87 | 84 | 88 | 91 | 58 |
| 57 | 87 | 81 | 88 | 89 | 57 |
| 56 | 87 | 81 | 83 | 89 | 56 |
| 55 | 87 | 76 | 83 | 89 | 55 |
| 54 | 81 | 76 | 83 | 81 | 54 |
| 53 | 81 | 76 | 83 | 81 | 53 |
| 52 | 81 | 70 | 75 | 81 | 52 |
| 51 | 74 | 70 | 75 | 81 | 51 |
| 50 | 74 | 70 | 75 | 78 | 50 |
| 49 | 74 | 64 | 69 | 78 | 49 |
| 48 | 70 | 64 | 69 | 78 | 48 |
| 47 | 70 | 56 | 69 | 72 | 47 |
| 46 | 70 | 56 | 63 | 72 | 46 |
| 45 | 62 | 56 | 63 | 61 | 45 |
| 44 | 62 | 50 | 63 | 61 | 44 |
| 43 | 62 | 50 | 55 | 61 | 43 |
| 42 | 53 | 45 | 55 | 52 | 42 |
| 41 | 53 | 45 | 55 | 52 | 41 |
| 40 | 53 | 45 | 43 | 52 | 40 |
| 39 | 45 | 40 | 43 | 42 | 39 |
| 38 | 45 | 40 | 43 | 42 | 38 |
| 37 | 45 | 30 | 35 | 42 | 37 |
| 36 | 33 | 30 | 35 | 35 | 36 |
| 35 | 33 | 30 | 35 | 35 | 35 |
| 34 | 33 | 23 | 24 | 35 | 34 |
| 33 | 25 | 23 | 24 | 23 | 33 |
| 32 | 25 | 19 | 24 | 23 | 32 |
| 31 | 25 | 19 | 16 | 16 | 31 |
| 30 | 16 | 11 | 16 | 16 | 30 |
| 29 | 16 | 11 | 16 | 16 | 29 |
| 28 | 16 | 11 | 10 | 11 | 28 |
| 27 | 8 | 6 | 10 | 11 | 27 |
| 26 | 8 | 6 | 10 | 11 | 26 |
| 25 | 2 | 2 | 5 | 3 | 25 |
| 24 | 2 | 2 | 5 | 3 | 24 |
| 23 | 2 | 1 | 5 | 1 | 23 |
| 20 - 22 | 1 | 1 | 1 | 1 | 20 - 22 |
| Number of Examinees | 204 | 204 | 204 | 204 | |
| Mean | 41.2 | 44.1 | 41.5 | 41.2 | |
| Median | 39 | 42 | 40 | 39 | |
| Standard Deviation | 12.6 | 13.8 | 12.3 | 12.8 | |

Subscore 1: Physical Chemistry

Subscore 2: Organic **Chemistry**

Subscore 3: Inorganic Chemistry

Subscore 4: Analytical Chemistry

**Appendix III**

**h.** Comparative Data Report for Columbus State University Institutional Means Total Score Distribution MFT in Chemistry for Seniors from Domestic Institutions - September 2011 to May 2014

| Mean Total Score<br><br>Range (120 - 200) | Percent Below |
|---|---|
| 159 - 200 | 99 |
| 158 | 90 |
| 157 | 90 |
| 156 | 80 |
| 155 | 80 |
| 154 | 80 |
| 153 | 80 |
| 152 | 80 |
| 151 | 80 |
| 150 | 80 |
| 149 | 70 |
| 148 | 70 |
| 147 | 60 |
| 146 | 60 |
| 145 | 60 |
| 144 | 60 |
| 143 | 60 |
| 142 | 60 |
| 141 | 60 |
| 140 | 60 |
| 139 | 60 |
| 138 | 40 |
| 137 | 30 |
| 136 | 30 |
| 135 | 30 |
| 134 | 20 |
| 133 | 20 |
| 132 | 20 |
| 131 | 20 |
| 130 | 10 |
| 120 - 129 | 1 |
| Number of Institutions | 10 |
| Mean | 141.6 |
| Median | 138 |
| Standard Deviation | 9.8 |

# Appendix III

**i.** Comparative Data Report for Columbus State University Institutional Means Subscore Distributions for Seniors from Domestic Institutions - September 2011 to May 2014

| Subscores [2] | Subscore Percent Below | | | | Subscores [2] |
|---|---|---|---|---|---|
| Range (20 -100) | S1 | S2 | S3 | S4 | Range (20 -100) |
| 64- 100 | 99 | 99 | 99 | 99 | 64- 100 |
| 63 | 99 | 99 | 99 | 90 | 63 |
| 62 | 99 | 99 | 99 | 90 | 62 |
| 61 | 99 | 99 | 99 | 90 | 61 |
| 60 | 99 | 99 | 99 | 90 | 60 |
| 59 | 99 | 99 | 99 | 90 | 59 |
| 58 | 99 | 99 | 99 | 90 | 58 |
| 57 | 90 | 90 | 99 | 90 | 57 |
| 56 | 90 | 80 | 99 | 80 | 56 |
| 55 | 80 | 70 | 99 | 80 | 55 |
| 54 | 80 | 70 | 99 | 80 | 54 |
| 53 | 80 | 60 | 99 | 80 | 53 |
| 52 | 80 | 60 | 80 | 80 | 52 |
| 51 | 80 | 60 | 80 | 80 | 51 |
| 50 | 80 | 60 | 80 | 80 | 50 |
| 49 | 80 | 60 | 80 | 80 | 49 |
| 48 | 80 | 60 | 70 | 80 | 48 |
| 47 | 80 | 60 | 70 | 80 | 47 |
| 46 | 70 | 60 | 70 | 70 | 46 |
| 45 | 70 | 60 | 70 | 70 | 45 |
| 44 | 60 | 60 | 70 | 70 | 44 |
| 43 | 60 | 60 | 60 | 70 | 43 |
| 42 | 50 | 60 | 50 | 60 | 42 |
| 41 | 50 | 60 | 50 | 60 | 41 |
| 40 | 50 | 50 | 40 | 40 | 40 |
| 39 | 30 | 40 | 40 | 30 | 39 |
| 38 | 30 | 40 | 30 | 30 | 38 |
| 37 | 30 | 30 | 30 | 30 | 37 |
| 36 | 20 | 30 | 30 | 30 | 36 |
| 35 | 20 | 30 | 30 | 20 | 35 |
| 34 | 20 | 20 | 10 | 10 | 34 |
| 33 | 10 | 20 | 1 | 10 | 33 |
| 32 | 1 | 20 | 1 | 10 | 32 |
| 31 | 1 | 20 | 1 | 10 | 31 |
| 30 | 1 | 10 | 1 | 1 | 30 |
| 29 | 1 | 10 | 1 | 1 | 29 |
| 20 - 28 | 1 | 1 | 1 | 1 | 20 - 28 |
| Number of Institutions | 10 | 10 | 10 | 10 | |
| Mean | 42.3 | 42.9 | 41.6 | 42.5 | |
| Median | 40.5 | 39.5 | 41 | 40 | |
| Standard Deviation | 8.1 | 10.7 | 6.8 | 9.6 | |

## Appendix III

**j.** Comparative Data Report for Columbus State University Institutional Assessment Indicator Mean Score Distributions for Seniors From Domestic Institutions - September 2011 to May 2014

| Mean Percent Correct | Assessment Indicators[2] Percent Below | | Mean Percent Correct |
|---|---|---|---|
| | A1 | A2 | |
| 65 - 100 | 99 | 99 | 65 - 100 |
| 64 | 90 | 99 | 64 |
| 63 | 90 | 99 | 63 |
| 62 | 90 | 99 | 62 |
| 61 | 90 | 99 | 61 |
| 60 | 90 | 99 | 60 |
| 59 | 80 | 99 | 59 |
| 58 | 80 | 99 | 58 |
| 57 | 80 | 99 | 57 |
| 56 | 80 | 90 | 56 |
| 55 | 70 | 90 | 55 |
| 54 | 70 | 80 | 54 |
| 53 | 70 | 80 | 53 |
| 52 | 60 | 80 | 52 |
| 51 | 60 | 80 | 51 |
| 50 | 60 | 80 | 50 |
| 49 | 60 | 80 | 49 |
| 48 | 60 | 80 | 48 |
| 47 | 60 | 80 | 47 |
| 46 | 60 | 80 | 46 |
| 45 | 60 | 70 | 45 |
| 44 | 60 | 60 | 44 |
| 43 | 60 | 60 | 43 |
| 42 | 50 | 60 | 42 |
| 41 | 40 | 60 | 41 |
| 40 | 40 | 60 | 40 |
| 39 | 40 | 60 | 39 |
| 38 | 30 | 60 | 38 |
| 37 | 30 | 60 | 37 |
| 36 | 30 | 60 | 36 |
| 35 | 20 | 60 | 35 |
| 34 | 10 | 40 | 34 |
| 33 | 10 | 40 | 33 |
| 32 | 10 | 30 | 32 |
| 31 | 10 | 30 | 31 |
| 30 | 10 | 20 | 30 |
| 29 | 10 | 20 | 29 |
| 28 | 1 | 20 | 28 |
| 27 | 1 | 20 | 27 |
| 26 | 1 | 10 | 26 |
| 25 | 1 | 10 | 25 |
| 24 | 1 | 10 | 24 |
| 23 | 1 | 10 | 23 |
| 0 - 22 | 1 | 1 | 0 - 22 |
| Number of Institutions | 10 | 10 | |
| Mean | 44.8 | 37.7 | |
| Median | 41.5 | 34 | |
| Standard Deviation | 11.4 | 10.9 | |

# Appendix III

**k.** Comparative Data Report for Columbus State University Demographic Summary for Seniors from Domestic Institutions - September 2011 to May 2014

| Demographic Category | Percent in Category |
|---|---|
| GENDER | |
| Male | 39% |
| Female | 55% |
| No Response | 6% |
| EDUCATIONAL LEVEL | |
| Freshman (0-30 credits) | 0% |
| Sophomore (31-60 credits) | 0% |
| Junior (61-90 credits) | 0% |
| Senior (91-120 credits) | 100% |
| Graduate (over 120 credits) | 0% |
| Other | 0% |
| No Response | 0% |
| EDUCATION PLANNED | |
| Associate | <1% |
| Bachelors | 11% |
| Masters | 11% |
| Doctorate | 58% |
| Other | 4% |
| Undecided | 9% |
| No Response | 6% |
| TRANSFER STUDENT | |
| No | 78% |
| Yes | 19% |
| No Response | 3% |
| ENROLLMENT STATUS | |
| Full-time | 86% |
| Part-time | 9% |
| No Response | 5% |
| BEST LANGUAGE | |
| English | 89% |
| Other | 3% |
| Both | 3% |
| No Response | 4% |

| Demographic Category | Percent in Category |
|---|---|
| MAJOR DISTANCE LEARNING COURSES | |
| None | 79% |
| Less than 40% | 9% |
| 40% to 90% | 1% |
| More than 90% | <1% |
| No Response | 10% |
| OVERALL UNDERGRADUATE GPA | |
| 3.50 – 4.00 | 25% |
| 3.00 – 3.49 | 39% |
| 2.50 – 2.99 | 22% |
| 2.00 – 2.49 | 7% |
| 1.00 – 1.99 | 0% |
| Less than 1.00 | 0% |
| No Response | 8% |
| MAJOR FIELD GPA | |
| 3.50 – 4.00 | 27% |
| 3.00 – 3.49 | 35% |
| 2.50 – 2.99 | 23% |
| 2.00 – 2.49 | 4% |
| 1.00 – 1.99 | 0% |
| Less than 1.00 | 0% |
| No Response | 11% |
| ETHNICITY | |
| American Indian or Alaskan Native | 1% |
| Asian American or Pacific Islander | 7% |
| Black or African American | 47% |
| Latin American or Other Hispanic | 1% |
| Mexican American | 1% |
| Puerto Rican | <1% |
| White | 34% |
| Other | 5% |
| No Response | 3% |

## Appendix III

**I.** Major Field Test results for Fall 2011

| TOTAL TEST | | |
|---|---|---|
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 200 | 0 | 100 |
| 195-199 | 0 | 100 |
| 190-194 | 0 | 100 |
| 185-189 | 0 | 100 |
| 180-184 | 0 | 100 |
| 175-179 | 0 | 100 |
| 170-174 | 0 | 100 |
| 165-169 | 0 | 100 |
| 160-164 | 0 | 100 |
| 155-159 | 0 | 100 |
| 150-154 | 0 | 100 |
| 145-149 | 0 | 100 |
| 140-144 | 0 | 100 |
| 135-139 | 1 | 75 |
| 130-134 | 2 | 25 |
| 125-129 | 0 | 25 |
| 120-124 | 1 | 0 |

| | Mean | Standard Deviation |
|---|---|---|
| **Total Test Scaled Score** | 132 | 7 |
| **Subscore 1** | 35 | 9 |
| **Subscore 2** | 30 | 7 |
| **Subscore 3** | 35 | 7 |
| **Subscore 4** | 36 | 8 |

**Appendix III**

**m.** Major Field Test results for Physical Chemistry in Fall 2011

| | Subscore 1 | |
|---|---|---|
| | Physical Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 0 | 100 |
| 45-49 | 1 | 75 |
| 40-44 | 0 | 75 |
| 35-39 | 1 | 50 |
| 30-34 | 1 | 25 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

## Appendix III

**n.** Major Field Test results for Organic Chemistry in Fall 2011

| | Subscore 2 | |
|---|---|---|
| | Organic Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 0 | 100 |
| 45-49 | 0 | 100 |
| 40-44 | 0 | 100 |
| 35-39 | 1 | 75 |
| 30-34 | 2 | 25 |
| 25-29 | 0 | 25 |
| 20-24 | 1 | 0 |

## Appendix III

**o.** Major Field Test results for Inorganic Chemistry in Fall 2011 Major Field Test Fall 2011

| | Subscore 3 | |
|---|---|---|
| | Inorganic Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 0 | 100 |
| 45-49 | 0 | 100 |
| 40-44 | 2 | 50 |
| 35-39 | 0 | 50 |
| 30-34 | 1 | 25 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

**Appendix III**

**p.** Major Field Test results for Analytical Chemistry in Fall 2011 Major Field Test Fall 2011

| | Subscore 4 | |
|---|---|---|
| | Analytical Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 0 | 100 |
| 45-49 | 1 | 75 |
| 40-44 | 0 | 75 |
| 35-39 | 1 | 50 |
| 30-34 | 1 | 25 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

## Appendix III

**q.** Major Field Test Spring 2012

| TOTAL TEST | | |
|---|---|---|
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 200 | 0 | 100 |
| 195-199 | 0 | 100 |
| 190-194 | 0 | 100 |
| 185-189 | 0 | 100 |
| 180-184 | 0 | 100 |
| 175-179 | 0 | 100 |
| 170-174 | 0 | 100 |
| 165-169 | 0 | 100 |
| 160-164 | 0 | 100 |
| 155-159 | 0 | 100 |
| 150-154 | 0 | 100 |
| 145-149 | 1 | 89 |
| 140-144 | 2 | 67 |
| 135-139 | 2 | 44 |
| 130-134 | 2 | 22 |
| 125-129 | 1 | 11 |
| 120-124 | 1 | 0 |

| | Mean | Standard Deviation |
|---|---|---|
| **Total Test Scaled Score** | 135 | 8 |
| **Subscore 1** | 36 | 11 |
| **Subscore 2** | 34 | 11 |
| **Subscore 3** | 44 | 9 |
| **Subscore 4** | 35 | 8 |

**r.** Major Field Test results for Physical Chemistry in Spring 2012

| | Subscore 1 | |
|---|---|---|
| | Physical Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 2 | 78 |
| 45-49 | 0 | 78 |
| 40-44 | 0 | 78 |
| 35-39 | 3 | 44 |
| 30-34 | 1 | 33 |
| 25-29 | 2 | 11 |
| 20-24 | 1 | 0 |

## Appendix III

**s.** Major Field Test results for Organic Chemistry in Spring 2012

| | Subscore 2 | |
|---|---|---|
| | Organic Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 1 | 89 |
| 45-49 | 1 | 78 |
| 40-44 | 0 | 78 |
| 35-39 | 2 | 56 |
| 30-34 | 2 | 33 |
| 25-29 | 1 | 22 |
| 20-24 | 2 | 0 |

## Appendix III

**t.** Major Field Test results for Inorganic Chemistry in Spring 2012

| | Subscore 3 Inorganic Chemistry | |
|---|---|---|
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 1 | 89 |
| 50-54 | 1 | 78 |
| 45-49 | 3 | 44 |
| 40-44 | 3 | 11 |
| 35-39 | 0 | 11 |
| 30-34 | 0 | 11 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

## Appendix III

**u.** Major Field Test results for Analytical Chemistry in Spring 2012

| | Subscore 4 | |
|---|---|---|
| | Analytical Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 0 | 100 |
| 45-49 | 2 | 78 |
| 40-44 | 0 | 78 |
| 35-39 | 4 | 33 |
| 30-34 | 1 | 22 |
| 25-29 | 1 | 11 |
| 20-24 | 1 | 0 |

## Appendix III

**v.** Major Field Test results for Fall 2012

| TOTAL TEST | | |
|---|---|---|
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 200 | 0 | 100 |
| 195-199 | 0 | 100 |
| 190-194 | 0 | 100 |
| 185-189 | 0 | 100 |
| 180-184 | 0 | 100 |
| 175-179 | 0 | 100 |
| 170-174 | 0 | 100 |
| 165-169 | 0 | 100 |
| 160-164 | 0 | 100 |
| 155-159 | 0 | 100 |
| 150-154 | 0 | 100 |
| 145-149 | 0 | 100 |
| 140-144 | 1 | 50 |
| 135-139 | 0 | 50 |
| 130-134 | 0 | 50 |
| 125-129 | 0 | 50 |
| 120-124 | 1 | 0 |

| | Mean | Standard Deviation |
|---|---|---|
| **Total Test Scaled Score** | 131 | 13 |
| **Subscore 1** | 39 | 17 |
| **Subscore 2** | 31 | 5 |
| **Subscore 3** | 33 | 11 |
| **Subscore 4** | 33 | 18 |

**Appendix III**

**w.** Major Field Test results for Physical Chemistry in Fall 2012

| | Subscore 1 | |
|---|---|---|
| | Physical Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 1 | 50 |
| 45-49 | 0 | 50 |
| 40-44 | 0 | 50 |
| 35-39 | 0 | 50 |
| 30-34 | 0 | 50 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

**Appendix III**

**x.** Major Field Test results for Organic Chemistry in Fall 2012

| | Subscore 2 | |
|---|---|---|
| | Organic Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 0 | 100 |
| 45-49 | 0 | 100 |
| 40-44 | 0 | 100 |
| 35-39 | 0 | 100 |
| 30-34 | 1 | 50 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

## Appendix III

**y.** Major Field Test results for Inorganic Chemistry in Fall 2012

| | Subscore 3 Inorganic Chemistry | |
|---|---|---|
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 0 | 100 |
| 45-49 | 0 | 100 |
| 40-44 | 1 | 50 |
| 35-39 | 0 | 50 |
| 30-34 | 0 | 50 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

**Appendix III**

**z.** Major Field Test results for Analytical Chemistry in Fall 2012

| | Subscore 4 Analytical Chemistry | |
|---|---|---|
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 0 | 100 |
| 60-64 | 0 | 100 |
| 55-59 | 0 | 100 |
| 50-54 | 0 | 100 |
| 45-49 | 1 | 50 |
| 40-44 | 0 | 50 |
| 35-39 | 0 | 50 |
| 30-34 | 0 | 50 |
| 25-29 | 0 | 50 |
| 20-24 | 1 | 0 |

## Appendix III

**aa.** Major Field Test results for Spring 2013

| TOTAL TEST | | |
|---|---|---|
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 200 | 0 | 100 |
| 195-199 | 0 | 100 |
| 190-194 | 0 | 100 |
| 185-189 | 0 | 100 |
| 180-184 | 0 | 100 |
| 175-179 | 1 | 89 |
| 170-174 | 1 | 78 |
| 165-169 | 0 | 78 |
| 160-164 | 1 | 67 |
| 155-159 | 0 | 67 |
| 150-154 | 0 | 67 |
| 145-149 | 1 | 56 |
| 140-144 | 2 | 33 |
| 135-139 | 2 | 11 |
| 130-134 | 1 | 0 |
| 125-129 | 0 | 0 |
| 120-124 | 0 | 0 |

| | Mean | Standard Deviation |
|---|---|---|
| **Total Test Scaled Score** | 149 | 16 |
| **Subscore 1** | 50 | 19 |
| **Subscore 2** | 44 | 16 |
| **Subscore 3** | 54 | 13 |
| **Subscore 4** | 49 | 13 |

## Appendix III

**bb.** Major Field Test results for Physical Chemistry in Spring 2013

| | Subscore 1 Physical Chemistry | |
|---|---|---|
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 1 | 89 |
| 80-84 | 0 | 89 |
| 75-79 | 0 | 89 |
| 70-74 | 0 | 89 |
| 65-69 | 1 | 78 |
| 60-64 | 1 | 67 |
| 55-59 | 0 | 67 |
| 50-54 | 1 | 56 |
| 45-49 | 1 | 44 |
| 40-44 | 1 | 33 |
| 35-39 | 1 | 22 |
| 30-34 | 1 | 11 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

## Appendix III

**cc.** Major Field Test results for Organic Chemistry in Spring 2013

| | Subscore 2 | |
|---|---|---|
| | Organic Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 1 | 89 |
| 65-69 | 1 | 78 |
| 60-64 | 0 | 78 |
| 55-59 | 0 | 78 |
| 50-54 | 0 | 78 |
| 45-49 | 1 | 67 |
| 40-44 | 1 | 56 |
| 35-39 | 2 | 33 |
| 30-34 | 2 | 11 |
| 25-29 | 1 | 0 |
| 20-24 | 0 | 0 |

**Appendix III**

**dd.** Major Field Test results for Inorganic Chemistry in Spring 2013

| | Subscore 3 | |
|---|---|---|
| | Inorganic Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 1 | 89 |
| 70-74 | 0 | 89 |
| 65-69 | 2 | 67 |
| 60-64 | 0 | 67 |
| 55-59 | 0 | 67 |
| 50-54 | 1 | 56 |
| 45-49 | 2 | 33 |
| 40-44 | 3 | 0 |
| 35-39 | 0 | 0 |
| 30-34 | 0 | 0 |
| 25-29 | 0 | 0 |
| 20-24 | 0 | 0 |

**Appendix III**

**ee.** Major Field Test results for Analytical Chemistry in Spring 2013

| | Subscore 4 | |
|---|---|---|
| | Analytical Chemistry | |
| **Scaled Score Range** | **Number in Range** | **Percent Below** |
| 100 | 0 | 100 |
| 95-99 | 0 | 100 |
| 90-94 | 0 | 100 |
| 85-89 | 0 | 100 |
| 80-84 | 0 | 100 |
| 75-79 | 0 | 100 |
| 70-74 | 0 | 100 |
| 65-69 | 2 | 78 |
| 60-64 | 1 | 67 |
| 55-59 | 0 | 67 |
| 50-54 | 0 | 67 |
| 45-49 | 2 | 44 |
| 40-44 | 2 | 22 |
| 35-39 | 1 | 11 |
| 30-34 | 1 | 0 |
| 25-29 | 0 | 0 |
| 20-24 | 0 | 0 |

# Appendix III

## **ff.** Graduation Rate of Program

**Six-Year Graduation Rates by Baccaureate Program (*)**

* The cohorts below are first-time full-time undergraduate students enrolled in a baccalaureate program fall semester who entered CSU in the fall or the preceding summer term.

| Major Program | Number in Fall 2003 Cohort | Fall 2003 Cohort Graduating by 2009 Number | Rate | Number in Fall 2004 Cohort | Fall 2004 Cohort Graduating by 2010 Number | Rate | Number in Fall 2005 Cohort | Fall 2005 Cohort Graduating by 2011 Number | Rate | Number in Fall 2006 Cohort | Fall 2006 Cohort Graduating by 2012 Number | Rate | Number in Fall 2007 Cohort | Fall 2007 Cohort Graduating by 2013 Number | Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Baccalaureate** | | | | | | | | | | | | | | | |
| Accounting | 29 | 8 | 27.6% | 23 | 9 | 39.1% | 19 | 8 | 42.1% | 23 | 10 | 43.5% | 20 | 6 | 30.0% |
| Art | 13 | 5 | 38.5% | 11 | 3 | 27.3% | 14 | 3 | 21.4% | 18 | 4 | 22.2% | 18 | 7 | 38.9% |
| Art Education | 2 | 0 | 0.0% | 2 | 1 | 50.0% | 2 | 1 | 50.0% | 1 | 0 | 0.0% | 2 | 0 | 0.0% |
| Biology | 98 | 36 | 36.7% | 78 | 23 | 29.5% | 101 | 38 | 37.6% | 83 | 33 | 39.8% | 85 | 29 | 34.1% |
| Chemistry | 13 | 4 | 30.8% | 11 | 5 | 45.5% | 24 | 9 | 37.5% | 23 | 6 | 26.1% | 13 | 4 | 30.8% |
| Communication | 26 | 8 | 30.8% | 20 | 5 | 25.0% | 19 | 9 | 47.4% | 23 | 8 | 34.8% | 13 | 2 | 15.4% |
| Computer Science | 37 | 11 | 29.7% | 29 | 2 | 6.9% | 29 | 10 | 34.5% | 24 | 7 | 29.2% | 40 | 19 | 47.5% |
| Criminal Justice | 23 | 7 | 30.4% | 30 | 11 | 36.7% | 40 | 11 | 27.5% | 20 | 9 | 45.0% | 20 | 8 | 40.0% |
| Early Childhood Education | 57 | 29 | 50.9% | 63 | 28 | 44.4% | 56 | 25 | 44.6% | 51 | 23 | 45.1% | 42 | 27 | 64.3% |
| Earth & Space Science/Geology | 2 | 2 | 100.0% | 2 | 1 | 50.0% | 1 | 0 | 0.0% | 2 | 1 | 50.0% | 2 | 1 | 50.0% |
| English Language | 25 | 9 | 36.0% | 20 | 7 | 35.0% | 23 | 8 | 34.8% | 22 | 11 | 50.0% | 15 | 8 | 53.3% |
| Exercise Science | 8 | 2 | 25.0% | 15 | 8 | 53.3% | 18 | 7 | 38.9% | 10 | 7 | 70.0% | 12 | 5 | 41.7% |
| Finance | 6 | 4 | 66.7% | 8 | 4 | 50.0% | 12 | 7 | 58.3% | 11 | 4 | 36.4% | 9 | 4 | 44.4% |
| General Business | 74 | 26 | 35.1% | 45 | 17 | 37.8% | 38 | 16 | 42.1% | 32 | 8 | 25.0% | 40 | 13 | 32.5% |
| Health & Physical Education | 12 | 2 | 16.7% | 9 | 1 | 11.1% | 9 | 0 | 0.0% | 3 | 2 | 66.7% | 4 | 0 | 0.0% |
| Health Science | 10 | 1 | 10.0% | 11 | 5 | 45.5% | 13 | 6 | 46.2% | 8 | 1 | 12.5% | 2 | 0 | 0.0% |
| History | 17 | 6 | 35.3% | 18 | 4 | 22.2% | 17 | 3 | 17.6% | 18 | 8 | 44.4% | 17 | 7 | 41.2% |
| Management | 15 | 3 | 20.0% | 22 | 6 | 27.3% | 40 | 17 | 42.5% | 34 | 12 | 35.3% | 21 | 5 | 23.8% |
| Management Information Systems | 19 | 8 | 42.1% | 9 | 4 | 44.4% | 12 | 3 | 25.0% | 13 | 3 | 23.1% | 6 | 2 | 33.3% |
| Marketing | 21 | 7 | 33.3% | 16 | 6 | 37.5% | 32 | 8 | 25.0% | 16 | 5 | 31.3% | 18 | 7 | 38.9% |
| Mathematics | 11 | 7 | 63.6% | 14 | 6 | 42.9% | 11 | 3 | 27.3% | 15 | 5 | 33.3% | 9 | 1 | 11.1% |
| Middle Grades Education | 6 | 2 | 33.3% | 1 | 0 | 0.0% | 4 | 2 | 50.0% | 2 | 2 | 100.0% | 5 | 0 | 0.0% |
| Modern Language & Culture | 0 | | | 1 | 0 | 0.0% | 2 | 1 | 50.0% | 7 | 2 | 28.6% | 2 | 1 | 50.0% |
| Music Performance | 25 | 14 | 56.0% | 13 | 8 | 61.5% | 21 | 11 | 52.4% | 19 | 10 | 52.6% | 14 | 5 | 35.7% |
| Music Education | 34 | 19 | 55.9% | 16 | 11 | 68.8% | 20 | 13 | 65.0% | 22 | 20 | 90.9% | 28 | 14 | 50.0% |
| Music, General | 4 | 2 | 50.0% | 5 | 2 | 40.0% | 6 | 3 | 50.0% | 3 | 2 | 66.7% | 9 | 3 | 33.3% |
| Nursing | 57 | 27 | 47.4% | 67 | 36 | 53.7% | 90 | 29 | 32.2% | 75 | 32 | 42.7% | 53 | 23 | 43.4% |
| Political Science | 26 | 7 | 26.9% | 28 | 8 | 28.6% | 23 | 9 | 39.1% | 17 | 3 | 17.6% | 9 | 2 | 22.2% |
| Psychology | 50 | 16 | 32.0% | 36 | 9 | 25.0% | 36 | 10 | 27.8% | 42 | 15 | 35.7% | 34 | 11 | 32.4% |
| Sociology | 1 | 0 | 0.0% | 3 | 2 | 66.7% | 3 | 1 | 33.3% | 3 | 1 | 33.3% | 10 | 3 | 30.0% |
| Spec Ed - General Curriculum | 4 | 2 | 50.0% | 3 | 0 | 0.0% | 2 | 1 | 50.0% | 1 | 0 | 0.0% | 2 | 2 | 100.0% |
| Theatre | 16 | 4 | 25.0% | 14 | 5 | 35.7% | 23 | 8 | 34.8% | 38 | 18 | 47.4% | 27 | 9 | 33.3% |
| Theatre Education | 9 | 3 | 33.3% | 9 | 5 | 55.6% | 8 | 5 | 62.5% | 11 | 6 | 54.5% | 9 | 4 | 44.4% |
| *Total Baccalaureate* | *750* | *281* | *37.5%* | *652* | *242* | *37.1%* | *768* | *285* | *37.1%* | *690* | *278* | *40.3%* | *610* | *232* | *38.0%* |