

Excellent Undergraduate Chemistry Programs

An excellent chemistry program is an integrated, broad-based, challenging chemical experience designed to provide an undergraduate with the intellectual, experimental, and interactive skills to participate effectively in the chemical sciences enterprise. It is the product of an energetic and accomplished faculty offering a coherent and rigorous program of study and engagement that grounds the student in the molecular perspective of chemistry and encourages students to extend their understanding through the basic precepts of the scientific method. An excellent program is performed in well-designed facilities with modern sophisticated instrumentation. An excellent program also fosters in the student the professional skills of communication, teamwork, and desire to learn that are hallmarks of the successful modern chemist.

The excellent program is the product of careful planning by the department and the institutional administration and requires the commitment of financial, physical, and human resources. It is designed to build competence and promote significant student achievement, while meeting the particular needs of the institution's student body. An excellent program has a vibrancy that creates a clear sense of sustainability and resilience to ensure a constant stream of dedicated and accomplished students.

The four basic elements of an excellent program – curriculum and student learning, pedagogy, infrastructure, and faculty – are discussed below.

Curriculum and Student Learning

The curriculum of an excellent program is designed to instill in the student an appreciation of chemistry in science and in society from a molecular perspective. The specific implementation of the curriculum is defined with respect to the mission of the institution, goals of the program, and career goals of the students.

Student-Centered Aspects in the Curriculum

- **Foundation Courses.** Course work in core areas of chemistry (analytical, biochemistry, inorganic, organic, and physical).
- **In-depth Courses.** Course work that builds upon the foundation courses. These courses focus on a specific area within the chemical sciences or provide a modern chemistry perspective to an interdisciplinary topic.
- **Laboratory Experiences.** “Hands-on” laboratory experiences that involve the synthesis of molecules and the measurement of chemical properties and phenomena; “hands-on” use of modern instrumentation and technologies. These experiences promote observation of phenomena, critical thinking, and interpretation of data by the student.
- **Information and Literature Searching.** Opportunities for students to search and use the primary and secondary chemical literature and scientific databases.
- **Computational Chemistry.** Computer modeling to understand and predict chemical properties and phenomena.
- **Research.** Opportunities for undergraduates to participate in the basic discovery process that leads to the creation of new knowledge as a means for students to apply their chemistry knowledge and skill. The undergraduate research experience culminates with a comprehensive written report.
- **Professional Skills.** Development of the ability to work safely in a laboratory environment; effective oral and written communication; the ability to work effectively as a member of a team; the ability to ask questions, design experiments, and interpret results within the context of current scientific knowledge; the behaviors and thought patterns leading to innovation; enhanced leadership abilities; the capacity for lifelong learning; and the internalization of an intellectual framework leading to ethical scientific conduct.

Programmatic Aspects

An excellent program supports the development and maintenance of a modern curriculum through:

- **Coherent Design.** Student experiences build upon previous educational experiences. The frequency of course offerings must support student enrollment in courses with a logical progression.
- **Responsive to Student Needs.** Course content and delivery which reflect the needs, diversity, and desired outcomes of the student body, including those of transfer students.
- **Support for Innovation.** Support and encouragement for course innovation to achieve ongoing improvement.
- **Regular Assessment of Curriculum.** Regular review of the curriculum to ensure that it reflects modern developments in chemistry.
- **Regular Assessment of Student Learning.** Continual assessment of student learning and incorporation of results to improve the learning process.

Pedagogy

The pedagogical approaches of an excellent program generate an integrative experience in which students learn to apply their knowledge in new contexts and can seamlessly transition to postgraduate activities.

Content is delivered in a manner that is challenging, engaging, inclusive, and taught in a manner that accommodates a variety of learning styles. Achieving these goals requires a mechanism for regular evaluation and improvement of pedagogical approaches. The development of innovative and dynamic pedagogy enhances the program's ability to achieve excellence in content delivery while aiding the development of student capacity in the professional skills outlined above.

Faculty-student interactions should

- excite students about chemistry;
- provide students with the ability to apply knowledge and skills to new situations; transfer knowledge from one context to another;
- provide effective mentoring; and
- offer feedback to students leading to enhanced competency in professional skills.

In addition to faculty-student interactions that take place within the formal curriculum, these outcomes are achieved in excellent programs through additional programmatic activities such as seminars, student involvement in outreach activities, research, internships or cooperative experiences, and participation in scientific conferences.

Infrastructure

A modern, well-maintained infrastructure is an essential component of an excellent program. Excellent programs develop strategic plans to sustain a high quality infrastructure that are sufficiently flexible to accommodate new program initiatives over time. The hands-on use of instrumentation, software, and chemical information access tools by students is essential for their effective training.

Student-Centered Aspects

- **Instrumentation.** Instruments available to students are reasonably recent models, in good working order, that are currently used by professional chemists; several sophisticated instruments suitable for undergraduate instruction and research are available to students, as are computer facilities for data analysis and database mining.
- **Computational Capabilities and Software.** Capabilities to compute chemical properties and phenomena are available to students that complement experiments by providing understanding and predictive power; computing facilities and computational chemistry software is available for use in course work and research.
- **Chemical Information Resources.** Access to the chemical literature, technical databases, and resources for searching the literature is of paramount importance for faculty and students. Facilities that allow easy access to electronic information are required. Timely access of journal articles not available on site must also be provided.

Programmatic Aspects

- **Physical Plant.** A well-maintained physical plant provides adequate classroom, laboratory, office, and interactive spaces (common access for discussion) to accommodate all aspects of the program. Dedicated laboratory space for faculty and student research is available. Facilities to support teaching and research, such as machine and electronics shops and glass blowing, are also desirable.
- **Administrative Structure.** The administrative structure of the department provides the appropriate level of financial and personnel support to maintain an excellent program. Administrative, stockroom, and technical support staff are available to assist faculty with ancillary activities, thereby freeing faculty to devote their time and effort to academic responsibilities and scholarly pursuits.
- **Chemical Safety.** Laboratories are well ventilated and equipped with the required safety features; chemical waste handling capabilities and expertise are available. All students and faculty receive appropriate safety training, use safety documentation, and wear personal protective equipment.

Faculty

The faculty represents an essential element of an excellent undergraduate program and performs a number of critical roles. First, the faculty is responsible for definition of overall goals of the undergraduate program within the context of the mission and student body characteristics of the institution. In addition, the faculty defines the vision for student outcomes of a particular chemistry program. Finally, the faculty interfaces with the administration of the institution and articulates student and programmatic needs for sustaining an excellent undergraduate program.

The faculty is the conduit through which the content knowledge and professional skills that comprise an undergraduate program in chemistry are transmitted. As such, the faculty is energetic and significantly engaged in the educational mission of the department through their participation in activities that support sustained program excellence such as curricular and program improvement and activities for faculty-student interaction (research, seminars, etc.). To meet these demands, the faculty is comprised of a suitable number of members with the appropriate educational background and expertise. Faculty members hold the PhD degree, have collective expertise in the major subdisciplines of chemistry, are reflective of the diversity that exists in society, and maintain their professional competence at a level that reflects the current state of the discipline.

Programmatic Aspects

An excellent program has in place suitable mechanisms for identification and recruitment of new faculty members and assessment of faculty competence in areas related to the performance of their jobs in terms of teaching, research, and service as appropriate to the institutional mission.

An excellent program pays adequate attention to sustainable faculty development and has mechanisms in place for ensuring such. The creation of this environment requires

- competitive faculty compensation;
- opportunities for regular faculty renewal through sabbaticals and participation in professional meetings and other professional activities; and
- a reasonable limit on faculty teaching contact hours.

An excellent chemistry program has in place sustainable mechanisms for

- faculty mentoring;
- development of faculty leadership; and
- regular assessment and feedback of faculty strengths and areas for improvement.

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