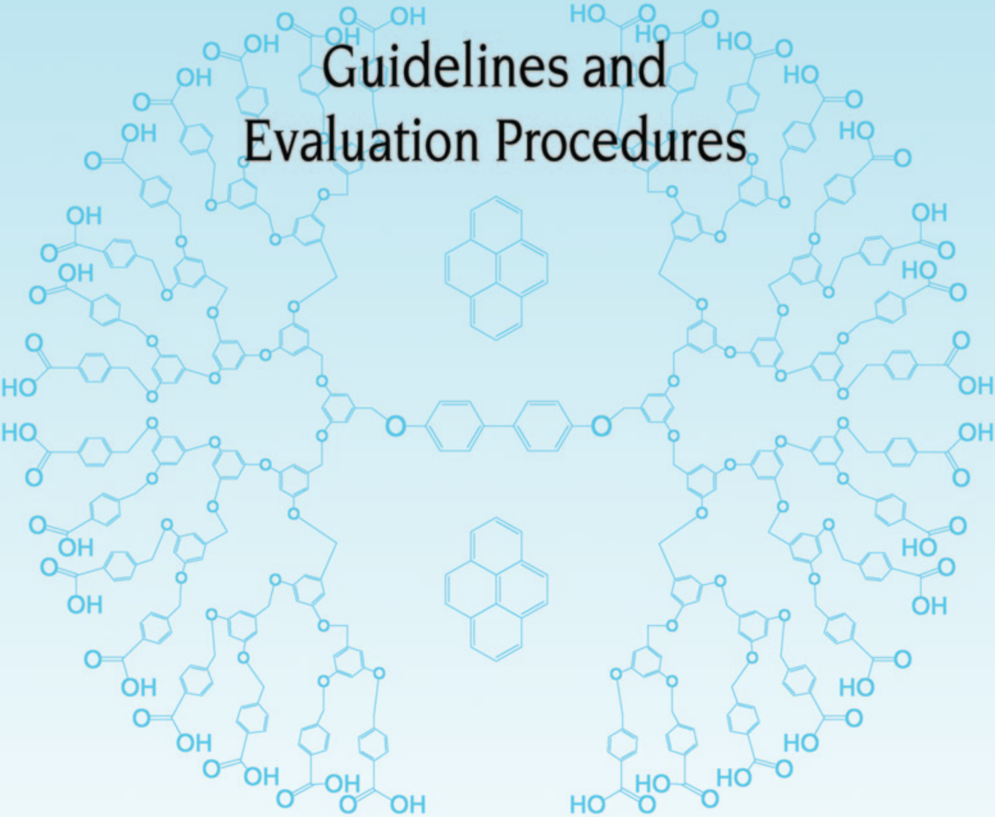
Undergraduate Professional Education in Chemistry

Guidelines and Evaluation Procedures



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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.

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INTRODUCTION

This booklet contains the guidelines of the American Chemical Society (ACS) for chemistry departments in colleges and universities that prepare undergraduate students for employment as professional chemists, for entrance into graduate school in chemistry and related fields, and for employment in areas in which a strong background in chemistry is needed. The Committee on Professional Training (CPT) of the Society has developed the guidelines and administers their application. The Committee also publishes annual reports in *Chemical & Engineering News* on the number of graduates of chemistry departments with ACS-approved programs and supports graduate education in several ways. Day-to-day operations of the Committee are administered by the Secretary of the Committee, who is located in the Office of Professional Training at the ACS headquarters in Washington, D.C. Current information about the guidelines and the work of the CPT is available from the ACS website at www.chemistry.org.

Work of the Committee on Professional Training. The primary objective of the CPT is to facilitate the maintenance and improvement of the quality of chemical education at the postsecondary level. The Committee strives to do so in a variety of ways:

- **Undergraduate Education**—by developing and administering the guidelines that define high-quality undergraduate programs. On behalf of ACS, the Committee approves those departments or programs that meet the guidelines. In turn, the chair of an approved department or program certifies annually those students who successfully complete an approved degree program. The Committee reviews the programs of approved departments on a five-year cycle and provides assistance to colleges and universities that desire to be added to the list of approved schools. A group of Associates of the CPT assists by visiting departments that seek ACS approval or have approved programs that no longer meet the guidelines.
- **Graduate Education**—by publishing biennially the *ACS Directory of Graduate Research* (DGR). This compilation, which is also available online by subscription, contains information of particular interest to students considering graduate education in chemistry, chemical engineering, biochemistry, and closely related fields in the United States and Canada. The DGR is also useful to others who are interested in the faculty makeup and productivity of graduate departments.

The Committee conducts studies on graduate education in the chemical sciences and publishes reports of the findings. Typically these studies are based on questionnaires.

- **Analysis of Trends in Chemical Education and Maintenance of Records**—by maintaining extensive records on the undergraduate programs of all institutions approved by the Society. The Committee also collects and reports information on trends, developments, and problems in chemical education.
- **Cooperation**—by cooperating with the chemical industry and with various professional and educational organizations concerned with maintaining high-quality postsecondary education.

The Committee meets twice a year at the time of the spring and fall national meetings of the Society. At the national meetings the Committee also holds open meetings to afford members of the Society and others the opportunity to discuss, comment on, and offer suggestions concerning the activities of the Committee. The Committee also holds a midwinter meeting.

Publications of the CPT. The Committee has several publications in addition to this guidelines booklet and the DGR. A report summarizing the Committee's activities is submitted annually to the ACS Board and Council. The annual report, which includes the numbers of graduates (bachelor's, master's, and doctoral degrees) in chemistry from the ACS-approved schools and in chemical engineering from the AIChE/ABET-accredited chemical engineering departments, is published in *Chemical & Engineering News* each year. Recent reports are available on the CPT website. Twice a year the Committee publishes the *CPT Newsletter*, which is sent to all chemistry faculty members at ACS-approved schools. This newsletter reports on surveys, describes changes in the guidelines that are under consideration or that have been made, and tells about innovations in chemistry curricula and teaching at the undergraduate level. The Committee also publishes two booklets: *Planning for Graduate Work in Chemistry* provides advice to students planning to go to graduate school in the chemical sciences, and *Planning for a Career in Industry* provides advice to students planning to seek employment after finishing baccalaureate studies.

Mandate of the CPT. The CPT was established by a resolution of the ACS Council in 1936, one year before the ACS Charter was issued by an Act of Congress on August 25, 1937. This resolution authorized the president of the ACS to appoint a continuing committee to study the training of professional chemists and chemical engineers. In 1968 the CPT became a Joint Committee of the ACS Board and Council, reporting to both. In 1979 the responsibilities of the CPT were codified in ACS Bylaw III,3. The pertinent section is:

(h) Committee on Professional Training

(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.

Membership of the CPT. The CPT currently has 17 members. One serves as chair, and one is a nonvoting staff secretary. Sometimes the Committee retains one or more former members as nonvoting consultants. Members are usually appointed to three-year terms and may be reappointed for up to a total of nine years of service. All appointments and reappointments are made jointly by the chair of the ACS Board of Directors and the president of the Society with the advice of the ACS Committee on Committees. The members of the CPT are experienced educators and scientists from all areas of the country. The members are chosen to represent different fields of chemistry, different points of view, and different types of academic as well as nonacademic institutions concerned with chemical education and the chemical sciences. Consultants are appointed to the Committee on special occasions to provide expertise and continuity of operation.

Costs Associated with the CPT and the Approval Program. With the exception of the *ACS Directory of Graduate Research*, which is self-supporting, funds to support the Committee and its various activities are provided entirely by ACS. The Society makes no charges to academic institutions for the evaluation program, including visits by Associates.

Structure of the Guidelines Booklet. Section 1 of this booklet gives the specific guidelines that have been established for undergraduate professional education in chemistry, and Section 2 describes the procedures for administering the guidelines, including the initiation and continuation of the approval process. The guidelines are designed only for professional programs and are, therefore, not directly applicable to programs with less extensive requirements, which nevertheless may meet a particular department's criteria for a major in chemistry. Indeed, many institutions with ACS-approved degree programs offer other degree programs that require less chemistry than is needed for the professional degree.

Flexibility in the Administration of the Guidelines. The first edition of the guidelines, which appeared in 1939, consisted of a set of minimum standards that were presented in a qualitative fashion. Over the years the guidelines have become increasingly quantified, particularly with respect to the number of classroom and laboratory hours. From the outset, however, the willingness of the Committee to be flexible in its administration of the guidelines has been stressed, and this practice continues to be the case. Chemistry is primarily an experimental science, and the teaching of chemistry should be approached in an experimental vein. Innovative curricula and novel methods for solving pedagogical problems are encouraged. The Committee attempts to interpret the guidelines with sufficient latitude to accommodate a variety of approaches to providing quality education in chemistry. Since 1988, the guidelines have facilitated this variety by including several options that complement the regular chemistry track. Included in these options are ones with an emphasis on biochemistry, chemical physics, chemistry education, environmental chemistry, materials, or polymers. These options are all built on a core in common with the chemistry degree program.

Why Have an Approval and Certification Program? Over 600 chemistry programs in colleges and universities in the United States are ACS-approved. Over 120 chemistry programs also offer degree options. About 40 percent of the students graduating from these chemistry programs are ACS-certified. Many departments seek ACS approval and advertise that they are approved to assure students that they have high-quality programs in chemistry. Some institutions use ACS approval of another institution as a basis for accepting transfer credits in chemistry. For the student, a certified degree in chemistry is a valuable personal credential that serves as national-level recognition for successfully completing a rigorous academic chemistry curriculum in an ACS-approved department. In many college and university chemistry departments, more than one path is offered for a chemistry, biochemistry, or related major. The program that results in an ACS-certified degree invariably is the more demanding one. The extra rigor and additional requirements of the certified degree are valued by potential employers and graduate schools alike. Employers realize that graduates of approved programs have better preparation for technical employment. Some companies offer higher starting salaries to certified degree holders than to noncertified classmates. Although graduate school admissions committees are unlikely to consider overtly whether a graduate holds a certified degree, the admissions committees will be impressed by the stronger preparation required for a certified degree and by a student being a graduate of an approved department. An ACS-certified graduate is eligible for immediate membership in the ACS and thus is able to secure the benefits of membership, which include helpful services such as finding employment.

Correspondence concerning activities of the Committee and requests for its assistance and cooperation should be addressed to the Secretary, Committee on Professional Training, American Chemical Society, 1155 Sixteenth Street, N.W., Washington, DC 20036. The e-mail address is cpt@acs.org.

SECTION 1
THE GUIDELINES

In reading the following guidelines, one should keep in mind that ***approval*** refers to the approval of an overall program as satisfying the guidelines of ACS, whereas ***certification*** refers to action by the program chair in designating a particular graduating student as having satisfied ACS curricular guidelines. On behalf of ACS, the *CPT approves* programs. *Chairs certify* annually those students who have met the curricular guidelines of approved programs.

1.1 Scope and Organization of the Chemistry Program

An effective, modern program of chemical education at the undergraduate level must do more than prepare professional chemists. Chemistry, the central science, is an important component of many disciplines and should be made accessible to all students seeking a liberal education. Chemists should contribute actively to raising the level of scientific literacy of all students. The nature of any particular undergraduate program will be governed by the overall educational objectives and resources of an institution. In every case, however, the entire program should serve all students in the institution by recognizing their different needs, interests, and career goals. For programs intended to prepare students for professional work in chemistry or for entrance into graduate school in accordance with the guidelines, not only must there be strong institutional commitment, as reflected in faculty size, laboratory facilities, instrumentation, and library resources, but there must also be a sufficient number of students in chemistry to justify this commitment.

A strength of chemistry as general education as well as professional training is that problem-solving skills are emphasized and developed. Problem-solving skills cross the traditional subdivisions of chemistry. Enhancing the learning of how to solve problems may lead to less emphasis on coverage of content and to greater emphasis on projects. The guidelines are expressed in ways that encourage integrating the subareas of chemistry and emphasizing problem solving. Optimum learning occurs where problem solving and laboratory experience reinforce the study of essential content. In addition, undergraduate research projects can be powerful examples of problem solving. Problem solving also lends itself to teamwork, the manner in which much research and development work is done. Experience-based learning through industrial internships and other work opportunities also contributes to learning how to solve problems. Of comparable importance to problem solving is effective communication through writing and speaking.

The chemistry program should be administered by a chemistry department organized as an independent unit with control of an adequate budget. The department should be involved in and exercise reasonable control over faculty selection and promotion, course development, assignment of teaching responsibilities, grading standards, and similar intradepartmental activities. At those institutions where the department is administered as a division of a larger unit, it is essential that the chemistry faculty have enough autonomy and budget control to carry out these functions and responsibilities within the division. The institution should have procedures for periodic self-evaluation of its programs that assess their effectiveness, their achievements, and their compatibility with other institutional objectives.

1.2 Financial Support

An adequate level of financial support, with continuity and stability, is essential to a strong, modern program of education in chemistry. The institution must display a willingness and ability to make such a financial commitment, and the level should be consistent and reasonable in relation to the overall resources of the institution and its educational goals. Financial support for the institution is necessary for

- a chemistry faculty of sufficient size and scientific breadth to offer the variety and level of chemistry courses specified in these guidelines;
- enough nonacademic personnel for administrative support services, stockroom administration, and instrument and equipment maintenance;
- laboratories and classrooms that meet current safety standards;
- capital equipment acquisitions, replacements, and expendable supplies as required for high-quality laboratory instruction;
- equipment maintenance and repair;
- adequate waste-handling and disposal facilities;
- a suitable amount and variety of chemical information resources, including chemical research periodicals (print or online), reference materials, and *Chemical Abstracts* and other database searching facilities;
- chemical computation;
- student and faculty research;
- faculty and student travel to professional meetings; and
- opportunities for scholarly growth of faculty, including sabbatical leaves.

1.3 Curriculum Requirements

Introduction. The principal purpose of the ACS approval process for undergraduate programs is to help departments provide chemistry majors with a sound education in the fundamental areas of modern chemistry. The CPT believes that it can help departments best by setting general curricular goals rather than by specifying exact curricular structure, realizing that a department's curriculum should build on the strengths of the institution and its faculty. Programs as different in character as those with a major emphasis on fundamental principles and those that are strongly based on industrial applications have produced students who have gone on to have distinguished careers in chemistry. As stated in the Introduction, the Committee encourages departments to explore the many ways in which a curriculum can meet the guidelines described below.

Core Curriculum Requirements. Programs of study in chemistry curricula for majors and nonmajors can be organized in many ways to reflect the institution's mission, the available facilities, and the interests and capabilities of the students and faculty. Regardless of which organization of the curriculum is adopted, that part of the program specified as the core curriculum is taken by all certifiable chemistry graduates and includes a minimum of 28 semester credit hours (or the equivalent for institutions on the quarter system) of basic instruction with comparable emphasis on the areas of **analytical chemistry, inorganic chemistry, organic chemistry, and calculus-based physical chemistry**. At least three semester credit hours of **biochemistry** must also be part of the undergraduate curriculum for all certified graduates. There are at least three possible modes for satisfying the biochemistry requirement. One consists of integrating the equivalent of three semester credit hours of biochemistry into the core by distributing the material among other core courses. The second is to offer biochemistry as a separate core course. The third is to require biochemistry as one of the advanced courses. For degree options other than chemistry itself, some of the core may be modified as indicated in the Degree Options section below.

The 28 semester credit hours of study shall include a minimum of 7 semester credit hours (300–350 contact hours) of laboratory instruction distributed, not necessarily in equal proportions, among synthesis and characterization of inorganic and organic compounds, chemical and instrumental methods of analysis, and experimental physical chemistry. Although a laboratory component is not required for biochemistry, such experience is welcome.

All of the core should be taught annually. Under special circumstances, some core courses may be taught on a regular biennial schedule that enables all students to take them in a planned way.

Advanced Course Requirements. Advanced courses build in a significant way upon concepts introduced in the core curriculum (see Commentary on Advanced Courses in Sec. 1.4). A minimum of two advanced courses must be taught on a regular cycle. In addition to the core curriculum, minimum requirements for approval of the chemistry degree program and for certifying students as having completed this program follow.

Chemistry. Six semester hours of advanced courses that include sufficient laboratory work to bring the total number of laboratory contact hours to 500. For individual students, the advanced courses may include or even consist entirely of research that culminates in a comprehensive written report. If the equivalent of three semester credit hours of biochemistry is not incorporated into the core, one of the advanced courses must be a course in biochemistry.

Degree Options. In addition to the required chemistry degree program, approved departments may offer up to six degree options. Minimum requirements for the following five degree options are completion of the core curriculum, the equivalent of three semester credit hours of biochemistry, a total of 500 laboratory contact hours, and advanced course work as described below. Advanced courses may be offered by departments other than chemistry.

Biochemistry. Beyond the introductory level, three semester hours of biology, which contains cell biology, microbiology, or genetics; six semester hours of biochemistry that has organic chemistry as a prerequisite; and one semester of a laboratory in biochemical methods. Research in biochemistry culminating in a comprehensive written report is highly recommended.

Chemical Physics. Six semester hours of physics beyond the first-year level and at least six semester hours selected from advanced theoretical chemistry, advanced physics, or advanced mathematics. These advanced courses may include physics laboratory and/or research culminating in a comprehensive written report.

Environmental Chemistry. Six semester hours of biology, geology, or other environmentally related science, and at least six semester hours of advanced work in chemistry of the environment, including some aspects of aquatic chemistry, atmospheric chemistry, and geochemistry. Field work and studies of modeling in environmental systems are encouraged in the advanced work. These advanced courses may include research culminating in a comprehensive written report.

Materials. Equivalent of six semester hours of materials science, including polymer ceramics, metallurgy, and solid-state devices; one semester of materials science laboratory, including synthetic and physicochemical characterization of processed materials; and at least three semester hours of an advanced course, which may be research culminating in a comprehensive written report.

Polymers. Equivalent of six semester hours of polymer science, including an introduction to materials science and the organic, inorganic, and physical chemistry of polymers; one semester of polymer science laboratory; and at least three semester hours of an advanced course, which may be research culminating in a comprehensive written report.

Departments have the flexibility in association with the above degree options of reducing the core by up to four semester hours. The expectation for the core remains that it includes balanced emphasis on the areas of analytical, inorganic, organic, and physical chemistry. The reduction in the core should not entirely eliminate any of these areas.

The sixth degree option that an approved department may apply to offer is chemistry education, which is designed for students who are also completing education courses for a pre-college teaching career.

Chemistry Education. The core, laboratory, and advanced course requirements are different for the chemistry education degree option. Minimum requirements for this degree option are a total of 33 semester credit hours of core and/or advanced chemistry courses, which include no fewer than 270 total laboratory contact hours. Students take the same first two years that certified chemistry majors take in introductory and organic chemistry, but only one semester of organic chemistry laboratory is required. Experiences equivalent to one-semester courses in biochemistry, analytical or environmental, inorganic, and physical chemistry are required, along with one additional course or research that builds on this foundation. In addition, the equivalent of a three-semester-credit-hour course in chemistry teaching methods is required (see Commentary on Chemistry Education in Sec. 1.4). Students are also expected to complete the courses in education needed for teacher certification as defined by state requirements.

Chemistry faculty are expected to be directly involved in the design and instruction of the chemistry teaching methods course.

Approval of degree options requires that the chemistry program itself be approved. Degree options may involve departments other than chemistry, but appropriate materials must be submitted for approval with the cooperation of the previously approved chemistry program, which provides the core.

Graduates may only be certified in degree options if those options have been approved by ACS. Individual graduates may be certified in more than one degree option *but are counted as certified only once by ACS.*

Ancillary Course Requirements. Calculus is required for physical chemistry. Certified graduates should study calculus through multivariate analysis and be exposed to linear algebra and differential equations. Work equivalent to at least a one-year, laboratory-based course in physics, preferably at a level involving calculus, is required and should precede the basic course in physical chemistry and most advanced work in chemistry.

Minors in Chemistry. A minor in chemistry should include a minimum of 20 semester credit hours (or equivalent). Two or more areas of chemistry should be chosen beyond the first-year courses in chemistry from the following: analytical, biochemistry, environmental, inorganic, organic, and physical. A minor should include 200 total contact hours of laboratory experiences in at least two different areas beyond first-year chemistry. The award of a minor in chemistry to a graduate does not lead to certification of the student.

Although the Committee provides advice for a minor in chemistry, the only minor evaluated by the CPT is the minor in chemistry education described below. Graduates may only be awarded an ACS minor in chemistry education if the minor has been approved by ACS.

Minor in Chemistry Education. In addition to the above description of a chemistry minor, one semester of physics with laboratory and the equivalent of a three-semester-credit-hour course in chemistry teaching methods. Students who receive an ACS minor in chemistry education are also expected to complete a major in another natural science.

1.4 Commentary on Curriculum Requirements

The Core Courses in Chemistry. The Committee recognizes that numerous course structures and sequences exist, particularly with regard to integration of core topics throughout the curriculum. Many institutions choose to retain a traditional first-year course, which includes general principles of chemistry, descriptive chemistry of the elements, introductory principles of physical chemistry, and chemical analysis. In other cases, a student's introduction to college chemistry may be through courses that are more specific in coverage of organic chemistry, inorganic chemistry, or quantitative chemical analysis. In any case, portions of the first-year course may be used to satisfy some of the core requirements. For the Committee to assess the contribution of first-year course work to overall coverage of core topics in the curriculum, supporting documentation in the form of syllabi and examinations is required.

The guidelines provide considerable flexibility in satisfying the curriculum that is required for approval. For example, if basic inorganic chemistry and chemical analysis along with organic chemistry are covered in the first two years, the remaining core material is covered typically with additional study of physical chemistry, inorganic chemistry, and instrumental methods of analysis. Frequently, the study of inorganic chemistry and instrumental analysis requires organic chemistry and calculus-based physical chemistry as prerequisites. If biochemistry is part of the core, it could be distributed in the analytical chemistry, inorganic chemistry, organic chemistry, and physical chemistry sequences.

Having a degree option without excessive requirements may depend on creative reworking of the core. Integrated laboratories are one accepted way to make a curriculum more efficient. Wherever possible, core courses should include examples of materials chemistry, polymer chemistry, and applied chemistry, particularly in cases where these areas are not covered in advanced courses. Throughout the core, attention should be given to teaching the principles of chemical safety and to the systematic use of chemical information.

The First-Year Courses in Chemistry. A first-year course in chemistry poses a challenge for many departments. A course designed for students who already have an adequate background in chemistry can include partial coverage of some of the core topics discussed above. A course designed for science-oriented students lacking this background, however, may be more general in character. Chemistry departments must also recognize their special obligation to serve the educational needs of students not oriented to science, an obligation that is a major challenge to the profession and an excellent opportunity to make a significant contribution to the careers and intellectual development of many future citizens and community leaders. The Committee welcomes innovative approaches to meeting these challenges. At the same time, however, the Committee is attentive to determining whether a particular first-year course is playing its intended role as part of the core curriculum. For this reason, the Committee asks the department to provide information regarding the distribution of core topics throughout the curriculum, particularly the manner in which they are included in first-year courses.

A first-year course and the subsequent courses in chemistry should incorporate historical perspective as well as references to current developments in chemistry. Emphasis on pure theory has too often led to neglect of the practical, aesthetic, and humanistic aspects of chemistry. Classroom experiments and demonstrations are particularly effective in presenting descriptive material and in generating lasting interest in chemical phenomena, and they should be employed wherever possible. Discussions of real-world problems and an early introduction to instrumental and computational techniques can give students an immediate sense of how chemistry is done today. Such teaching can also be an effective way to capture student interest. Similarly, efforts should be made to use various forms of multimedia learning resources such as computers, slide and videotape presentations, hands-on classroom activities, and Internet-based instructional materials.

Laboratory Work in Chemistry. Laboratory instruction should include practical experience with instrumentation for spectroscopy, chemical separations, and electrochemical methods. It should give students hands-on experience with chemistry and the self-confidence and competence to

- keep legible and complete experimental records;
- synthesize and characterize inorganic and organic compounds;
- perform accurate and precise quantitative measurements;
- use and understand modern instruments, particularly NMR, FT-IR, and UV-vis spectrometers; GC, GC-MS, and HPLC instruments for chemical separations; and electrochemical instruments;
- interpret experimental results and draw reasonable conclusions;
- analyze data statistically and assess reliability of results;
- anticipate, recognize, and respond properly to hazards of chemical manipulations;
- design experiments;
- plan and execute experiments based on searching and using the literature;
- communicate effectively through oral and written reports; and
- work effectively in small groups and teams.

A number of schools have combined the experimental techniques from such specialties as physical chemistry, chemical analysis, and synthetic organic and inorganic chemistry into integrated laboratory experiments or into problem-based laboratory experiences. In such cases, care should be taken to ensure that the number and types of experiments are at least equivalent to those of more traditional laboratory curricula and that the integration of laboratory work does not result in the loss of important concepts stressed in a particular chemical specialty. To assess the coverage in integrated laboratories, the Committee asks to see syllabi and experiment lists.

While computer simulation can enhance instruction in laboratory instrumentation, computer-simulated instruments cannot substitute for actual instruments and real samples. On the other hand, chemical computation of the properties of molecular and macromolecular systems has become a familiar and important part of chemical laboratories, and such experiences may count toward the laboratory requirement for certified majors.

Biochemistry. Biochemistry must be part of the curriculum for all certified majors. Approved programs may implement this requirement by integrating the equivalent of three semester credit hours into required core courses, offering a separate required core course in biochemistry, or requiring certified graduates to take an advanced course in biochemistry. A laboratory experience in biochemistry is optional. If a department adopts the advanced course approach, the minimum number of semester credit hours of basic instruction in the core would continue to be 28. If biochemistry is integrated into the core, the remaining part of the core must have a comparable emphasis on analytical, inorganic, organic, and physical chemistry. When biochemistry is integrated into the core, the CPT expects syllabi and exams to be supplied as part of five-year reports. If the biochemistry course is used as an advanced course and is not taught in the chemistry department, it must meet the standards for advanced courses described below.

Advanced Courses. For the purpose of approval of departmental programs and certification of graduates, advanced chemistry courses are defined as those that (a) are not part of the core (some of which might carry the department's description as "advanced") and (b) have a major portion of the core curriculum as a prerequisite, including physical chemistry in many but not necessarily all cases. Advanced courses must build in a significant way upon concepts introduced in the core curriculum. For example, a biochemistry course that uses quantitative concepts involving kinetics, thermodynamics, and solution properties of macromolecules and has two semesters of organic chemistry as a prerequisite would be acceptable. Similarly, a synthesis course that builds on elementary courses and offers truly advanced material is acceptable without a physical chemistry prerequisite. Assessment tools for advanced courses should verify that the course material builds significantly upon the core curriculum. For those advanced courses for which physical chemistry is not a stated prerequisite, the Committee requests copies of the course syllabi, all examinations, and other assessment tools.

At least two advanced courses must be taught on a regular schedule that permits students to enroll in the courses in proper sequence and with reasonable flexibility.

Although an individual student may be certified by the substitution of six semester hours or the equivalent in research for two advanced courses, the department is expected to teach advanced courses for two reasons. One reason is to provide an alternative path for certification for students who do not do sufficient research. The other reason is to engage faculty members in the professional enrichment that comes from teaching advanced courses.

Research. Undergraduate research can integrate the components of the core curriculum into a unified picture and help undergraduates acquire a spirit of inquiry, independence, sound judgment, and persistence. By doing research, undergraduates develop the ability to use the chemical literature and report effectively in spoken and written presentations. Also, supervision of research helps the faculty maintain enthusiasm, professional competence, and scholarly productivity.

The Committee strongly endorses undergraduate research as one of the potentially most rewarding aspects of the undergraduate experience. A successful project requires proper and careful attention by the faculty advisor. It places heavy demands on the faculty, the students, and the institution. The ideal research project is well-defined, stands a reasonable chance of completion in the time available, avoids excessively repetitive work, requires the student to use advanced concepts as well as a variety of experimental techniques and instruments, and develops chemical information that might be publishable. It brings the student into active contact with the research literature. Though reality frequently falls short of the ideal set of goals, the experience can nevertheless be extremely valuable.

A well-written, comprehensive, and well-documented research report must be prepared, regardless of the degree of success of a student's project. The faculty supervisor should constructively criticize the report during the draft stage. Oral, poster, and computer presentations do not meet the requirement of a comprehensive written report. Student co-authorship on a journal article, while highly desirable, is not a substitute for a comprehensive report written by the student.

As much as two semester equivalents (six semester hours) of research consistent with this description may take the place of advanced courses for certification of individual students. A good research project would involve at least 90 hours of work per semester (or the equivalent in quarter hours) and could provide the additional hours to bring the laboratory total to 500 hours. If research is used as one or both advanced courses for certification of students, the Committee asks to see examples of graded student research reports as part of each five-year review.

Research done off campus must meet the same high standards as on-site research. In addition, a faculty member at the home institution must take responsibility for the quality of the research done off-site and for the quality of the final report on the research. Such comprehensive reports on the research done off-site should be evaluated by the sponsor at the home institution and made available for submission to the CPT as part of a five-year report.

Many institutions have substantial summer undergraduate research programs. Student participation in some of these research programs may even be required. Research done during the summer, even though it may not be credit-bearing, may count toward certification of individual students (*e.g.*, in place of senior research). For summer research experiences to be counted in this way, the work should be of at least eight weeks in duration, and the standards of final report writing should be as high as those expected during the academic year. Such final reports must be evaluated by a faculty member at the home institution and must be available for submission to the CPT as part of a five-year report.

Chemistry Education Option and Minor. There is a critical need for high school chemistry teachers, who will have a substantial impact on undergraduate and graduate chemical education, as well as on the profession. Many well-trained high school chemistry teachers are close to retirement, and most teachers of high school chemistry courses have limited college-level work in chemistry. The CPT has developed two programs for addressing the need to prepare students for a high school teaching career: a streamlined chemistry education option and a new minor in chemistry education. Both of these can be offered by ACS-approved chemistry programs after applying to the CPT and receiving approval.

The chemistry education option degree is designed for students preparing for a pre-college teaching career in chemistry. The total number of chemistry courses and laboratory contact hours has been reduced for this option degree to provide the requisite time in an undergraduate curriculum for students to complete course work in education needed for state certification to teach in secondary schools. The Committee recognizes the importance of laboratory work for pre-service teachers as preparation for their future chemistry teaching through inquiry-based exercises and therefore strongly encourages laboratory experience beyond the minimum requirement through course work or research. The chemistry teaching methods requirement for this option and the minor in chemistry education ensures that students develop the skills needed for teaching secondary school chemistry. This requirement may by satisfied by completion of a specific course or by other experiences that include laboratory experiment design and preparation, acquisition and storage of chemicals and laboratory apparatus, safety, disposal of chemical waste, teaching assistant experience, and the literature of chemical education. This requirement may be met through various means, including independent study, teaching assistantships, a specific methods course, and interdisciplinary study. Chemistry faculty are expected to be directly involved in the design and instruction of the chemistry teaching methods course.

The minor in chemistry education is designed for students preparing for a pre-college teaching career in a natural science other than chemistry. High school science teachers are often called upon to teach many science disciplines. The minor in chemistry education would enable a student who is majoring in a different natural science to obtain some chemistry knowledge and practical skills used in teaching high school chemistry.

Related Studies. Well-prepared students should emerge from a program in chemistry with

- a firm foundation in the fundamentals and applications of calculus, including proficiency with partial derivatives and some knowledge of differential equations;
- an understanding of the basic principles of linear algebra;
- practical knowledge of statistics with applications to validation of data and design of experiments;
- experience with computers, including an ability to use word processors, spreadsheets, numerical and nonnumerical algorithms, simulations and computation, data acquisition, and databases for information handling and retrieval; and
- a good foundation in physics.

Chemistry pervades our modern social and economic life. All chemists, including those whose interests focus strongly on research, can benefit from an understanding of economics, marketing, business, and the environment. Courses in these subjects are recommended to the extent permitted by other academic requirements. Within chemistry courses themselves, advantage should be taken at all levels of course sophistication to point out the connections between science and society.

Foreign Language. If American students are to participate fully in chemistry today, which is worldwide in scope, they should know at least one other language and culture, even though English is the international language of science. The study of a foreign language, although not required, is highly recommended, particularly for students who plan to pursue graduate studies in chemistry.

Communication and Teamwork Skills. Effective written and oral communication skills and interpersonal skills are no less essential to the well-trained scientist than to the humanist. Speech and English composition courses alone are rarely enough to give students sufficient communication skills. Frequent exercises in writing and speaking should be a part of the chemistry curriculum and should be critically evaluated by the chemistry faculty. Ideally, every course should be an exercise in expressing ideas clearly. Seminars, progress reports, term papers, laboratory reports, problem sets, and examinations should be evaluated for clarity as well as accuracy. Tutoring and assisting in the laboratory also are highly effective ways for students to consolidate their chemical knowledge and improve their communication skills.

The ability to work in multidisciplinary teams is essential for a well-educated scientist today. Programs should incorporate teamwork experiences in classroom and laboratory components of the chemistry curriculum.

Curricular Innovation and Pedagogical Approaches. The Committee considers the guidelines to be consistent with using a wide range of pedagogies. Research in teaching and learning is generating an increasingly detailed picture of how students learn in their courses. Chemistry faculty are using this knowledge to improve student learning by, for example, having students build from their past experiences, using laboratory experiences to drive course instruction, organizing course content around topics of particular relevance to students, having students work in groups to build knowledge, and having students communicate their learning and results to others. The Committee encourages innovative pedagogical efforts and curriculum development.

Chemical Literature and Information Retrieval. Students preparing for professional work in chemistry must learn how to retrieve specific information from the enormous and rapidly expanding chemical literature. The complexity of this task is such that one can no longer easily acquire the necessary skills without some formal instruction. An excellent means for doing so is with a specific course, which usually would not qualify for the advanced course requirement. Other means for imparting these skills involve coordinated instruction integrated into individual courses. Library and computer exercises should be included in such instruction. In departments requiring undergraduate research, instruction in information organization and retrieval may be a part of the introduction to research. It should be recognized that adequate presentation of the subject, including an understanding of the use of *Chemical Abstracts*, *Science Citation Index*, *Current Contents*, *PubMed*, and other compilations, will generally require formal instruction. It is essential that students gain experience with online, interactive database searching, which can include some of the compendia mentioned above.

Professional Ethics. Chemistry is a discipline in which high standards of conduct must be exemplified by teachers and researchers in ways that students cannot fail to observe and adopt. Openness about discoveries and independent verifiability of experiments reinforce good ethical practice in the field. Disclosures of unethical practices by some scientists have caused many chemists to conclude that presenting ethical principles should be an intentional part of teaching chemistry. The Committee recommends that such instruction be part of the chemistry curriculum.

Safety. Discussions of current health and safety issues must be an integral and important part of the chemistry curriculum. Students should develop a high degree of safety awareness, beginning early in the core courses with discussions of the potential hazards associated with chemicals and laboratory equipment. Recognized safety practices should be stressed both in classroom and laboratory discussions, including, but not limited to, compliance with the regulations of OSHA (Occupational Safety and Health Administration), the recommendations in the ACS manual *Safety in Academic Chemistry Laboratories* and in the NAS-NRC *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, and applicable government regulations. Students should have access to Material Safety Data Sheets and be knowledgeable about the physical, chemical, and biological properties of the substances they handle. They should recognize potential hazards, minimize their risk and exposure to hazardous materials, and be prepared for the worst possible situations.

Cooperative Education and Industrial Chemistry. A distinctive feature of cooperative education is the placement of students in industry and government laboratories. Co-op programs can provide students with

- an appreciation of technology;
- broader exposure to team research, interdisciplinary research, and societal problems;
- a synthesis of pure and applied chemistry;
- opportunities to use sophisticated instruments;
- early professional experience, contacts, and information for career planning; and
- additional practice in preparing oral and written reports and in meeting deadlines.

The Committee strongly endorses cooperation between the chemical industry or government laboratories and academic institutions in educational projects. In some cases, part or all of the advanced course requirement might be satisfied through cooperative research carried out in an industrial or government laboratory and culminating in a comprehensive written report. Such cases will, however, be considered on an individual basis to ensure that the experience truly fulfills the advanced course requirement and includes the necessary faculty supervision.

Self-Instruction Programs. Self-instruction and distance-learning programs are available to help students reach one of the principal goals of professional education that is vital to the avoidance of obsolescence, namely, the ability to learn without the help of an on-campus teacher. The Committee recommends that departments explore, perhaps in cooperation with ACS local sections, self-instruction materials as supplements to traditional classroom instruction. For example, audio, video, and computer courses are available on such topics as catalysts, engineering, industrial chemistry, polymers, surfaces, signal analysis, and use of the chemical literature. Laboratory experience is, however, an essential part of learning chemistry. Such work requires hands-on experience that cannot be supplied with videotape or over computer networks. Video courses are not by themselves an appropriate substitute for advanced courses.

Supplements to the Guidelines. Supplements to the guidelines are available for many of the areas discussed in this section. Included are

- lists of topics for core courses and laboratories,
- information about degree options,
- advice on writing comprehensive research reports,
- journal subscription requirements,
- chemical information retrieval guidelines,
- laboratory safety and safety education,
- guidelines for undergraduate research, and
- teaching of professional ethics.

The supplements are reviewed and updated regularly to ensure that they reflect the current state of chemistry. The supplements are available at the CPT website and on request from the Office of Professional Training.

1.5 Faculty, Staff, and Facilities Requirements

Faculty Requirements. Faculty size and competence must be adequate to allow the teaching on a regular basis of the full range of chemistry courses needed for undergraduate professional education in chemistry. Courses required for the certified degree program should be taught by regular, full-time faculty. The scientific and educational capabilities of the faculty should be distributed over the major areas of chemistry so that upper-level and advanced courses are taught by persons qualified in each specialty. At least 75% of the faculty in chemistry must have a doctoral degree in the chemical sciences. At least four full-time chemistry faculty members are required for an approved program.

An ACS-approved degree option will often require chemistry faculty to offer additional courses beyond those required for the chemistry degree program. The addition of a fifth faculty member is typically necessary in such cases to ensure the presence of appropriate faculty expertise and to keep teaching loads at acceptable levels. An exception could be when faculty from other departments, such as biology, geology, or physics, contribute to the teaching of some of the needed advanced courses.

Supporting Staff Requirements. Administrative support, stockroom, and technical staff should assist faculty members with supporting activities, permitting faculty members to devote their time and effort more fully to academic responsibilities and scholarly pursuits.

Teaching Contact Hour Restrictions. Under no circumstance should a teaching load exceed 15 contact hours per week in any semester or quarter, and significantly lower loads are strongly recommended by the Committee. The 15-hour limitation applies to actual contact time in classrooms and laboratories each week. The number of students supervised in a laboratory section by a faculty member alone or by a teaching assistant should be consistent with good safety practice and with the principle of providing each student with ready access to helpful instruction. For laboratory instruction, the number of students supervised by a faculty member alone or by a teaching assistant should not exceed 24. Many laboratories require smaller numbers for safe and effective instruction.

Training of Student Teaching Assistants. Having upper-class chemistry students serve as laboratory teaching assistants helps these students reinforce their knowledge of chemistry and gives students in the laboratories more attention. If graduate or undergraduate students are to serve as teaching assistants, the Committee expects that they will receive appropriate training for this role.

Library Requirements. Essential to an approved chemistry program is a good library where faculty and students have access to books and periodicals and where adequate support for database searching is available. *Chemical Abstracts* (print or online) must be a part of the collection, and full abstracts must be accessible, not merely titles. If the only access to *Chemical Abstracts* is online, then the department is expected to demonstrate that students have good and timely access to this reference work. An institution with a broad spectrum of research activity will require extensive library holdings. The department meets the minimum library requirement for approval if its library provides ready access to 20 or more refereed journals (print or online) in the chemical sciences and has a range of other reference materials. If an institution provides access to fewer than 20 current refereed journals in the chemical sciences, then ready access should be provided to no fewer than 14 current journals chosen from the CPT recommended journal list (available from the CPT website). Of the 14, at least 4 must be from the general content list, and at least 1 each must be from the areas of analytical, biological, inorganic, organic, and physical chemistry. For journal articles that are not readily accessible, the library should provide access to them via interlibrary loan or document delivery services to support teaching and research. Microfiche for current subscriptions are not acceptable because they do not give students easy and inviting access to the literature. Microfiche are, of course, acceptable for back files of journals.

Access to individual journals by online subscriptions is acceptable in place of hard-copy subscriptions if the full text and graphic material from all papers and good printing facilities with graphics capabilities are available to students. If the primary access that students have to *Chemical Abstracts* and to the literature is by means of computers, it is essential that this access not be unduly limited by cost considerations or by impractical times for access. When online subscriptions are used, the Committee will seek statistical information about the extent of student use.

Classroom and Laboratory Requirements. The classrooms for chemistry courses and the offices for faculty should be located near the instructional and research laboratories. Classrooms should meet modern standards of lighting, ventilation, and comfort and should be equipped with demonstration and projection facilities. Laboratories should be suitable for instruction in the chemical sciences and should meet applicable governmental regulations. Fume hoods, safety showers, eyewashes, fire blankets, first aid kits, and fire extinguishers should be readily available and in proper working order. Construction or renovation of laboratory facilities should be in conformance with the regulations of OSHA.

In addition to the instructional laboratories, provision should be made for faculty and student research laboratories with facilities appropriate to the type of work intended and for the maintenance of semipermanent setups for experiments that require extended periods of time.

Instrumentation Requirements. The instruments available to the students should be reasonably recent models in current use by professional chemists (see Commentary on Equipment and Instrumentation in Sec. 1.6). A department should have several major pieces of sophisticated equipment suitable for undergraduate instruction as well as for research. One of these must be an NMR spectrometer. Of comparable importance to having a good representation of instruments is having realistic provisions for maintaining these instruments in good working order.

Ancillary Facilities Requirements. Machine shop, electronics, and glassblowing facilities should be accessible in the institution or in a nearby area for the construction of special apparatus often needed for instruction and research.

Safety Requirements. Faculty and staff should receive safety training and have safety reference materials available. Safety awareness should be promoted by suitable means. Personal protective equipment (e.g., gloves, lab coats, face shields, bench shields, and safety suits) and appropriate facilities should be readily available for handling and storing chemicals. Hazardous materials should be disposed of regularly in compliance with government regulations. Safety rules regarding eye protection should be posted in all laboratories and should be rigorously enforced. Emergency procedures should be established, and emergency numbers should be easily accessible at all times to persons working in laboratories.

1.6 Commentary on Faculty, Staff, and Facilities Requirements

Faculty and Supporting Staff. Sound policies regarding salaries, teaching loads, promotions, sabbatical leaves, and tenure are essential. Otherwise, an institution will not be able to maintain an up-to-date faculty with high morale or attract and retain a chemistry faculty of the necessary high quality. Similarly, adequate institutional support and facilities are necessary for faculty members who are active in research and who direct students' independent study and research.

While the minimum number of full-time chemistry faculty members in an approved department is four, it is highly desirable to have at least five in order to provide expertise in all chemistry subdisciplines, permit the regular teaching of all courses required for certification, maintain reasonable faculty contact hour loads, and allow for regular faculty sabbatical leaves.

The chemical profession will continue to benefit from the broader inclusion of members of underrepresented groups, including women and minorities. Toward this end, it is essential that chemistry faculties reflect the diversity of the modern profession. The Committee expects institutions to show evidence of a strong commitment to these principles in their faculty hiring and professional development practices. The Committee will look for continuing, significant progress in this important area of staffing.

Required courses at all levels for a certified degree in approved chemistry programs are normally taught by regular, full-time faculty. The desirability of occasionally taking advantage of the expertise and availability of highly qualified individuals outside the regular faculty for the delivery of special courses is acknowledged. However, depending on temporary, adjunct, or part-time faculty to teach any significant portion of the ACS-approved program is undesirable and is discouraged. The use of properly trained and supervised student assistants in stockrooms and laboratories can reduce faculty loads while providing worthwhile experience for the students themselves.

Teaching Contact Hours. The size of teaching loads is particularly important. Faculty are understood to be all the persons who have teaching responsibilities, either full-time or part-time. Teaching loads should be at a level that leaves time for every faculty member to stay abreast of developments in chemistry and related areas, to modernize courses, and to engage in research and other types of scholarly and professional activities that promote the continued effectiveness of the individual as a teacher, scholar, and scientist. The prescribed teaching load limits apply to all chemistry course teachers, including temporary, adjunct, part-time, and full-time faculty and instructors. Even where chemistry enrollments may not be large, teaching loads that exceed 15 contact hours per week (including laboratory supervision) will weaken the program and erode the continued effectiveness of these individuals. Supervision of an effective student laboratory commits the time and energy of a faculty member or instructor as fully as the preparation for and presentation of a classroom experience. These factors are given considerable weight by the Committee in its evaluation of teaching loads.

In reviewing some schools, the Committee encounters three forms of excessive teaching that lower teaching effectiveness and interfere with the professional development of faculty members. One is regular summer school teaching. Another is teaching overloads for extra compensation. Some institutions appear to underpay faculty members and then compensate by providing summer school teaching or overloads. A third is part-time teaching at more than one institution. Such forms of excessive teaching are undesirable and are discouraged.

Formal teaching loads are generally much lower than 15 contact hours per week at institutions offering strong graduate programs in which research activities are a central educational and professional responsibility of the faculty. Four-year institutions should give faculty who direct undergraduate research substantial teaching credit (in the form of reduced course and classroom responsibilities) for time spent guiding independent study and student research, since the informal contact between research students and a faculty member often far exceeds that of conventional lecture and laboratory courses.

Faculty Mentoring, Professional Development, and Sabbaticals. The professional development of faculty is essential for maintaining an up-to-date curriculum and providing a positive learning environment for students. Mentoring of junior faculty by senior faculty is an important step in their professional development and can be especially important for junior faculty from underrepresented groups, including women and minorities. When done properly, mentoring reduces isolation and introduces junior faculty members to the culture of their particular academic unit, institution, and the broader chemical profession, and helps to start them on a successful career path. Departments are strongly encouraged to pay particular attention to this stage of faculty development in order to ensure the future stability and vitality of their program.

Professional development opportunities are essential for all faculty. Examples include technical meeting attendance, participation in professional workshops and short courses, involvement in research, and sabbatical leaves. Financial support and adequate time within the normal work schedule must be provided for professional development. The need for continuing professional development applies equally to temporary, adjunct, and part-time faculty as well as to regular full-time faculty and instructors.

Institutions should have a formal policy for regular sabbatical leaves and provide financial support for sabbaticals. Qualifying faculty members should be encouraged to take advantage of sabbatical leave opportunities.

Student Mentoring and Advising. Effective advising and mentoring of undergraduate students are central to student achievement. Successful mentors provide guidance for students' education and development, networking, confidence building, and career planning. Undergraduate research activities can provide excellent opportunities for successful mentoring. Many career opportunities are available for baccalaureate graduates in chemistry, and students should be advised about the different options. Underrepresented groups, including minorities and women, should be encouraged to consider chemistry as a career. Students with a strong interest in and aptitude for teaching and/or research and possessing strong academic qualifications should be encouraged to continue for advanced study in chemistry or a related science. Available free of charge from the Office of Professional Training at ACS are two booklets to guide students in selecting courses and making other preparations for the years immediately after college: *Planning for Graduate Work in Chemistry* and *Planning for a Career in Industry*. Additional career resources are available at the ACS website.

Equipment and Instrumentation. Instruments and equipment now used in a good undergraduate chemistry program typically include, in addition to analytical balances, pH meters, desktop computers, and specialized glassware, most of the following:

- apparatus for inert atmosphere manipulations,
- atomic absorption spectrometer,
- computer workstations for computational chemistry and molecular modeling,
- FT-NMR spectrometer,
- gas and liquid chromatographs (GC and HPLC),
- gas chromatograph-mass spectrometer (GC-MS),
- multipurpose electrochemical instrumentation,
- optical spectrometers (FT-IR, UV-vis), and
- vacuum systems.

They may also include instruments or apparatus for the following purposes:

- calorimetry and thermal analysis,
- electrophoresis,
- kinetics measurements,
- laser-based applications,
- mass spectrometry,
- molar weight measurements,
- radiochemistry (including counting equipment and sources),
- Raman spectroscopy,
- ultracentrifugation, and
- X-ray crystallography.

Nuclear magnetic resonance spectroscopy has become an indispensable experimental method for chemistry. Approved chemistry programs must have an operational NMR spectrometer.

1.7 Minimum Number of Graduates

For a program to be approved and remain on the list of approved schools, an average of at least two graduates per year must receive degrees from the program over five years. Although there is no specification about the number of graduates who are certified, the Committee looks for a reasonable number of certified graduates when evaluating a program.

1.8 Joint Programs

In exceptional circumstances, it is possible for two or more neighboring institutions to combine their resources and facilities to provide an approved program. Each case for cooperation will be considered on its own merits but must have strong prospects for permanence, clearly stated designations of responsibility for curriculum planning and development, and established procedures for overall program administration and the certification of graduation. The initial application, subsequent applications for approval of options, and all reports must be submitted jointly.

1.9 Certification and Baccalaureate Graduates

Those chemistry majors receiving a baccalaureate degree and completing a curriculum described in the Curriculum Requirements Section (Sec.1.3) may be certified to the Society by the chair of the ACS-approved program. A student is certified provided that the program chair considers the student to have met the requirements outlined in this booklet. Normally, certification of graduates occurs at the time of graduation with the baccalaureate degree. Those students who initially obtain a noncertified baccalaureate degree from an approved program and who subsequently complete sufficient additional courses (given by an ACS-approved program) to qualify for certification may then be certified. Certified graduates are eligible to become Members of the Society. Those who receive noncertified baccalaureate degrees in chemistry may become Associate Members; after three years of professional experience in chemistry or chemical engineering, they may become Members.

SECTION 2
EVALUATION POLICIES AND PROCEDURES

2.1 Preliminary Requirements for Program Evaluation

The ACS, through its Committee on Professional Training, is always glad to discuss with any member of a chemistry department or officials of a college or university questions pertaining to postsecondary education in chemistry. If requested, the Committee is willing to offer suggestions and guidance to those institutions wishing to improve their educational programs in chemistry for students preparing at the undergraduate level for professional careers in chemical sciences and for the many other students who may be seeking knowledge of chemistry to fulfill different career objectives or for general educational purposes.

When institutions approach the Committee for evaluation and approval of their undergraduate professional program, the Committee requests evidence of the following prior to the evaluation:

- accreditation by the regional association. This accreditation of the institution is important, because an educational program in chemistry that meets the guidelines described in Section 1 of this booklet requires broad institutional support in areas such as mathematics, physics, the liberal arts, and, for some students, other areas such as economics, marketing, and business administration.
- a suitable, stable organization of the chemistry program. The program organization, size and quality of the faculty, curricular offerings in chemistry, and educational facilities available for approval of the program must have become established over a reasonable period of time, and the program must have produced at least one class of baccalaureate graduates.
- completion of the self-study questionnaire designed by the Committee.

2.2 Initial Review: Self-Study and Conference

It is the practice of the Committee to hold a conference at an ACS national meeting with the person in charge of the chemistry program as a prelude to the formal evaluation. The conference provides an opportunity for a frank and constructive discussion of the program and an opportunity for the institution to learn more about the criteria, policies, and procedures of the Committee. Administrative officials of the institution are always welcome to attend and participate in the conference. Preparation for this conference should be based on the questionnaire that the Committee provides through the ACS Office of Professional Training.

The completed questionnaire and associated information provided about the program are carefully reviewed by the Committee prior to the conference. The results of the self-study and of the conference are used by the Committee to develop a preliminary impression of the program's characteristics, strengths, and weaknesses. Following the conference, the Committee decides that (1) it would be appropriate to proceed with further evaluation of the program (see below), or (2) certain changes and/or improvements need to be made in the program before further evaluation is recommended, or (3) the program is unlikely to meet the standards for approval in the immediate future.

Information concerning the recommended changes and improvements is sent to the head of the chemistry program.

2.3 Further Evaluation Procedures

If the initial review indicates that a full evaluation would be timely, the principal administrative officer of the institution is requested to send a letter to the Committee indicating that a visit to the campus by one of the Committee's Visiting Associates would be welcome as the next step in the evaluation process.

The on-site visit requires one to two days during a regular instructional period. The date of the visit should be mutually convenient to the Associate and the person in charge of the chemistry program and at a time that will permit the Associate to meet with one or more of the principal administrative officials of the institution. The Society does not charge the institution for such an evaluation, and all costs incurred by an Associate for an on-site visit are assumed by the Society.

The purpose of the visit by the Associate is to examine for the Committee areas of the program in which questions may exist and to obtain any additional data that the Committee might need for its evaluation; to meet personally with faculty members, students, and administrative officials; and to observe the general educational and scientific environment that exists at the institution. Background material and instructions are prepared and sent to the Associate by the Committee prior to the visit. The report of the Associate is studied by the Committee at its next regular meeting, at which time a complete review is made of all information available about the program.

The specific program areas reviewed during an evaluation are those described in Section 1 of this booklet. The Committee pays special attention to the overall quality of the program as judged by the number and competence of the teaching faculty; teaching loads; level, breadth, and depth of instructional offerings (especially at the advanced course level); adequacy of facilities and supporting personnel; the aptitude of the students; the number of chemistry graduates per year; and the subsequent performance of those graduating from the program. Details of program implementation (such as course titles and format) are not prescribed. The program as a whole must be up-to-date, coherent, and challenging to the students.

2.4 Actions Following the Evaluation

The specific types of action by the Committee after an evaluation are as follows:

- ***Approval***—Program meets the guidelines of the Society.
- ***Deferral***—Final decision postponed until specific additional information is provided, or to allow an adequate period of time for the institution to implement planned or suggested improvements in the program, or to allow time for a program to demonstrate that it is sustainable at the level that meets the guidelines.
- ***Approval Withheld***—Program does not meet the guidelines of the Society, nor does it appear that program changes can be achieved within a reasonable period of time to qualify for approval.

All decisions of the Committee are communicated to the program chair. In cases of deferral or approval withheld, the areas in which the program was found not in compliance with ACS guidelines are indicated. If a Committee Associate has visited the institution in response to a request from the institution, the Committee's decision is also communicated to the principal administrative officer. The principal administrative officer of an institution is free to withdraw the invitation extended to the Society for an evaluation at any time prior to the completion of the evaluation. In such an event the evaluation is discontinued.

A program is approved if it meets the spirit and substance of the guidelines established by the Society for undergraduate professional education in chemistry, as set forth in Section 1. The name of the institution then appears on the list of colleges and universities whose programs have been approved by the Society. This list and a statistical report on graduates are published each year in *Chemical & Engineering News* as part of the Committee's annual report.

2.5 Visiting Associates

Visiting Associates of the Committee are experienced educators and scientists familiar with the Society's guidelines and knowledgeable about both the administrative and technical aspects of conducting successful undergraduate programs. Meetings are held periodically with the Visiting Associates to help keep them informed about interpretation of the guidelines, evaluation procedures, and techniques and educational trends in the chemical sciences.

In the selection of an Associate for a particular on-site evaluation visit, every effort is made to eliminate any possibility of bias or conflict of interest. For instance, a graduate of the institution under evaluation or a person having a close and continuing relationship with the institution would not be chosen to assist in the visit and evaluation. Neither would an Associate be selected who is a faculty member at an institution in the immediate geographical area.

2.6 Initial Approval of Degree Options

Degree options, such as in biochemistry, are built on the chemistry degree program. In the initial evaluation of a department or program seeking ACS approval, only the chemistry degree program is considered. Once the chemistry degree program is approved, the department or program may apply for one or more degree options by completing the appropriate questionnaire supplied by the ACS Office of Professional Training. Approval of degree options is handled through correspondence. Departments with previously approved chemistry programs follow the same procedure in seeking approval of degree options.

2.7 Initial Approval of Minor in Chemistry Education

The minor in chemistry education is built onto the chemistry degree program. After a program is approved by ACS, the department may apply to offer a minor in chemistry education by completing the questionnaire supplied by the ACS Office of Professional Training. Approval of the minor in chemistry education is handled through correspondence.

2.8 Annual Reports and Reevaluations

Approved institutions must report annually to the Committee on numbers of students receiving different degrees in chemistry and on the baccalaureate graduates certified as having completed a program that meets the guidelines of the Society. If the program has approved degree options in chemistry, the number of students certified under these options must also be reported. The statistical information concerning the numbers of graduates at the various degree levels is summarized and published each year.

Approved institutions must complete full reevaluations of their programs at five-year intervals. An earlier reevaluation may be requested by the institution in the event of significant program changes. A reevaluation consists of completion of a questionnaire prepared by the Committee for this purpose. These reports also enable the Committee to keep abreast of trends and innovations in the teaching of chemistry throughout the country. As part of the review, the Committee may ask questions to clarify areas in which information is puzzling or incomplete.

If the institution has approved degree options, questionnaires about these options are completed and submitted with the five-year reports. The degree options are reviewed at the same time as the chemistry program. Continued approval of the chemistry program is a prerequisite to continued approval of degree options.

If the review of an institution's report indicates that its chemistry program continues to meet the guidelines of the Society and remains healthy and vigorous, a favorable decision is reported to the department. Occasionally, the Committee has sufficient doubts so that an on-site visit of an Associate is included as part of the reevaluation. As in the case of initial evaluations, no charge is made by the Society for a reevaluation or for continued listing of an institution on the approved list. The expenses incurred by an Associate for an on-site visit are paid by the Society.

2.9 Action Following Reevaluation

Following the completion of a reevaluation, one of the following actions is taken by the Committee:

Approval Continued

Approval with Comment

Request for Additional Information

Visit or Probation

Approval Withdrawn

When the decision of the Committee is for continued approval or approval with comment, the person in charge of the program and the principal administrative officer of the institution are so advised in a letter that includes whatever suggestions and recommendations the Committee might deem appropriate to promote the continued strength and vitality of the program. Requests for additional information are sent to the person in charge of the program. If the Committee concludes that a program should be visited or put on probation or that approval should be withdrawn, the reasons for the action are summarized in letters to the principal administrative officer of the institution and to the person in charge of the program.

2.10 Probation and Withdrawal of Approval

An institution is placed on probationary status prior to any decision to withdraw approval. Probationary status is assigned whenever changes have occurred that, in the judgment of the Committee, prevent the institution from continuing to offer a program that meets the Society's guidelines. Examples of such changes include reduction in faculty size below the minimum level for approval, excessive teaching loads, reduction in the quality and distribution of faculty capabilities, insufficient course offerings, too few required chemistry lecture or laboratory hours, inadequate library holdings, or too little budgetary support. Every effort is first made by the Committee to encourage and assist the institution in strengthening its program in the deficient areas. If problems remain, a period of time—usually no more than 12–18 months—is allowed for the institution to correct the deficiencies and to bring the program back into compliance with the guidelines.

If compliance is not achieved within the prescribed period or if the principal administrative officer of the institution indicates to the Committee that the institution prefers under the circumstances not to proceed with the reevaluation, approval of the institution is withdrawn. When approval is withdrawn, the institution is no longer listed in the annual report in *Chemical & Engineering News*.

2.11 Appeal of an Adverse Evaluation Decision

An adverse evaluation decision by the Committee is defined as the withdrawal or denial of approval. An institution may petition for review of an adverse decision 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 should be sent to 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 then provide whatever additional information and documents it wishes to present in support of the petition.

Upon receipt of a petition and supporting information, the Committee will review the matter at its next regular meeting, which will include a conference with representatives of the institution if a conference is desired by the institution or the Committee. After the meeting, the Committee will report 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 Appeals Board, consisting of three individuals who are not members of the Committee, will be appointed by the Society's president and Board chair as needed.

Although there is no formal mechanism for appealing decisions of the Appeals Board, it is important to note that 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.

2.12 Procedures for Complaints

Any administrative official of an institution, department chair, faculty member, student, or other person who disagrees with one or more of the policies, procedures, or activities of the Committee and who wishes to present a complaint should do so in an appropriately documented letter to the Committee. The same procedure is to be followed should the complaint allege failure of an approved institution to adhere to ACS guidelines or allege that there is a situation tending to jeopardize the quality and vitality of a program at an approved institution. It will then be the responsibility of the Committee to investigate the matter and to advise the complainant of the Committee's conclusions.

2.13 Confidentiality of Information

Institutions requesting the cooperation of the Society for the evaluation of their undergraduate programs of education in chemistry are expected to provide the Committee with detailed information pertinent to the programs. Institutions on the approved list of the Society are obligated to do so periodically as one of the conditions for continued approval. The information provided and all related discussions and correspondence between the Committee and an institution are solely for the confidential use of the Committee. However, in the event that an institution appeals a Committee decision, the Committee would release to the appeal bodies the information necessary for the proper conduct of the appeal.

In its annual published reports, the Committee identifies those institutions whose programs are currently approved as meeting 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 release information about a particular program or evaluation.

Members of the Committee on Professional Training Who Participated in the Preparation of This Edition of the Guidelines

Current Committee

Charles E. Carraher, Jr., *Florida Atlantic University*

F. Fleming Crim, *University of Wisconsin–Madison, Chair 2003*

Royce C. Engstrom, *University of South Dakota*

Carlos G. Gutierrez, *California State University, Los Angeles*

Jeffrey W. Kelly, *Scripps Research Institute*

John W. Kozarich, *ActivX Biosciences (Merck Research Labs when appointed)*

Edward N. Kresge, *ExxonMobil Chemical Company (Retired)*

Dale W. Margerum, *Purdue University (Consultant)*

Margaret V. Merritt, *Wellesley College*

Nancy S. Mills, *Trinity University*

Jerry R. Mohrig, *Carleton College, Chair 1997–99 (Consultant)*

Jeanne E. Pemberton, *University of Arizona, Chair 2000–02 (Consultant)*

William F. Polik, *Hope College*

C. Dale Poulter, *University of Utah, Vice-Chair 2003*

Joel I. Shulman, *University of Cincinnati (Procter & Gamble when appointed)*

Elizabeth C. Theil, *Children's Hospital Oakland Research Institute*

Cathy A. Nelson, *American Chemical Society, Committee Secretary*

Other CPT Members Who Participated

Sally Chapman, *Barnard College, Chair 1994–96*

Norman C. Craig, *Oberlin College*

Billy Joe Evans, *University of Michigan–Ann Arbor*

Dennis H. Evans, *University of Delaware*

Slayton A. Evans, Jr., *University of North Carolina at Chapel Hill (deceased 2001)*

Michael Jaffe, *Rutgers University (Hoechst Celanese Corp. when appointed)*

Notes

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

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