

Undergraduate Professional Education in Chemistry

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



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

Disclaimer

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

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I. GUIDELINES FOR PROGRAM APPROVAL AND STUDENT CERTIFICATION

1. Goals of Program Approval and Student Certification

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

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

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

needed to be an effective chemist. Certification gives a student an identity as a chemist and helps in the transition from undergraduate studies to professional studies or employment.

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

2. Institutional Environment

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

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

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

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

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

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

3. Faculty and Staff

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

3.1 Faculty. The faculty of an approved program should have the range of

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

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

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

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

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

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

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

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

4. Infrastructure

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

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

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

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

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

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

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

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

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

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

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

5. Curriculum

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

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

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

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

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

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

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

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

Foundation course work typically builds on the introductory chemistry experience. Textbooks for foundation course work are specialized books that

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

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

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

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

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

foundation areas and therefore have those foundation courses as prerequisites.

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

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

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

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

Degree tracks offer the opportunity to incorporate emerging areas of chemistry, take advantage of faculty and local expertise, and match departmental and institutional missions. The faculty is responsible for defining these degree tracks for its program. The responsibility for student learning,

consequently, resides with those who can best implement and assess it. While the ACS approves chemistry programs, it does not approve specific degree tracks developed by individual chemistry programs.

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

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

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

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

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

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

6. Undergraduate Research

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

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

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

writing a comprehensive report.

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

7. Development of Student Skills

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

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

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

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

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

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

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

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

7.6 Ethics. Ethics should be an intentional part of the instruction in a chemistry program. Students should conduct themselves responsibly and be aware of the role of chemistry in contemporary societal and global

issues. As role models, faculty should exemplify responsible conduct in their teaching, research, and all other professional activities.

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

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

8. Program Self-Evaluation

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

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

9. Certification of Graduates

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

II. APPROVAL PROCESS AND REVIEW PROCEDURES

1. Membership of the Committee

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

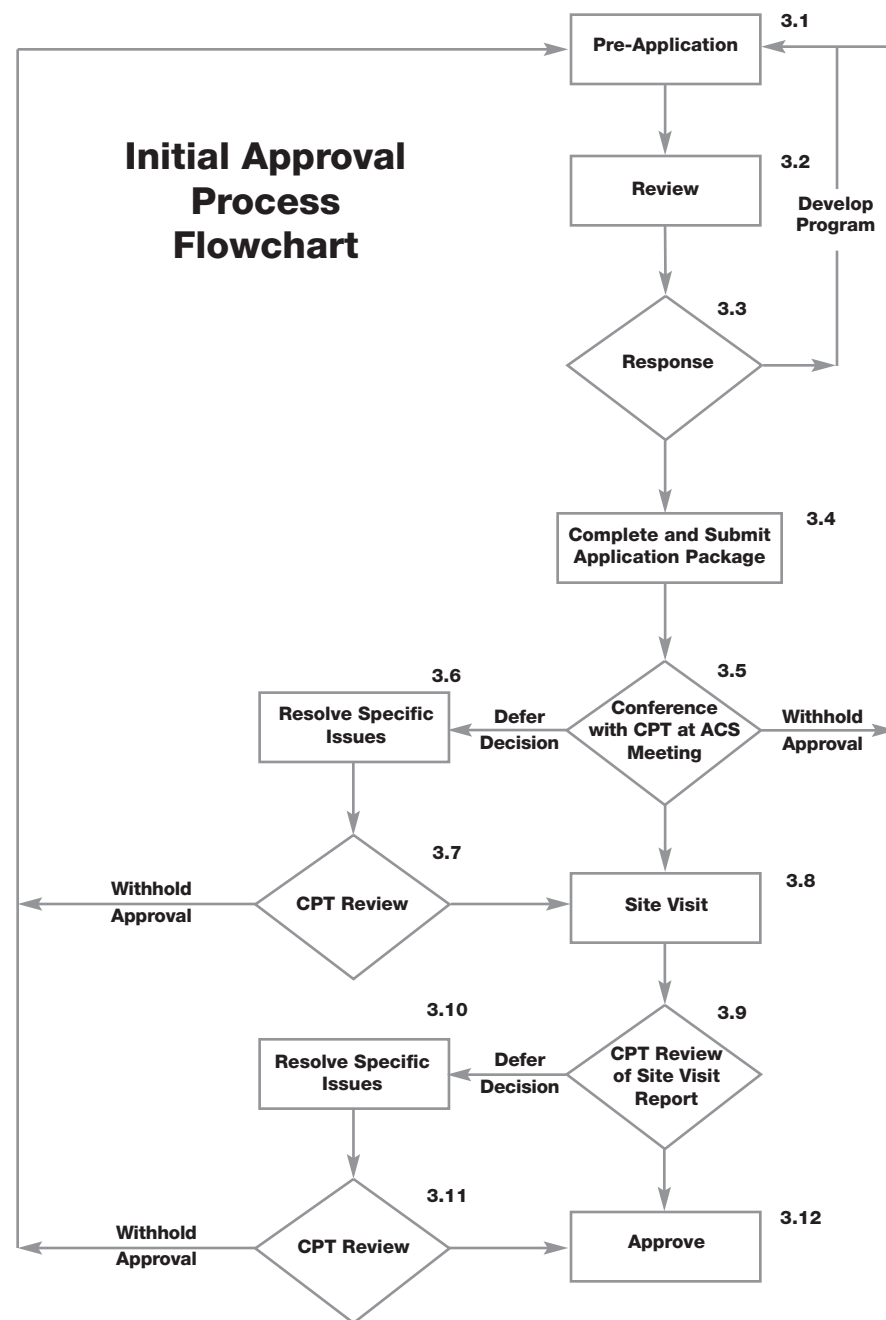
2. Costs Associated with the Approval Program

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

3. Initial Approval Process

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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

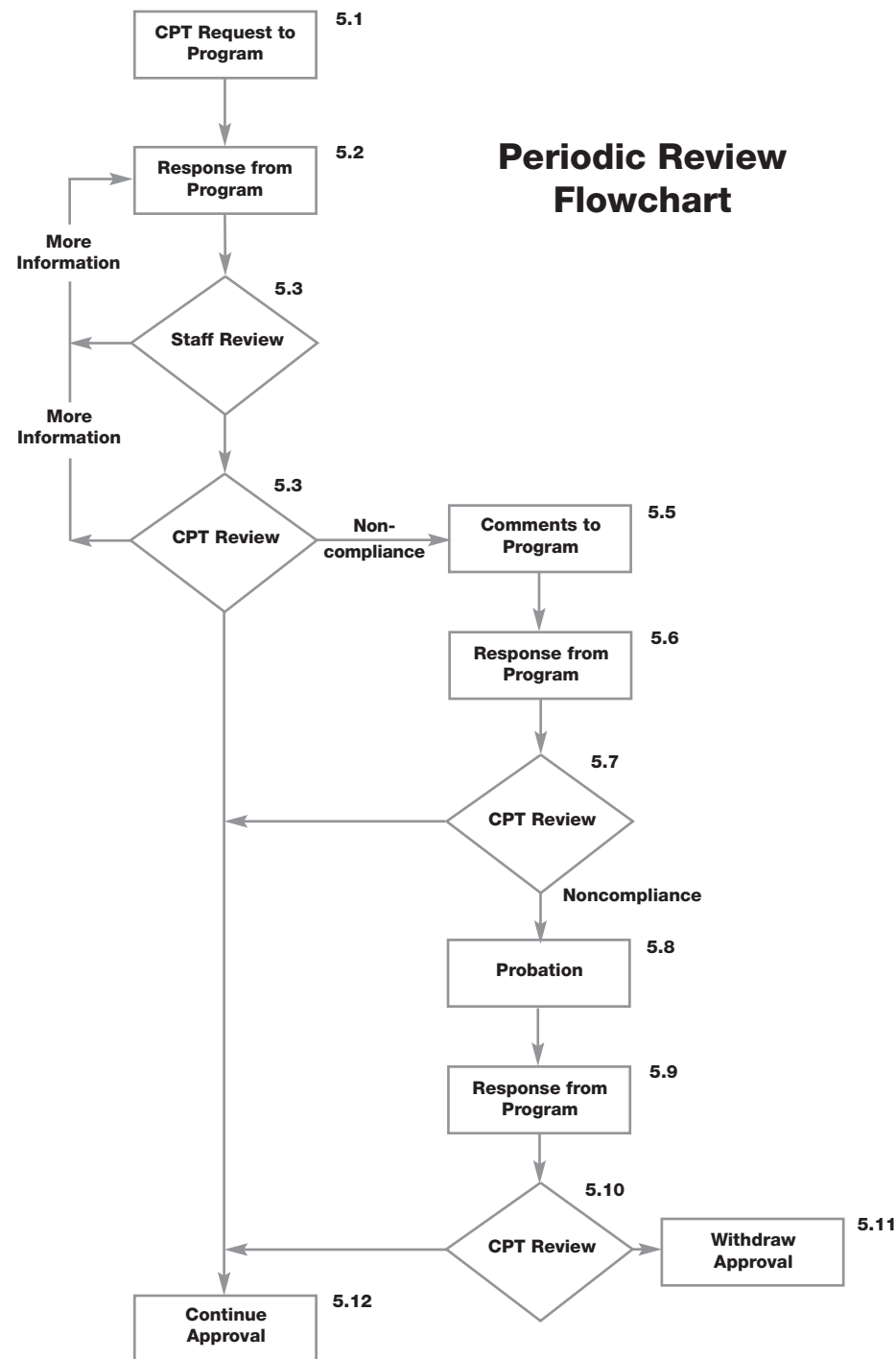
3.12 Approve. The Secretary of CPT writes to the president of the institution and the chair of the department that administers the chemistry program to report this decision. The Committee will post the name of the institution on the list of ACS-approved chemistry programs on its Web site. An approved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

4. Annual Review

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

5. Periodic Review

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6. Administrative Probation

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

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

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

7. Appeal of an Adverse Decision

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

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

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

8. Visiting Associates

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

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

9. Confidentiality

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

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

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

APPENDIXES

A. The Formal Mandate of the Committee on Professional Training

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

- (1) The SOCIETY shall sponsor an activity for the approval of undergraduate professional programs in chemistry. The Committee on Professional Training, constituted as an Other Joint Board-Council Committee under this Bylaw, shall act for the Board and Council in the formulation and implementation of the approval program with published criteria and/or guidelines, as well as published evaluation policies and procedures.
- (2) The goals of the approval program shall be *inter alia*:
 - a. promoting and assisting in the development of high standards of excellence in all aspects of postsecondary chemical education, and undertaking studies important to their maintenance,
 - b. collecting and making available information concerning trends and developments in modern chemical education, and
 - c. cooperating with SOCIETY and other professional and educational groups having mutual interests and concerns.
- (3) Institutions may petition for review of adverse evaluation decisions to an established Appeals Board consisting of three members of the SOCIETY, not members of the Committee, appointed jointly by the President and the Chair of the Board.

B. Members of the Committee on Professional Training

CPT Members – 2008

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