cpt newsletter
Committee on Professional Training

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# Models for Integrating Biochemistry into Core Chemistry Courses

The 1999 edition of *Undergraduate Professional Education in Chemistry: Guidelines and Evaluation Procedures* announced a change in the requirements for ACS-approved programs to include topics in biochemistry as part of the curriculum for certified students. To provide departments with maximum flexibility in meeting the guidelines, the new requirement may be met by requiring an advanced course in biochemistry or by integrating equivalent material into the required core.

> Approved programs may implement this requirement either by requiring certified graduates to take the equivalent of three semester credit hours of biochemistry as one of the advanced courses or by integrating the equivalent of three semester credit hours into the required core. *A laboratory program 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.
>
> *Selected passage from the 1999 guidelines booklet (pages 10 and 11).*

These course modifications should be in place by 2001. Students graduating in 2005 and thereafter must have studied biochemistry to receive an ACS-certified degree. The 2001 deadline was designed to give departments time to develop and implement new course material. The Committee will request information about the biochemistry requirement starting with the five-year reports to be submitted in December 2001.

While many schools may choose to require an advanced course or a stand-alone biochemistry course within the core, considerable interest has been expressed in integrating biochemistry topics into the traditional core areas of analytical chemistry, inorganic chemistry, organic chemistry, and calculus-based physical chemistry. For many chemistry departments, the integration of biochemistry into traditional core courses is a new approach.

The ACS Committee on Professional Training, the Biological Chemistry Division, and the Division of Chemical Education sponsored a one-day symposium at the ACS National Meeting in San Francisco in March 2000 to highlight a few innovative ways educators have integrated biochemistry topics into traditional core courses. Dr. Dale Poulter (University of Utah, CPT member) moderated the morning and afternoon sessions. Nine talks were presented, with a panel discussion at the end of the day.

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**MORNING SESSION**

Biochemistry in Introductory Chemistry
A. J. Wolfson (Wellesley College)

Bioanalytical Chemistry: Integrating Biochemical Content into Analytical Chemistry Classes
H. Drossman (Colorado College)

Integrating Biochemistry into Organic Chemistry
W. H. Fuchsman (Oberlin College)

Biochemistry in Undergraduate Curricula
E. C. Theil (CPT member, Children's Hospital Oakland Research Institute)

**AFTERNOON SESSION**

General Chemistry and Cellular and Molecular Biology: An Experiment in Curricula Symbiosis
A. T. Swartz, J. Serie (Macalester College)

"Organic First" as a Vehicle for Introducing Biochemistry Early and Often
I. D. Reigold (Juniata College)

HPLC and GC in Undergraduate Laboratories: Introduction of Chromatography across the Undergraduate Chemistry Curriculum
S. B. Jones (UNC Wilmington)

Qualitative Comparisons of Two Methods of Biochemistry Integration into General Chemistry
D. R. Kimgrough (University of Colorado at Denver)

Undergraduate Course in Molecular Modeling
R. Viswanathan (Yeshiva College)

## In This Issue . . .

# Highlights of Morning Talks

Dr. Adele Wolfson from Wellesley College began the symposium by sharing some of her experiences with a second semester introductory chemistry course that imbeds biological examples in traditional introductory topics. Her approach, in part, reverses the traditional approach for introducing chemical structures, as suggested by Emeric Schultz (*J. Chem. Educ.* **1996,** *73*, 447–449). "Rather than starting with the simplest possible molecule and building up to more complex systems, start with a complex problem and then deconstruct it to a simpler one the students can understand." The idea is to hit the students with a headline—a biological example that piques their interest. Under each traditional chemistry topic, she lists the biological connection. A few examples she presented were solubility–drug design, chemical kinetics–enzymes and metabolic pathways, and nuclear chemistry–radiation in medicine. While she admits that integration of biochemistry at the introductory level may not fully satisfy the ACS requirements, she feels it is important to start introducing these topics to chemistry majors early in their curriculum. One of the benefits she noticed was that the number of declared chemistry and biochemistry majors increased by 25–40% for the two semesters that she taught the integrated minicluster.

Dr. Howard Drossman's presentation, "Bioanalytical Chemistry: Integrating Biochemical Content into Analytical Chemistry Classes", covered his experiences with integrating biochemical content into analytical chemistry. In his view, four questions should be addressed when incorporating biochemical content into an analytical course: 1) What analytical skills and content are essential for all chemists? 2) Where and how do chemists learn analytical chemistry? 3) What analytical topics contribute to biochemical literacy? 4) How is the material best assessed and organized? Dr. Drossman has made his course materials available on the Web (address listed at the end of this article). Included are course syllabi, descriptions of content, quantitative analysis, physical biochemistry, and biophysical chemistry materials.

In the third talk of the morning, Dr. Fuchsman discussed the approach that Oberlin College is taking to integrate biochemical topics into organic chemistry. He began by describing the typical structure of chemistry programs in relation to biochemistry and what he describes as the "chemist's dilemma" and the "biologist's dilemma". Biology students must usually take two semesters of organic chemistry before they are able to master topics in biochemistry, while chemistry students typically need two or three biology courses. These prerequisites and the absence of a bridging course have posed a significant barrier to chemistry students who might otherwise be interested in studying biochemistry.

Since 1994–1995, Oberlin College has offered a second semester undergraduate chemistry course on the organic chemistry of biological systems (bioorganic chemistry). After a semester of organic chemistry, students may choose between the bioorganic course or a course that emphasizes organic synthesis and mechanisms. Together, the first semester and the synthesis/mechanism courses contain all the material in a traditional organic course. However, taking the first semester course allows the students to proceed to the bioorganic course in the second semester, while still receiving substantial organic coverage. The bioorganic course and the mechanisms and synthesis course are not mutually exclusive, and some chemistry students take all three courses to their advantage.

In order to teach the bioorganic course, some material from a traditional second semester organic course was shifted to the first semester, which now covers functional groups, mechanistic intermediates, and several reaction types not typically seen until the second semester. These changes were made to give students additional exposure to reactions, such as substitution at carbonyl groups, which are needed to explain many biological processes. The bioorganic chemistry course covers many organic chemistry topics in a biological context. Some examples are organic redox chemistry, phosphate derivatives, hetereocyclic chemistry, metal–ligand interactions, macromolecules, catalysis, kinetics, organosulfur chemistry, equilibrium and thermodynamics, and photochemistry. This approach emphasizes the role of chemistry in biochemistry, plays to the chemist's strengths, and emphasizes core chemistry principles.

In the final talk of the morning, Dr. Elizabeth Theil discussed a recent book she edited, *Principles of Chemistry in Biology*, which is designed to be a teaching companion for faculty who want to include biochemical topics in first year chemistry courses. Dr. Theil taught for 29 years in the Biochemistry Department at North Carolina State University before moving to the Children's Hospital Oakland Research Institute and has long been interested in education at the chemistry–biology interface. Several of the ideas for the book arose from an ACS symposium in 1991 entitled "The Chemistry/Biology Interface: The Education of Future Scientists". While the book is not intended to be a text for a biological chemistry course, it lists many examples and problems that chemistry instructors can use to make a biological connection. Dr. Theil believes that beginning and advanced students can also benefit from the book. The chapter titles and authors are given below.

1. Structure: Organic Biological Molecules. Dale Poulter and David Goldenberg.
2. Bonds in Biological Molecules. R. Wolfenden.
3. Thermodynamics. Victor Bloomfield.
4. Introduction to Basic Kinetics. George McLendon and Robin C. Henderson.
5. Redox and Electrochemistry. Joan Selverstone Valentine.
6. Biochemical Spectroscopy and Dynamics. Betty J. Gaffeney.
7. The 1% Solution: The Inorganic Chemistry of Life. James Penner-Hahn and Elizabeth C. Theil.

Appendix. RasMol: A Molecular Visualization and Conceptualization Tool. Ron Rusay, Marco Molinaro, and Leverett Smith.

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*Integrating Biochemistry* *from page 2*

## Issues Raised during the Panel Discussion

Dr. Poulter began the panel discussion by emphasizing that there are many ways to integrate biochemistry into the core curriculum. The Committee on Professional Training is reluctant to provide a detailed set of instructions for fear that it may stifle new, creative approaches. It is not at all clear what the "best way" might be or that a "single solution" will be optimal for all schools. The Committee will carefully consider each program's coverage of biochemistry at the time of the five-year review and allow departments a reasonable period in which to respond to any deficiencies identified.

A member of the audience expressed concern that the integrated approach was an attractive alternative to a semester course in biochemistry but that the integration might not provide the same coverage as a dedicated course: "In general and organic chemistry we are using more biochemical examples, but it is not clear to me that this is biochemistry." One panelist agreed that students would probably not get the same coverage as in a separate biochemistry course but noted that the intent of the guideline was to increase exposure of chemistry students to biochemistry. In the past, too many students graduated with no exposure to biochemistry. The idea of the new guideline is to infuse enough biochemistry into the chemistry curriculum that students can make the connection between chemistry and the life sciences. Naturally, a student interested in biochemistry would need to take additional courses.

A panelist emphasized that the idea is not to stop teaching chemistry in the integrated model but to use molecules that are important in biology to teach chemistry. For example, "Don't teach physical chemistry in the gas phase. Teach it in the aqueous phase where biological reactions happen. Teach traditional chemistry that is found in biology." Dr. Poulter emphasized that integration should be across the core curriculum. For example, biochemical topics might appear in an analytical laboratory, in physical chemistry, and in inorganic chemistry. The idea is to integrate three semester hours of biochemistry over a wide range of topics taught in the total 28-semester-hour core.

Another question from the audience concerned using an existing course in biochemistry to satisfy the requirement. "Our dilemma is which course to eliminate from the core. What is the flexibility allowed by CPT?" Dr. Poulter pointed out that there are two different possibilities in this case. If the biochemistry course is advanced, the department could use that course as one of the two required advanced courses (six semester hours) to fulfill the biochemistry requirement. Students would, however, have to select biochemistry as one of the advanced courses for ACS certification. This approach would not change the department's core curriculum or require an additional course. However, it would reduce the flexibility in selection of advanced courses from two to one for certified majors. Also, the advanced biochemistry course must still meet the advanced course requirements (page 7, 1999 guidelines). Alternatively, a three-hour course in biochemistry could be part of the core curriculum. However, the courses in other areas may need to be adjusted if the department wishes to offer both a 28-hour core curriculum yet still retain comparable emphasis on the other four areas of chemistry. In other words, a department cannot eliminate one segment of the existing required core to make room for biochemistry.

Finally, a member of the audience commented that there might be a large difference in the content covered between programs integrating biochemistry into the first two years and programs using the advanced course option. Members of CPT on the panel agreed but thought that it was important to make the new requirements as flexible as possible.

**Announcement.** A supplement to the guidelines that will list suggested topics for satisfying the biochemistry requirement will appear in the next newsletter, and will also be posted on the CPT Web site after the August meeting.

**Reference Materials**

**A. J. Wolfson** (www.wellesley.edu/Chemistry/wolfsona.html)
**H. Drossman** (www.catamount.coloradocollege.edu/CC/ch345.htm)
**ChemLinks** (chemlinks.beloit.edu/)
**Project Kaleidoscope** (www.pkal.org/)
*Principles of Chemistry in Biology—A Teaching Companion;* Theil, E. C., Ed.; American Chemical Society: Washington, DC, 1998.

# Implementation of the New ACS Guidelines

*The Committee would like to recognize the extraordinary contributions of Dr. Norman Craig in the development of the 1999 edition of the ACS guidelines. Dr. Craig shepherded the Committee's discussions of the pertinent issues and then meticulously tracked the decisions that had been made and the items that warranted further deliberation. He also served as the sole editor of the document and took responsibility for crafting language that accurately and clearly describes the policies and procedures of the ACS approval program. The Committee deeply appreciates Dr. Craig's hard work and his tireless dedication to the timely completion of this project.*

A revised version of the ACS guidelines booklet, *Undergraduate Professional Education in Chemistry: Guidelines and Evaluation Procedures*, was published and mailed to all chemistry faculty at ACS-approved schools in the fall of 1999. Despite the new dusty rose cover, these guidelines should look generally familiar, but there are some substantive changes. The first and most far-reaching (and some say long overdue) is the requirement that all ACS-certified students must study biochemistry (page 7). Second, the guidelines are now explicit about the extent to which the chemistry core may be modified for ACS-approved options (page 8). Third, the biology course requirement for the biochemistry option is more detailed (page 7). Finally, there are suggestions about instruction in safety and in ethics (page 14), stronger language encouraging undergraduate research culminating in a comprehensive report written by the student (page 12), along with some other

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# Electronic Access to Journals

Full text of journal articles on the Web is increasingly common and desired by students and faculty. Impact on teaching and research, as well as cost, are important considerations.

In addition to the convenience of reading articles in labs, offices, dorms, and homes, other features promote electronic journal use. Increasingly, indexes such as Chemical Abstracts (CA) enable chemists to move easily from their indexed records to the full electronic article. A search in CA about protein folding will find review articles, for example, in *Accounts of Chemical Research*, as well as research articles. Students can choose to go directly to the full-text article from the CA reference, if their library has a Web subscription. Once there, they can learn about the different parts of journal articles, such as the abstract, introduction, experimental procedures, discussion and results. HTML versions offer many added features. Students can often follow links in footnotes to indexes to find other related articles and full text of the footnoted references. For *Accounts of Chemical Research* articles, students can find similar articles as indexed in PubMed (a version of Medline, the comprehensive medical index) and CA. The ease of moving between articles and indexes can encourage students to use these indexes and articles more often and effectively. The HTML versions also offer opportunities to zoom in on graphics and sometimes rotate images. Some electronic journals also offer the opportunity to locate additional articles on the same topic or by the same authors in the same journal, different journals from the same publisher, and soon between publishers.

Some journals provide additional information with their Web versions. For example, *Journal of Chemical Education* includes a feature for "evaluated Web sites" and additional information that is too extensive for inclusion in print versions. Similarly, the "Supporting Information" that accompanies some American Chemical Society journal articles is now available on the Web.

Many publishers, such as the ACS, publish new articles on the Web as soon as they are accepted for publication. These articles are abstracted in CA at that time, so access to these articles occurs immediately. With some publishers (such as ACS) and databases (such as UnCover, an online service that offers automated current awareness service from 18,000 periodicals), readers may request that they be notified when articles are published in a specific journal or on a specific topic. Currently, ACS's version (ASAP Alerts) enables readers to be notified by e-mail every time a new article for a specific journal appears on the Web. With ASAP Alerts, a click on the Web address contained in the e-mail launches the reader directly to the full text of the journal article on the Web.

All electronic journals include "Instructions for Authors", as well as copyright and permission information on the Web. For ACS, the copyright information includes an instruction component that can be used to teach students about copyright.

In most cases, access to electronic journals is via the library subscription, and often a library can extend its access to additional journals through consortia membership. Sometimes libraries and consortia subscribe to the entire range of journals published by a specific publisher, which increases the number of journals available to students and faculty. Usually, an electronic subscription to journals includes all years for which the electronic version is available. Costs vary considerably among publishers and may depend on special consortial prices or whether publishers use print or electronic subscriptions as the base for prices. Because of the complex pricing issues, close communication and cooperation between chemistry departments and libraries are crucial in making access available for chemists.

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# CPT Symposium at BCCE

On July 31, 2000, CPT will sponsor a full-day symposium at the 16th Biennial Conference on Chemical Education (BCCE) on the 1999 ACS guidelines for undergraduate professional education in chemistry. BCCE will be held at the University of Michigan in Ann Arbor, July 30–August 3, 2000. Information on registration for the 16th BCCE can be found at www.umich.edu/~bcce. The CPT symposium is called "The New ACS Guidelines and the Future". The symposium organizers are Jerry Mohrig of Carleton College and Norman Craig of Oberlin College.

During the morning session, speakers will discuss the changes in the new ACS guidelines. In the afternoon, there will be informal discussion on issues facing chemical education now and in the future. These discussions will help to form the basis of future CPT consideration of these issues.

**MONDAY 9:30 a.m.–noon**
**Presider: Jerry R. Mohrig**

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|---|---|
| 9:30 | Opening Remarks—Jerry R. Mohrig |
| 9:40 | Overview of the New ACS Guidelines—Norman C. Craig |
| 10:05 | Biochemistry in the ACS Guidelines—C. Dale Poulter |
| 10:30 | Questions and Discussion |
| 10:50 | Chemistry Degree Options and the New Guidelines—Sally Chapman |
| 11:15 | The Place of Undergraduate Research in the ACS Guidelines—William F. Polik |
| 11:40 | Questions and Discussion |

**MONDAY 2–5 p.m.**
**Presider: Norman C. Craig**

2–3:15 Discussion Sessions

Impact of Electronic Tools on Chemical Education
Mike Jaffe, Facilitator

Depth vs Breadth in Undergraduate Chemical Education
Billy J. Evans, Facilitator

3:15–4:30 Discussion Sessions

The Tension between Content and Pedagogy in Undergraduate Chemical Education
Jerry R. Mohrig, Facilitator

Part-Time Faculty and Faculty Development
Jeanne E. Pemberton, Facilitator

*Implementation* *from page 3*

changes. How soon are departments expected to respond to these new guidelines?

**Biochemistry.** Since the new biochemistry requirement for certified students has potentially broad curricular ramifications, CPT has been publicizing this change, along with a specific timetable, for some time. The course modifications, which may involve a separate course or a distributed model (material integrated into existing courses) should be in place by 2001. Students graduating in 2005 and thereafter must study biochemistry to receive an ACS-certified degree. The 2001 deadline was designed to give time for departments to develop and implement new course material. The Committee will request information about this material starting with the five-year reports to be submitted in December 2001. Departments submitting five-year reports in 2000 may, of course, request early review of their plans, but such a review is optional.

**Flexibility in the core for ACS-approved options.** For more than a decade, ACS-approved departments have been allowed to request approval of chemistry-based options in various chemistry-related areas. Biochemistry is the most popular, adopted by about $^1/_6$ of the approved schools. Environmental chemistry, introduced more recently, is growing. Each option is based on a common chemistry core. However, there has been some ambiguity (and perhaps some inconsistency) in the degree to which the core requirements for any option may be modified from those for the straight chemistry program. The new guidelines are more explicit: Up to four semester hours may be omitted from the core, as long as reasonable balance is maintained. (Appropriate substitutions, such as a good biologically oriented physical chemistry course for the biochemists, or an environmentally oriented analytical course, are always welcome.) For some schools, this four-semester-hour reduction may introduce greater flexibility. Since this policy is not really a change but rather an effort for greater consistency, it is being implemented immediately.

**Biology requirements in the biochemistry option.** This policy is also more a clarification than a change. The new guidelines state "beyond the introductory level, three semester hours of biology, which contains cell biology, microbiology, or genetics." Courses with such titles often cover overlapping material. This requirement does not require a comprehensive (or even balanced) exposure to all three areas. The appropriate selection needs to be made by each department, based on the available courses. Most biochemistry programs include such a requirement already—often more. This policy is therefore effective immediately and will be included in Committee reviews starting this year.

**Other changes.** Other changes in the guidelines fall more in the category of encouraging best practices. Good instruction in safety, consideration of professional ethics, the importance of continuing instruction in writing and speaking, and the central role that undergraduate research can play in the life of a chemistry student are nothing new for strong chemistry programs. The greater emphasis placed on these in the revised guidelines is to encourage all departments to adopt these practices.

**Implementation for schools seeking approval.** More than 600 chemistry departments have ACS-approved programs. These are reviewed on a five-year cycle. About 30 schools are in the process of seeking ACS approval; some are in the early stages of application, and others have already had visits from a CPT Visiting Associate. It is essential that a school seeking ACS approval have the resources and curriculum to meet the new guidelines in the future. For the new biochemistry requirement, the courses again need not be taught before 2001; however, if they are not currently being offered, a clear and detailed implementation plan must be presented.

# Changes in CPT Membership for 2000

The ACS Committee on Professional Training is a joint Board–Council committee of the Society. As such, the ACS Committee on Committees makes recommendations to the ACS President and Chair of the Board, who then jointly make the final appointments to CPT. For 2000, the new members are Dr. Margaret V. Merritt and Dr. William F. Polik. Dr. Merritt is an analytical chemist and a professor in the Department of Chemistry at Wellesley College. Her current research activities involve reactions at gold interfaces and the formation and characterization of colloidal gold arrays. Dr. Polik is a professor in the Department of Chemistry at Hope College. He is a physical chemist whose primary research interest is the development of sensitive spectroscopic methods to study energetic molecules. The Committee would like to express its appreciation for the contributions of Dr. Mitsuru Kubota who concluded his terms of service on CPT at the beginning of this year.

# Certificates for Graduates

Chemistry majors who receive a baccalaureate degree from an ACS-approved program and complete a curriculum described in the ACS guidelines may be certified to the Society for membership purposes by the head or chair of the approved institution. We will be happy to send certificates to certified graduates. When you request a certificate, please include the student's current mailing address. If you would like to have certificates available for presentation to your certified graduates, please let us know the number of certificates you would like and the date you need them. Send all requests by mail to the Office of Professional Training, American Chemical Society, 1155 Sixteenth Street, N.W., Washington, D.C. 20036 or by e-mail to cpt@acs.org.

# ACS Committee on Professional Training 2000




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