Chemical Literature
A Course Composed of Traditional and Online Searching Techniques

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Effective use of the chemical literature is of utmost importance to undergraduate, graduate, postdoctoral, and professional chemists. A thorough understanding of the organization and use of library sources is necessary to efficiently utilize the chemical literature. Although it can be taught in an independent chemical literature course, surveys indicate that the majority of chemistry departments do not offer an independent course (1–3). A majority of chemical literature papers submitted to this journal over the past two decades advocate incorporation of chemical literature studies into the lectures and laboratories of other courses (4), including general chemistry (5, 6), organic chemistry (7–9), instrumental analysis (10, 11), physical chemistry (12, 13), and advanced organic chemistry (14, 15).

A variety of reasons have been given for the lack of an independent chemical literature course: a curriculum too crowded to add another course, faculty unqualified to teach the course, and lack of instructional materials (1). Although a single teaching source may not be readily available, bibliographic sources that provide materials for teaching the chemical literature course are available in this journal (16) and on the Internet (17). These bibliographies allow one to assimilate information and produce a chemical literature course that corresponds to one's available library sources. It is not necessary that literature courses be taught by a librarian; a chemistry faculty member who has an interest in teaching the chemical literature course may be better qualified to do so than a librarian with little chemical background. This is the case at our small liberal arts university, where librarians have had minuscule exposure to the physical sciences yet excellent training in library sciences. Chemistry instructors would be prudent to utilize the expertise of university librarians to enhance the chemical literature course. While the demands on chemistry curricula may make it difficult to add a chemical literature course, we have found that a three-hour course offered in alternate years does not diminish the course offerings of our American Chemical Society (ACS) accredited undergraduate program and, in our opinion, is a better way to teach students how to use the chemical literature. Although incorporation of chemical literature into other courses is admirable, in our experience it is not a substitute for an independent course.

A significant number of articles that describe an independent chemical literature course have been published in recent years and may be categorized according to their prescribed course of study: a traditional course of study (19–21), an online course of study (21–24), or a mixture of traditional and online techniques (25–29). My experience as instructor of a chemical literature course for the past ten years has been that a mixture of traditional and online techniques taught in an independent course best prepares students for literature searching in any area of study. Literature searches in other chemistry courses reemphasize the techniques for students who have taken the chemical literature course and provide a brief introduction for other students. This strategy of a basic course in chemical literature, with continuing emphasis in other courses, was reported by Skolnik in 1984 (30).

Although an extensive bibliography is available for a chemical literature course and various aspects of a course have been previously presented, it is no small task to incorporate these into a newly developed course. The course description that follows is sufficiently general to allow an instructor to quickly establish a chemical literature course, after which the course can be gradually modified to fit the circumstances that prevail at a particular institution.

This paper describes a one-semester undergraduate chemical literature course that incorporates both traditional and online searching techniques. The discussion covers course enrollment and organization, lecture topics, and the associated library exercises, and a correlation table of lecture topics and library exercises is included in the paper. A list of supplementary materials (handouts) and sample library exercises are available at the Journal of Chemical Education Web site (http://jchemed.chem.wisc.edu). The library exercises can be easily modified to conform to the chemical literature available at other university libraries.

Course Enrollment

The chemical literature course is open to students who have completed the two-semester general chemistry course. The average class size has been 11 students (range 4–18), comprising sophomores (17%), juniors (38%), and seniors (45%). The majority of chemical literature students have been chemistry majors (58%), although numerous biology majors (18%) and preprofessional students (9%) have also taken the course. Many of the students have gone on to industrial positions (12%), chemistry graduate school (14%), and medical school (10%).

Course Organization

The chemical literature course is divided into six progressive areas of study: general library information; primary, secondary, and tertiary sources of information; periodicals and periodical directories; abstracts and indexes; literature of specific chemical areas; and patents and government documents. The basic format of the course is lecture, supplemented with handouts. Each of the six areas of study has exercises that reinforce the lectures and allow students to perform a variety of literature searches in the library. Thirteen library exercises are assigned during the semester (approximately one per week). Final grades are based on the library exercises (70%), written midterm and final exams (10% each), and a practical final exam (10%) involving...
a library search. The library exercise grades are based on correct answers and correct citation format of the answers.

**General Library Information (Library Exercise 1)**

The course begins with a review of library policies and a survey of the library's organization. Library cataloging systems (Library of Congress and Dewey decimal) are examined for general, science, and chemistry classifications; a detailed Library of Congress classification scheme for chemistry is also examined (32). The cataloging systems for books (traditional library catalog and online) and periodicals are studied, followed by an explanation of Library of Congress subject headings (33). Students are required to use the ACS citation format (34) in each library exercise. Library exercise 1 provides an introduction to the library. A sample answer sheet for exercise 1, using the required outline format, is provided as a guide for preparing library exercise answer sheets.

**Primary, Secondary, and Tertiary Sources of Information (Library Exercises 2 and 3)**

Definitions, descriptions, and examples from the chemical literature are provided for each of the three general types of literature sources: primary, secondary, and tertiary. Some of the chemical literature examples discussed are an encyclopedia (36), dictionaries (37–39), handbooks (40, 41), tables (42), formularies (43, 44), a directory (45), a treatise (46), and a monograph (47) that are available in the university library. Search techniques are discussed for each of the sample sources, and students are encouraged to locate and use introductory guides and explanations that are available in many books. Library exercises 2 and 3 provide students the opportunity to use the secondary and tertiary literature to gain an appreciation of the diversity of information found in the chemical literature, a knowledge of the vast availability of chemical literature sources, and a realization of the enormous amount of information located in each.

**Periodicals and Periodical Directories (Library Exercises 4 and 5)**

This section of the course examines the periodical literature. Initial discussion includes a definition and synonyms used for periodicals, and differentiation of primary, secondary, and review-type journals. Descriptions and examples are presented for periodicals differentiated by their origin (learned societies, governmental bodies, professional bodies, commercial publishers, etc.) and scientific category (general science, general chemistry, analytical chemistry, inorganic chemistry, etc.). A list of ACS and Chemical Society (London) journals is reviewed, including development of the Chemical Society journals from 1841 to present. Descriptions of CASSI (48), Ulrich's (49), and Gale (50) periodical directories and their entries are also presented.

Library exercise 4 requires students to use seven different scientific journals, at least one of which is in microform, to perform author and subject searches using journal indexing information. Library exercise 5 requires students to search periodical directories for a variety of information associated with four different journals when given the full name, abbreviated name, or order of citation ranking (CASSI). Both regular and irregular serials are utilized in exercise 5, and ACS (Washington, DC) journals are used exclusively for the Gale directory search. These assignments provide the students with an insight into searching the primary journal literature and an appreciation of future searching for journal articles using Chemical Abstracts.

**Abstracts and Indexes (Library Exercises 6–9)**

Initial discussion includes the definition and contents of an abstract, followed by lists of chemical abstracting services since the 19th century. Chemical Abstracts (CA) (51) is discussed in detail, beginning with printed CA, then advancing to CA online. Discussion of printed CA includes bi-weekly section groupings (sections 1–34 and 35–80) and subject groups of the abstracts (52), the seven basic document types that are abstracted, and the contents of CA abstracts. Weekly, volume, and collective CA indexes are discussed, including the index guide. Handouts of materials from Chemical Abstracts Service (CAS) (53) provide ample reading information. Library exercises 6 and 7 utilize printed CA only and are completed before advancing to CA online. Discussions of CA online servers (54) and CA online searching (14, 15, 55) have been published in this journal. Students use the STN Mentor program to perform library exercises 8 and 9. The STN Mentor program allows them to work at their leisure, at any hour of the day, and obtain multiple displays without additional costs. This program, although limited to approximately 500 files, is an excellent teaching alternative to the more costly learning CA files (LCA).

Library exercise 6 is an excellent introduction to CA and requires students to use the index guide and the author, general subject, chemical substance, and formula index of printed CA. Library exercise 7 is a bibliographic search of printed CA that allows students to comprehend the ease of citation recovery when compared to exercise 4; however, it also serves as a stepping stone towards a recognition of the usefulness of CA online searching in exercise 8. Library exercise 8, an introduction to CA online searching, is similar in nature to exercise 6 (printed CA), yet provides a comparison between CA print and online search methods. Library exercise 9 requires students to use Boolean operators during a CA online search and affords a periodical citation that is available in the university library. These four exercises provide a solid foundation in printed CA searching and an appreciation of CA online searching.

Several indexing journals are discussed in this portion of the course, including Chemical Titles (56), Current Contents (57), and Science Citation Index (SCI) (58). The scope and limitations are discussed for each and their usefulness is reinforced with handouts (59–61).

**Literature of Specific Chemical Areas (Library Exercises 10–12)**

This portion of the course describes and discusses the secondary literature of analytical, biochemical, inorganic, organic, and physical chemistry. Discussion of the organic chemical literature begins with Beilstein's handbook (62), including the history of Beilstein's various editions and descriptions and explanations of how to use the fourth edition (63). The organic literature discussion continues using treatises (64), monographs (47, 65), dictionaries (38), and syntheses (66–68), reaction (65, 69, 70), and reagent (70, 71) chemical sources. The inorganic chemical literature discussion begins with Gmelin's handbook (75) and follows the method of Berylstein. Other inorganic literature sources discussed are treatise (76–78), monograph (79), synthesis (80), technique (81), and textbook (82, 83) sources. Discussion of the physical chemistry literature begins with Carnahan, Boorse, Bohn, and Bornstein (84) and the Landolt-Bornstein New Series (85). It then continues with other sources including treatises (86), handbooks (40, 41), and tables (87–89). Discussion of the analytical and biochemical literature includes treatises (46, 90–92) and other chemical sources.

Library exercise 10 is limited to the examination of organic literature, while exercise 11 surveys the inorganic, analytical, and physical chemistry and biochemistry litera-
ture. These exercises provide an introduction to the literature sources of the various areas of chemistry.

Many colleges and universities that do not have doctoral programs in chemistry find it cost prohibitive to hold collections of major works such as Beilstein, Gmelin, and Landolt-Bornstein; however, this need not prevent students from being exposed to these treatises. There are often large research institutions within a short driving distance at which the librarians are amenable to class trips from smaller schools, especially if the visiting students have had library instruction by means of a chemical literature class. Exercise 12 utilizes Belstein’s fourth edition (62), Gmelin (75), and Landolt-Bornstein’s 6th edition (84) or the New Series (85), as well as Science Citation Index (58).

**Patents and Government Documents (Library Exercise 13)**

The discussion of patents includes a definition, goal, and brief history of patents, the basic elements of patentability, the description and claims of a patent, and patent types. These topics are followed by a listing of U.S. patent headings and specifications, patent classifications, and a description of patent depository libraries and the cost of obtaining patent documents from the U.S. Patent and Trademark Office. The three types of periodicals that list patents (patent journals, abstracting journals, and industrial chemical journals) are discussed with descriptions of the Official Gazette (93) and the CA patent indexes.

The discussion of government documents includes a description of government publications, the general organization and activities of federal agencies (94), and the involvement of each in scientific studies. A description of depository libraries and sources used to locate federal (95) and state (96) publications is also presented.

Library exercise 13 requires students to search the patent literature and government publications. The patent literature search involves both author and patent number searches and utilizes the CA Numerical Patent Index, CA Patent Concordance, and CA Patent Index. The government publication search utilizes the Monthly Catalog of U.S. Government Publications (95), its indexes, and the university library government publication catalog to locate the assigned subject and keyword from an assigned year.

**Conclusions**

This paper is an effort to encourage science educators to provide a mechanism for their students to become familiar with the chemical literature and its effective use. My goal was to provide ample sources, ideas, and examples so that one can develop a chemical literature course at any university library. Both traditional and online searching techniques have been described and incorporated into 13 library exercises that can be easily modified to correspond with available library sources.

The true usefulness of a chemical literature course may be best stated by former students. Two statements that I have heard repeatedly are “I only wish I had taken the chemical literature course earlier in my college career” and “The chemical literature course was one of the most useful courses I took in college.” Regardless of how important we as science educators realize that a chemical literature course may be, when students recognize its importance and usefulness, then we must provide them with the opportunity for a complete education.

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**Notes**

1. Although it is no longer in print, I used Mellon’s *Chemical Publications* (18) as the course text from 1985 to 1993. I currently use handouts from a variety of sources (see *Supplementary Materials – Handouts* at the J. Chem. Educ. Web site http://jchemed.chem.wisc.edu) and lecture notes from previous years in the chemical literature course.

2. The initial format of the library exercises in this paper originated from Gorin and Dermer (31) and has been revised to conform with the chemical literature available at our university library. Although other schools may not have the specific literature sources described in this paper, a variety of other sources can be easily substituted for all library exercises, and the assigned items for each exercise can be easily located by perusal of one’s available chemical sources.

3. University library handouts are utilized, including a map with descriptions of the individual areas of the library.

4. Online searching of the library catalog has only become available at the APSU library since the chemical literature class was last taught.

5. Both the Chemistry Department and the university library have computer laboratories that have WordPerfect for Windows programs installed and are available for student use. Students are required to perform a practice exercise using the outline format found in a WordPerfect for Windows guidebook (35).

6. The chemical literature course described in this article does not currently utilize the LCA and LREGISTRY files; this option may be added to the course in the future, but only after students have had training using the STN Mentor program.

7. Appropriate search topics for library exercise 9 that produce citations available in the university library can be located by performing a search of the STN Mentor program for journals available in the library, via the coden search parameter (e.g., SEARCH JCEDAB/CO for all papers in this Journal).

8. *Science Citation Index*. Beilstein, Gmelin, and Landolt-Bornstein are not available at the Austin Peay State University library. Exercise 12, which includes these indexes and treatises, is performed at the Vanderbilt University Stevenson Science Library in nearby Nashville, TN.

9. A series of papers has been published in this *Journal* that provides material regarding organic chemistry information sources (72–74).

**Literature Cited**
