

# Using *The Poisoner's Handbook* in Conjunction with Teaching a First-Term General/Organic/Biochemistry Course

Daniel R. Zuidema\* and Lindsey B. Herndon

Department of Chemistry, Covenant College, Lookout Mountain, Georgia 30750, United States

## S Supporting Information

**ABSTRACT:** Deborah Blum's *New York Times* bestselling nonfiction book *The Poisoner's Handbook* was used as supplementary reading in our first-term General/Organic/Biochemistry course. This course serves as both the first course for our Allied Health chemistry sequence and a core science course. Our goal was that, through reading this book, students would learn more about the origin of forensic chemistry in the historical context of the Jazz Age and the toxins that were often involved in poisonings near the beginning of the 20th century. Outcomes and student feedback to this initiative are discussed.



**KEYWORDS:** General Public, High School/Introductory Chemistry, First-Year Undergraduate/General, History/Philosophy, Textbooks/Reference Books, Applications of Chemistry, Enrichment/Review Materials, Forensic Chemistry

## INTRODUCTION

Poison. Murder. Chemistry. Few words possess the ability to evoke a sense of fear and mystery as well as these.<sup>1,2</sup> Deborah Blum's 2010 *New York Times* bestseller, *The Poisoner's Handbook*, deftly weaves an intriguing tale that recounts the interrelatedness of poison, murder, and the beginnings of forensic chemistry in 1920s New York.<sup>3</sup> One of the age-old challenges that chemistry instructors face is rousing the curiosity and interest of students. The authors wish to describe their most recent efforts to this end. At Covenant College, Introductory Chemistry I serves both as a core laboratory science course and as the first-term course in the General/Organic/Biochemistry (GOB) chemistry sequence. Some of the concepts studied include measurement, atomic structure, nuclear chemistry, electronic structure and periodicity, bonding/nomenclature of ionic and covalent compounds, molecular geometry, chemical reactions, stoichiometry, intermolecular forces, states of matter, and acid–base chemistry, among others. In order to give readers a sense of the overall structure of the course, a syllabus is provided in the [Supporting Information](#). In any given year, approximately two-thirds of the students enrolled are aspiring health-science majors who intend to pursue careers in nursing or physical therapy. The rest are taking the course to satisfy their laboratory science core requirement. There is significant public interest in television programs that focus on forensic science. Indeed, shows such as *CSI*, *Bones*, and *Forensic Files* have been among some of the most popular programs on the air for more than a decade.<sup>4,5</sup> The effect that the increased number of crime and forensic television shows has had on science education has been

discussed previously.<sup>6</sup> Using forensic science applications to engage students of all ages has a long and well-documented history in this Journal.<sup>7–11</sup> Given the large percentage of enrolled students interested in health sciences, and given the public interest in forensic/crime television programs, we believed that reading *The Poisoner's Handbook* would serve to pique student interest in the relationship between chemistry and forensic science. We hoped it would also serve as an engaging way for students to learn more about the simple toxins commonly implicated in both accidental and homicidal poisonings in the early 20th century. Informal conversations revealed that students were immediately drawn in by the title, and understandably so. The integration of topics related to chemistry, medicine, forensic science, and American history made the book especially appealing for use in a course that doubles as a laboratory science core course and a first-term GOB chemistry course.

## BACKGROUND

Using a popular book to supplement instruction in a college-level chemistry course is an idea that is not without precedent. For instance, Bucholtz has described using *Napoleon's Buttons: 17 Molecules That Changed History* in a two-semester organic chemistry course.<sup>12,13</sup> Students read various chapters of *Napoleon's Buttons* as they progressed through the course—readings were made to correlate with the subject matter being discussed in lecture. Generally, students were reported to have responded favorably to use of the book in conjunction with the

Table 1. Ways in Which *The Poisoner's Handbook* Chapters Were Integrated into First-Term GOB Course

Chapter	Poison Discussed	Demonstrations/Examples
1	Chloroform	Density was measured in density experiment; molecular shape and polarity were considered in VSEPR unit.
2	Wood alcohol	Density was measured in density experiment, molecular shape considered in VSEPR unit, and capability for H-bonding discussed in bonding unit.
3	Cyanides	Molecular model (of HCN) was built in modeling activity; Lewis dot diagram for HCN was given as a lecture example.
4	Arsenic	Electron configuration of As was given as a lecture example; As <sub>2</sub> O <sub>3</sub> was examined in an activity in which observations were made of various elements and compounds.
5	Mercury	Both Hg and HgCl <sub>2</sub> were examined in an activity in which observations were made of various elements and compounds.
6	Carbon monoxide (I)	Molecular model was built in modeling activity; CO was cited as an example of a molecule that forms a coordinate covalent bond and that contains a polar covalent bond.
7	Methyl alcohol	Please see entry for "Wood Alcohol" above.
8	Radium	Alpha decay process of radium was shown as an example in nuclear chemistry unit.
9	Ethyl alcohol	Density was measured in density experiment.
10	Carbon monoxide (II)	Please see entry for "Carbon monoxide (I)" above.
11	Thallium	Flame test of thallium was shown as a demonstration in atomic spectroscopy lab.

course, as it provided them with a broader sense of how various organic molecules have influenced history, politics, and society. Samet and Higgins have reported using the same book in connection with their nonmajors' core chemistry course, where students were required to work together to compose their own book modeled after the structure of *Napoleon's Buttons*.<sup>14</sup> Each individual chapter was to focus on a particular molecule and its role in shaping history. (For readers who may be unfamiliar with this title, *Napoleon's Buttons* is a chronicle of how 17 different molecules or classes of molecules significantly influenced the course of historical events. The book has been reviewed in *Chemical & Engineering News*.<sup>15</sup>) Students in this study were also reported to have responded positively to their instructors' choice to use *Napoleon's Buttons* to augment learning. Amaral and Shibley have documented their use of *The Omnivore's Dilemma* and *Living Downstream* in one- and two-semester organic chemistry courses, respectively.<sup>16–18</sup> The one-semester course required students to interact with thoughts from the book in both class discussions and a short paper; the two-semester course focused much more on the paper than on in-class discussion. Again, the majority of student feedback was reported to be generally positive. Given its popularity, we were surprised to see that no one had reported using *The Poisoner's Handbook* as a supplementary text for a chemistry course in this Journal. Thus, we decided to communicate our own experience with using *The Poisoner's Handbook* in this capacity.

## ■ OUR MODEL FOR IMPLEMENTATION

In our model, students were required to read one chapter of *The Poisoner's Handbook* each week; a detailed schedule was provided in the syllabus at the beginning of the course. This did not take the place of our ordinary textbook, H. Stephen Stoker's *General, Organic, and Biological Chemistry*; rather, it was used as supplementary reading to stimulate student interest and enrich the content of the course. On the first day of class, the rationale behind reading the book was explained. We shared that our goal was to use *The Poisoner's Handbook* to learn more about the origin of forensic chemistry in the historical context of the Jazz Age, and that this would serve to illustrate ways in which chemistry could be applied to real-life (and death) problems. Each week a brief quiz was given in order to hold students accountable for doing the reading. Surveys were given to the class to assess student opinions of the project and to solicit feedback. A prequiz was given at the beginning of the course to gauge baseline knowledge. Then, at the conclusion of

the course, students were given a final assessment that contained questions identical to those on the prequiz. Prior to the final assessment, students were required to watch *The Poisoner's Handbook* documentary on *American Experience*, which is a 2 h movie available on the web.<sup>19</sup> Because class and lab time is precious, students were required to do this outside of class. The assignment was given over Thanksgiving break. Students were advised that watching the movie would serve as an excellent, entertaining way to prepare for the final assessment. We found that students responded favorably to this assignment, as they appreciated the utility in watching the movie in order to prepare for an assessment. Although they were not used in this particular study, the *American Experience* Web site has a number of interesting teaching resources related to *The Poisoner's Handbook* that instructors could conceivably find helpful in incorporating the book into a science course. Some of these resources include laboratory simulation activities that mimic some of the observations described in the book, and interactive electronic simulations that allow students to "perform" forensic tests on a computer or mobile device. In our course, poisons from *The Poisoner's Handbook* were often chosen to serve as centerpieces for various examples, demonstrations, and laboratory experiments throughout both the lecture and laboratory components of the course. A sampling of these methods of application of the contents of *The Poisoner's Handbook* to first-term GOB course material can be found in Table 1.

We were particularly pleased with how *The Poisoner's Handbook* provided a tangible starting point for several different conversations throughout the course. For instance, students were asked to memorize a list of polyatomic ions during the unit on ionic bonding. Among the ions students memorized were the cyanide, nitrite, and thiocyanate ions. By this point in the course, students had read the chapter of *The Poisoner's Handbook* that describes cyanide poisoning. A class discussion on the role of the nitrite and thiocyanate ions in cyanide antidote chemistry naturally followed. The instructor also took this opportunity to illustrate the simple point that correct spelling of ions and careful reading of labels is critical, as the difference of just one letter can mean the difference between life and death—a victim of acute cyanide poisoning who is treated with nitrite rather than nitrate will likely die. As another example, in the context of covering solutions, time was spent discussing the chemistry and public policy issues associated with denatured alcohol. Prior to this discussion, students had

already read the chapters in *The Poisoner's Handbook* that describe methyl alcohol and its use as a denaturant in ethyl alcohol. Discussions such as these were valuable and supported some of the broader goals of the course, i.e., to contribute to students' liberal arts educations and prepare them for the health-science fields. *The Poisoner's Handbook* addresses several political, social, historical, and cultural aspects relating to many public health issues. This made it an ideal choice for supplementary reading for a class that doubles as both a core laboratory science class and a first-term GOB course. It also allowed for fruitful discussions about how the discipline of chemistry can be used for just and noble purposes as well as for unjust and criminal purposes.

As Covenant College is primarily an undergraduate institution, we do not have graduate teaching assistants. Rather, students can perform various tasks for financial aid in a work-study program. Thus, we frequently employ our chemistry majors as teaching assistants for introductory-level courses. The teaching assistant for Introductory Chemistry I was a chemistry major who was interested in pursuing chemical education. She was asked to read *The Poisoner's Handbook* during the summer so she would be familiar with it by the time it was being used in the course. She also participated in writing some of the weekly reading quiz questions, grading assessments, and processing data from the student surveys—all activities that dovetailed well with concepts she was learning in her education courses.

## ASSESSMENT AND RESULTS

### Weekly Reading Quizzes

In order to assess student learning, several small quizzes were given that covered the reading. Reading quizzes for each of *The Poisoner's Handbook* chapters can be found in the [Supporting Information](#). These did not replace the assessments covering traditional course content from the Stoker textbook. Students were told to expect a quiz over each assigned *The Poisoner's Handbook* chapter, to be taken at the beginning of their weekly laboratory session. The quizzes typically consisted of five multiple choice items and one short answer question. Multiple choice questions were written in such a way that someone who had done the reading would be able to do well on the quizzes; questions were not aimed at testing students' technical understanding of the reading. The short answer question usually tested the students' ability to recollect the chemical formula of the toxin discussed in the chapter. Class mean scores on the quizzes ranged from a 69% (SD = 27, N = 13) to a 94% (SD = 15, N = 16) with the class's overall *The Poisoner's Handbook* reading quiz average being an 85% (SD = 18, N = 164). For nine of the 11 chapters, quiz averages were greater than 80%. As the final course average was a 75% the term these statistics were gathered, the weekly reading quizzes generally served to raise students' overall grades.

### Prequiz versus Final Quiz Outcomes

A prequiz was given at the very beginning of the semester to assess students' baseline knowledge level coming into the course. The quiz consisted of ten matching items that evaluated students' basic knowledge about several poisons described in *The Poisoner's Handbook*. The quiz also contained one multiple choice item testing students' knowledge of when Prohibition occurred. This quiz was given only a few days after the students learned that they were to order the book, and it was confirmed that none of the students had read the book before. Because we planned to use the exact same assessment questions at the end

of the course to serve as a metric of student progress, we intentionally did not return the corrected prequizzes to students. This served to guard against the possibility that students would simply remember which items had been the correct choices on their returned prequizzes. Not surprisingly, student performance on the 11 question prequiz was dismal. The class average was a 23% (SD = 15, N = 14). At the conclusion of the course, students were given a final quiz that contained the same 11 questions that appeared on the prequiz. For these 11 items, the class average rose to a 71% (SD = 23, N = 14). A paired samples *t* test was conducted to determine whether the mean scores were significantly different. The difference was significant ( $t = -9.055$ ,  $p < 0.001$ ). Cohen's *d* is 2.4, which is considered a large effect size, confirming that students' basic knowledge about the various poisons discussed in the book significantly improved.<sup>20</sup> It was also interesting to see that student performance rose markedly for almost every individual question on the quiz, as shown in [Table 2](#).

**Table 2. Student Response Data for the Prequiz and Final Quiz**

Question	Percentage of Students Answering Correctly	
	Pre-Quiz (N = 14)	Final Quiz (N = 14)
1. Which is a sweet smelling liquid that has been used as an anesthetic?	29	79
2. Which was often used as a source of toxic alcohol during the Prohibition era, causing blindness, coma, and death?	43	86
3. Which was used in paints for the dial faces of watches?	7	79
4. Which was an ingredient found in rat poison and gives a brilliant green flame test?	0	50
5. Which of these is the alcohol found in alcoholic beverages today?	50	71
6. Which is a combustion product that is toxic?	57	57
7. Which poisonous material was found in "inheritance powder"?	14	64
8. Which of these did Standard Oil Company add as an antiknocking agent in gasoline?	0	71
9. Which was used as a fuel in gas lamps in the early 20th century and was called "illuminating gas"?	0	57
10. Which was an ingredient, thought to give health and energy to the user, added to face creams, lotions, candy, drinking water, and swimming pools?	0	71

Surprisingly, the only quiz item that did not see significant improvement was a question about carbon monoxide, a molecule to which *The Poisoner's Handbook* devotes two chapters to discussing.

The final quiz also assessed whether students had completed the assignment of watching the *American Experience* movie. To this end, four multiple choice questions were included that could be easily answered by someone who had watched the movie. According to student responses on the final survey, 86% of the students watched all or nearly all of the movie, and this translated into students collectively scoring 77% on these four particular items. Copies of the quizzes are available in the [Supporting Information](#).

### Survey Outcomes

In order to solicit candid feedback from the students about the use of *The Poisoner's Handbook* in our course, surveys were



given at both the middle and end of the term. Students were allowed approximately 10 min at the beginning of the laboratory period, and were encouraged to give honest, constructive criticism. Midterm surveys were completed 6 weeks into the course; final surveys were given on the last day of lab. Survey questions, along with a summary of student response data, are shown in Table 3. As there were no significant differences between the midterm and final survey results, only final survey results are shown in Table 3.

Students were also invited to give feedback on two free response questions. The survey, along with students' free responses, can be viewed in the Supporting Information.

Table 3. Survey Results

Survey Questions	Mean Score ± SD (N = 14)
1. Overall percentage of the book you have read:	5.64 ± 0.63 <sup>a</sup>
2. As a result of the book, I have become more interested in the course material (chemistry).	4.43 ± 0.76 <sup>b</sup>
3. I would encourage the use of this book in future terms.	4.86 ± 0.36
4. Knowing that there would be a weekly quiz caused me to be more likely to read the assigned chapter.	4.71 ± 0.47
5. I believe I would have done the assigned reading even if there hadn't been weekly quizzes holding me accountable.	3.29 ± 1.27
6. I enjoyed the application to the medical aspect of chemistry that the book made.	4.50 ± 0.65
7. I enjoyed the application to forensic chemistry/crime fighting that the book made.	4.43 ± 0.65
8. I found the contents of the book to be applicable to the course content.	4.29 ± 0.61
9. I found the examples in class connected to the book to be helpful to my overall understanding of course content.	4.21 ± 0.80
10. I found that the demonstrations/activities in lab connected to the book to be helpful to my overall understanding of course content.	4.29 ± 0.73
11. Reading this book has taught me new things about how chemistry is applicable to forensic science.	4.79 ± 0.43
12. If I was to take the second semester continuation of this course (CHE 104), I would be interested in reading a similar book in that course.	4.64 ± 0.63
13. I found the weekly reading quizzes to be of the appropriate difficulty level.	4.00 ± 1.04
14. I felt that the weekly reading quizzes were often overly simplistic/too easy.	2.29 ± 0.91
15. I would say that reading the book enhanced/positively added to my overall experience of the course.	4.57 ± 0.65
16. I believe reading the book was a valuable use of my time and taught me something important.	4.43 ± 0.65
17. Overall amount of the American Experience <i>The Poisoner's Handbook</i> movie you watched:	3.43 ± 1.09 <sup>c</sup>
18. I enjoyed watching the American Experience movie based on <i>The Poisoner's Handbook</i> .	4.58 ± 0.51 <sup>d</sup>
19. I found the movie to be a beneficial way to prepare for the final quiz.	4.66 ± 0.65 <sup>d</sup>
20. On <i>The Poisoner's Handbook</i> final quiz, I felt that the questions <u>about the movie</u> were of the appropriate difficulty level.	4.31 ± 0.48 <sup>d</sup>
21. On <i>The Poisoner's Handbook</i> final quiz, I felt that the questions <u>about the movie</u> were overly simplistic/too easy.	2.08 ± 0.95 <sup>d</sup>

<sup>a</sup>Question 1: 1 = 0–20%; 2 = 20–40%; 3 = 40–60%; 4 = 60–80%; 5 = 80–99%; 6 = 100%. <sup>b</sup>Questions 2–16, 18–21: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree. <sup>c</sup>Question 17: 1 = none; 2 = less than 1 h; 3 = more than an hour, but not all of it; 4 = all of it. <sup>d</sup>For questions 18–19 and 20–21, N = 12 and 13, respectively; students that had not watched the movie abstained from answering these questions.

## DISCUSSION OF RESULTS

Results from the reading quizzes and survey question 1 (Table 3) suggested that students generally appeared to take the reading assignments seriously. We were interested to see that students seemed to have a realistic outlook concerning their likelihood to do the reading apart from having the accountability of a weekly reading quiz, as shown in their collective response data for item 5 on the survey (Table 3). It was our goal to ask questions on the reading quizzes that would be relatively simple to answer for students who had done the reading. In order to gauge whether we were successful in doing this, we asked two questions on the survey about the difficulty of the reading quizzes. We felt obligated to dedicate two survey questions to this as we wanted to remove possible ambiguity that might arise if students said they disagreed with either item 13 or 14. Taken together, we were able to see that students were generally of the opinion that quiz questions were of an appropriate difficulty level. Students also seemed to believe that the quiz questions about the review movie were of a reasonable level of difficulty, as evidenced by their responses to survey items 20 and 21.

One concern that we had in introducing *The Poisoner's Handbook* as supplementary reading was that it would present an additional burden on the students that had not been there in previous years the course was taught. The rest of the course was not modified in any other way in comparison with how it had been taught in previous years; the workload was not reduced to accommodate the additional reading expectation. Our concern was that time students might normally have spent reviewing lecture notes, working homework problems, studying for quizzes, reading the textbook, etc. would now be devoted to the supplementary readings and that their performance in the course might suffer in comparison with student performance from previous years. In order to evaluate whether this was the case, we examined two lines of evidence. At Covenant College, we give the general subtest of the American Chemical Society (ACS) standardized GOB exam to evaluate our students at the end of the term. Over the four previous iterations of offering the course, a total of 39 students had taken the ACS exam, averaging at the 70th percentile (SD = 23). During the semester in question, 14 students took the ACS exam, averaging at the 66th percentile (SD = 23). An independent samples *t* test assuming equal variances indicated that the two means were not significantly different ( $t = 0.588$ ,  $p = 0.559$ , two-tailed). Also, we compared students' final lecture course percentages. Over the four previous iterations of offering the course, students averaged a 74.9% (SD = 15.2,  $N = 39$ ). During the semester in question, the course average was a 74.8% (SD = 13.0,  $N = 14$ ). Again, an independent samples *t* test assuming equal variances indicated that the two means were not significantly different ( $t = 0.038$ ,  $p = 0.968$ , two-tailed). These two lines of evidence suggest that the additional workload did not negatively impact students' performance in the course.<sup>21</sup>

We believe that overall, using *The Poisoner's Handbook* enhanced the students' experience. This came through clearly not only in the student responses to items on the surveys (i.e., items 3, 6, 7, 11, 15, 16), but also in some of the students' free responses:

I loved reading this book. Chemistry is a difficult subject and a lot of principles are hard to grasp, but I think the book gave examples which applied nicely to the material we studied and made it a bit easier to understand. Not only did it help me in this aspect, but I think it reduced the overall stress I had about this course and added a fun aspect to the class.

Really enjoy the side reading that is not strictly related to the textbooks. Enjoying the application of forensic science the most.

I just have really enjoyed this book. I like the quizzes every week to keep me reading constantly [sic], and I think using this book in coordination with lab has made it very enjoyable.

Although *The Poisoner's Handbook* component of the class constituted a fairly minor component of students' overall grade (the quizzes amounted to counting for approximately 2% of their final grade), it made a significantly positive contribution to student morale and the ethos of the class.

## CONCLUSIONS

It was our desire that, through reading *The Poisoner's Handbook*, students would become better educated about the forensic chemistry associated with some of the simple poisons commonly encountered by medical examiners during the Jazz Age. Student opinion surveys indicated that reading *The Poisoner's Handbook* was an effective way to spark interest in the forensic and medicinal chemistry of poisons. The surveys also indicated that students believed reading *The Poisoner's Handbook* caused their knowledge about the forensic chemistry associated with early 20th century poisons to deepen. The objective evidence of the prequiz and final quiz scores coupled with the reading quiz scores showed this notion to be correct. Even though our particular sample size was somewhat small, we believe the initiative and observations reported in this study should be applicable and beneficial to chemistry instructors regardless of the number of students enrolled in their classes.

## ASSOCIATED CONTENT

### Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00205.

Quizzes, syllabus, final survey, and student free responses from the survey (PDF, DOCX)

## AUTHOR INFORMATION

### Corresponding Author

\*E-mail: [zuidema@covenant.edu](mailto:zuidema@covenant.edu).

### Notes

The authors declare no competing financial interest.

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- (20) At the beginning of the semester 17 students took the prequiz. Over the course of the semester, three students dropped the course, so only 14 students took the final quiz. Thus, for purposes of the paired samples *t* test, these three students' prequiz scores were discounted from the prequiz statistics.
- (21) For all five of the terms being compared, the textbook, homework assignments, quizzes, lecture notes, and instructor were all the same, meaning that the student experiences were more or less identical but for the use of *The Poisoner's Handbook* as supplementary reading during the most recent term.