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Articles

Content and Conflict

THE USE OF CURRENT EVENTS TO TEACH CONTENT IN A BIOCHEMISTRY COURSE*

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Case study exercises, based on newsworthy current events, have been written for a biochemical audience that include elements of both "content" and "conflict." The cases have been written in such a way as to teach students basic biochemical principles. At the same time, a dilemma is posed to the students, who must use what they have learned about the issue to come to a decision to resolve the conflict. In this manner, the students learn important biochemical principles but are also asked to deal with the scientific or social conflict posed in the case.

Keywords: Problem-based learning, case study analysis, current events, classroom exercise.

The use of the case study method in the science classroom has increased dramatically during the past decade. Several educational journals, including this one, have included examples of case study exercises as a regular feature of each issue [1, 2]. Conferences have been held to instruct faculty in the art of teaching the case study method [3, 4]. The University at Buffalo and the University of Delaware have compiled collections of case studies that are available on line [5, 6]. Courses have been redesigned to follow a case study analysis format [7]. But the case study method is not as widely used as it might be because of the perception that the use of this method would require the instructor to sacrifice course content to allow time for the students to work on cases.

However, it *is* possible to carry out case study analysis without sacrificing content. The "directed" case study method can be used as a vehicle to convey the same content that might otherwise be covered in a lecture format. The directed case study method was first described by physiologists Cliff and Wright [8] and has subsequently been used by other instructors in other fields such as organic chemistry[1] and biochemistry [10]. Directed case study analysis is more focused than an open-ended case study exercise and involves the introduction of the case by the instructor who then poses a series of specific questions designed to focus student attention on certain key issues of the topic. In this manner, the instructor can cover the same scientific content as the lecture, and the use of the case study method has the effect of increasing student interest so that concepts are mastered with a greater depth of understanding.

Current events are a rich source of material for writing case studies. Events in the news are of interest to the students, and a thorough understanding of the complex scientific concepts involved allows the students to make informed decisions supported by the available scientific evidence. It is also an important aspect of our students' training as scientists. It is quite likely that families and friends of our students turn to them for answers and explanations of current events as they read newspaper accounts that might be incomplete or misleading.

Many instructors in various fields of science have used current topics as their inspiration when writing cases. Environmental scientists have used case-based analysis to examine global warming [11], biodiversity, endangered species, and other ecological issues. Geneticists have used cases to study the link between genetics and disease and genetically modified organisms. Biologists have used case studies to focus on the issues involving the use of stem cells and current medical problems such as Alzheimer's disease [12]. There are examples of several of these case studies on both the University of Buffalo and University of Delaware web sites [6, 13]. Neither site has a specific category for biochemistry; however, there are cases in areas of science that are related to biochemistry such as anatomy and physiology, medicine and health, microbiology, molecular biology and genetics, nutrition, and plant science.

While these problems are of interest to the students because they are ongoing societal problems, I have found that student interest is particularly piqued when a case study involves a specific newsworthy event. Instructors in other scientific fields have written case studies based on a single episode reported in the news. Frank Dinan and Joseph Bieron [14, 15] have written a number of media-inspired case studies for their general and organic chem-

* The thalidomide case study was prepared with Nicole Bennett with support from the Pew Charitable Trusts Foundation. The Olestra and anthrax case studies were prepared with support from the Committee to Aid Faculty Research at Providence College.

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[1] L. Hodges and L. C. Harvey, manuscript in preparation.

istry studies. One of their case studies, titled "Avogadro Goes to Court" was based on an assignment given by a general chemistry instructor at Pace University who instructed his students to determine the cost of a single aluminum atom in a roll of aluminum foil [16]. Frustrated by the open-ended nature of the assignment, several students successfully sued the professor. Peaslee *et al.* [17] have written a case for 1st-year chemistry students based on the four children who died after consuming a deadly strain of *Escherichia coli* in undercooked hamburgers at Jack-in-the-Box restaurants in the western United States. The popular movie Apollo 13, based on the true story of an oxygen tank explosion, was used as the basis of a case study to examine basic chemical principles in a general chemistry course [18].

BIOCHEMICALLY BASED "CONTENT AND CONFLICT" CASES

I have written several cases for a biochemical audience based on current events that involve both elements of "content" and "conflict." These cases combine the elements of the directed case as described by Cliff and Wright [8] and the "decision/dilemma" case described by Herreid [19]. In this manner, the students learn important biochemical principles but are also asked to deal with a scientific or social conflict posed in the case. One such content and conflict case involves the recent Food and Drug Administration (FDA)[2] approval of the controversial drug thalidomide in the United States [20]. This case has been used in my junior introductory biochemistry course at Providence College and in a sophomore second-semester organic chemistry course by my colleague Nicole Bennett at Hope College (Bennett has also adapted this case for use in a freshman non-science major seminar course.) The case is introduced after the concept of chiral molecules has been covered. Thalidomide was approved only for use in treatment of leprosy, but an approved drug may be used "off label" by physicians in any manner in which they see fit. While hailed by AIDS activists and cancer sufferers who found relief from some of their severe symptoms from the drug, the approval was strongly opposed by surviving thalidomide victims born in the early 1960s (mainly in Europe since thalidomide was not approved for use in the United States at that time) whose mothers had taken the drug as a treatment for morning sickness. In the case study exercise, students analyze the original published data that demonstrated teratogenicity, and they write mechanisms for the $R \rightarrow S$ enantiomeric conversion of the compound. Students interpret data that demonstrate the ability of thalidomide to decrease cellular levels of tumor necrosis factor-α, a cellular mediator responsible for many of the symptoms of cancer and AIDS. The students are also required to analyze thalidomide analogues and design alternative compounds that would be effective at treating the disease while minimizing undesirable side effects.

But in addition to the science, students are asked to deal with the ethical and social ramifications of FDA approval. Is the benefit to AIDS and cancer patients worth the risk that a developing fetus will be exposed to the drug? What is society's responsibility to thalidomide victims? Is it possible to design a distribution protocol that is 100% risk-free?

A second content and conflict case involves the fat substitute Olestra, a sucrose polyester food additive developed by Proctor & Gamble. This case was used in a junior/senior level advanced biochemistry course to accompany the section on lipid structure and digestion but would also be appropriate for a junior level introductory biochemistry course. In seeking approval for their product and to demonstrate its safety, Proctor & Gamble conducted literally hundreds of animal and human studies, spent over $200 million dollars, and submitted nearly 150,000 pages of data to the FDA [21]. As a condition of the approval process, Proctor & Gamble was required to continue to monitor the effect of consumption of Olestra on consumers and to continue to study its long term physiological effects. In June of 1998, the advisory committee of the FDA met, reviewed all of the available data, and pronounced Olestra a safe product, stating that there is still a "reasonable certainty of no harm." In response, Michael Jacobson, the executive director of the Center for Science in the Public Interest (CSPI), a consumer watch dog group, filed a formal appeal to the FDA to take Olestra off the market. Jacobson actively encourages consumers experiencing gastrointestinal symptoms to report them to CSPI, who tracks the calls and reports all accounts to the FDA. If the appeal is denied, CSPI plans to take the FDA to court [22]. Student interest groups defined for this case study include Proctor & Gamble scientists, FDA scientists, and consumer groups. Students representing the Proctor & Gamble scientists examine the chemical and physical properties of various formulations of sucrose polyester. Students representing the FDA scientists analyze data from a study conducted by Dutch scientists that showed that consumption of even small amounts of sucrose polyester caused depletion of fat-soluble vitamins in serum. Students representing consumer groups read papers by several public health officials who oppose the FDA approval of the fat substitute. Following class presentations of each of the groups, the entire class addresses the following question: should the FDA rescind its approval of Olestra?

A third content and conflict case was compiled following the events of September 11, 2001. In the weeks following the terrorist attacks on the World Trade Center and the Pentagon, several individuals and organizations in the United States were targeted by an as-yet-to-be-identified bioterrorist who sent "weaponized" powdered anthrax through the mail, exposing many individuals and killing five. Coincidentally, at the same time, scientists solved the last remaining pieces of the anthrax "puzzle" by determining the three-dimensional structure of the lethal factor, one of the three proteins that comprise the "anthrax toxins." The mechanism of infection of the anthrax toxin is now well understood. This topic contains a wealth of biochemical, microbiological, and genetic material for the students to analyze, but the case also allows students to address several important societal issues involving national preparedness and the appropriate use of antibiotic therapy. I use the case in a junior/senior level advanced biochemistry course after the topics of receptor-mediated endocytosis,

[2] The abbreviations used are: FDA, Food and Drug Administration; CSPI, Center for Science in the Public Interest.

transcriptional regulation, and signal transduction have been covered. The students are given detailed background information and sufficient print and Internet resources to allow them to thoroughly research the topic. The class is divided into three "interest" groups: biochemists, geneticists, and microbiologists. Each group is required to answer a series of questions related to the topic in their assigned area. The students in the microbiologists' group explore the mechanism of antibiotic action and also deal with the ethical questions of vaccinations. The biochemists carry out a thorough analysis of the data in R. John Collier's *Nature* paper [23] in which he and his colleagues describe the development of an effective anthrax antitoxin. Students in the geneticists' group develop a PCR protocol to detect one of the anthrax toxin proteins and describe how to prepare gene libraries of these proteins using the naturally occurring plasmid that carries the gene. They also explore how the techniques of amplified fragment length polymorphism (AFLP) and multilocus variable number tandem repeat (VNTR) are used to identify the different strains of anthrax.

CASE STUDIES AS A VEHICLE FOR CONVEYING CONTENT

A directed, rather than open-ended, case study approach works well with these types of cases because the instructor's goal is to teach specific topics to the students. Thus it is essential that the instructor first decide, when writing the case, which content areas he or she wishes to cover. The completed case study material is then accompanied by a list of specific directed questions that require the students to focus on these key content areas. The students study the same course material they would in a more traditional assignment, but the use of the directed case study method allows those same topics to be covered in a manner that is more interesting and engaging to the students.

ASSESSMENT

Students in the advanced biochemistry course who participated in the Olestra and anthrax case study exercises delivered well researched oral presentations, and the discussion following each presentation was lively. (On occasion, I had to remind the students that the class was over and that they needed to leave to be on time for their next class; this rarely happens when I am lecturing.) Answers to the questions I posed were thoughtful and technically accurate and in some cases were in greater depth than what I had expected when I wrote the question. Mastery of important biochemical principles was achieved as measured by the performance of these students on an essay final exam that was nearly identical to the exam given to students the previous year who had not had the opportunity to carry out these two case studies. Answers to final exam questions on the topics covered by the case study earned higher grades and showed a greater depth of understanding than students' answers from the previous year's class (although no formal statistical analysis was carried out). Informal discussions with the students after the assignment was completed revealed that the majority of the students preferred the case study exercise to traditional assignments.

WRITING CASE STUDIES BASED ON CURRENT EVENTS

Source material for these types of case studies is as close as your daily newspaper, weekly newsmagazine, or radio or television broadcast. *The New York Times* devotes an entire section to science issues on Tuesdays, and searching for science articles on the web site is easily done [24]. National Public Radio journalists routinely cover medicine and health issues on their daily news broadcasts [25]; in addition, National Public Radio's *Talk of the Nation* daily call-in show features scientific topics on *Science Friday* [26]. Programs on scientific topics are regularly televised on the Public Broadcasting System in the United States [27]. Science news magazines such as *Science News* [28] and *Scientific American* [29] are available for a reasonable price to educators, and many of their articles are available free on line. The newspaper *The Scientist* has life scientists as its audience, and subscriptions are available free on line [9].

SUMMARY

The use of a current event as a vehicle to teach biochemical principles was a highly effective method for introducing the students to important mechanisms in biochemistry. At the same time, student interest was heightened because the content centered on a "story" that they could relate to in their own lives. In addition, the use of a case study that involves an element of conflict allows students to address the results of scientific inquiry on society.

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