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2004-2005 Proposal Cover Sheet**

Project Title: **A Textbook Prototype for Non-Science Majors Cancer Biology Courses**

Faculty Name: **Pamela K. Hanson**

Institution: **Birmingham-Southern College**

Faculty Department: **Biology**

Phone: **(205)226-4881**

Fax: **(205)226-3078**

E-mail: **phanson@bsc.edu**

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I. Project Summary

Research in the field of science education has documented a variety of factors that hinder learning in introductory courses, including excessive use of jargon, failure to relate to other disciplines, emphasis on content rather than process, lack of a unifying concept, and irrelevance to life outside the classroom [1-3]. Thematic courses help overcome many of these problems by providing a central topic (cancer, AIDS, or the physics of music, for example) that often proves to be interdisciplinary and relevant to students' development into educated, proactive citizens, one of the central goals of a liberal education [4]. Despite these advantages, the resources available for thematic courses are scattered at best, and at worst they are out of date or incorrect. To overcome this problem for non-majors courses in cancer biology, I will develop a prototype textbook that uses an interdisciplinary, evidence-based approach to acculturate students to the process of science while teaching them about the origins, diagnosis, treatment, and prevention of cancer. Naturally, this text will be interdisciplinary, exploring statistics (what does cancer "risk" really mean?), physics (the nature of the electromagnetic spectrum and its role in causing, detecting, and treating cancer), as well as the ethical, legal, and social implications of the disease.

This textbook, along with other aspects of the course (lecture, lab, class discussions, etc.), will help students to understand the process of science including how to critically evaluate evidence and arrive at educated conclusions based on the available data. As critical thinkers, these students will be better able to function in society, making decisions about their own healthcare as well as influencing policies related to healthcare availability and research funding [1, 4].

II. Project Description

II. A. The Challenge of Teaching Non-Majors

When asked about their experience in introductory science courses, many students cite sources of dissatisfaction that include an emphasis on memorizing content, a lack of connections between topics presented in the course, a lack of connection between the introductory science course and other disciplines, and irrelevance to life outside the classroom [1-3]. In addition to these barriers to learning, research in the field of science education has uncovered a variety of other obstacles including the faulty paradigms (or misconceptions) that students bring with them [3, 5, 6]. Although thematic courses, such as those that focus on cancer biology, alleviate some of these problems by providing a unifying concept that students naturally view as relevant [3], many of the problems listed above cannot be addressed solely by application of a theme. Thus it is up to course instructors to gather appropriate course materials, develop laboratory modules, and establish a teaching style that engages students in the process of science through active learning, which may take the form of class discussions, discovery-based labs, or group problem-solving exercises [7]. Such innovations create an active learning environment that has been well documented to improve student learning, retention of key concepts, and student attitudes about science [7, 8].

II. B. History of BI 149: Cancer – Biology and Beyond

In its first full semester offering at Birmingham-Southern College (Spring 2003), the thematic course *Cancer – Biology and Beyond (BI 149)* was designed to meet two curricular needs: (1) the general education requirement that all students take a laboratory science and (2) the requirement that all students take three “First Year Foundations (1Y)” courses during their first year at BSC. The over-arching goal of 1Y courses is to establish an “interactive scholarly community” by establishing intellectual connections and engagement through means such as collaborative learning, community involvement, peer teaching, technology use, and oral presentations [9]. Because of its 1Y status, *BI 149* evolved into a biology-centered interdisciplinary course that incorporated topics from fields such as physics and psychology. However, the thematic and interdisciplinary nature of the course made it impossible to find an appropriate textbook. The existing textbooks on cancer are geared toward advanced undergraduates majoring in biology, graduate students, and/or healthcare professionals, and the vast majority of such books neglect topics like the psychological impact of cancer diagnosis as well as fundamental concepts like the nature of the electromagnetic spectrum. In order to cover these diverse topics, I resorted to a collection of readings including Robert Weinberg’s book “One Renegade Cell” [10], the 1996 *Scientific American* issue “What You Need to Know about Cancer” [11], and a variety of on-line sources including selections from the “How Stuff Works” website (www.howstuffworks.com). Despite these efforts to find relevant sources written at an appropriate level, many students were frustrated with the lack of an actual textbook to provide a more traditional framework, and they expressed these frustrations when asked on anonymous course evaluations whether the course texts were helpful:

“Nice to read but not really helpful...”

“Somewhat – Need one that went more along with the biology side of the course.”

“Yes, but I often lost track where we were because there was no traditional one textbook and ‘read this chapter’.”

“Get a small textbook. Even though you drew great pictures, it would have helped to see them while we were reading.”

In an effort to address these concerns during the Spring 2005 offering, I adopted the non-majors textbook *Discover Biology*, which has some appropriate materials addressing the macromolecules, the cell cycle, and even cancer [12]. Despite the addition of this text to the reading list, some students have still expressed dissatisfaction, informally telling me that they would prefer a more comprehensive resource.

II. C. BI 149: Symptom of a Broader Problem?

Although it is tempting to speculate that the 16 students who take *BI 149* at BSC every other Spring are experiencing an isolated misfortune, a quick web search reveals that at least 6 other colleges and universities offer cancer biology courses for non-majors, relying on scattered resources many of which are pitched at an inappropriate level or are simply out of date. Furthermore, the same informal search strategy reveals that there are at least 16 additional institutions that list cancer as a key topic in their broader non-majors’ biology courses. The most common item to find on the reading lists of dedicated cancer biology classes is the 1996 *Scientific American* issue “What You Need to Know about Cancer.” Although it provides a substantial amount of valuable information, this resource is clearly out of date. For example, it describes immunotherapy as a cancer treatment of the future [11], when in fact, the antibody-based therapy Herceptin was approved by the Food and Drug Administration in 1998, and several other antibody-based treatments have been approved since [13]. Other pitfalls of using “What You Need to Know about Cancer” as a primary resource is that it is not structured like a textbook and thus lacks some of the key components of good textbooks such as a glossary, an

index, references to other articles/chapters so students can see connections between topics presented throughout the term, and questions at the end of each chapter so students can test their knowledge. Furthermore, authors of some of the *Scientific American* articles use excessive facts and jargon, a teaching *faux pas* that has been demonstrated to hinder student learning [2]. Finally, “What You Need to Know about Cancer” rarely employs an “evidence-based” approach, wherein students are given insight into the scientific process by presenting the experimental results that support the models and conclusions presented in the text [14-17]. Thus, there is clearly a need for a new resource for non-majors enrolled in cancer biology courses, and this resource should initiate the process of active learning by posing questions to students and then providing evidence that will help them confront any misconceptions they might have, a key step in the learning process [3, 5, 6, 16, 17].

II. D. Project Goals and Projected Timetable

The goal of this project is to construct a prototype non-majors cancer biology textbook (~200 pages in length) that uses an interdisciplinary, evidence-based approach to engage students in the process of science while also presenting substantial and rigorous content (a preliminary table of contents is available upon request).

Because it is unrealistic to single-handedly write an entire textbook in the course of one year while juggling the demands of a full teaching load and committee work, a significant number of the chapters in the proposed prototype will consist of sections from other textbooks and materials obtained on-line. In gathering these materials, copyright laws will be obeyed and any material usage fees will be folded into the purchase price of the book. Chapters and supplementary materials that cannot be obtained from other sources will be written during the summer of 2005. Although I do not have prior experience writing textbooks, I have written lab

manuals for use in *BI 149* and other courses, and I successfully conveyed a diverse array of complex ideas to a general audience while working at the *Chicago Tribune* in 2000. The strategies I will use when writing this textbook prototype include presenting common myths about cancer [18] and then presenting data that forces students to confront these myths. The prototype will also include lists of key terms and study questions at the end of each chapter. Furthermore, the vast majority of chapters will be interdisciplinary in nature and will refer to concepts presented in other places in the text. One section that will incorporate all of these approaches is the chapter on carcinogens. In this chapter, students will read about ultraviolet radiation and x-rays, exploring how these types of radiation can damage DNA, the structure and function of which would have been covered in previous chapters. The reader will then be presented with the common myth that cell phones cause cancer, which will introduce the broader concept of the electromagnetic spectrum and the energy of different types of radiation. Finally, the text will present data from well-designed population studies [19], encouraging students to explore the concepts of good experimental design and appropriate data analysis as well as the limitations of the current data. Combined, this text-based presentation of physics and epidemiology will provide students with facts to help correct any faulty paradigms they might possess, a strategy that has proven effective in the past [20, 21]. Thus rather than falling into the common trap of writing a textbook “thick with facts and figures” [22], this prototype will emphasize the process of science, a central goal of the scientific literacy movement [23]. Ultimately, these new course materials will be designed to initiate active learning and conceptual change outside the classroom, freeing up additional class time for use in inquiry-based activities and discussion of the broader impacts of science and technology on society.

After assembling the text, the newly written materials and the overall flow will be evaluated by student editors during the '05-'06 academic year. Each semester, two former *BI 149* students will be hired to evaluate the materials, paying particular attention to several points including organization, clarity, and appropriate use of the evidence-based, conceptual change approach.

In conclusion, the goal of this project is to design a textbook that actively and intentionally engages students in interdisciplinary learning. Even though active learning is best facilitated in the classroom and lab, it can begin with reading assignments, but only if the chosen text is designed to dispel previous misconceptions and encourage students to critically evaluate claims in the light of carefully acquired data [20, 21]. After building this foundation of scientific thought, students will be better equipped to apply their critical analysis skills to other coursework and to practical decision-making in the workplace and in life [1, 4].

III. Evaluation, Dissemination and Continued Support

III. A. Evaluation

The initial evaluation of the textbook prototype will be conducted by student editors during the '05-'06 academic year. For each chapter, student editors will complete an evaluation form with several items in a 5 point Likert-type scale as well as open-ended questions. Together, these will address a variety of issues including organization, clarity, and effectiveness of the evidence-based, concept change approach. The results of this initial analysis will be included in the final report submitted to the ACS.

Due to staffing limitations, *BI 149* will not be offered again until Spring 2007 at which point students enrolled in the course will be asked to evaluate the quality of the text. To separate

the effectiveness of the text from the effectiveness of the overall course, students will evaluate each chapter using forms similar to those employed by the student editors the year before. These results will be compared to similar, albeit less thorough, evaluations of the assigned readings from previous course offerings. A follow-up report summarizing these results will be submitted no more than 30 days after the end of the Spring 2007 semester.

III. B. Dissemination

Initial dissemination of the results of this project will occur at the poster session of the 2005 American Society for Cell Biology Meeting in San Francisco which has a significant science education component. The poster will outline the problem presented herein and describe the key features of the new text. Sample chapters will be available for distribution to interested meeting attendees.

Upon completing the revision process and incorporating the feedback of the student editors, there will be an initial printing of the book, and one copy each will be distributed to faculty members at other institutions who teach non-majors cancer biology courses. Copies will also be available for interested faculty members from ACS institutions.

After using the text in the Spring 2007 offering of *BI 149*, results of the student analysis will be submitted to an appropriate journal such as *Cell Biology Education*.

The long-term goal of this work is to find a publishing house that will fund rewriting of borrowed chapters and facilitate dissemination of the finished text on a national level. With the prototype developed by this project, this long-term goal is feasible, especially given the prevalence of non-majors courses on cancer biology and the well-recognized problem that there are few effective, evidence-based science texts that facilitate concept change [24, 25].

III. C. Continued Support

Historically, the faculty and administration of BSC have been very supportive of course development initiatives related to *BI 149*. For example, during the summer of 2002, I received a summer stipend to facilitate the initial development of the course. During the summer of 2003, I also received a stipend to work with BSC's analytical chemist on the development of a laboratory module examining the migration of dioxins from plastics into vegetable oil during microwaving. Due to the college's investment in this project thus far, and based on positive student feedback, I am confident that we will continue to offer this course at least every other spring. Furthermore, as additional course development needs arise, the course will surely be given full consideration for additional intramural funding. Finally, a letter of support from the Chair of the Division of Science and Mathematics is included on the following page.

IV. Literature Cited

1. *Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology*, National Science Foundation: Washington, D.C., 1996.
2. **Sundberg, M.D., Dini, M.L. and E. Li.** Decreasing Course Content Improves Student Comprehension of Science and Attitudes toward Science in Freshman Biology. *J. Res. Sci. Teach.* **31**: 679-693, 1994.
3. **Stover, S. and M. Mabry.** Merging Science and Society: An Issues-Based Approach to Nonmajors Biology. *J. Coll. Sci. Teach.* **34**: 40-43, 2005.
4. *Greater Expectations: A New Vision for Learning as a Nation Goes to College.* Association of American Colleges and Universities: Washington, D.C., 2002.
5. **Norden, J.** Principles of Course Design and Assessment. *ACS Science Education Reform Workshop.* Millsaps College: Jackson, MS, 2004.
6. **Smith, L.E., Blakeslee, D.T. and W.C Anderson.** Teaching Strategies Associated with Conceptual Change Learning in Science. *J. Res. Sci. Teach.* **30**: 111-126, 1993.
7. **McNeal, A.P. and C. D'Avanzo, ed.** *Student-Active Science: Models of Innovation in College Science Teaching.* Harcourt Brace & Company: Orlando, FL, 1997.

8. **Wilke, R.R.** The Effect of Active Learning on Student Characteristics in a Human Physiology Course for Nonmajors. *Adv. Physiol. Educ.* **27**: 207-223, 2003.
9. *First-Year Foundations Courses: Common Goals and Features.* Birmingham-Southern College: Birmingham, AL, 2000.
10. **Weinberg, R.A.** *One Renegade Cell: How Cancer Begins.* Basic Books: New York, 1998.
11. What You Need to Know About Cancer. *Sci.Am.* **275**: 56-167, 1996.
12. **Cain, M.L., Damman, H., Lue, R.A. and C.K. Yoon.** *Discover Biology, 2nd ed.* Sinauer and Associates: Sunderland, MA, 2002.
13. **Karlin, S.** New Drugs Target Cancer. *Discover.* **26**: 37, 2005.
14. **Budiansky, S.** The Trouble with Textbooks. *PRISM online.* February 2001.
15. Project 2061 Textbook Evaluations. *Project 2061 web-site:*
<http://www.project2061.org/publications/articles/textbook/default.htm>, retrieved March 12, 2005.
16. **Roseman, J.E., Kesidou, S. and L. Stern.** *Identifying Curriculum Materials for Science Literacy: A Project 2061 Evaluation Tool.* American Association for the Advancement of Science: Washington, D.C., 1997.
17. **Roseman, J.E., Kulm, G. and S. Shuttleworth.** Putting Textbooks to the Test. *ENC Focus* **8**: 56-59, 2001.
18. **Gansler, T.** Myths and Half-Truths About Cancer. *American Cancer Society Web-site:*
http://www.cancer.org/docroot/PED/PED_11_Cancer_Myths.asp, retrieved March 13, 2005.
19. **Ahlbom, A., Green, A., Kheifets, L., Savitz, D. and A. Swerdlow.** Epidemiology of Health Effects of Radiofrequency Exposure. *Environ. Health. Perspect.* **112**: 1741-54, 2004.
20. **Çakir, Ö.S., Geban, Ö. and N. Yürük.** Effectiveness of Conceptual Change Text-oriented Instruction on Students' Understanding of Cellular Respiration Concepts. *Biochem. Mol. Biol. Educ.* **30**: 239-243, 2002.
21. **Dole, J.A.** Readers, Text, and Conceptual Change Learning. *Read. Writ.* **16**: 99-118, 2000.
22. **Stokstad, E.** Reintroducing the Intro Course. *Science* **293**: 1608-1610, 2001.
23. **Shamos, M.H.** *The Myth of Scientific Literacy.* Rutgers University Press: New Brunswick, NJ, 1995.
24. **Styer, D.F.** Science as a Liberal Art. *J. Coll. Sci. Teach.* **32**: 139-142, 2002.

25. **Tobias, Sheila.** Revitalizing Undergraduate Science: Why Some Things Work and Most Don't. Research Corporation: Tucson, AZ, 1992.