Students in the United States struggle with literacy skills, a problem that extends into their undergraduate education and beyond. Particularly in the sciences, reading assignments are usually singularly academic in nature and do not impart the importance of creativity and innovation. We propose a curriculum strategy and lesson plan that employs a “reading across the curriculum” approach to enhance literacy skills in biology students while simultaneously encouraging scientific discourse and creativity.

**Key Words:** Scientific literacy; reading across the curriculum; fiction; literature; biology; creativity.

**Problems with Literacy**

At its most fundamental level, scientific literacy does not begin with the understanding of science; it begins with literacy (Norris & Phillips, 2003). Recent reports show the average literacy level of U.S. students to be less than proficient when assessed via national standards. Only a third of middle school students possess requisite comprehension skills to critically evaluate what they read (Reardon et al., 2012), and the advancement of literacy skills continues to diminish throughout high school (Carnegie Council on Advancing Adolescent Literacy, 2010). Literacy of college students remains a concern, with fewer than half of students at four-year colleges and fewer than a quarter of students at two-year institutions rated as proficient (Baer et al., 2006). While reading competencies may vary slightly with demographic factors, a comparison of 16- to 24-year-olds in America and Europe showed literacy proficiency in the United States to be the lowest (OECD, 2013).

Recent reports show the average literacy level of U.S. students to be less than proficient when assessed via national standards.

Scientific literacy, in particular, requires a broad range of critical-thinking and problem-solving skills that are often undermined by textbook-only or content-focused approaches. The AAAS’s (2011) *Call to Action* urges science instructors to provide authentic experiences for exploration and discovery, with emphasis on problem solving, a reduction of memorization, and an overall “less is more” approach. With a shift away from content-based information, the need for educators at all levels of education to teach students about the process of discovery is more important than ever.

To address issues of scientific literacy, educators must critically examine assigned readings for quality and breadth. Students transitioning from high school to universities are often inundated with academic reading from style manuals, scholarly articles, and, most commonly, textbooks. Yet an evaluation of precollege math and science textbooks concluded that most “cover too many topics and fail to develop any of them well” (AAAS, 2009). Unfortunately, when teachers rely too heavily on textbooks as reading assignments, students may fall short in real-life skills required for comprehension and literacy; textbooks at any level present too many facts and very little of “the heart and soul of the scientific enterprise” (Yager, 2004).

Scientific problem solving, experimental design, and innovation require creativity (Lin et al., 2003; Kaufman et al., 2015). Unfortunately, science teachers often question their own aptitudes for originality and overall potential for scientific creativity (Demir, 2015). Moreover, scientific writing is often dry and formulaic because of misperceptions that creatively written texts reflect lower credibility (Caulley, 2008). As a consequence, reading assignments for science majors may be exclusively academic in nature and often dry; this may be especially problematic in introductory science classes.
A Possible Solution in Fiction

A “reading across the curriculum” strategy has been shown to help struggling readers (Bruce & Wasser, 1996; Anderson & Kim, 2011; Bharuthram, 2012) and to further benefit students by allowing them to critically evaluate written texts (Horning, 2007). Scientific literacy, in particular, is a broad concept; it requires understanding substantive content and being able to apply it in forming decisions, as well as reading and writing about it (DeBoer, 2000; Norris & Phillips, 2003). As a method to increase literacy skills, critical thinking, and creative thought in the sciences, we propose that science instructors incorporate a “reading across the curriculum” approach that integrates fiction. The National Science Teachers Association and others recognize the use of nonfiction trade literature as an effective way to introduce students to scientific content (Bull & Dupuis, 2013; National Science Teachers Association, 2013). Others suggest the use of popular fiction as a means to teach and discuss content-specific topics (Czerneda, 2006; Singletary, 2010; Cook & Dinkins, 2015).

We strongly advocate that fiction, in particular, may serve three important purposes that are not accessible through nonfiction:

1. Assigning specific fiction texts will allow students to further develop the cognitive skills required for critical thinking. The Association of American Colleges & Universities (2010) defines the formation of critical-thinking skills as developing “a habit of mind characterized by the comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating an opinion or conclusion.” Fiction provides a creative framework in which “what ifs” are played out to reach a hypothetical resolution. If guided with the right sorts of questions, these “what ifs” provide a theoretical context within which students can evaluate information to form value judgments and propose solutions to problems.

2. Fiction has a stronger potential than nonfiction (such as textbooks, scientific articles, and trade nonfiction) to evoke personal and emotional responses—which, in turn, fosters a deeper understanding of concepts (Djikic et al., 2009; Bal & Veltkamp, 2013; Crosson & Lesaux, 2013). Reading from a character’s point of view will also allow students to experience the struggles, frustrations, and successes of science beyond what a textbook or journal article can impart. We posit that reading relevant fiction will allow students to form personal connections to topics in the sciences, because students are more likely to willingly engage in literacy-based activities (e.g., journaling, reading) if they have a personal interest that compels them to do so (Luttrell & Parker, 2001).

3. Students tend to form crucial reading habits during the elementary school years, but these habits increasingly diminish by the time they reach college (Carnegie Council on Advancing Adolescent Literacy, 2010). Research further suggests that a student’s academic success may be directly correlated to their reading habits, but many students progress through college without reading a book for pleasure (Galik, 1999). Incorporating fiction may encourage students to reconnect with reading habits that were lost in the rigors of the high school and college years. Teachers who show enthusiasm for course content may impart that same enthusiasm for learning to their students, viewing reading as a worthy endeavor may increase the motivation of students to learn from reading (Guthrie, 2004).

For the integration of literary fiction to meet the needs of students, they must understand the difference between the goals of an academic text and those of fiction. The former provides factual information, examples, and summaries, while the latter provides information through metaphor, symbolism, messages about morals and world implications, and empathy for characters (Djikic et al., 2009; Bal & Veltkamp, 2013). In a science curriculum, fiction could be used to effectively discuss relevant scientific topics, including but not limited to bioengineering, forensics, genetics, evolution, ecology, environmental issues, biotechnology, and social issues. We emphasize that the focus of using fiction in a science class should not be to critique what is perceived to be “bad science” in the fictional work, which might produce feelings of distrust toward science (Czerneda, 2006). Instead, stories and characters in fiction should be used to invoke a deeper understanding about the process of scientific discovery, the nature of science, and the human side of science.

We also emphasize that fiction should be paired with, and not take the place of, science-based academic reading. A combined reading strategy will allow students to relate the science of the scholarly article to the concepts presented in creative fiction. Such comparisons between scientific literature and creative literature will lend themselves to discussions regarding the possibilities and limits of science, thereby nurturing creative elements that lead to scientific discovery (Czerneda, 2006).

Finally, we stress the importance of making the reading process enjoyable and, for the initial stage of reading, not content-based or instructor-driven. An important contributor to continued lifelong literacy is the motivation to pursue it, student-derived motivation to read is heavily influenced by personality, personal interests, and reasons for reading (Cole, 2002). Students must, therefore, be encouraged to read in a way that allows them to explore their own interests.

Implementation

The prospect of adding an assignment, particularly one that requires additional reading, can seem daunting given a class’s time constraints, but this exercise is designed as a natural extension to the reading, discussion, and analysis of peer-reviewed scientific literature that occur regularly as a part of science curricula. Assessment of students might include reports on reading progress, online review, and/or discussions of principles showcased in the fiction that align with scientific theory. Students could be asked to journal their thoughts, perceptions, and favorite quotes during reading. A final assessment of their ability to make connections with academic topics should occur after completion of the reading (Figure 1).

Here, we describe how we implemented this integrated reading approach in a three-credit, semester-long General Biology course for undergraduate majors as well as nonmajors. We have also successfully adapted this exercise for other classes by modifying the reading selections (using excerpts instead of an entire book, for example) or by varying the requirements for the written component. We have graded students on reading journals, discussion contribution, and a paper, for a total of 20% of their final grade.

Our course emphasized evolution, botany, zoology, and biodiversity. Accordingly, we had the students choose one of the following books:
Remarkable Creatures, by Tracy Chevalier (evolution); The Martian, by Andy Weir (botany); and Endangered, by Eliot Schrefer (zoology/biodiversity). We selected these on the basis of their science content, reader reviews, and colleague suggestions that considered content and the enjoyment factor. We also used the “Listopia” feature on the social reading site Goodreads (https://www.goodreads.com/list) to search for fiction with elements of science. For an extended list of our book recommendations for biology classes, see the Appendix.

When introducing these reading choices to students, the instructor should explain that the fiction books address “what if” questions of science. Care should be taken to clarify the difference between a fiction text that portrays the process of discovery through the eyes of characters and a scientific article focused on the methodology of questioning and final outcomes.

We asked students to read one book from our recommendation list, with autonomy to read at their own pace over four weeks; however, instructors can adjust the reading time-frame to suit specific course needs. We required students to join Goodreads and added them to a permission-only group so that we could easily track progress. There, students recorded impressions during each reading session as “reading updates”; journal entries ranged from favorite quotes to personal responses. The purpose of this initial step was to foster engagement with the reading.

Figure 1. Lesson plan for incorporating fiction into a biology curriculum.
The following are examples of journal entries depicting engagement, written by two students who were reading Schreer’s Endangered (see Appendix):

“Sophie explains her feelings about Congo; how beautiful she thought it was as a child, full of vibrant green and beautiful nature. Once she left and lived in America, Congo seemed nothing but poor and dirty. As she meets Otto and starts to care for him she starts to see the beauty in her surroundings again.”

“Sophie’s connection with Otto is so strong and the love that they feel for each other is as strong . . . as a love between two humans. My little sister Sidney has such a big heart, and animals are naturally drawn to her. As I read Sophie and Otto’s story, I am constantly relating it to Sidney.”

After our students completed the reading, we opened an online discussion and posed open-ended questions to (1) allow for critical analysis of the children’s choices within the story and (2) facilitate analysis regarding scientific content within the text. Instructor participation was limited to posing questions (general and specific to the particular reading) and moderating discussion.

The following are examples of questions and student responses during discussion (based on Endangered):

**Critical-thinking question**: Did you empathize with Sophie’s mother’s decision to dedicate her life to conserving bonobos?

**Student response**: Sophie states, “I had always been my mom’s philosophy that the way we treat animals goes hand in hand with the way we treat people.” I’d never thought that conservation of other animals was based on empathy that we have with people, but it makes sense that we should treat all creatures with respect.

**Content question**: How did the book portray social relationships among bonobos?

**Student response**: Much like human babies who must be cared for, young bonobos need to remain close by their mother or a female in the social group. Schreer referenced an experiment done on baby bonobos where “one was made of wire, but provided food, and the other was made with snuggly cloth, but didn’t offer any food. The babies would always choose the cloth mother, even if it meant they didn’t have any nourishment to live on.”

After discussions, we instructed the students to select a scientific research article related to one of the main scientific themes of the story. In the example of Endangered, these articles ranged in scope from general studies on endangered species to more specific studies on bonobo social behavior and comparative analysis of primates. Students were responsible for choosing a theme and a scientific article and establishing a connection between them. Their final assignment was a paper, which we used to assess their exploration of the story’s theme, article summary, description of connections between the two, and reflections of their impressions of the topic from both types of reading. Here is an example of questions asked and answered in a reflection paper:

**Question**: What conclusions about the book’s theme can you make from reading the scientific article? Conversely, what can we learn about science from the book? How did the creative elements of the book contribute to your view of the living world?

**Excerpt of student response**: [The story] shows us the protective nature of the females and their support for each other in social groups. The scientific article I chose discusses these aspects of the nature of bonobos, but I feel like I got a better picture of these things by reading the story and about Sophie’s connection to Otto… All species are connected in this world, and by taking the time to study related species, we can see that some of the differences between our counterparts are often minuscule. I enjoyed seeing the human–animal bond portrayed so realistically in the book. Some people wonder why we should concern ourselves with animals when there is so much human cruelty in the world, but to me they are connected.

**Conclusions**

For the sake of both overall literacy and scientific literacy, we strongly advocate a reading-across-curriculum approach that incorporates fiction. Reading and writing are important elements of scientific literacy (Glynn & Muth, 1994; Norris & Phillips, 2003), and others have recognized the value of science fiction in science classrooms (Czerneda, 2006). In this activity, we used a broad selection of fiction with science elements to create opportunities for our students to engage with a topic, journal their impressions, discuss opinions and judgments, and make analytical comparisons between different types of readings. Via discussions and navigation through a network such as Goodreads, students also had opportunity to discuss relevant content and interact within a reading community.

By dividing this reading assignment into separate stages, students could engage with the reading before discussions and the written portion of the assignment. During our pilot semester, 18 out of 59 students (30.5%) continued to be active on Goodreads after they had finished reading their assigned book. Final course assessments at the end of the semester indicated that 56 of the 59 (94.9%) felt they had learned as much about science from the fiction book as they had from the scientific article, “but in a different, and by this I mean a more creative, way” (a student response).

Our approach allowed for discussion of issues that don’t easily arise within a traditional curriculum based on purely academic texts; having students discuss “what ifs,” express beliefs, and take a stance on a topic were critical-thinking exercises that arose naturally during discussions and in their writing. Finally, our lesson plan provided an opportunity for students to immerse themselves within a fictional setting and experience an emotional reaction similar to what they might experience in real life; this is the ultimate power of fiction over nonfiction (Djiskic et al., 2009; Bal & Velikamp, 2013). We also cannot ignore the intrinsic value of getting students to read; if we are to promote lifelong scientific literacy in our students, we must do so in ways that are sustainable outside of the classroom.

**References**


---

**Appendix. List of recommended fiction books for biology classes.**

<table>
<thead>
<tr>
<th>Book</th>
<th>Summary</th>
<th>Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A Natural History of Dragons: A Memoir by Lady Trent</em>&lt;br&gt;Author: Marie Brennan&lt;br&gt;Macmillan Genre: Fantasy 335 pp.</td>
<td>Lady Trent is a bookish young woman who nurtures a passion for learning and natural history, and who defies the stifling conventions of her day as the world’s first dragon naturalist.</td>
<td>Ecology&lt;br&gt;Natural history&lt;br&gt;Nature of discovery&lt;br&gt;Scientific inquiry</td>
</tr>
<tr>
<td><em>Endangered</em>&lt;br&gt;Author: Eliot Schrefer</td>
<td>When an armed revolution leads to an attack on a bonobo sanctuary, Sophie and an infant bonobo, Otto, must</td>
<td>Animal behavior&lt;br&gt;Bioethics&lt;br&gt;Ecology</td>
</tr>
<tr>
<td>Book</td>
<td>Summary</td>
<td>Connections</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Scholastic</td>
<td>escape into the jungle. Caught in the crosshairs of conflict, they must struggle to keep safe, to eat, and to live.</td>
<td>Environment</td>
</tr>
<tr>
<td><em>Ishmael</em></td>
<td>When a disillusioned writer answers a personal ad from a teacher, he discovers that the teacher is a gorilla named Ishmael, who poses deep questions about the history and future of life on Earth.</td>
<td>Evolution ecology nature of discovery philosophy of science</td>
</tr>
<tr>
<td><em>Pilgrim at Tinker Creek</em></td>
<td>A personal narrative of a year’s exploration of Virginia’s Roanoke Valley, depicting the nuances of wildlife along Tinker Creek; an exhilarating tale of nature and its seasons.</td>
<td>Biodiversity ecology nature of discovery natural history</td>
</tr>
<tr>
<td><em>Remarkable Creatures</em></td>
<td>Mary Anning discovers ancient marine reptiles, such as the ichthyosaur. This, along with her gender and working-class background, shakes the scientific community and leads to new ways of thinking about the creation of the world.</td>
<td>Archaeology evolution nature of discovery women in science</td>
</tr>
<tr>
<td><em>State of Wonder</em></td>
<td>Pharmaceutical researcher Dr. Marina Singh sets off into the Amazon jungle to find the remains of a colleague who recently died under mysterious circumstances.</td>
<td>Bioethics ecology environment physiology scientific inquiry women in science</td>
</tr>
<tr>
<td><em>The Martian</em></td>
<td>Mark Watney is part of a team sent to the red planet. Stranded and facing certain death, he makes a remarkable effort to survive: constructing a livable habitat, finding a way to grow food, making water, and getting himself off the planet.</td>
<td>Agriculture horticulture botany engineering geology physics</td>
</tr>
<tr>
<td><em>The Prodigal Summer</em></td>
<td>Three stories of love are woven within a larger tapestry of lives in the forested mountains and struggling small farms of southern Appalachia.</td>
<td>Conservation ecology environment wildlife biology</td>
</tr>
<tr>
<td><em>The Signature of All Things</em></td>
<td>Alma Whittaker is a clear-minded scientist focused on botany and evolution. She falls in love with Ambrose Pike, a utopian artist who ponders the spiritual, divine, and magical. They each pursue their botany environment evolution scientific inquiry women in science</td>
<td></td>
</tr>
<tr>
<td>Book</td>
<td>Summary</td>
<td>Connections</td>
</tr>
<tr>
<td>------</td>
<td>---------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| The Speed of Dark | Lou Arrendale is living a low-key, independent life as a high-functioning autistic adult, when he is offered a chance to try a brand-new experimental “cure” for his condition. | Bioethics  
Scientific inquiry  
Genetic engineering  
Medicine |
| Author: Elizabeth Moon  
Ballantine  
Genre: Medical science fiction  
378 pp. | desperate need to understand the workings of this world and the mechanisms behind all life. | |