Letter to the Editor

Providing Structure for Research Students Coming and Going

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Dear Editor:

A growing body of research has documented the positive outcomes of research experiences for undergraduates. Undergraduates have reported cognitive gains, such as increased confidence in their ability to do science and learning to "think and work like a scientist"; affective gains, such as finding research enjoyable and exciting; and behavioral outcomes, such as clearer intentions to pursue further education or careers in science (Junge et al., 2010; Harrison et al., 2011; Thiry et al., 2012). For more than 40 yr, the National Science Foundation (NSF) has funded Research Experiences for Undergraduates or its precursor, Undergraduate Research Program (www.nsf.gov/funding/pgm_summ.jsp?pims_id=5517& org=NSF), to engage cohorts of students in research. It is widely recognized that undergraduates who are awarded a Barry Goldwater Scholarship or an NSF Graduate Fellowship must have conducted research and they typically have published at least one paper (www.gvsu.edu/events/ goldwater-scholarship-nsf-graduate-resarch-fellowship -information-session/). In short, undergraduate research experiences have become the "farm league" for employers, graduate schools, and postundergraduate scholarships, such as NSF, Fulbright, and Rhodes.

Thiry and colleagues (2012) describe how undergraduates who participate in extended research experiences realize

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© 2012 A. M. Campbell *et al. CBE—Life Sciences Education* © 2012 The American Society for Cell Biology. This article is distributed by The American Society for Cell Biology under license from the author(s). It is available to the public under an Attribution– Noncommercial–Share Alike 3.0 Unported Creative Commons License (http://creativecommons.org/licenses/by-nc-sa/3.0). "ASCB®" and "The American Society for Cell Biology®" are registered trademarks of The American Society for Cell Biology. unique outcomes when compared with novice undergraduate researchers. However, many summer research programs only accept new students, either because of funding agency restrictions or to reach a larger number of students. As a result, undergraduates may be limited in their opportunities to achieve the greater benefits of extended research. In this multi-institution study, many of the undergraduates were mentored by graduate students who were not much more experienced than the undergraduates. Furthermore, graduate student mentors are transient. Therefore, institutions and faculty members must continuously invest in preparing graduate students to be effective mentors in order to maximize the benefits undergraduates realize from research. The authors closed by calling for more efforts to optimize undergraduate research experiences, given the limitations of time and money.

We wondered whether the undergraduates, especially the novices, could benefit from a structural component to encourage them to maximize the opportunities afforded by participating in research. For 6 yr, four faculty from Davidson College and Missouri Western State University (one biology and one mathematics faculty from each campus) have collaborated in synthetic biology research with students from different backgrounds. Specifically, we have students who are math or biology majors, ranging from rising sophomores to rising seniors. Each summer, the four faculty have supervised a total of 16–20 students across both campuses. Twice during the summer—once at the beginning and again at the end-everyone convenes on one of the campuses. Given the call for optimizing undergraduate research experiences, we wondered whether others have developed mechanisms similar to what we do to help students as they begin and end their summers.

Over the years, we established a tradition to help students and mentors make the most of their summers together. The beginning of the summer can be awkward, and mentors often search for activities that set the right tone. Our approach has been to watch as a group the 2007 movie *Lions for Lambs*, starring Robert Redford, Meryl Streep, and Tom Cruise (see the trailer here: www.youtube.com/watch?v=n _V6ulwA0KE). The movie consists of three seemingly unrelated stories that gradually become intertwined. The story follows three college students, two of whom come from disadvantaged backgrounds and enlist in the Army. The third student is privileged but does not seem to value the educational opportunity he has been given by his family. The key moment of the movie is a scene between a college professor (Robert Redford) and the third, privileged, bright student (Andrew Garfield), who has been given many opportunities his whole life. The professor tries to explain to his talented but unmotivated student that becoming an adult means making decisions that will influence the rest of your life (see this key moment online: www.youtube.com/watch?v=j1jUjvFP978). We watch how the three students' lives, and those of the three adults, play out as a consequence of earlier decisions and are left wondering what the unmotivated student will decide to do. In our view, undergraduate researchers face a similar situation. Our students were selected based on the potential we see in them, but the decisions they make during their research experiences will influence how much they learn from these opportunities. Student learning can far surpass just the research that brought them to the lab.

We asked two undergraduates (and coauthors of this letter) from the Summer of 2012 to summarize their thoughts from this first movie:

We watched Lions for Lambs early during the summer when we were still uncertain whether we had made a good choice to do research. As students, it was a great opportunity to see our new lab mates outside of work and meet our collaborators, in a relaxed and social environment with food and fellowship. Unlike college classes that require us to watch movies for homework, we would have chosen to watch this movie on our own or with some friends. We were able to relate to the unmotivated student because, like him, we had an opportunity before us and we had the option to make the most of its potential, or to coast for the summer with a "blue collar B." We benefited by watching this movie at the beginning of our research, before it was too late, to help us see that we were about to make a series of small daily choices that would influence our summer and ultimately college experience. Throughout the summer, we kept in mind the unmotivated student and the opportunities before us.

To close out the summer, we watch the 2011 movie Moneyball (see the trailer here: www.youtube.com/watch?v= -4QPVo0UIzc). The story centers on the 2002 Oakland Athletics professional baseball team, which was underfunded and had a seemingly hopeless future. Manager Billy Beane (Brad Pitt) decides to employ the talents of a recent collegegraduate math whiz (Jonah Hill), who uses the results of statistical analyses to hire a winning team. The entire approach contradicts the tradition of signing players based on the instincts and recommendations of seasoned scouts, but Beane and his whiz kid put all their energy and trust in the untested method. The team exceeds everyone's expectations, but they do not win the last game of the season and do not make it to the World Series. For a professional athlete, losing is worse than not winning. Beane feels like a failure, despite the record-breaking string of wins. The key moment comes when Beane and the math whiz (watch the key moment online:

www.youtube.com/watch?v=bxJ0PGSJ-Uc) watch a film of a minor league player who assumes he cannot hit a home run, but then does so without realizing it. This scene is a metaphor for Beane's situation; he has changed the game of baseball forever, even though he can only see the most recent loss as a personal defeat. Using Beane's approach, the Boston Red Sox build a championship team in 2004 that broke the 86-yr "curse of the Bambino." The same two summer research students summarized their reaction to the second movie this way:

The post-movie discussion started by one of our mentors telling all of the students that we too had hit a home run by swinging for the fences and making the most of our summer research experiences. We may not see the change in ourselves, but like the college students in Lions for Lambs, the daily decisions we made for 10 weeks altered our lives forever. As new researchers in a lab, some of our experiments didn't work as we had hoped. After watching this movie, we realized we needed to look at our summer in its entirety rather than as a recent failure, the way Beane focused on the last game of the season. We learned many valuable lessons this summer-new protocols, public speaking, researching methods, and presenting posters. These lessons will stay with us long past our summer research, and we should remember all these "wins" and not focus on losses or failed experiments. By measuring success in the lab as personal growth rather than publishable data, this summer was definitely a home run.

We believe that the bracketed structure provided by the experience of watching, discussing, and reflecting on these movies could contribute to the call for optimizing summer research programs for undergraduates. Research mentors, including young graduate students, could view and discuss these movies with undergraduate researchers to set a tone (Lions for Lambs) and reflect on the summer experience (Moneyball). We propose that jointly viewing the movies offers a nucleating point for ongoing discussion and reflection by the undergraduates. Thiry and colleagues (2012) reported that the undergraduates in their study wanted more interactions with senior scientists; movies provide an easy way to engage in personal discussions with minimal time preparation. Sometimes it is easier to hear a life lesson when it is delivered by characters in a movie. We hope Thiry and others will continue to study how to maximize the benefits of summer research programs. Perhaps they or others will measure how informal experiences such as ours could contribute to the overall goals of research programs.

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