**Title:** PLUS Biology: Peer-Led Supplemental Discussions Enhance Student Learning  
**Department:** Molecular Biosciences, University of Kansas; Initiative for Maximizing Student Diversity

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**Executive Summary:** Peer Led Undergraduate Supplements (PLUS) are small, one-hour discussion groups facilitated by student peer leaders; these discussion groups complement the large introductory biology classes by reinforcing lecture materials through interactive activities. As one index of the positive impact of the PLUS, we find that exam performance and overall course grades are higher for participants in the PLUS groups as compared to the class average.

**Background**  
Biology 150 (Principles of Cellular and Molecular Biology) is the first part of the introductory biology series (Biology 150 and Biology 152) for first-year science majors. This course typically enrolls 350-500 students a semester and is administered in a large lecture-format course. The format is highly challenging for some students, especially those students who have never been in a big lecture class before. The sheer size of the room can be overwhelming. While most Biology 150 professors engage students through questions and answers, participation is often limited to those who sit toward the front of the lecture hall. Because of the format of the class and the hall itself, seeking additional help may seem daunting for some students. In addition, the lecture format does not offer many opportunities for hands-on engagement with course material.

In order to address these challenges, the Peer Led Undergraduate Supplements (PLUS) in Biology program were developed in the Fall of 2005, as a required component of the Biology 150 course. During subsequent semesters, PLUS Biology sessions became voluntary; they are now open to any student enrolled in the Biology 150 and 152 sequence. These sessions are 90 minutes in length and are offered almost every day of the week. The PLUS sessions are designed as discussion sessions, as well as interactive learning experiences, aimed at reinforcing lecture material in a small class setting. In particular, these sessions provide students with hands-on experience with the application of lecture material. While it was expected that all students would benefit from attending PLUS sessions, the program was specifically designed to target minority or under-represented student groups, in an attempt to increase student diversity in the math and science (STEM) disciplines.
Implementation
PLUS Biology provides students in Biology 150 with a smaller classroom educational experience to supplement the large lecture portion of the course. Each week multiple discussion groups are led by undergraduate peer leaders. Students may attend any of the session(s) of their choice and are encouraged to attend multiple sections each week. Depending on the material, PLUS sessions may engage students through interactive games, round-robin question/answer exercises, peer-teaching, small group work, simulations, demonstrations, and skits/role playing. The content of each week’s discussion is aligned with the content of the large lecture section. At the start of each semester, additional topics such as note taking, study skills, and test-taking are also discussed.

An example of a popular PLUS session activity is a real-time reenactment of cellular respiration, or the process of energy conversion within a cell. Students write a short script and use large felt molecules to make a “movie” of the process. Another favorite activity among the students is a skit demonstrating the cell signaling pathway. For this activity, students are each assigned roles and scripts that parallel the cell signaling pathway in a skit. After the skit, students are asked to present the material in another form to the group. To guide their thinking, students are given a handout of the components that should be included in their presentation, and peer leaders are also provided with a handout that identifies the key ideas that students should take from this activity. Another activity that is positively received by students is the use of a game of Jeopardy to review the components and functions of macromolecules. A student handout (link to macrostudent.doc) and peer leader handout are also provided for this activity.

Several methods are employed to encourage student attendance at the PLUS sessions. First, all students are encouraged to participate in the PLUS sessions through announcements in the lecture sessions, weekly emails and/or Blackboard announcements, and a laboratory campaign during which peer leaders visit lab classes to promote the PLUS sessions. Additionally, students who are performing poorly based on quiz and exam scores are sent an individual email that emphasizes the benefits of the program. Posters with the PLUS discussion schedule are also posted on laboratory doors and throughout the science building.

Peer leaders are recruited in a variety of ways. Applications are invited from well-qualified undergraduates involved in the teaching and prepping of introductory biology labs. Additionally, peer leaders are recruited via the undergraduate biology email newsletter and from the tutor applicant pool. Peer leaders are trained by the Graduate Coordinator based on the peer-led team learning methodology. The leaders attend a weekly “prep” meeting where they not only review the week’s discussion exercises but also receive training in active learning techniques. (Click here for an example of the lesson plan peer leaders receive and the corresponding student handout for a session on “Transport and Enzymes.”)
Student Performance
We collected data on student attendance at the PLUS sections for Biology 150 and 152, across both the spring and fall semesters. In tracking attendance at the PLUS sections, we noted that many students attend more than one session each week. At the first session they attend, students participate in the activity, learning through their own experience. At subsequent sessions, these students often help explain or guide their fellow students through the activities and find that their own understanding deepens through this explanation.

We were interested in whether students who regularly attended PLUS sessions also earned higher grades than students who did not regularly attend these sessions. In fact, we found that to be the case: Students who attended at least 5 PLUS sessions in the span of the 16-week course out-performed the rest of the class by at least half a letter grade on exams. Final grade distribution also reflected this trend: over 80% of regular attendees received an A or B in the course. For a more detailed representation of the relationship between PLUS attendance and final course grades, please see Figure 1 below. This figure indicates that as the number of PLUS sessions increased, so too did students’ final grades.

Figure 1. Final Grades in Fall 2009 Biology 150 according to the number of PLUS sessions that students attended.

Further, we were interested in whether PLUS attendance was related to individual exam performance. First, we plotted the relationship between PLUS attendance and performance on the first exam. We found that students who attended four or more PLUS sessions before the first exam earned noticeably higher marks on the exam as compared to the class average and to the exam performance of students who attended fewer than four PLUS sessions.

Figure 2. Exam 1 Performance According to the Number of PLUS sessions Attended.
Finally, we were interested in how the attendance of PLUS sessions between Exam 1 and Exam 2 impacted students’ exam performance across the two exams. In Figure 3, we see that as the number of PLUS sessions attended increases, so too does the size of the increase in exam performance between Exam 1 and Exam 2. However, it should also be noted that students who attended a greater number of PLUS sessions also earned higher grades on Exam 1, perhaps suggesting that higher-achieving students may be more motivated to attend the PLUS sessions in the first place.

Figure 3. Exam 1 and Exam 2 Grades, According to the number of PLUS sessions attended
Reflections

Encouragingly, we find that students who attend a greater number of PLUS sessions earn higher grades in the large introductory biology course than do students who attend fewer sessions, or none at all. While the regular attendees may represent a subsection of the overall enrolled students who are already intrinsically motivated to commit additional time and effort into their studies, the PLUS sections do serve as an available small-group resource for students who have identified a need for additional help.

The success of the PLUS program relies on providing an alternative educational experience for students in Biology 150 and 152. Since the students meet in a small classroom environment rather than in an enormous lecture hall, students receive the opportunity to engage with biological material in a hands-on, discussion format, designed to encourage active learning. Through these activities, the students become participants in the learning process instead of mere receivers of information. When students return to multiple PLUS discussions each week, they are able to demonstrate their knowledge and understanding to themselves and others by helping their fellow students understand the material. As evidenced by student reflections on their experience with the PLUS sessions, students report gaining not only a better understanding of biology, but also a sense of personal confidence with the material. They also report that the peer leaders serve as positive role models and mentors. As we continue to monitor the impact of the PLUS sessions on student learning, it would also be helpful to examine whether minority students who attend a greater number of PLUS sessions are more likely to remain involved in the biological sciences, as one metric of the impact of early engagement with the course material on increasing the diversity of students in the STEM disciplines.

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