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Integrated Life Sciences (ILS): A New Honors Living-Learning Program at the University of Maryland

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Abstract

Integrated Life Sciences (ILS) is a new living-learning program for life-science students offered at the University of Maryland (UMD). This program consists of four components: 1) a residential community composed of 60-72 students entering each year, 2) an honors track of life-science classes designed according to recent national initiatives in undergraduate biology education, 3) research experiences on the UMD campus and at the federal research and biomedical institutes in the Washington, DC area, and 4) service-learning experiences. Several assessment measures indicate that ILS is successfully meeting major objectives of national biology initiatives, as well as realistic student and program expectations.

Integrated Life Sciences (ILS): A New Honors Living-Learning Program at the University of Maryland

This paper reports on the development of a new living-learning program for high-achieving honors students called Integrative Life Sciences (ILS) at the University of Maryland (UMD). ILS students are enrolled in various life-science disciplines offered at the UMD campus, including biological sciences, biochemistry, and bioengineering. ILS is structured as a modified 2+2 honors program, with the first two years devoted to academic courses and initial co-curricular experiences, and the second two years devoted to more ambitious co-curricular experiences and leadership opportunities. The first ILS class entered in Fall 2011 and graduated in Spring 2015.

In abbreviated form, the mission statement of ILS is: to inspire and prepare life science students to pursue meaningful careers that will advance our knowledge in the life sciences, improve the health of our world at all levels from individuals to the environment, and express active leadership in the life sciences in our global, interdependent world. To accomplish this mission, the ILS program is composed of four major components:

1) An interactive, supportive, and scholarly residential community composed of 60-72 students entering each year,

2) An honors track of accelerated courses in the life sciences offered by accomplished scholar-teachers,

3) Meaningful research experiences on the UMD campus and at the federal research and biomedical institutes in the Washington, DC area, and

4) Engaging service-learning experiences related to healthcare, STEM education, and environmental sustainability.

The (immodest) goal of ILS is to create a model for contemporary undergraduate education in the life sciences at large research universities.

Background

The overall design of ILS is guided by the academic and residential opportunities offered by the Honors College at UMD, and by the national initiatives to reform undergraduate biology education.

The Honors College at UMD is designed to recruit, educate, and launch the careers of the large number of high-achieving students enrolling each year at the University. It is noteworthy that the public schools in Maryland are often ranked first in the nation,[1] with the result that UMD is able to recruit approximately 1,000 outstanding honors students representing 25% of the total freshmen class. The Honors College at UMD offers seven different living-learning programs to entering honors students. These programs provide the experiences of living together in residential communities to those students who have identified common academic and/or co-curricular goals. In essence, the Honors College at UMD is following an extensive body of education research literature that documents the effectiveness of living-learning communities for promoting student learning, engagement, sociocultural tolerance, and self-efficacy.[2] In the

[1] Education Week Research Center. 2013. State and national grades issued for education performance, policy; U.S. earns a C-plus, Maryland ranks first for fifth straight year. *Education Week*. http://www.edweek.org/media/QualityCounts2013_Release.pdf. Accessed 10 July 2015; and Education Week Research Center. 2015. Quality Counts introduces new state report card; U.S. earns C, and Massachusetts ranks first in nation. *Education Week.* http://www.edweek.org/media/qualitycounts2015_release.pdf. (MD ranks third in this index.) Accessed 10 July 2015.

[2] For example, see Inkelas, K.K., Zaneeta, E.D., Vogt, K.E., and Leonard, J.B. 2007. Living-learning programs and first-generation college students' academic and social transition to college. *Research in Higher Education* 48: 403-434; Inkelas, K.K., Soldner, M. Longerbeam, S.D., and Leonard, J.B. 2008. Differences in student outcomes by types of living-learning programs: The development of an empirical typology. *Research in Higher Education* 49: 495-512; Lichenstein, M. 2005. The importance of classroom environments in the assessment of learning community outcomes. *Journal of College Student Development* 46: 341-356; Longerbeam, S.D. (2010) Developing openness to diversity in living-learning program participants. *Journal of Diversity in*

Honors College, all these outcomes are also seen in the UMD living-learning communities, plus much higher retention and graduation levels as compared to the overall campus levels.[3] Although further discussion of the Honors College outcomes falls outside of the goals of this paper, it is worth noting nevertheless that living-learning programs in general offer significant advantages for both the quality of undergraduate education *and* for the metrics used to determine national rankings of universities.

One-half of all honors students at UMD participate in the general honors program called University Honors, which is largely modeled after the Swarthmore Honors Program that almost a century ago was the first honors program instituted in the United States.[4] The fundamental structure of University Honors is known as a traditional 2 + 2 program. In the first two years, University Honors offers its students a wide range of different honors seminar courses that are specifically designed to be more rigorous than regular courses covering similar subjects. Each year University Honors offers over 125 honors seminars having enrollment limits of 20 students in all major academic disciplines. 70% of these courses are taught by distinguished MD faculty, and the other 30% are taught by government officials and other off-campus authorities drawn from the local Washington, DC area. In their final two years, University Honors students are encouraged to engage in original scholarship working under the mentorship of individual UMD faculty in various programs that are collectively referred to as Department Honors.

Higher Education 3: 201-217; and Szelenyi, K., Denson, N., and Inkelas, Women in STEM majors and professional outcome expectations: The role of living-learning programs and other college environments. *Research in Higher Education* 54: 851-873.

[3] Dorland, W.D. 2014. *University of Maryland Honors College Self-Study Report*. UMD, College Park.

[4] Aydelotte, F. 1944. *Breaking the Academic Lockstep: The Development of Honors Work in American Colleges and Universities*. Harper & Brothers, New York; Wood, R. (2012). *Transforming Campus Culture*: *Frank Aydelotte's Honors Experiment at Swarthmore College*. University of Delaware Press, Newark, DE; and Swarthmore College. 2015. Honors Program. http://www.swarthmore.edu/honors-program. Accessed 10 July 2015.

The other half of all honors students at UMD participate in six thematic living-learning programs,[5] which are currently structured as either 2-year academic and co-curricular programs that also offer additional leadership opportunities, such as peer mentoring and undergraduate teaching assistantships, to their upperclassmen, or a 4-year program called Gemstone that forms small undergraduate teams to conduct interdisciplinary research on important problems. The 2-year programs have been given names that are more or less self-explanatory: Advanced Cybersecurity Experience for Students (ACES), Design | Cultures & Creativity (DCC), Entrepreneurship & Innovation (EIP), and Honors Humanities (HH) (for further information, see UMD Honors College, 2015b)[6], plus the Integrated Life Sciences (ILS) program described in this paper.

In general, these programs offer a core of advanced academic and co-curricular courses, plus a capstone experience that requires research scholarship, creative arts, special projects, and/or business plans, as is appropriate to the specific goals of each program. Although some students from the thematic programs proceed to participate in Department Honors, most students do not seek additional honors experiences, in part due to the redundancy between their capstone experiences and Department Honors, and in part due to the limited carrying capacity of the honors programs offered by most departments. Furthermore, most thematic programs emphasize professional development, in order to help prepare the students for enrolling in professional schools and/or for entering the workplace following their graduation from UMD. For example, ILS organizes advising presentations from the UMD Health Professions Advising Office,

[5]University of Maryland. 2015a. Honors College. http://www.honors.umd.edu. Accessed 10 July 2015.
[6]University of Maryland. 2015b. Honors College 7 Living-Learning Program Comparison. https://docs.google.com/document/d/1eaJeLUK3-C0JAQ1b_Hitx4XEVHA-fapjj0XiRE004D0/pub. Accessed 10 July 2015.

because many ILS students are intending to pursue academic, clinical, and research experiences that will strengthen their future goal of applying to medical school.

The national initiatives to reform undergraduate biology education are the second major consideration affecting the design of ILS. The most significant drivers of this effort are two initiatives from prominent scientific organizations that were published in recent years.

The report called *Vision and Change in Undergraduate Biology Education: A Call to Action* (American Association for the Advancement of Science, 2011)[7] presents the efforts of the biology education and biology education research communities to develop a shared vision for undergraduate biology education and to identify the practices necessary to achieve that vision. This vision focuses on: fundamental principles, core competencies, and disciplinary practices that should be mastered in the biology curriculum; innovative, student-centered pedagogies that engage students as active participants, not passive recipients, of scientific reasoning; and effective integration of authentic research experiences into the curriculum. Moreover, assessment tools, professional development opportunities, and institutional changes necessary for implementing that vision are also described in this report.

Over the past 20 years, undergraduate biology educators realized that the adjustments being routinely made to align the biology curriculum to the Medical College Admissions Test (MCAT) had become a major impediment to proposed efforts to reform that curriculum.[8] In addition, the standard course requirements for pre-medical students were established a century ago by the so-

[7] American Association for the Advancement of Science. 2011. *Vision and Change in Undergraduate Biology Education: A Call to Action*. AAAS, Washington, DC.
[8] For example, see pp. 111-112 in National Research Council. 2003. *BIO 2010: Transforming Undergraduate Education for Future Research Biologists*. National Academies Press, Washington, DC.

called Flexner Report (1910),[9] and thus, it was timely to address the question of whether the Flexner pre-medical curriculum was still appropriate for training contemporary students.

The resulting report called *Scientific Foundations for Future Physicians* (Association of American Medical Colleges, 2009)[10] identifies the scientific competencies that pre-medical students are expected to demonstrate before their entry into medical school. Of particular note, this report emphasizes the fundamental knowledge, reasoning skills, and scientific practices, as opposed to specific required courses, for designing the new curriculum for training pre-medical students. This report prompted the dramatic revision of the MCAT, and new MCAT 2015 was launched in Spring 2015.[11] MCAT 2015 is specifically designed to require students to apply basic principles, fundamental knowledge, and quantitative reasoning from the physical, natural, and social sciences to answer questions that they were unlikely to have encountered before.

In essence, the *Scientific Foundations* report transformed the standard pre-medical curriculum so that it became aligned with the emerging consensus among biology educators that would soon result in the publication of the *Vision and Change* report. What both biology and pre-medical educators came to realize is that thinking like a scientist is virtually identical to thinking like a physician. Thus, it is anticipated that the reforms recommended in the *Vision and Change* report should greatly improve the quality of the undergraduate education for all biology students, including those in the pre-medical track. Together, the *Vision and Change* and *Scientific Foundations* reports provided the guidelines for designing ILS within the framework of the Honors College at UMD.

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[9] Flexner, Abraham. 1910. *Medical Education in the United States and Canada: A Report to the Carnegie Foundation for the Advancement of Teaching*. The Carnegie Foundation for the Advancement of Teaching: New York, NY.

[10] Association of American Medical Colleges. 2009. *Scientific Foundations for Future Physicians*. AAMC: Washington, DC.

[11] Association of American Medical Colleges. 2015. Medical College Admission Test®(MCAT®) https://www.aamc.org/students/applying/mcat. Accessed 10 July 2015.

Students

ILS is composed of exceptional students. For the class entering in Fall 2014, the mean weighted high school GPA is 4.57, which reflects the fact that ILS students are typically awarded 30 or more UMD credits due to their high scores on Advanced Placement and International Baccalaureate exams. Almost all entering ILS students have already participated in several meaningful service, clinical, and/or research experiences during high school, which are often the basis for their decision to major in the life sciences and to join ILS. Another noteworthy consequence of these co-curricular experiences is that many ILS students have developed a genuine commitment to serve those less fortunate than themselves. From the perspective of ILS faculty and staff, this commitment makes it quite rewarding to have the opportunities to teach, mentor, and advise these students.

ILS students enroll in life-science majors according to the following distribution: 60% Biological Sciences, 20% Biological/Chemical Engineering, 10% Biochemistry/Chemistry, and 10% other life-science majors. Many ILS students complete a second major or a minor in other science and non-science subjects. Only a few students have left the ILS program in order to pursue other majors than the life sciences, so that the 4-year graduation rate for the first graduating class was 92%. To date, almost all ILS students have expressed their strong interest in attending professional schools after earning their BS degrees: 55% MD, 15% MD/PhD, 20% PhD, and 10% other degree programs.

Academic Program

The academic program of ILS consists of an honors track of accelerated courses in the life sciences offered by accomplished scholar-teachers. All students entering ILS are expected to have earned high scores on the Advanced Placement Biology Exam so that they can waive the

freshmen sequence of molecular and cell biology and of evolutionary biology and ecology, or to have taken that sequence at UMD or another institution. In general, ILS classes follow the guidelines in the *Vision and Change* report, namely, they emphasize the mastery of fundamental principles and core concepts in the life sciences; the application of multidisciplinary perspectives toward understanding major problems; the use of learner-centered pedagogies, especially collaborative learning; and the integration of research techniques, results, and perspectives into the classes (Table 1).

Of particular value are the genetics and genomics, biomathematical modeling, and scholarship-in-practice courses, because they provide perspectives, skills, and knowledge for doing contemporary research in the life sciences and for applying its results toward solving important problems. The HLSC 100 service-learning course helps students develop the skill of self-reflection that is critical for meaningful service learning and future career planning. The HLSC 207 integrated organismal biology course is designed to help students master the use of multidisciplinary perspectives toward understanding major principles in the physiology, structure, and diversity of all organisms in subsequent science courses. ILS students will usually take all the above courses within their first two years at UMD, except that engineering students waive the mathematical modeling course, because it is redundant with other courses required in their majors. ILS classes substitute for required sophomore- and junior-level courses in most life-science majors, but they are taught at more challenging levels with greater expectations for classroom participation than the comparable courses offered to non-honors students.

In addition to their academic goals, these classes are purposefully designed to contribute to the personal development of ILS students. Initially, these students are often quite averse to doing group work, because during high school, they felt that they had to contribute

disproportional efforts to group assignments in order to ensure the high grades they expected to receive for completing those assignments. Nevertheless, their future professional successes in the life sciences, including medicine, will be crucially dependent on their ability to work on collaborative projects with other people having different skills. ILS courses, especially those offered in the first semester, provide numerous in-class projects and homework assignments that reward students for their willingness to work together without suffering the negative consequences typically associated with group work.

Another concern is that ILS students, like most honors students, are accustomed to viewing themselves as being the best students in their classes. Thus, a major challenge in ILS courses is: how to support the healthier aspects of competitive behavior, e.g., the effort to do one's best, while discouraging the more destructive, and ultimately futile, behavior of trying to one-up everyone else. In order to reduce unhealthy competition, all ILS courses are graded on an absolute scale, which means that grades are awarded according to pre-specified cutoffs based on expected levels of subject mastery, as opposed to grading each student based on his/her performance relative to the rest of the class. More significant for the development of healthy competition may be the efforts devoted to building a strong sense of community among ILS students, including the collaborative learning described above. Indeed, ILS students almost unanimously view the ILS community as being the most important aspect of the ILS experience. The central role that community plays in the ILS experience will be explored in subsequent papers.

Research Experiences

It is an extraordinary time to encourage undergraduate students to become life-science researchers. In the 21st century, life scientists are developing new perspectives, methods, and

equipment that are leading to the rapid discovery of new knowledge at an unprecedented rate. This research will undoubtedly shape the future careers of ILS students, and it is therefore critical that the students acquire a deep appreciation for the research process responsible for generating that new knowledge.

The research component of the ILS program is designed to facilitate meaningful experiences in basic biological, biomedical, and clinical research on the UMD campus and at federal research centers and biomedical institutes in the Washington, DC area, such as National Institutes of Health in Bethesda, Food and Drug Administration in College Park, US Agricultural Research Center in Beltsville, and Smithsonian Institution in Washington. All these federal institutes have international reputations for research excellence, and thus, they offer many internship opportunities for doing cutting-edge research that are readily accessible to ILS students.

All ILS students are expected to complete at least one authentic research experience, including an electronic portfolio of their experiments, results, and reflections, during their first two years on the UMD campus. Over the last four years, 37% of ILS students have participated in research internships on the UMD campus, 33% at National Institutes of Health, 16% at other federal laboratories in the DC area, and 14% at other university, public, and commercial laboratories. These internships have spanned all the life sciences, including human physiology, molecular biology, environmental sustainability, infectious diseases, public health, biomedical engineering, ecology, cell biology, genomics, and bioinformatics.

Furthermore, ILS sponsors the UMD undergraduate research team in the international Genetically Engineered Machines (iGEM) competition.[12] iGEM is the premier synthetic biology competition at which student-directed teams from major universities worldwide present novel

[12] International Genetically Engineered Machines Foundation. 2015. iGEM synthetic biology based on standard parts. http://igem.org/Main_Page. Accessed 10 July 2015.

synthetic biology projects targeted towards addressing real-world problems. The UMD team, including eight ILS students, earned a gold medal at the Fall 2014 Giant Jamboree competition for its work developing a biosensor for detecting the presence of *Perkinsus marinus*, which is a devastating bacterial pathogen that is killing oysters growing in the Chesapeake Bay. A second ILS/UMD team was also awarded a gold medal in the Fall 2015 Giant Jamboree competition for its work developing a new approach for stabilizing plasmids in engineered microbial cells without the use of antibiotics.

Service Learning

Service learning is an educational approach that connects traditional classroom instruction, community service, and guided reflections about personal attitudes, socioeconomic considerations, and alternative strategies for addressing real-world problems.[13] It is claimed that Maryland was the first state in the USA to require high-school students to engage in service-learning activities as a compulsory condition for their graduation.[14] Consequently, it should not be surprising that many students entering the ILS program are already aware that they have been given great gifts by their families, mentors, and educations, and thus, they are often planning on career paths that will help them share those gifts with others who are less fortunate than themselves. In fact, service learning was not included in the original design of ILS, but the first cohort of ILS students insisted that ILS incorporate service learning as an essential component of the overall program.

In essence, the goal of the service-learning program is to cultivate the abilities of ILS students to develop into future leaders who can capably serve their local and global communities.

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[13] Jacoby, B., Ed. 1996. *Service Learning in Higher Education*. Jossey-Bass, San Francisco, CA; and Jacoby, B. 2015. *Service-Learning Essentials: Questions, Answers, and Lessons Learned.* Jossey-Bass/Wiley, San Francisco, CA

[14] Maryland Department of Education, 2015. Service Learning in Maryland. http://www.marylandpublicschools.org/MSDE/programs/servicelearning. Accessed 10 July 2015.

In the HLSC 100 class that is offered in the first semester of the ILS program, student teams provide around 800 hours of community service to various providers of STEM education (e.g., several underserved high schools and the Upward Bound Pre-college Program), environmental sustainability (e.g., CHEARS Community Garden and 4-H Adventures in Soil Science), and health and social services (e.g., Kids Enjoy Exercise Now. Capital Area Food Bank, Loaves and Fishes Soup Kitchen, and NIH Children's Inn). Moreover, every year ILS sponsors an alternative spring break experience called Terps Helping Turtles for 10-12 students that involves a week of volunteer service at the Karen Beasley Sea Turtle Rescue and Rehabilitation Center in Topsail, NC.

In the semesters following HLSC 100, ILS students are embracing their roles as service leaders on the UMD campus. They have assumed leadership roles in numerous campus organizations dedicated to community service, such as Health Leads, Engineers without Borders, UMD Health Center Advisory Board, American Medical Student Association, American Medical Women's Association, and UMD Honors College Student Advisory Board. Lastly, ILS students have founded and are directing new student organizations providing volunteer service to underserved communities in STEM education (e.g., Foundations in Science and Health) and health care (e.g., Eyes on Health, Global Dental Brigades, and Supporting Hospitals Abroad with Resources and Equipment). Global Dental Brigades won the Grand Prize in the 2015 Do Good Challenge competition among student service organizations on the UMD campus.[15]

Awards

Even though ILS is a small program, its students received an impressive number of academic and co-curricular awards in academic year 2014-2015 (Table 2). Of particular note, an ILS senior received a Rhodes Scholarship for graduate study at Oxford University that was the first

Rhodes Scholarship awarded to a UMD student in over 40 years, and two ILS juniors received Goldwater Scholarships that are given for undergraduate research excellence in science, technology, engineering, and mathematics (STEM) fields. ILS students have also received noteworthy recognition for their collaborative efforts: ILS students are leading the student service organization that won the Grand Prize in the UMD 2015 Do Good Challenge for outstanding social philanthropy,[15] and ILS students formed most of the UMD research team that won Gold Medals at the 2014 and 2015 iGEM competitions described in the Research Experiences section above.

Assessment

ILS has a robust, ongoing research and internal evaluation process. Current research on ILS students focuses on understanding how they participate in collaborative learning, and how their learning expectations and the various features of the ILS community constrain and afford the productive collaborative learning[16]. Data collected for ILS research and evaluation efforts include observations and field notes from classes, discussion sections, and community activities; program assessment meetings; and informal gatherings in the dormitory. Other data include videos of students working together in class and in the dorm, recorded focus groups and semi-structured interviews, and annual surveys.

Detailed analysis of this large set of data is beyond the scope of this paper. However, a overview of some survey data can provide meaningful insights into students' perceptions of the program along important dimensions of the mission of ILS. Quotes from interviews and focus groups serve to elaborate on survey results. Two salient aspects of the ILS mission can be

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[15] UMD School of Public Policy. 2015. Do Good Challenge. http://www.dogood.umd.edu. Accessed 10 July 2015.

[16] Jardine, H., Levin, D.M., Quimby, B.B., & Cooke, T.J. (2016). Understanding collaborative learning in a life sciences living-learning program through multiple grains of focus. Paper presented at the Annual Conference of Ethnography in Education, Philadelphia, PA.

viewed through students' eyes: the value of the living-learning experience in building community and the alignment of the program with undergraduate biology education reform. The survey results reported here primarily come from the 2015 annual survey that was given to first-year (N=50) and second-year (N=63) ILS students.

Building community through the living-learning experience: Ideally, the living-learning experience helps students to develop a sense of belonging to the program, resulting in positive attitudes that tend to promote students' satisfaction, their retention in the program, and ultimately, their academic performance.[2] In a survey conducted among first year students in an earlier year, a group of survey questions from each student was used to create a composite score for "sense of belonging." This composite score showed a correlation between sense of belonging and grade point average (GPA). A hierarchical regression model was conducted in which GPA was regressed on sense of belonging at the first level and "social support" (another composite score) at the second level. Sense of belonging was shown to be a positive and significant indicator of GPA and explained 10% of the variance, $R^2 = .101$, $F(1,81) = 9.08$, $p = .003$.

Results from a similar group of survey questions on the 2015 annual survey suggest an overall strong sense of belonging among ILS students, particularly in the first year (Table 3). The small differences between the first year and second year students' responses are not statistically significant, but the program is concerned with sustaining students' sense of belonging as they move through the program. The first year is more intense, as students live together for the first time, and are encouraged by the program and instructors to know each other well and to work together to learn science. An important finding from the internal evaluation is that the program needs to continually make efforts to maintain the strong sense of belonging that is so salient in the early part of the program.

In an interview, a second year student described what she valued about the program coming in as a first year student, and changes from first to second year:

"*I like the community aspect of ILS. Coming to UMD that was what helped me a lot, the community is that initial safety net…support group. Now all of us as sophomores have our own lives on campus, we don't do everything together anymore, but it's still nice that the support group is still there."*

Alignment of the program with undergraduate biology education reform: Analysis of the annual surveys also provides insights into how students perceive the program's alignment with priorities of undergraduate biology education reform, including a focus on particular fundamental principles, core competencies, disciplinary practices, students' abilities to apply of multidisciplinary perspectives toward solving problems, and students' participation in collaborative learning.

On the annual surveys, both first and second year students are asked to check core biological concepts and competencies that they perceive were addressed in each of their ILS courses. Tables 4 and 5 show the perceptions of the 2015 first year students (N=50). Generally, the first year students perceived the ILS courses to address the core concepts and competencies, with very few students perceiving particular omissions (Table 4). The numbers are slightly lower for the second year students, but this is likely because coursework becomes more specific, and concepts and competencies covered in those courses are unavoidably more specialized.

The surveys also ask students specific questions aimed at gauging their appreciation of the nature of science and interdisciplinarity in science (Table 5). These data are generally encouraging. The decrease in perceptions of biology as being about memorizing facts potentially suggests that the program supports in coming to understand science as a way of knowing that

requires much more than just accumulating information. The survey also suggests that students have an appreciation for the relevance of physics and mathematics in biology.

The annual survey can also provide some insight into the intensity of competition that students feel and the extent to which collaboration in the program balances or mitigates that issue. Insofar as ILS students enter this program with the self-perceptions of being high achieving and competitive students, they often perceive high levels of competition among themselves and often compare themselves to each other (Table 6). It is somewhat disconcerting that the proportion of students perceiving competition increases between the first and second year. This could possibly be related to the decrease in collaborative learning opportunties, as suggested by the last two questions, and the possible decrease in sense of belonging reported earlier. Again, the program remains committed to sustaining the strong sense of belonging, supporting student collaboration, and discouraging unproductive competition. Students recognize and appreciate the program's commitment to encouraging collaboration, demonstrated by the response of one student to an open-ended survey question: "The emphasis on group work helped form a bond between peers and establish group study habits."

In addition to data collected by ILS, it is worth considering the survey data collected by Student Advisory Board of the UMD Honors College (Fig. 1). This survey, which was designed, administered, and analyzed by UMD honors students, is interesting, because it reflects those features of the UMD Honors College that the students view as being the most important. This survey was conducted as an on-line survey of several questions that were answered on a standard Likert scale from strongly disagree (1) to strongly agree (5) response.

Judging from their responses to these four statements, ILS students have quite high perceptions of the ILS program. Because ILS students are high-achieving honors students, it is

reassuring that 100% agreed or strongly agreed with statement Q2 ("My LLP classes were challenging"), and 92% agreed or strongly agreed with statement Q3 ("I learned a lot in LLP classes"). These results suggest that ILS is achieving its goal of encouraging academic excellence. It is also worth noting that the acceptance into their preferred living-learning program was influential for a high percentage of UMD honors students in making their decision to attend UMD. This result implies that the living-learning programs are a significant factor contributing to UMD's ability to recruit such a large number (~1,000) of outstanding honors students each year. Finally, UMD students indicate that the LLP's in general, and ILS in particular, do frequently meet their expectations, but they were not asked to identify the precise nature of those expectations in this survey.

Campus Impacts and Potential Scalability

It is crucial for their long-term survival that honors programs at flagship universities are not perceived as being isolated programs serving only elite students. Instead, honors programs should act as good campus citizens to support the overall mission of quality undergraduate education. Accordingly, ILS serves as an incubator for developing new courses, innovative pedagogies, classroom activities, and/or laboratory exercises that are being incorporated in the regular curricula for life science majors. For example, ILS faculty developed BSCI 330H Cell Biology, which is a flipped cell biology course featuring on-line videos, class discussions, and experimental laboratory exercises that is now being taught as a regular course in the Biological Sciences curriculum, and they are developing new bioinformatics exercises for HLSC 322 that are also intended for the regular genetics course. ILS supported the development of HLSC 374 Mathematical Modeling in Biology that will soon be made available to all Biological Sciences majors as a more biologically relevant elective following the required Calculus I and II sequence.

It is clear that the curricular and pedagogical innovations designed in ILS are transferable to the regular life science curricula on the UMD campus.

ILS is also making other contribution to the UMD campus. As a service available to all UMD students, ILS curates the on-line Life Sciences Research Internship Database that links to the websites of over 50 undergraduate research internship opportunities in the life sciences. In addition, the ILS director coordinates a seminar series on recent advances in biology education research that is offered to UMD graduate students and instructional faculty.

Finally, it is important to consider the related questions of scalability and of transferability of the entire ILS program. The current resources needed to support academic and co-curricular experiences for the first- and second-year ILS cohorts and additional programming and leadership opportunities for the third- and fourth-year cohorts include: 1) the salary lines of one Ph.D.-level staff member for program administration, admissions, and the scholarship-in-practice course and of one M.S.-level staff member for student advising, service learning, and activity programming, 2) a budget of $30,000 for student programming and service learning, and 3) the in-kind faculty contributions from the UMD biology departments to teach the organismal biology, genetics and genomics, and biomathematical modeling courses in lieu of teaching comparable, albeit larger, versions of these courses in the regular Biological Sciences curriculum. One of these three faculty members is also serving as the half-time faculty director of the ILS program. Based on our limited understanding of the finances of other honors colleges, we anticipate that these expenses are roughly comparable with the amounts spent to provide equivalent experiences to comparable numbers of honors students at other universities.

In our opinion, the ILS program is certainly scalable to larger sizes provided that the cost per student remains constant. Indeed, some cost savings could potentially be achieved with larger

class sizes, because several ILS courses use a small-group active-engagement pedagogy with circulating undergraduate teaching assistants that can scaled up to larger sizes in appropriate active-learning classrooms while still being taught by a single faculty member. However, we envision that the major constraint on both the scalability of the ILS program to larger sizes and its transferability to other institutions would be the availability of research experiences and service-learning opportunities in the surrounding community. This constraint may not apply to large universities located in most major metropolitan areas, such as Washington, DC, but it is likely to provide a significant challenge in other universities having rural locations.

Conclusion

It is reasonable to conclude that ILS students, staff, and faculty working together have successfully created a new living-learning program emphasizing academic excellence, research experiences, and community service for talented honors students in the life sciences. Because ILS is following rather closely the guidelines from the report *Vision and Change in Undergraduate Biology Education*, it appears that ILS has the potential to become a national model for achieving effective student-centered education in the life sciences.

Table 1. Brief descriptions of ILS classes.

HLSC 100 Integrated Life Sciences: Developing Life Scientists for the Global Good (1 credit) – focuses on service learning, community building, and other academic skills, such as resume preparation and course selection. Service learning involves team projects in healthcare, environmental sustainability, and STEM education.
HLSC 207 Principles of Biology III: **Organismal Biology** (3 credits) - utilizes fundamental mathematical, physical, chemical, genomic, and evolutionary principles to develop multi-disciplinary perspectives toward the functioning and evolution of all organisms, including humans.
HLSC 322 Genetics and Genomics (4 credits) – a lecture and laboratory course providing an overview of basic Mendelian and molecular genetics, and then focusing on the understanding and application of genomics to contemporary research, medicine, biotechnology, and societal issues.
HLSC 374 Mathematical Modeling in Biology (4 credits) - applies advanced mathematics and modeling techniques in order to address important problems in human physiology, epidemiology, and complex biological systems, such as viral pandemics and global climate change.
BSCI 330H Cell Biology (4 credits) – a flipped cell biology course with on-line videos, in-class discussions, and experimental laboratory exercises exploring the biochemical and physiological mechanisms underlying cellular structure and function.
HLSC 377 Research and Application in Life Sciences (3 credits) - a scholarship-in-practice course integrating the academic and experiential aspects of ILS to help students approach real-world problems in the life sciences, such as infectious diseases, ageing, green energy, and synthetic biology by developing their skills for the reading of primary research articles and by writing an NIH-style grant proposal

Table 2. A partial list of university, national, and international awards won by ILS students during the academic year 2014-2015. Awardees are designated by their ILS class: Sr, senior: Jr, Junior; and So, sophomore.

Students	**Award**	**Description**
1 Sr	Rhodes Scholarship	For graduate study at Oxford University
1 Sr	German Academic Exchange Service (DAAD) Scholarship	For graduate study at a German university
2 Jr	Goldwater Scholarship	For outstanding undergraduates pursing STEM research careers
1 Jr	Critical Language Scholarship	For outstanding students to study critical-need foreign languages (US Dept. of State)
1 So	Hollings Scholarship	For outstanding undergraduates interested in oceanic, atmospheric, and other environmental science (NOAA)
4 Sr, 3 Jr	Omicron Delta Kappa Inductees	For outstanding undergraduate leadership (ODK is national leadership honor society)
2 Sr, 2 Jr	HHMI Undergraduate Research Fellowships	For outstanding research projects in medicine-related fields on UMD campus
1 Sr, 1 Jr, 1 So	UMD Do Good Challenge Grand Prize	For outstanding student organization dedicated to social philanthropy in the UMD Do Good Challenge (ILS students represent >50% of organization leadership)
1 Sr	UMD Undergraduate Researcher of the Year	For outstanding undergraduate research on the UMD campus
6 Jr, 2 So	iGEM Gold Medal	For outstanding project and presentation at the iGEM Giant Jamboree (>50% of UMD iGEM team composed of ILS students)
1 Sr	UMD University Medal	For the most outstanding graduating senior at UMD
1 Sr	UMD H.C. Byrd Citizenship Prize	For the graduating male senior who most contributed to the advancement of UMD

Table 3. ILS students' sense of belonging (4-point scale: 1- strongly disagree, 2-disagree, 3-agree, and 4-strongly agree).

Question	Mean (first-year students)	Mean (second- year students)
I feel I belong in the ILS program.	3.30	3.00
Being a student in ILS is an important part of who I am.	2.80	2.79
I feel like an outsider in the ILS program.	1.98	2.11
Others label me as an ILS student.	2.71	2.76
My peers in ILS care about my personal well-being.	3.30	3.11
My peers in ILS help and support me academically.	3.10	3.14
I feel a sense of community with other people in the ILS program.	3.14	3.03
Living with other ILS students is a valuable experience.	3.38	3.00

Table 4. Numbers of 2015 first-year ILS students who believe that core concepts and disciplinary competencies are addressed in the first-year ILS courses (N=50)

Core Concepts	HLSC207	HLSC322
Evolution	47	48
Structure and Function	49	38
Information	36	37
Pathways	48	21
Systems	47	24
Disciplinary Competencies		
Applying the process of science	42	40
Using quantitative reasoning	40	35
Using modeling and simulation	42	29
Interdisciplinary nature of science	43	32
Communicating and collaborating with other disciplines	34	30
Understanding relationship between science and society	20	49

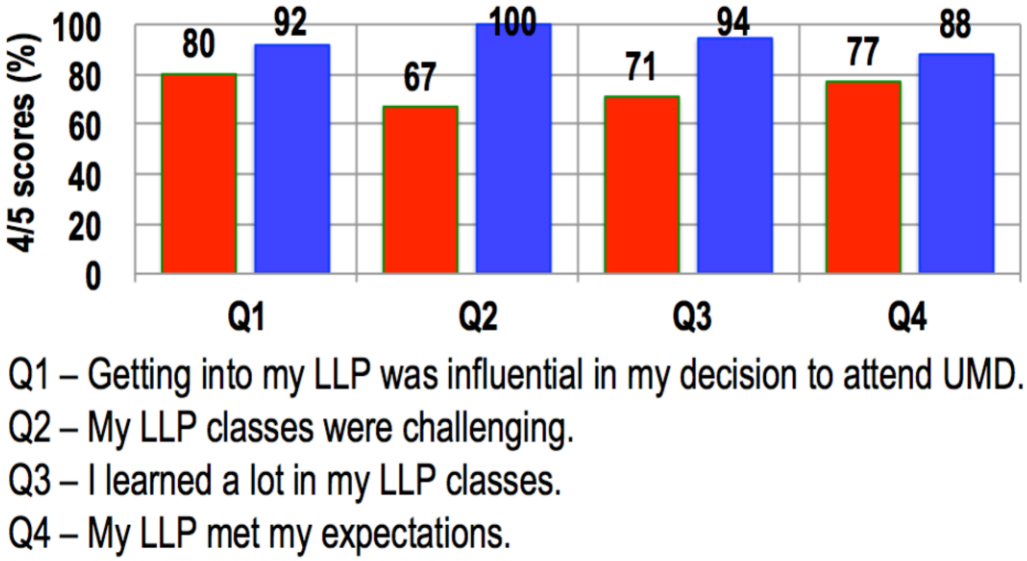
Table 5. ILS students' perceptions of the interdisciplinary nature of science (4-point scale as in Table 3).

Question	Mean (first-year students)	Mean (second-year students)
Learning biology is about memorizing the facts presented	2.76	2.37
Physics and math are relevant for understanding biological processes.	3.44	3.27
Discussing subjects such as physics or math in a biology course is not necessary.	1.56	1.71

Table 6. ILS students' perceptions of competition and collaboration (5-point scales - first question uses: 1 – none, 2 – low, 3 – some, 4 – high, and 5 – extremely high; and all other questions use: 1 – never, 2 – rarely (once or twice a semester), 3 – sometimes (monthly), 4 – often (weekly), and 5 – extremely often (daily)).

Question	Mean (first-year students)	Mean (second-year students)
What do you perceive as the level of competition?	3.30	3.54
How often do you find yourself comparing yourself to other students?	2.86	3.63
I work with other ILS students on HW and studying for ILS courses.	3.39	3.00
I work with other ILS students on HW and studying for courses I am taking outside of the ILS program.	3.24	3.00

Fig. 1. Student perceptions of the living-learning programs in the UMD Honors College. The data are presented as the percentage of combined agree (4) and strongly agree (5) responses over the total number of responses. The percentages of combined 4 and 5 answers from ILS students are shown by the blue bars. The percentages of combined 4 and 5 answers for the UMD Honors College (red bars) were calculated as the mean percentages of all seven living-learning programs (LLP's) in the Honors College. Each program had a response rate of at least 30%. Source: UMD Honors College Student Advisory Board. Used with permission.



The Authors

Todd J. Cooke (Ph.D., Cornell University, 1979) Professor of Cell Biology and Molecular Genetics, and Director of Integrated Life Sciences, Honors College. Dr. Cooke's research interests lie in the development and evolution of green plants and in the process of biology student learning. His teaching efforts are focused on the development of multidisciplinary courses for teaching undergraduate biology students. His awards include a Guggenheim Fellowship, a College Teaching Excellence Award, and a Creative Educator Award from the Board of Visitors. Dr. Cooke was named a Life Science Education Fellow of the National Academies for 2009-2010.

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Nicole Horvath (M.S., University of Maryland, 2013) Previous Assistant Director of Integrated Life Sciences, Honors College. Ms. Horvath’s academic background and professional experience as an environmental educator have guided her interest in sustainability education. Her research focused on assessing student knowledge of sustainability principles and the integration of sustainability across the college experience. During her time with ILS, Ms. Horvath focused on developing a strong sense of community among the students through a first year experience

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