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PART 2

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About the cover: Professor Stephen Aldrich (Indiana State University) demonstrates the use of a GPS.

CONTENTS *Winter 2016 Web*

Undergraduate Research in the Curriculum, Part 2

Focus Article

Departments

CURQ on the Web, Winter 2016 edition
http://www.cur.org/publications/curq_on_the_web/

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CUR Focus

Partnering with State Enriches Environmental Research for First-year Students

Abstract

Introduction to Environmental Sciences (ENVI 110) and its lab, Environmental Sciences: Human and Environmental Change Laboratory (ENVI 110L), offer large numbers of first- and second-year students a significant and meaningful research experience at Indiana State University. All students are required to complete at least one science course with a lab, and ENVI 110/110L is one of only four ISU-approved courses. Thus a high percentage of students taking these courses and benefiting from the research opportunity offered are not science majors. The lab includes a field day at Indiana's newest fish and wildlife area, known as the Wabashiki (a Native American name for the Wabash River). The goal of the experience is for each student to collect at least two soil samples, take GPS coordinates of each soil sample, determine soil color, texture, and pH, and use that data to test a hypothesis of their own making. After careful checking of the students' soil samples, those deemed complete and valid are compiled and the results reported every semester to the Indiana Department of Natural Resources to help officials track the environmental status of the area. Surveys of students suggest high levels of satisfaction with the experience.

Keywords: *hypothesis development and testing, field trip, environmental science, first-year students, undergraduate research*

The Introduction to Environmental Sciences course (ENVI 110) and its lab, Environmental Sciences: Human and Environmental Change Laboratory (ENVI 110L), annually offer 700 to 800 mostly first- and second-year Indiana State University (ISU) students a significant and meaningful research experience. The university's Foundational Studies Curriculum requires every student to complete at least one science course with a lab, and the environmental science course and lab (hereafter ENVI 110/L) is one of only four approved ISU courses. Thus most students in the course are not science majors, and so the lab offers an opportunity to expose many nonscience majors to a research/fieldwork experience.

We will discuss the history of ISU's Foundational Studies curriculum; students' process of hypothesis development, field testing, and the field day; how collected soil samples are used by others; students' assessment of the research experience; and how other faculty could integrate a similar field experience and research project into their large first-year courses.

Introductory Environmental Sciences in the Curriculum

The introductory environmental science course and lab (ENVI 110/L) has been evolving over eight years. It emerged during a stressful time in the then-Department of Geography, Geology and Anthropology. Three separate programs were deciding whether to go their separate ways or seek a common identity. After one unsuccessful attempt at proposing the course and lab and after the department decided to seek a common identity as Earth and Environmental Sciences (EES), ENVI110/L was first taught online in summer 2009 and on campus in fall 2009. Initially the lab did not include the field experience.

Simultaneously, broader institutional changes were underway that contributed to an emphasis on a meaningful hands-on experience in the introductory environmental science course and lab. In 2009 Indiana State University launched its current strategic plan, "Pathway to Success." Goal Two is to "advance experiential learning so that all ISU students have a significant experiential learning experience within their major" (Indiana State University 2009). Goal Three is to "enhance community engagement to foster the engagement of students, faculty, and staff in the life of our communities and in pursuits improving their economic and social well-being" (Indiana State University 2009).

Two initiatives from Goal Two—"apply the science of learning to the learning of science" (referring to the NSF Science Education for New Civic Engagements and Responsibilities program) and creation of the Center for Student Research and Creativity—joined another strategic-plan initiative, creation of the Institute for Community Sustainability, to create a new climate on campus. These changes, plus the new identity of the department, have led to different hiring decisions—new faculty hiring has focused on interdisciplinary researchers working in the nexus between the physical and social sciences. All of this has combined to support and contribute to the continued evolution of ENVI 110/L into its current form, with 700 to 800 students annually participating in a field day at the Wabashiki Fish and Wildlife Area just outside Terre Haute, Indiana (http://www.in.gov/dnr/fishwild/6188.htm).

Because our introductory environmental course and lab served as both a general-education lab science course and

as the gateway to the newly named department, the existing published lab manuals were no longer appropriate. A self-published lab manual was created for 110L, which is now published by Hayden-McNeil (Latimer 2016). The goal is to provide a hands-on experience that touches on many of the major concepts covered in introductory environmental science regardless of who is teaching the course—water quality, erosion, soil chemistry, environmental health, extinction, scientific method, atmospheric processes, climate change, etc. The topics are arranged so that students can see how the samples they collect fit into the bigger picture.

Before 2009, ISU and the Department of Earth and Environmental Sciences, in particular, began to embrace the program called Science Education for New Civic Engagements and Responsibilities (SENCER), which is an NSF-funded program to make STEM (science, technology, engineering, and mathematics) education more meaningful by shaping students' learning around important civic issues. Two of this article's authors, Latimer and Speer, met and discussed integrating a field trip to the Wabashiki area into the introductory environmental course. Thereafter, the lecture and lab became more hands-on through use of real-world research projects.

The goal of the field trip—which began as an all-day Saturday experience and was later reduced to two half-day experiences as enrollment in the course grew—was not to collect samples but to expose students to a wetland field experience. But it continued to evolve into complete and meaningful research. In fall 2010 students gathered the first samples of soil nutrients. There were insufficient resources to process the soil samples for analysis by the department, and thus the students collected data but could not analyze it.

Spring 2012 marked the last of the all-day Saturday field trips, as the logistics of the field trip became too difficult due to surging enrollments. The department and the two new campus centers described above all contributed funds to purchase a portable XRF (x-ray fluorescence spectrometer) so that the soil samples could be analyzed accurately and economically, providing up to 800 students each academic year with a research experience proceeding from hypothesis formation to data collection, to analysis, and drawing of conclusions. In fall 2013 the field day became an "in-class" field trip for 110L, and it has remained so. To prepare the students for the class fieldwork, the laboratory curriculum was rearranged to offer skill-building activities building up to the research project.

There are challenges. The timing of the fall field trip is complicated because the Indiana Department of Natural Resources prefers that students avoid the area during hunting season. Thus the trip occurs earlier in the seminar than is optimal given the current curriculum. The students now collect samples, save them, do the skill-building activities, and then return to their samples later in the semester to undertake the analysis. In the spring, we sometimes must battle weather, especially seasonal spring flooding. Over the past year, the department's faculty members have begun experimenting with other sites for the field trip. Some classes have gone to a local county park, and others have gone to the ISU Community Garden.

Further, depending on their area of concentration and on faculty members' disciplinary backgrounds, many students majoring in Earth and Environmental Sciences may learn more about social science research methods and theories emphasizing the human/community-environmental relationship before they approach material lending itself to physical research at a field site. A fruitful avenue to pursue would be to extend the human/community-environmental hypotheses in partnership with other departments or courses, to create more meaningful social and behavioral hypotheses. Nevertheless, the commitment for ENVI 110/L is to create a meaningful research experience that also reflects engagement with civic concerns.

Hypotheses, Sampling, Testing

As noted, the fieldwork site is Indiana's newest fish and wildlife area. Its location just a few miles from campus makes it possible to conduct the fieldwork within the time limits of the weekly 110-minute laboratory period. Prior to acquisition by the State of Indiana, much of the 2,400-acre tract was farmed, quarried, and used for illegal dumping. The field day serves as an important mechanism to collect soil samples, geospatial data, and biogeochemical samples to better understand how the once-drained bottom lands return to their more natural state. The goal of the experience is for each student to develop a hypothesis and test it by collecting at least two soil samples, taking GPS coordinates of each soil sample, and determining soil color, texture, nutrient status, and pH. The samples are dried and prepared for further analysis on campus.

Prior to the field trip, groups of students learn to develop a testable hypothesis. Lab activities leading up to the field day are aimed at building specific skills, for example learning how to determine soil texture, how to use test kits to quantify nutrients, and learning about contaminants in the environment. An entire day in the lab part of the course is devoted to the scientific method and development of hypotheses. Activities focus on developing a hypothesis that the students test and evaluate. Students are asked about the outcomes of

Professor Stephen Aldrich demonstrates the use of a GPS smartphone application.

flipping a coin, coming up with a sampling strategy to understand the layering of a candy bar, and trying to determine what might happen when two solutions are mixed based only on their initial observations. Because students are familiar with coins and candy bars, the outcomes of their experiments are predictable. The last activity, however, forces students to confront unexpected results. They mix warm milk and vinegar together and are surprised to find their final product is plastic.

In the lab session the week before the field trip, the students' preparation includes information on what a wetland is, why wetlands are important, and how they are threatened. This leads to information about the Wabashiki, its history, and its legal and (past) illegal uses. The purpose of this lab session is for each student to develop an individual hypothesis about Wabashiki soils and a sampling plan to address the hypothesis.

During the following week's field trip, each student collects at least two soil samples and records the following:

1. His or her sample GPS coordinates using a free smartphone application
2. Soil color
3. Texture
4. pH

The student also quietly observes the location and answers questions in a packet prepared for this trip. The packet includes a log for observations, a prompt about the kind of plant life has been observed (a minimum of two species), the kind of animal life observed (and if none is observed, the student is told to speculate about what kind of wildlife might live there), the way in which the wetland might benefit the wildlife, an explanation of any disturbances observed, an explanation about whether it is important to remediate the wetland area or not, methods for possible protection of the sanctuary, speculation on whether protecting the wetlands is beneficial to the student, aspects of the field trip that impressed the student, and changes in the trip that the student would recommend (and why).

Students have hypothesized, for example, that:

1. Soil samples with higher water content will have a lower pH.
2. Heavy metal concentrations will decrease with depth.
3. Soil pH will increase with distance from the pond.
4. Open areas will have higher metal concentrations than those with tree cover.
5. Former agricultural areas will have lower macronutrient levels than forested areas.
6. Nutrient levels will be higher at the bottom of slopes than at the top.
7. Soils closer to the "dump" will have greater macronutrient concentrations than soils in the former agricultural areas.

A student collects soil samples in the Wabashiki. The test kit is in the foreground.

Back on campus, students dry their samples, crush or sieve them, and use the spectrometer to collect data on soil elements. Considerable stress is put on the final report, and students are told that their data will be shared with the State of Indiana, thus assuring them that their work is important and not merely an academic exercise. Although the students work in groups, each student is required to submit an individual final report on the field trip.

The final written report must be a minimum of three pages and be written as a scientific report. A class handout provides detailed examples of the composition of the report, including two charts, two graphs of the data, and other specifics. Groups of students also prepare an oral report in the form of a PowerPoint presentation, which must be at least five minutes in length; all group members must speak and describe at least one slide. They must include their hypothesis, their testing strategy, all test results, and their conclusions.

Use of Collected Samples by Others

As described in the previous section, students prepare their soil samples following a protocol that makes them useful to the state's Department of Natural Resources. To date, other than "environmental monitoring," it is not clear how the agency is using the samples. The authors directly involved with ENVI 110/L report that the previous contact in the state department was more "hands-on" with the data than the current one.

However, author Aldrich prepared a comprehensive report for the department in fall 2013 following the introduction of the field trip and research project into the course. This report was based on 166 valid student samples with correct GPS coordinates; XRF data; and information on complete soil chemistry, texture, and color in most cases. Aldrich and a staff member conducted an initial analysis of the concentrations of four heavy metals—lead, nickel, arsenic, and mercury—at the Wabashiki. They found few samples with overly high concentrations of those metals. However, although they were few and sporadic, individual samples had extremely high levels of the metals. Aldrich and the staff member concluded that some samples "display heavy metal contamination from human impacts on the environment. While some areas show little to no contamination, other areas, and specifically dump areas, are higher in contamination" (Aldrich 2013, 50).

The data from the students' samples are used regularly in three Geographic Information Systems (GIS) classes, Introduction to GIScience, Introduction to Geographic Information Systems, and GIS: Applications. The data are also sometimes used in statistics classes.

To date, the authors are unaware of any students or faculty members using the data collected by the students in ENVI 110L for research, although some undergraduates have used the data for class projects in GIS classes.

Assessment of the Research Experience

Faculty members created a survey that students filled out in fall 2014 that directly assessed the field trip and research project. Unfortunately, spring rains made the field trips impossible and evaluations unnecessary in spring 2015. In fall 2015 rains made it impossible for some lab sections to complete a field trip.

At ISU, students are asked multiple times to evaluate their courses via an online system, but evaluations of the ENVI 110/L field trip are conducted through a survey administered via the Learning Management System (LMS, Blackboard). Although online evaluations yield lower response rates than paper-based questionnaires in most cases, students report confusion with the LMS survey, and response rates suffer significantly. There is a plan to administer the survey differently to avoid this problem in the future.

Students are asked to answer 19 questions on the LMS survey using a five-point Likert scale. Five indicates "strongly agree," and 1 indicates "strongly disagree." A 3 indicates "neither agree nor disagree." Table 1 contains average scores and standard deviations for fall 2014 and fall 2015.

Most item averages vary less than one standard deviation from each other, suggesting consistency in the students' ratings. The scores also suggest that students generally agree with the statements but without much intensity. Future evaluations may ask students to compare the field trip to conventional lab experiences, altering the response categories and modifying the wording of some questions.

The survey results thus far suggest the field trip is perhaps slightly more successful at aiding "understanding of environmental issues globally and in my community" than in improving confidence in "my abilities as a scientist." However, even higher averages were obtained for the statement that the research project helped a student to "better understand how to develop and test a hypothesis," a necessary skill for gaining confidence as a scientist and becoming a critical consumer of scientific reporting.

It may also be that scientist is not something that many students in the course aspire to be or identify with. Among the highest average numbers were the responses to "I learned some skills and knowledge about environmental science that I could not have learned in a classroom." This, we think, is

Table 1. Student Perceptions of the Environmental Sciences Fieldwork

	Fall 2014		Fall 2015	
Question	average (*n*=195)	standard deviation	average (*n*=83)	standard deviation
Participation in the field trip was a rewarding experience.	3.90[a]	0.93	3.81	0.97
As a result of the field trip, I understand environmental science better than before.	3.79	0.78	3.71	1.07
I felt well prepared for the field-trip activities.	3.70	1.09	3.72	0.97
I learned some skills and knowledge about environmental science that I could not have learned in a classroom.	3.96	0.90	3.77	1.007
Overall, I think the field trip has enhanced my learning and interest for the course.	3.65	0.97	3.57	0.98
Field-trip activities were worthwhile.	3.75	1.05	3.61	1.04
I was able to use skills I learned in class on the field trip.	3.93	0.94	3.77	1.13
This field trip had a significant impact on my learning for the course.	3.63	0.99	3.41	1.04
Field instructors provided clear instructions and guidance.	4.04	0.97	3.9	1.02
I enjoyed the field trip.	3.61	1.16	3.51	1.11
The field trip was a valuable use of my time.	3.60	1.06	3.49	1.15
The field trip was well organized.	3.92	0.84	3.61	1.02
I enjoyed the research project.	3.50	1.03	3.24	1.10
After completing the research project, I better understand how to develop and test a scientific hypothesis.	3.88	0.74	3.73	1.03
The research project was a good use of my time.	3.42	1.00	3.49	1.06
Were you aware that your data will be shared with the Department of Natural Resources?	NA	NA	45.8% Yes	0.50
The research I completed is important to the community.	3.88	0.90	3.61	0.93
After completing the field trip and research project, I am more confident in my abilities as a scientist.	3.62	0.78	3.48	1.04
After completing this course, I have a better understanding of environmental issues globally and in my community.	3.84	0.75	3.85	0.91

[a]A 5-point Likert scale was used with the following elements: 1=Strongly Disagree, 2=Disagree, 3=Neither Agree nor Disagree, 4=Agree, 5=Strongly Agree

the strongest student-evaluation evidence for the efficacy of the field trip and research project, and a good reason for others to develop similar research projects in comparable courses.

We conclude that the students' evaluation data, on average, supports the following conclusions:

- The field-trip research experience and research project were rewarding and worthwhile experiences for students, and they enhanced students' learning in the course.
- Students learned skills and knowledge they would not otherwise acquire in the classroom, and those skills are useful.
- The field trip and research project led to better understanding of environmental science, the scientific process, and global and local environmental issues.
- The students understood that their research efforts contributed to the local community.

Discussion and Conclusion

ISU emphasizes experiential learning and community engagement as core values. To that end, there is a supportive institutional setting for a logistically challenging field trip and research project for the mostly first-year students enrolled in ENVI 110/L. Even in such a supportive environment, however, resources are tight, and the experience requires faculty who are personally dedicated to the experience. Our experience shows that, although unsettled times may seem to support a conservative approach to curricular innovation, departmental or university upheavals may also be fertile moments for initiating significant change. Given this, the experience of ISU faculty with ENVI 110/L leads to some concrete suggestions:

Identify a site. Getting students out of the lab and into the field begins with identifying a place nearby. ISU is fortunate that the Wabashiki is so close to its campus. Other possible field sites could be city/county parks, brownfield sites, redevelopment sites, campus grounds, local school grounds, or cemeter-

ies—the possibilities are many. Approaching the managers of the site is necessary to gain access but also to make the project meaningful. It is possible that the local park district might appreciate the environmental monitoring that annual or semi-annual soil samples (or water samples) would provide. It is also possible that some financial support could be part of the partnership to help offset the added costs of the field trip, sample processing, and database management. By routinely returning to the same site, faculty also gain experience; the process becomes more standardized, and the accumulated data becomes a more valuable resource for possible uses in the classroom or for undergraduate researchers completing their own research projects for capstones, senior theses, and other projects.

Start small. Do not try to take hundreds of students into the field the first time. Pilot the field trip with a single lab section. The current ENVI 110/L field trip and research project resulted from several years of iterations, leading eventually to the creation of a handbook on how to prepare students for the trip and how to efficiently and effectively organize students on the day of the trip. The activity takes experimentation and refinement. Ramp up slowly but steadily to inclusion of all class sections.

Seek support. Check on whether there are any funds for curriculum transformation or to support "community engagement" or course-based field trips. If there is an office for undergraduate research on campus, perhaps the staff could also support the effort.

Partner with students. Ask them what they like and dislike about the experience and look for good ideas from them. The faculty who developed the ENVI 110/L field trip received several good ideas from students about how to improve the experience. Our end-of-semester student evaluation contains an open-ended question about suggestions for improvement.

Don't fear failure. We tell our undergraduate researchers that failure is part of research, so faculty also shouldn't be discouraged by initial setbacks while piloting a field trip and research project. There will be logistical challenges. For example, some students may wait until the last minute to complete the testing of their samples, thus overwhelming available lab space, or local officials might change their minds about partnering in the endeavor. The weather at times will not cooperate. Let students know that something new is being tried, and they will accept that some plans do not work perfectly.

Persist. The experience is worth it for the students, plus it can lead to positive town-gown relations and can generate positive local publicity for the institution. Furthermore, long-term collection of data can drive forward meaningful science and develop ideas that may bear fruit for both classroom instruction and future research.

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CURQ Vignettes

Redesign of a Research Methods Course in Psychology: A Model for Teaching and Integrating Undergraduate Research

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Courses in statistics and research methods serve as foundations for more advanced courses for undergraduate psychology majors. For the past three years, we have engaged in a collaborative redesign of our Research Methods in Psychology course to provide a standardized approach to course delivery that incorporates innovative practices for teaching undergraduate research. We were fortunate that the need for the redesign of this course occurred in conjunction with our department's adoption of learning goals that aligned with those presented in the APA Guidelines for the Undergraduate Psychology Major (American Psychological Association, 2013). The redesign of this course has allowed us to better incorporate learning goals related to scientific inquiry and critical thinking, ethical responsibility, communication, and professional development. It also has helped us promote the importance of the skills developed in this course as necessary for students to become effective consumers of research.

We have put effort into establishing and communicating expectations to students by creating and refining, as a group, the learning outcomes for this course and a set of standardized rubrics for all major course requirements (e.g., drafts for all sections of the final paper, poster, and presentation). The restructuring has allowed us to continue our focus on providing students with continual feedback and support from faculty, teaching assistants, and classmates throughout all aspects of the research process, including creating, conducting, writing about, and presenting the project.

The steering committee for the redesign met before the start of each semester and then weekly throughout the semester. Arriving at consensus regarding learning outcomes, assignments, and rubrics required diplomacy and compromise by everyone, but the collaborative process resulted in course materials that were well understood, had strong support, and could be implemented with fidelity. The consensus-building process illuminated the strengths of individual faculty, enhanced respect and rapport among faculty, and continues to provide a strong foundation as the course materials evolve. The consistency of assignments and their implementation helped strengthen the links between the Research Methods in Psychology course and both prerequisite courses (e.g., Introduction to Statistics in Psychology) and subsequent upper-level courses (e.g., Senior Capstone in Psychology).

One of the strongest aspects of this redesign is that it gives students an authentic research experience by requiring student groups, under the supervision of course faculty, to obtain approval for their proposed research before they can conduct their class project, and by requiring them to construct and present a research poster at a campus symposium. Students complete the modules in the Social and Behavioral Research Basic Course using the Collaborative Institutional Training Initiative in order to review ethical principles, including those presented in the Belmont report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). They also receive a briefing on the history and role of the institutional review board from a representative of our IRB.

Additionally, in their research groups, students complete an IRB application (including a consent form and debriefing document) that mimics the application form used by researchers at the university. Their application is then reviewed by the faculty who teach the course to ensure that the proposed research meets the criteria of being a "class project" (i.e., minimal risk with non-identifiable data and no contribution to generalizable knowledge). Although all research in this research-methods course is designed to be a "class project," students do have limited within-institution dissemination outlets (i.e., an internal symposium and Northern Arizona University's peer-reviewed, online undergraduate journal).

Every semester, all of the undergraduates in this class (usually between 120 and 150 students) present a professional-quality poster (in small research groups of three to five students) at the College of Social and Behavioral Sciences fall symposium or at the university's undergraduate symposium in the spring. Both of these symposia allow students to present their research through a conference-style poster presentation to their peers, professors, and the university and city communities. These "stand-and-deliver" experiences provide students with a broad audience beyond the usual presentation of their research in class or at a departmental event—opportunities that most students would not have experienced without this course.

Most recently, the number of presentations from this class accounted for approximately 30 percent of the presentations made by undergraduates in our department at the university-wide symposium and 10 percent of the undergraduate presentations made at this event by students in our college. Together, these components of the course provide students

with a more genuine research experience, one that is consistent with the experience of an academic presenter at a professional conference.

This redesigned model has also helped to create a culture in which research is valued and psychology is viewed as a science. We now have a directive to increase opportunities for research that will be infused into upper-level courses in the major. Last semester, 88.89 percent of instructors of upper-level courses incorporated skills and knowledge related to research methods into their courses (e.g., having students use library resources to conduct an effective literature search or synthesizing findings across multiple research articles). Instructors have also designed assignments that required students to collect and analyze data on a small scale, and then assess the validity and reliability of established measures and, ultimately, create and present an evidence-based poster or paper.

Data from our annual senior exit survey (n=190) suggest the majority of our students continue to have meaningful research experiences after completing our redesigned research-methods course, with 95 percent reviewing primary scientific literature, 75 percent contributing to a poster or paper presented at a conference, and 64 percent attending a conference where their research was presented. These are remarkably high percentages, given that only 26.15 percent of students surveyed reported participating in our undergraduate research experience course, in which students work on original research with faculty. Thus, the practices incorporated into this redesign of the undergraduate research methods in psychology course provide a strong model for both teaching research methods and incorporating meaningful undergraduate research experiences into the major.

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A Community Model for Course-based Student Research That Advances Faculty Scholarship

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Educator-scientists are well aware of the many pedagogical benefits of engaging undergraduates in original scientific inquiry. However, doing so in a classroom setting to reach more students is challenging, time-intensive, hard to sustain, and intellectually draining for busy faculty members who struggle to balance the demands of teaching and research. Despite their best intentions, many faculty members who teach laboratory courses resort to straightforward "cookbook" lab exercises that require little to no problem solving and have ready-to-go teaching materials but do not provide students with experience in original inquiry.

To address these challenges, we formed a vibrant learning community of faculty members at multiple institutions. In our group, the Ciliate Genomics Consortium (CGC), all faculty members use a common model organism—*Tetrahymena thermophila*, a common single-celled inhabitant of pond water—in their research. Over the past 11 years, the CGC has developed a modular curriculum that exposes undergraduates to original research, contributes to scientific knowledge, and advances the varied research interests of participating faculty members.

The CGC curriculum includes five core modules using *Tetrahymena:* testing in silico gene models by reverse transcriptase polymerase chain reaction, determining gene expression profiles, assessing effects of gene knockouts, determining protein localization, and identifying protein interaction partners. Each faculty member may apply any combination of modules (designed for standard three- or four-hour laboratory sessions) to study any set of genes relevant to his or her particular research interests. We designed the modules to be highly flexible so faculty members can use them to address a broad range of biological questions in cell biology, molecular biology, genetics, biochemistry, and introductory biology courses.

For example, one class might use the protein localization module to investigate where proteins of interest act in a cell by tagging them with a fluorescent protein and examining localization in live cells by fluorescence microscopy. Another class might use the gene expression module to monitor changes in expression of selected genes when cells are exposed to environmental stressors or when growing in competition with another species. The flexible and modular

nature of the curriculum has promoted its adoption, in one form or another, at 22 institutions to date.

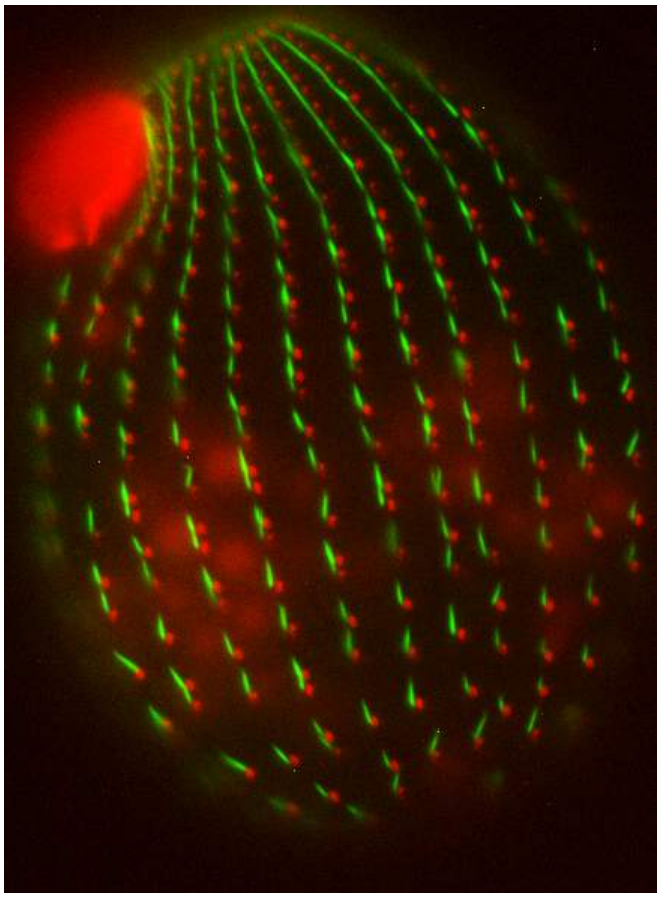
We have identified five key benefits of the CGC curriculum. First, it is sustainable over the long term. Currently, around 100 students per year each investigate a different gene. Of the approximately 28,000 genes in the *Tetrahymena* genome, the functions of only a few hundred have been characterized. Thus, even if the CGC model is expanded tenfold, initial studies on every gene in the genome will require nearly three decades to complete.

Second, students are engaged in original research and take ownership of the new knowledge they create. Validated assessment instruments such as the Classroom Undergraduate Research Experience (CURE) survey (Denofrio et al. 2007) and Student Assessment of Their Learning Gains (SALG; salgsite.org) strongly support the idea that these students broaden their understanding of the scientific process and other measures that are key to retaining students' interest in science majors. In the past three years, we have encouraged student ownership of their research by creating an Internet database (suprdb.org) on which students can immediately publish research reports describing their findings (Wiley and Stover 2014). Students know that their work will be accessible to the broader community because the report pages are linked to the official *Tetrahymena* Genome Database (Stover et al. 2012).

Third, educator-scientists can leverage classroom-mentored research to advance their own areas of inquiry and/or to broaden their research programs. For example, a study initiated in a CGC course resulted in the first published characterization of the *Tetrahymena* nuclear import machinery (Malone et al. 2008). Even when course-based research projects have been less successful than this example, faculty members have been able to test genes of interest for potential follow-up or exclusion from their research efforts.

Fourth, the CGC curriculum has promoted new research collaborations, distribution of results and reagents, and sharing of technical skills among labs. Multiple student exchanges have occurred in which an undergraduate researcher visited a consortium member's laboratory to learn new techniques and then took that skill back to the mentor's lab in the home institution. In a particularly wide-ranging, multiyear example of collaboration and sharing of reagents, undergraduates at Drake University performed biochemical purification of cytoskeletal proteins. Faculty and students at St. Olaf College then identified the proteins by mass spectroscopy and sent the list of proteins to Washington University in St. Louis, where students in a molecular cell biology lab course fluorescently tagged and determined the subcellular localization of the proteins (Figure 1). Finally, the faculty member at

Figure 1. Localization of two *Tetrahymena* cytoskeletal proteins in classroom research. Kdf1 in green, Epn1 in red.



Washington University in St. Louis sent the student-generated *Tetrahymena* strains to Drake and St. Olaf, where students are performing follow-up analyses.

Lastly, the research performed by students in CGC courses has advanced scientific knowledge. Beyond the classroom, a gene-tagging strategy developed for undergraduate courses has facilitated discoveries in the broader community (e.g., Cole et al. 2008; Bright et al. 2010). Moreover, roughly 300 students have published their work on suprdb.org, more than 80 students have presented their work at scientific conferences, and numerous students have been included as authors on or acknowledged for their contributions to 10 manuscripts.

Our strategy, then, has proven to be mutually beneficial: a win for the students, who learn how knowledge is constructed; a win for the individual faculty members, who use student discoveries to advance their own scholarship; and a

win for the broader scientific community, which gains useful new knowledge. Although the CGC curriculum is focused on *Tetrahymena,* the affordability of genome sequencing means that this research/education model should be transferrable to many other communities of biologists working on a common organism. The only other thing they need is to share a passion for teaching—and learning from—the next generation of scientists.

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doi: 10.18833/curq/37/2/10

UNDERGRADUATE RESEARCH Highlights

Talamantes D, Biabini N, Dang H, Abdoun K, Berlemont R. Natural Diversity of Cellulases, Xylanases, and Chitinases in Bacteria. *Biotechnology for Biofuels*. 2016; 9:133. (California State University–Long Beach)

We identified 40,946 multi-domain/multi-activity proteins targeting cellulase, chitinase, and xylanase derived from 11,953 sequenced bacterial genomes and proposed new candidate lineages and protein architectures for carbohydrate processing that may play a role in biofuel production. All researchers worked on this project mid-2015 to mid-2016. Darrian Talamantes is an undergraduate majoring in microbiology and worked on this research as a volunteer in the lab. Nazmehr Biabani is applying to graduate school; she worked on this research as a volunteer. Hoang Dang is an undergraduate majoring in biochemistry; he worked on this research under a program called Building Infrastructure Leading to Diversity (BUILD). Kenza Abdoun is an undergraduate student in biological sciences and worked on this project as a volunteer. Renaud Berlemont is assistant professor (bioinformatics and microbial genomics) in the Department of Biology at CSULB. The research was supported by the CSU Program for Research and Education in Biotechnology (CSUPERB) and the National Institute of General Medical Sciences of the National Institutes of Health.

Barnett JL, Cherrette VL, Hutcherson CJ, So MC. Effects of Solution-Based Fabrication Conditions on Morphology of Lead Halide Perovskite Thin Film Solar Cells. *Advances in Materials Science and Engineering*. 2016; 4126163. (California State University–Chico)

We presented a critical review of the effects of processing conditions on the morphology of methylammonium lead iodide perovskite solar cells. Although difficult to decouple from synthetic and film formation effects, a single morphological feature, specifically grain size, has been evidently linked to the photovoltaic performance of this class of solar cells. In this work, we discuss experimental aspects of optimizing the (a) temperature and time of annealing, (b) spin-coating parameters, and (c) solution temperature of methylammonium iodide (MAI) solution. Jeremy L. Barnett is double majoring in chemistry and biochemistry. Vivien L. Cherrette is completing her B.S. in chemistry and minor in mathematics, whereas Connor J. Hutcherson is majoring in chemistry. All three students contributed equally to the review during spring 2016 for independent research and plan on applying to graduate programs in fall 2016. Monica C. So is an assistant professor of chemistry. Support was provided by California State University–Chico start-up funds.

Smolyaninova V, Jensen C, Zimmerman W, Johnson A, Shaefer D, Smolyaninov I. Lithographically Fabricated Magnifying Maxwell Fisheye Lenses. *Photonics*. 2016; 3:8. (Towson University)

Magnifying Maxwell fisheye lenses, which are made of two half-lenses of different radii, have been fabricated using photolithography and characterized. The lens action is based on control of polarization-dependent effective refractive index in a lithographically formed tapered waveguide. We have studied wavelength and polarization dependent performance of the lenses and their potential applications in waveguide mode sorting. Vera Smolyaninova and David Schaefer are professors of physics at Towson University. Christopher Jensen and Anthony Johnson are graduate students in physics at Towson. William Zimmerman, physics major at Towson, participated in the research for independent study credit. Zimmerman graduated from Towson University in May 2016 and was accepted to the Professional Master's Program in Applied Physics at Towson University. Igor Smolyaninov is a research scientist with the Department of Electrical and Computer Engineering at the University of Maryland–College Park. This research was supported in part by FCSM Undergraduate Research and Towson Undergraduate Research Grants, which were awarded to Zimmerman, and by NSF grant DMR-1104676 at Towson University.

Onochie C, Barengolts E, Kukreja S. High-Dose Vitamin D2 Supplementation for a Year Does Not Cause Serious Adverse Events Such as Emergency Room Visits and Hospitalizations in African American Men with a High Burden of Chronic Disease. *Endocrine Practice*. 2016; 22:5: 643–644. (University of Illinois at Chicago and Jesse Brown VA Medical Center)

The study assessed the long-term safety of high-dose vitamin D2 supplementation in a double blind placebo controlled randomized trial for African American male veterans with dysglycemia and hypovitaminosis D. All subjects received cholecalciferol (D3) 400 IU as multiple vitamins and either weekly ergocalciferol (D2) 50,000 IU or placebo. The SAEs, including emergency room visits and hospitalizations, were collected from the computerized patient record system at three time points: a year prior to the trial (T0), a year of the trial (T1), and a year after the trial (T2). Correlation

and regression analysis supported that high-dose vitamin D supplementation for a year did not cause an increase in serious adverse events in this population with high burden of chronic disease. As a senior at the University of Illinois at Chicago, Chizelle Onochie participated in the project as a part of independent research for the Honors College. She worked as a volunteer researcher for this project from 2013–2016 and currently is a 2019 MD candidate attending Indiana University School of Medicine. Elena Barengolts is a professor of medicine at the University of Illinois at Chicago and the chief of endocrinology at the Jesse Brown VA Medical Center. Subhash Kukreja is a professor of medicine at the University of Illinois at Chicago. The study was supported by a Merit Review grant funded by the Department of Veterans Affairs, Jesse Brown VA Medical Center, and in part by NIH grant number UL1RR029879.

Heyward FD, Gilliam D, Coleman MA, Gavin CF, Wang J, Kaas G, Trieu R, Lewis J, Moulden J, Sweatt JD. Obesity Weighs Down Memory through a Mechanism Involving the Neuroepignetic Dysregulation of Sirt1. *Journal of Neuroscience*. 2016; 36:1324–1335. (University of Alabama at Birmingham)

How does obesity make memory go bad, and what are the underlying molecular mechanism that drive this decline? Researchers found that epigenetic changes dysregulate memory-associated genes, and a particular enzyme in brain neurons of the hippocampus appears to be a link between chronic obesity and cognitive decline. Specifically, they found reduced amounts of one particular memory-associated gene product—SIRT1—as the principal pathogenic cause of obesity-induced memory impairment. Frankie D. Heyward is a PhD candidate in neuroscience at University of Alabama at Birmingham (UAB). Cristin Gavin is an assistant professor in the Department of Neurobiology and co-director of the Undergraduate Neuroscience Program at UAB. Jing Wang is a research associate in UAB's Department of Neurobiology. Garrett Kaas is research assistant professor in the Department of Pharmacology at Vanderbilt University. John Lewis is pursuing graduate studies to become a genetic counselor. Jerome Moulden is a graduate student at UAB. J. David Sweatt is chair of the Department of Pharmacology at Vanderbilt University. Daniel Gilliam and Richard Trieu conducted this research as part of the Undergraduate Neuroscience Program and Science and Technology Honors Program at UAB. Gilliam matriculated in Harvard's doctoral program in neuroscience in fall 2016, and Trieu will be graduating in spring 2017. This work was supported by NIH grants T32HL105349, MH57014, P60DK079626, P30DK56336.

Amblee V, Jeffery CJ. Physical Features of Intracellular Proteins that Moonlight on the Cell Surface. *PLoS One*. 2015: 10(6), e0130575. (University of Illinois at Chicago).

Vaishak Amblee's project focused on a subset of moonlighting proteins that have a canonical biochemical function inside the cell and perform a second biochemical function on the cell surface in at least one species. We identified 30 types of these proteins. Although a variety of intracellular proteins (enzymes, chaperones, etc.) are observed to be reused on the cell surface, for the most part, these proteins were found to have physical characteristics typical of intracellular proteins. The increasing number and variety of known moonlighting proteins suggest that there may be more moonlighting proteins than previously thought, and moonlighting might be a common feature of many more proteins. Constance Jeffery is an associate professor of biological sciences at the University of Illinois at Chicago. Vaishak Amblee was a member of the Jeffery Lab from 2011 through 2013. He was a member of the Honors College and completed his capstone project with Jeffery. He also participated in annotation of the MoonProt Database (moonlightingproteins.org) and is currently in medical school. Amblee's participation in the research was supported by the UIC Office of Undergraduate Research in the Office of the Vice Provost for Undergraduate Affairs.

Martyn-Nemeth P, Quinn L, Menon U, Shrestha S, Patel C, Shah G. Dietary Profiles of First-Generation Asian Indian Adolescents in the United States. *Journal of Immigrant and Minority Health*. 2016. (University of Illinois at Chicago)

This study sought to examine the dietary patterns, demographic characteristics, and health characteristics of first-generation South Asian Indian (SAI) adolescents living in the United States. SAIs have a high prevalence of cardiovascular disease and diabetes, and dietary behaviors contribute to this risk profile. A cross-sectional observational study design was employed with 56 adolescents from four community centers in the Chicago metropolitan area. Findings revealed several unhealthy dietary patterns: high saturated fat and sodium intake, as well as insufficient potassium, calcium, magnesium, and vitamin D intake. These trends can be reversed by advocating for greater consumption of low-fat dairy products, and more fruits and vegetables. Pamela Martyn-Nemeth is assistant professor and Laurie Quinn is professor at the University of Illinois at Chicago. Usha Menon is professor of nursing at the University of Arizona. At the time of this study, Sakun Shrestha and Grishma Sha were graduate students (nursing and public health respectively), and Chaula Patel was an undergraduate nursing student; the study was part of Patel's honors capstone in 2013–2014. All three stu-

dents are now working in their respective professions. This study was supported in part by the University of Chicago: Diabetes Research and Training Center: NIH-NIDDK: P60 DK020595-32S3 and by the UIC College of Nursing Internal Research Support Program (IRSP).

Li I, Babajanova G, Tuomala M, Simonson RD. Smartphone Diffusion and Consumer Price Comparison Shopping Behavior: Implications for the Marketplace Fairness Act. *Economics Bulletin*. 2016; 36(3): 1337–1353. (Minnesota State University Mankato)

Taxation of e-commerce sales is a contested issue with a potentially large impact on sales tax revenue collected by local and state governments. We examine the impact of Nexus and effective online sales taxes on smartphone-assisted online purchases. We estimate that smartphone consumers are 6% more likely to comparison shop and 74% less likely to purchase from an online retailer if they live in a state with a Nexus sales tax. The implied tax elasticity of online purchases (6.8) is significantly higher than comparable recent estimates. These results suggest that local and state government forecasts of online sales tax revenue under the Marketplace Fairness Act legislation may be lower than previous estimates. Ishuan Li is associate professor of economics and Robert Simonson is professor of economics at Minnesota State University Mankato. Guncha Babajanova is employed and is applying to PhD programs in finance and economics. Matthew Tuomala is an analyst at Reeher LLC.

Brez, CC, Allen, J. Adults' Views on Mathematics Education: A Midwest Sample. *European Journal for Science and Mathematics Education*. 2016; 4: 155–160. (Indiana State University)

This study addressed adults' beliefs and attitudes regarding math and math education in the United States. While we know about students' beliefs about math, we don't know as much about the greater population's views regarding this topic. Understanding the public's opinion is important for teachers who are trying to understand parents' attitudes toward math (specifically helping their children with math) as well as understanding support for public policy regarding math education. Caitlin Brez is an assistant professor of psychology at Indiana State University. Jessica Allen worked on this project as a senior taking research practicum course Psy 486. As part of her coursework, she worked as a research assistant in Brez's laboratory and completed data analysis for this project. She continued to work with Brez after graduation to prepare the manuscript for publication. Allen currently is a graduate student in the Clinical Mental Health Counseling program at Indiana State University.

Kuminski E, Shamir L. Computer-generated Visual Morphology Catalog of ~3,000,000 SDSS Galaxies. *The Astrophysical Journal Supplement Series*. 2016; 223(2): 20. (Lawrence Technological University)

The study applied computer vision to classify approximately 3 million Sloan Digital Sky Survey (SDSS) galaxies and produced the largest catalog of its kind to date. It is now included in the SDSS main database, and its availability to the community will allow better understanding of the composition of the universe and the correlation between the morphology and the physical characteristics of galaxies. The paper was an American Astronomical Society (AAS) editor pick, and the findings were reported by the popular press such as *The Atlantic*. The research was done as classroom-based research experience (CRE) in two consecutive computer science courses: Computer Science 2 and Data Structures. Evan Kuminski is a junior in computer science and Lior Shamir is an associate professor of computer science at Lawrence Technological University.

Savell KE, Gallus NV, Simon R, Brown J, Revanna J, Osborn MK, Song EY, O'Malley JJ, Stackhouse CT, Norvil A, Gowher H, Sweatt JD, Day JJ. Extra-coding RNAs Regulate Neuronal DNA Methylation Dynamics. *Nature Communications* 2016; 7: 12091. (University of Alabama at Birmingham)

The creation of memories in the brain involves addition or removal of methyl groups at precise spots on chromosomal DNA. But what controls the careful targeting of these neuronal DNA methylation dynamics? EcRNAs, they say, are fundamental regulators of DNA methylation patterns in the adult brain through interaction with DNA methyltransferase enzymes, and the ecRNAs may offer a promising future therapeutic avenue to treat neuropsychiatric disease states associated with changes in DNA methylation. Katherine E. Savell, Nancy V. N. Gallus, Mary Katherine Osborn, John J. O'Malley, and Christian T. Stackhouse are graduate students at the University of Alabama at Birmingham (UAB). Esther Y. Song graduated with a master's degree from UAB. Jordan Brown is in the graduate program at the Vanderbilt University School of Medicine. Allison Norvil and Humaira Gowher are graduate students in biochemistry at Purdue University. J. David Sweatt is chair of the Department of Pharmacology at Vanderbilt University. Jeremy J. Day is an assistant professor in the Department of Neurobiology at UAB. Jasmin Revanna is an undergraduate researcher in UAB's Undergraduate Neuroscience program. Rhiana Simon has matriculated in the graduate school at the University of North Carolina at Chapel Hill, and Revanna continues her research in Day's lab until her graduation in 2019. This

work was supported by NIH grants DA034681, DA039650, MH091122 and MH57014; DARPA grant HR0011-12-1-0015; and startup funds from UAB and the Evelyn F. McKnight Brain Research Foundation.

Cheng H, Chen T, Tor M, Park D, Zhou Q, Huang JB, Khatib N, Rong L, Zhou G. A High-Throughput Screening Platform Targeting PDLIM5 for Pulmonary Hypertension. *Journal of Biomolecular Screening*. 2016; 21(4): 333–41. (University of Illinois at Chicago)

The research aims to establish a high-throughput screening platform for PDLIM5-targeted drug discovery. The research team generated a stable mink lung epithelial cell line (MLEC) containing a transforming growth factor—β/Smad luciferase reporter with lentivirus-mediated suppression of PDLIM5 (MLEC-shPDLIM5) and measured levels of Smad2/3 and pSmad2/3. They found that in MLEC, suppression of PDLIM5 decreased Smad-dependent luciferase activity, Smad3, and pSmad3. The study suggests that this system is robust and suitable for PDLIM5-targeted drug discovery. Han Cheng and Lijun Rong are in the Department of Microbiology, College of Medicine, at the University of Illinois at Chicago (UIC). Tianji Chen, Merve Tor, Qiyuan Zhou, and Jason B. Huang are in the Department of Pediatrics at the UIC College of Medicine. Guofei Zhou is assistant professor in the department of pediatrics in the UIC College of Medicine. Deborah Park, a Goldwater Scholar, conducted this work in 2015–2016 as a senior biological sciences major at UIC. Nour Khatib conducted this work as a junior biological sciences major at UIC. The students were supported by the UIC Chancellor's Undergraduate Research Award through the UIC Office of Undergraduate Research, in addition to the sources named in the article.

Elischberger HB, Glazier JJ, Hill ED, Verduzco-Baker L. "Boys Don't Cry"—Or Do They? Adult Attitudes Toward and Beliefs about Transgender Youth. *Sex Roles*. 2016; 75: 197–214. (Albion College)

This study examined the attitudes and behavioral intentions of U.S. adults toward transgender youth. Participants reported favorable attitudes but expressed hesitation to allow transgender children to use the restroom aligned with their gender. Attitudes were less positive in respondents with a religious affiliation, conservative political views, stronger conformity to traditional gender norms, and stronger belief in environmental versus biological causes of transgender identity. Behavioral intentions were driven by attitudes and causal attributions, age, and (for women) personal connections to the transgender community. The authors discuss implications for the discourse surrounding transgender youth and the need for educating the public on the development of gender identity as well as the difference between gender identity and sexual orientation. Holger B. Elischberger is an associate professor of psychological science, Eric D. Hill is assistant professor of psychological science, and Lynn Verduzco-Baker is assistant professor of anthropology and sociology. Jessica J. Glazier undertook this project as her senior honors thesis in 2015; she is currently working as a research lab coordinator at the University of Michigan and is applying to PhD programs in clinical psychology. This research was supported by Albion College's Foundation for Undergraduate Research and Creative Activity (FURSCA).