

Objective Lens

Addressing the global antibiotic resistance crisis through a microbiology undergraduate course-based research experience (CURE)

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Fine Focus has, since our first issue back in 2014, showcased undergraduate research efforts globally. We have grown in many ways and have developed our review team and marketing team activities to continually evolve and stay relevant. Through our recent partnership with the Small World Initiative (www.smallworldinitiative.org), *Fine Focus* would like to be a venue to publish novel findings on new antibiotic discovery. Last year, Ball State University became one of the newest partner institutions with the SWI, and I'd like to share with you here how we are in the process of redesigning our majors microbiology course into a format that will allow for crowdsourcing new antibiotic discovery, all the while leading eventually to original research manuscripts publishable in *Fine Focus*. I invite and welcome other PUIs to do the same and would be happy to answer questions on how your CURE could submit a manuscript to our journal and showcase the work of your undergraduates, or to collaborate with us.

Statement of the Problem:

If no new antibiotics are isolated and made available by 2050, the CDC estimates that 10 million annual deaths will occur globally as a result of this inaction. Yet, surprisingly few have even heard of antibiotic-resistant bacteria or understand the implications for global health. In fact, no new classes of antibiotics have been developed to treat microbial infections in well over 30 years, as pharmaceutical companies have instead pursued research and development of more lucrative drugs for non-infectious diseases. Since this trend is likely to continue into the foreseeable future, this crisis must be addressed using alternative creative approaches. We propose to change our undergraduate microbiology class laboratory's focus from a traditional model to a course-based undergraduate research experience (CURE) design. Specifically, this effort at Ball State University to become a CURE can and must involve collaborations with colleagues in the

BSU Department of Chemistry to isolate and identify novel antibiotics from soilborne bacteria and fungi as well as a variety of dairy-relevant natural environments (raw milk, silage, manure, aged cheese, and feedlot samples). These natural environments have not been widely explored in this context before, and yet we will be able to rapidly screen hundreds of isolated bacteria and fungi using standard microbiological methods and well-established chemistry separation protocols used routinely in undergraduate teaching labs. Using resources, expertise, and protocols modified from the Small World Initiative (SWI), our goal is to isolate and identify multiple novel compounds from bacteria. Transforming the undergraduate microbiology curriculum in this way is completely new teaching and research direction for the PI, and will blend pedagogy and original research into an entirely different direction than at present.

Description of CURE Development:

Increasing bacterial resistance spanning over 70 years, combined with a cessation in the discovery of new antibiotics for over a generation has resulted in a global healthcare catastrophe. Crowdsourcing antibiotic discovery is a viable option to meet the challenge of this crisis. The American Society for Microbiology has been instrumental in supporting the Small World Initiative, SWI, (www.smallworldinitiative.org), an international not-for-profit consortium of research and teaching universities in over 17 countries. SWI began in 2012 at Yale University, and now has partner universities, community colleges, and high school partner institutions in 43 U.S. states. The SWI provides a wide range of expertise and physical resources for faculty to transform their research agenda and/or laboratory teaching curricula to systematic discovery of new antibiotics from natural environmental samples, largely soil. This effort will overview our plans to retool our undergraduate microbiology course laboratory's focus to directly

align with the SWI mission in order to identify and isolate new types of antibiotics with promise in the global healthcare sector. We will do this by rewriting the class lab to become a course-based undergraduate research experience (CURE). Our hypothesis is that through the CURE model, we will be able to isolate multiple species of naturally occurring bacteria and fungi from raw dairy milk (cow and goat), silage, manure, aged cheese, and feedlot samples, and that at least one novel antimicrobial compound (antibiotic) will be isolated and purified from the host microorganism on a larger scale for promise as a chemotherapeutic agent.

Goal and Objectives:

Our research goal is reflected in our hypothesis. Within this broad goal, we have two smaller objectives that will be addressed over the course of two semesters using a total of 150 undergraduate microbiology students (~75 each semester) in the CURE structure:

Using standard microbiological methods, we will isolate and identify multiple bacteria and/or fungi, at least one of which will produce a secreted compound demonstrating measurable antibacterial activity. Secondly, we will use traditional chemistry separation and analytical methods to purify (on a larger scale) and determine the structure and specific activity of each antibiotic quantified in the first objective. Using a modified course syllabus and student learning outcomes suggested by the American Society for Microbiology (ASM) SWI, we will be able to pilot the CURE for two semesters in order to generate the necessary research results and preliminary assessment data essential to show proof of concept and submit a larger, more collaborative proposal to NSF for external funding in early fall 2021.

Assessment:

A combination of both formative and summative assessments will be used and applied throughout the semester, including but not limited to weekly written quizzes, materials and methods oral self-quizzes (given among the student working groups), and an end-of-the semester capstone poster for each group presented at the spring University Student Research Symposium. Vigorous consultation will occur regularly throughout both semesters with our two science education research faculty, and assessment experts available through the SWI faculty network to ensure measureable data are being collected from these assessments to include in the NSF proposal upon submission in 2021.