

Global Change Biology project summary

A joint project between the Department of Biology, Department of Entomology, and the CMNS Teaching and Learning Center

Background and motivation

Global environmental change is unequivocally one of the greatest challenges of our time. Our planet is being dramatically altered by human activities, with impacts to the planet's climate as well as its land, oceans, freshwaters, and biological systems. The consequences are profound: global change exacerbates social injustice, threatens lives and livelihoods, contributes to economic and political upheaval, and broadly impacts Earth's capacity to sustain the current diversity of life. Understanding of global change draws from many fields including biology, chemistry, physics, environmental sciences and social sciences. Our overarching goal is to improve students' understanding of global change biology (GCB), the interdisciplinary study of the processes and consequences of global change for life on Earth.

To address the grand challenges of global change, we must train the next generation of scientists and citizens to navigate these complex problems. Students need to understand global change's diverse effects on organisms and ecological systems as well as the ways in which organisms themselves play diverse roles in mediating the pace and pattern of global change processes. Students also need to see ways to use their knowledge to effectively engage and help bring about positive changes. However, the current coverage of global change biology in our Biological Sciences (BSCI) curriculum is relatively sparse and disjointed among courses. Importantly, only a few courses include active learning to teach GCB, even though this field provides excellent opportunities to have our students engaged in experiential learning to understand key content and appreciate the relevance of their learning.

Proposed solution

We have developed a new GCB emphasis in the BSCI curriculum to better educate students about this grand challenge and equip them to affect positive change. GCB is being integrated across the curricula of foundational and advanced courses by through active-learning modules and data-rich case studies. In addition to curricular changes, we are building a community around GCB by organizing workshops and field visits to foster connections between students and faculty, and with the local environment. We have formed a collaborative implementation team spanning two departments. The team includes 16 faculty, 3 graduate students and 4 undergraduate students working across 12 courses, which impact over 1000 students, across multiple specializations, majors and colleges.

The Biological Sciences (BSCI) program

The BSCI major offers rigorous training in modern biology. BSCI is the second largest major on campus, approximately 1,700 students, and trains students in five specializations: General Biology, Ecology & Evolution, Cell Biology & Genetics, Microbiology, and Physiology & Neurobiology. The BSCI major serves a diverse student body; in Fall 2021, 25% of majors were from historically underrepresented backgrounds, a higher proportion than both the college (17%) and the university overall (22%). Courses in the BSCI major are also taken by numerous students outside of the major and college. For example, Principles of Organismal Biology (BSCI207) served students from 15 majors across 8 colleges in Spring 2021. Further, some courses associated with this effort are required or elective courses for other majors including ENSP, ENST, and NEUR. As a result, changes to the BSCI curriculum have far-reaching impacts. While a number of majors on campus address global change from other perspectives (e.g., atmospheric science, policy, technology), our focus is on how global change is impacting organisms - their diversity, their function, their responses to environmental change and their adaptation. This will draw on knowledge about past and present responses to change, with an eye towards predicting implications for the future.

Action plan

In this programmatic effort, we are adding a GCB thread to the BSCI curriculum in three ways: (1) incorporating active-learning modules into foundational courses to introduce GCB concepts, (2) incorporating active-learning modules and data-rich case studies into advanced courses, including a new, synthetic GCB course, and (3) building an interactive community of undergraduate students, graduate students, and faculty centered around experiential learning in GCB.

Foundational BSCI Courses

Three courses are central to our efforts: 1) BSCI207 - Principles of Organismal Biology, required of all BSCI majors (~640 students/yr), 2) BSCI361 - Principles of Ecology (~170 students/yr), and 3) BSCI370 - Principles of Evolution (~180 students/yr). All of the faculty who teach the different sections of these courses are involved with this proposal. These efforts will introduce new active learning modules centered on important GCB concepts in organismal physiology, ecology, and evolution, increasing GCB content and section consistency.

Advanced BSCI Courses

Nine different advanced courses (30-75 students/course/yr), spanning diverse biological sub-disciplines, will promote in-depth understanding of how organisms are impacted by and also affect global change. One of these will be the new course, BSCI426 Global Change Biology, which will synthesize how changing climate, land-use, and human impacts can affect organismal diversity, how organisms can impact climate, how organisms adapt over the short and long, and what mitigation strategies might be effective. These courses will provide GCB applications using real world data, allowing students to apply foundational skills and knowledge to address key questions about

organisms in a changing world. Many of these courses are open to graduate students in the Biological Sciences graduate program (BISI).

BSCI207 Principles of Organismal Biology	BSCI361 Principles of Ecology	BSCI370 Principles of Evolution
BSCI334 <u>Mammology</u>	BSCI337 Insect Biology	BSCI366 Environmental Physiology of Animals
BSCI400 Animal Diversity & Evolution	BSCI401 Animal Communication	BSCI426 Global Change Biology
BSCI462 Population Ecology	BSCI467 Freshwater Biology	BSCI477 Ecology & Evolution of Infectious Disease

Active learning activities and case-studies


We are working to add active-learning activities and data-rich case studies to twelve courses. Case studies involve presenting a problem, such as ocean acidification, and asking students to make predictions, e.g. effects on sea urchin shell thickness. Students will then examine data, e.g. shell thickness for sea urchins close to or far from a CO₂ ocean vent (Hall-Spencer et al 2008). This will enable them to see how increased CO₂ levels lead to both lower pH and thinner, weaker shells. A variety of activities will be developed through collaborations between graduate students, undergraduate students, and faculty members, emphasizing local communities and ecosystems where possible. These efforts will build on our previous experience developing active-learning exercises (Lombardi et al 2014; Carleton et al 2016; Lombardi 2017). Co-PI Hawthorne has extensive experience with case study development and socio-environmental education. He ran a workshop to help students and faculty conceive and develop case-study based exercises. Our goal is to help students learn to identify and analyze real-world problems, interpret scientific data, and propose solutions, while gaining 21st-century skills such as critical thinking, application skills, information literacy, and oral and written communication skills.

Building community around experiential learning

We are building a community of undergraduate students, graduate students, and faculty interested in global change biology to promote active engagement by students. These efforts emphasize experiential learning and local ecosystems. Undergraduate-focused activities include panels focused on careers relevant to GCB (e.g. involving researchers, local government agencies, NGO organizations, elected officials); local field outings to learn about and assess local biodiversity and global change impacts (e.g., on campus, across our local watershed); and environmental stewardship and outreach activities (e.g., partnering with the Anacostia Watershed Society).

For our graduate student community, we have organized seminars and discussions with local researchers focusing on global change impacts in the Chesapeake Bay. This included Dr Louis Plough (Horn Point Laboratory), Dr. Allison Tracy (Institute for Marine and Environmental Technology), Dr. Christopher Rowe (Chesapeake Bay Laboratory), and Dr. Emily Cohen (Appalachian Laboratory).

Assessment

To determine the effectiveness of our programmatic changes, we are assessing learning gains and perception shifts, based on longitudinal, horizontal assessment using pre and post surveys. These surveys have been implemented in four courses (BSCI207 Principles of Organismal Biology; BSCI361 Principles of Ecology, BSCI426 Global Change Biology, and BSCI473 Marine Ecology). For the learning assessment, we are collaborating with Dr. Emily Holt, University of Northern Colorado, who has developed a biotic assessment of climate change core concepts (Dunk et al. 2022). For an attitudes assessment, we are using questions from the Yale Climate Opinion Survey developed by the [Yale Center for Climate Change Communication](https://climatecommunication.yale.edu/). 

[\(https://climatecommunication.yale.edu/\)](https://climatecommunication.yale.edu/) The assessments are being conducted with the guidance of co-PI Marbach-Ad, Director of the CMNS Teaching & Learning Center, and graduate student Sara Gliese.

