Biologists and Graph Interpretation Network

Make your move: Interpreting graphs of pollinator behavior

A BioGraphI Module Lesson Guide for Instructors

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Course Information
Department/Program: Biology
Level: Introductory
Course type: Lecture
Delivery mode: In-person
Students: Biology majors
Number of students: max enrollment = 100
Estimated duration of activity: 50-75 minutes

Expected date or dates of implementation
July 2022

Purpose/Background
An in-class activity near the end of an introductory biology course's ecology unit

List of materials needed for the lesson
- Link to interview on YouTube (total running time, 10:35)
  - https://www.youtube.com/watch?v=h4sdlH3yKUo
- Link to presentation slides
  - 2_PresentationSlides_MakeYourMove
- Link to summative assessment (multiple choice test questions)
  - 3_SummativeAssessment_MakeYourMove

About BioGraphI modules

This lesson is a BioGraphI module. BioGraphI modules address data literacy while fostering diversity in undergraduate biology classrooms. They are lessons about graph and data interpretation, featuring the scientific contributions of biologists who are members of historically excluded groups (HEGs). They include video interviews with these biologists, allowing students to hear directly from HEGs about their discoveries. For more information about how the BioGraphI project is advancing inclusion in biology and improving data literacy, visit our webpage.

Student Learning Objectives

The BioGraphI Student Learning Outcomes (LOs) describe what instructors expect students to gain experience with during the BioGraphI lesson and improve their understanding of by the end of the BioGraphI lesson. We have adopted a student-centered format in writing our LOs by using the imperative form of each verb and second person pronouns, in order to communicate our learning expectations directly to students.

Quantitative learning objective(s)

1. Interpret graphs and/or data figures related to the concepts from this lesson
2. Reflect on your perceptions about using graphs or figures in biology.

Diversity/equity/inclusion learning objective(s)

3. Reflect on your perceptions of people who do biology.
4. Compare your own interests and/or identities to those of people who do biology.

Content learning objective(s)

5. Name the levels at which biodiversity is measured, and identify examples of each level.
6. Identify examples of the major interspecific interactions.
7. Relate outcomes of competition to competitive exclusion, resource partitioning, and character displacement.

Assessments

To help the BioGraphI Project to measure the effectiveness of our modules in improving data literacy and fostering diversity in biology classrooms, we invite your students to participate in a voluntary, anonymous pre-/post-lesson survey (Geneseo IRB #202021048). This survey is designed as an opportunity for reflecting on the Quantitative and D/E/I learning objectives above and administered via LimeSurvey. Click Instructions for access to BioGraphI PrePost-Lesson Student Survey to request a survey to be set up for your students, at least 7 to 10 days in advance of your class meeting date.

See presentation slides 2_PresentationSlides_MakeYourMove for the formative assessment activities, and test questions document 3_SummativeAssessment_MakeYourMove for multiple-choice test questions.

Objective(s)	Formative Assessment	Summative Assessments
1	Some multiple-choice questions on graphs in activity, with student responses gathered using iClicker Student (or other response system)	Multiple-choice test questions
2	BioGraphI Student Pre-Lesson Survey (link for instructions to access survey)	BioGraphI Student Post-Lesson Survey (link for instructions to access survey)
3 and 4	BioGraphI Student Pre-Lesson Survey (link for instructions to access survey)	BioGraphI Student Post-Lesson Survey (link for instructions to access survey)
4	Using social media to ask a question of the scientist	N/A
5, 6, and 7	Some multiple-choice questions on graphs in activity, with student responses gathered using iClicker Student (or other response system) Some think-pair-share class discussions	Multiple-choice test questions

Lesson context

Learning goals of unit

- Demonstrate an understanding of the concepts of ecology and methods of ecological inquiry.
- Explain how ecological principles relate to issues of personal and/or societal importance.
- Effectively communicate an understanding of ecological concepts and experimental outcomes, using relevant terminology.

Prerequisite skills or knowledge

- Conceptual background knowledge includes global change ecology (climate change, pollution, habitat loss), patterns of biodiversity and biodiversity loss, and ecosystem services.
- Skills practiced prior to this lesson include interpreting graphs and working in groups.

Preparation for lesson

- Assign BioGraphI Student Pre-Lesson Survey as homework for students to complete before this in-class activity.
- If you plan to assign social media activity as homework, contact the interviewee ahead of time, as a courtesy.
- Read textbook chapter or sections of community ecology chapter that focus on the interactions between species.

Lesson sequence

Each row of this table is a step of the activity. Column headings reveal what the instructor, interviewee, and students do at each step.

Information from instructor (live in-class)	**Information from scientist (within pre-recorded video interview)**	**Student follow-up or transition activity**
Prior to class, assign reading	N/A	Students complete homework/pre-lesson survey for BioGraphI project (combination of reflective writing prompts and closed-ended questions) • *Purpose*: prepare for class; LO 2 & 3 – Pre-lesson reflection on data literacy and perceptions of scientists
Provide empty graph on a ppt slide	N/A	**Fundamental activity:** Make reasonable guesses to what the graph is about, share out • *Purpose*: Warm-up and icebreaker, rewards creativity, normalizes errors (nearly impossible to be correct)
Plays first video segment to introduce	N/A	N/A

scientist to students		
Orient to graph (What do these axes mean? What do the units mean?) ● *Vocabulary to incorporate:* types of graphs, units, independent (explanatory, predictor) variables, dependent (response) variables,	N/A	**Fundamental activity:** Students interpret/re-interpret graph with the correct axis labels. Infer the hypothesis that was studied. Evaluate whether or not the hypothesis was supported. Share out. ● *Purpose*: LO 1A & 2 - Check student understanding of the concepts and vocabulary
Plays next video segment	Tell me about the research that these data came from: scientist confirms the hypothesis inferred by & the interpretations made by students. ● *Vocabulary to incorporate:* hypothesis, prediction, (explanatory, predictor) variables, dependent (response) variables, controlled (standardized) variables if applicable	Based on these results, what should the scientist investigate next? Share out. ● *Purpose*: Transition to next steps; could be used to align Content LOs or LO 1A or B
Plays next video segment	Tell me about the research that these data came from: Describe the follow up experiment or potential follow up experiments	What's significant about these findings? Share out. ● *Purpose*: LO 1A or B, and could be used to align Content LOs
Plays next video segment	Tell me about the research that these data came from: Explain the significance of this research	*Purpose*: Closes this portion of the lesson
Adds a little info about the scientist (ppt slide): a picture,	N/A	What questions do you have about [scientist]'s path to this work/where they are today? Share out.

affiliation		• *Purpose*: LO 4 - Identifying potential connections between students and scientist
Selects questions that align best to student generated questions; Must show the answers to at least the required interview Qs to students	***Required interview Qs*** **What kinds of scientific questions interest you the most?** **When and how did you know you wanted to be a scientist?** **Tell us about the paths and obstacles that led you to your current job.** **What is it like being a scientist who identifies as [fill in the blank]?** **Tell me about a moment when you felt like you really belonged in the field of science.** *Strongly suggested Qs* What is a typical day like for you? *Optional interview Qs* What do you do if you have questions about how to analyze your data?	*Purpose:* Answers the questions identified by students
Instructor collects leftover questions, compiles them, and emails to the scientist	(braces themselves for email deluge)	Students ask their questions during class (or homework!) • *Purpose*: LO 4 - Identifying potential connections between students and scientist. Closes the in-class portion of the lesson.
Instructor could provide other resources on scientist (e.g., website, papers, etc.)	N/A	Students complete post-lesson survey for BioGraphI project (combination of reflective writing prompts and closed-ended questions) • *Purpose*: LO 2 & 3 – Post-lesson reflection on data literacy and perceptions of scientists

Alignment to Universal Design for Learning Guidelines

UDL Guideline	Alignment in Lesson
Multiple means of Engagement	Recruiting interest: Students have the opportunity to generate their own questions for the scientist Self-regulation: Students reflect on their dispositions and knowledge of scientists and graph interpretation before and after the lesson
Multiple means of Representation	Perception: Captions are provided on the interview video. Google Slides offers automatic captioning for presenter. Alt text for images provided in Google Slides. Comprehension: Background knowledge is activated via clicker questions. Discussion prompts guide information processing for graph interpretation.
Multiple means of Action and Expression	Physical Action: Varied means are used to prompt students (clicker questions, verbal processing via discussion, written reflection following lesson). Expression & communication: Multiple types of media are used in the lesson (visual, audio, text).

Implementation notes

Notes on our implementation

We implemented this lesson in an introductory biology course at the University of Louisville in July 2022. The class was delivered in-person in a lecture-style classroom. It had a smaller enrollment (<25 students) and accelerated pace compared to a fall or spring semester class. Due to the small size of the class, we had extensive small group discussions for each prompt and all groups had time to report on their group's discussion to the whole class before proceeding to the next slide. With this slow pace, the lesson took us 75 minutes to complete. Students engaged well

with lesson activities that aligned with our Quantitative and Content LOs, but needed some additional encouragement from the instructor to fully engage in activities related to the DEI LOs.

Suggestions for adaptation

Reducing length of lesson activities

Some instructors may wish to reduce the length of this lesson for their courses. To preserve the learning objectives of the lesson, we recommend eliminating one or more of the following activities (see Presentation Slides): Discussion Question 2 (Slide 11), Discussion Question 4 (Slide 20), Discussion Question 5 (Slide 22), and/or all optional interview question slides (Slides 26 & 30).

Large enrollment courses

In a larger enrollment class, having undergraduate teaching assistants circulate the room during discussions would ensure most student groups stayed on task. Instructors of large classes could also randomly select two or three groups to report out after each small group discussion slide. Having student groups record discussion points on a whiteboard that they hold up after each discussion might also help keep student groups on task.

Online courses

In a synchronous online course, using the breakout room feature would allow for discussion. You can also create an additional student Google slide deck for the breakout rooms to record their thoughts/notes on each discussion prompt as the lesson progressed. For the student slidedeck, be sure it contains only the discussion prompts (no answers/videos) and that each group has its own blank slide for each prompt. By numbering breakout rooms and providing each room specific slides to comment on within the student slidedeck, instructors can keep track of which rooms are participating and which are not.

In an asynchronous online course, we suggest using conditional release in your learning management system to ensure that students brainstorm each prompt before proceeding to the next video segment for the answer. If you deliver this lesson over several days, you could also utilize online discussion boards, which would allow students to debate each graph (or perhaps even read the primary literature) before they hear from the scientist.

References/resources

1. Yang, S., Ferrari, M. J., Shea, K.. (2011). Pollinator Behavior Mediates Negative Interactions between Two Congeneric Invasive Plant Species. The American Naturalist, 177(1), 110–118. https://doi.org/10.1086/657433

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Transcript of interview

0:00-0:21

- Rachel Pigg (RP): I'm Dr. Rachel Pigg, an Assistant Professor at University of Louisville. For this BioGraphI interview, I'm talking today with Dr. Suann Yang, who is an Associate Professor at SUNY Geneseo. Suann and I have worked together for many years and are good friends. Welcome, Suann!
- Suann Yang (SY): I'm excited to be here, thanks for having me, Rachel!

0:21-0:40

- RP: Suann is a first author on a paper called "Pollinator Behavior Mediates Negative Interactions between two congeneric invasive plant species" published in American Naturalist." Today, we'd like to chat about your hypotheses from that paper and some of the graphs you made in Figure 3.

0:40-1:26

- RP: Tell us about the research in Figure 3B that you've subtitled Quantity of visits.
- SY: Pollinators like bees and butterflies are attracted to patches of flowering plants with more food resources. We studied the relative attractiveness of two different closely-related plant species, commonly called the plumeless thistle and musk thistle. For both species, we found that individual plants in larger patches were visited more often than individual plants in smaller patches. It was interesting that the effect was more pronounced for the plumeless thistle, suggesting that this species has characteristics that are more attractive to pollinators.

1:26-2:50

- RP: What does the second graph show in Figure 3C that you've subtitled Quality of visits?
- SY: From a plant's point of view, having fewer (a lower quantity of) visits by pollinators could mean that reproduction is less successful. However, when we tracked how pollinators were moving between individual plants, the plant species that was visited less often by pollinators–that is, musk thistle–was more likely to receive visits by pollinators that came from other individuals of the same species. This is because pollinators didn't

stick around on any single musk thistle plant for long. In contrast, a pollinator that landed on an individual plumeless thistle would hang out on that same individual plant for a long time, feeding at different flowering parts of the same plant. Musk thistle has relatively few, but large flowering structures. In contrast, plumeless thistle–the species that received more visits–has lots of small flowering structures. So, it seems that pollinators prefer to dine where their food is spread out somewhat at the smallest scale of an individual plant, but more concentrated at the scale of the patch of plants.

2:50-3:07

- RP: Taken together, what do these results mean?
- SY: Altogether, it seems that the plumeless thistle species is more attractive to pollinators; however individuals of this species are less likely to be pollinated with pollen from diverse sources.

3:07-3:43

- RP: What follow up experiments did you do?
- SY: To find out if the less attractive plant species–musk thistle–regains a competitive advantage through a greater diversity of pollen sources, we performed hand-pollinations to see if seed formation relies on the diversity of pollen donors. Turns out that both of the species that we studied are pretty successful at using self-pollination for seed production.

3:43-4:31

- RP: What's the significance of this research?
- SY: Matters for species that can self-pollinate. More self-pollination results in less genetic diversity for a population of plants, compared to populations where there is more pollination across individual plants, or outcrossing. Both of the plant species that we studied are introduced from Europe and Asia, and classified as invasive species. It's useful to know how the interactions between species might influence changes in genetic diversity from the initial introduction of a new species compared to later after the species are established.

4:31-5:00

- RP: Now, I'd like to ask a few questions about being a scientist and how you became a scientist. How does that sound?
- SY: Great!

- RP: What kinds of scientific questions interest you the most?
- SY: I'm interested in how the interactions between species shape the biodiversity of communities, and also how the structure of communities and ecosystems feed back into influencing the interactions between species.
- RP: Interesting!

5:00-5:37

- RP: So once you've collected data, what do you do if you have questions about how to analyze it?
- SY: If I know what I am trying to do and am stuck, I'll take a break and do something else for a while, away from my computer. If I have a question, I usually look it up on the Internet or ask for help! I do all of my data analysis using the R Programming Environment. It's an open source software with a huge community of volunteer software developers and users who are very willing to help anyone with their questions, no matter how big or small.
- RP: That's so great that there's a community to support scientists as they learn new ways to analyze their data.

5:37-6:10

- RP: When and how did you know you wanted to be a scientist?
- SY: I didn't always know I wanted to be a scientist; however, I definitely remember being interested in science in high school. I took some awesome courses for high school science credit at the Fernbank Science Center and Museum of Natural History in Atlanta, GA where I grew up. I got some great field ecology experiences there, and those definitely were part of the reason why I decided to pursue an undergraduate degree in biology, specifically ecology.

6:10-7:27

- RP: After you figured out that you wanted to be a scientist, what did you do next? Tell us about the paths that led you to your current job.
- SY: Not as straight as it might appear! When I started my undergraduate degree, I knew I had interests in ecology. In contrast, my parents really wanted me to become a medical doctor. I understand I'm not the only child of Asian American parents who have this desire for their children. I did my best to follow both paths, taking classes like wetland ecology while volunteering at a hospital and taking the MCAT. It definitely felt like I was disappointing my parents on the one hand by following the ecology path. On the other hand, both of them, as well as my siblings, have degrees beyond college and we always found common ground in how important education is. At first, after earning my PhD, a job as a professor was not really on my radar. Research was all I knew and loved. Even after I was a lecturer in a class for the first time, I didn't like it that much. That all changed after a good friend of mine invited me to apply to a teaching fellowship with her, and I discovered for myself that teaching is not only fun, it allows me to exercise my creativity, and most importantly, help people.

7:27-8:47

- RP: You mentioned that you identify as an Asian American. What is it like being a scientist with this identity?
- SY: There are not that many Asian American ecologists in the US, though there are a lot of Asians and Asian Americans in other fields of biology. So far, I have not met that many

ecologists who look like me. While it's a little lonely, I'm lucky that this lack of representation hasn't been a huge barrier to my work. The worst may have been a reviewer who suggested that a manuscript that I had written with others should be edited by a native English speaker (which I am). Fortunately, another reviewer had thought it was one of the most well-written papers they had read.

- RP: I'm so sorry they made an assumption about your identity based on your name.
- SY: Thank you. You know, writing ability really doesn't correlate to when a person learns to speak English. In fact, my coauthors learned to speak English in school but are excellent writers, so the reviewer was also making incorrect assumptions about them as well. Because of experiences like these and my background, I especially relate to students who may be immigrants or whose parents are immigrants and want to support their success.
- RP: Thank you for supporting them and for sharing this with us.

8:47-9:45

- RP: I'm sure some students would like to know what a typical day is like for you?
- SY: No two days are the same, but I try to start them and end them the same way. Before I go to work, I like to get some exercise with our dog. Most days during the academic year, I teach one, two, sometimes three classes, so a lot of time is spent preparing for class, helping students learn in class, and reviewing their work and providing feedback on it. All of my research is with undergraduate students, so I spend a fair bit of time working with them too. I'd say the bulk of each day is spent working together with other people, either students or my faculty colleagues. When I get home, the first thing is a dog walk, no matter what the weather is. I'm a knitter, so I try to knit a bit each day for some visible, tangible progress on something.
- RP: That sounds similar to my typical day, though I don't know how to knit! Maybe you can teach me sometime.
- SY: Sure!

9:46-10:35

- RP: Tell me about a moment when you felt like you really belonged in the field of science.
- SY: Right now! When someone thinks my research is interesting enough to want to talk to me about it, I know I belong. It shows me I'm connected to the broader community because I'm studying something that is important or useful, or someone can learn something from it.
- RP: Thanks so much for chatting with us today, Suann.
- SY: Thanks, Rachel, for the opportunity to share my work!
- RP: If you want to learn more about this work, you can read "Pollinator Behavior Mediates Negative Interactions between two congeneric invasive plant species," published in American Naturalist in 2011. We've included a link to it below this video.