

## Building Community: Using DNA Barcoding through a Collaborative Project Between Lower-Division and Upper-Division STEM Courses

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### Author Biography

Dr. Paul Melvin is an Associate Professor of Biology at Clayton State University. He earned a PhD in Biology from the University of Alabama at Birmingham, with a focus on environmental toxicology and endocrine disruptors. He teaches courses in molecular biology, general biology, and leads study abroad programs to the Bahamas and Costa Rica.

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### Goal of the activity

Building a sense of community and belonging among students within a department can produce many benefits for students, especially in first-generation college students and underrepresented minorities (URMs). Research has shown that student-student connections can impact a student's sense of belonging and lead to increased retention (Strayhorn, 2008; Meeuwisse *et al.*, 2010). This is particularly impactful in STEM courses (Hausmann *et al.*, 2007; Hurtado *et al.*, 2007; Walton and Cohen, 2011; Ballen *et al.*, 2017).

One way to build community and belonging is to encourage students to collaborate on projects. This is made more effective when bringing students of different class standings together by creating situations where more advanced students can serve as mentors for the more junior students. In this activity, I used a combination of field experiences and molecular techniques to bridge the gap between students in lower-division courses and senior undergraduate research students. The goals of this activity were to 1) increase student sense of belonging and community, 2) introduce students to field research, 3) increase student experience with molecular biological techniques, 4) introduce students to bioinformatics and databases, and 5) increase student understanding of biodiversity.

### Description of the activity

This activity relies on two different ways to identify a species of plant, animal, or insect – the traditional morphological method where the identifier relies on appearance to identify a species (e.g. using a field guide), or using a molecular technique called DNA barcoding.

DNA barcoding is a method that was developed to quickly identify species and is simple enough to perform for people who are not professionals (e.g. students). DNA barcodes are generated by examining short, but highly variable DNA sequences within specific mitochondrial and chloroplastic genes that vary between species. These characteristics allow DNA barcodes to be easily sequenced and used for identifying a specimen. The gene used for barcoding depends on the type of species you are trying to identify:

**Animals:** COI gene – encodes cytochrome C oxidase, a component of the electron transport chain

**Plants:** rbcL gene – encodes RuBisCo, the enzyme used for carbon fixation in plants

**Fungi:** ITS gene – spacer DNA located between rRNA subunit genes

To generate the barcode, DNA is isolated using a small piece of tissue from the sample of interest using standard, published protocols. Once isolated, the DNA sample is subject to Polymerase Chain Reaction (PCR) using primers to amplify the DNA barcoding region. The primers are not species specific, which contributes to the usefulness of DNA barcoding as the same primers can be used on all samples with the same taxonomic group (animal, plant, or fungi). After amplification, the samples are sent for sequencing,

and the data is analyzed using DNA subway and NCBI BLAST. If the species is already in the databases, the species can be identified. If it is not, the novel sequence can be contributed as a new species barcode.

I turned this into a joint project between two distinct cohorts of students: students enrolled my lower-level study abroad field course and students enrolled in our senior-level research practicum course. The lower-level students in the field course completed a project where they were responsible for collecting samples in the field and tentatively identifying them using field guides, keys, and other traditional materials. Each student was responsible for identifying one species in the field and collecting a tissue sample—such as a leaf, insect, etc.—and preparing it for DNA extraction. Once this was completed, the samples were transferred to the senior-level research students for DNA barcoding. The research students extracted the DNA from each sample, prepared it, and sent it for sequencing. After processing and receiving the sequencing results, the students uploaded the sequences into the database for identification. Once the species identification was completed using the barcoding technique, the two groups of students shared data to see if they had identified the same organism both morphologically and molecularly using barcoding. The students then completed joint research presentations at our research day on their findings.

A DNA barcoding kit purchased from Carolina Biological Supply (item # 211386) is an efficient and affordable way to implement the barcoding activity and was used for this project.

### Reflection on project goals

This activity supported the goals of the project:

- 1) **Increase student sense of belonging and community:** This was a collaboration between lower-level and senior students who worked together on a larger project. By working in groups and completing a joint presentation, students at different points in their academic career interacted with each other in a more meaningful way than they had before.
- 2) **Increase student understanding of biodiversity:** Students in the lower level field course gained an understanding of biodiversity by identifying species in the field. This incorporated learning about evolutionary relationships, adaptation, taxonomy, and ecological topics.
- 3) **Introduce students to field research:** Students gained understanding of how field research is carried out, the importance of record keeping and recording observations, and how to process samples for use later in the lab.
- 4) **Increase student experience with molecular biological techniques:** The senior research practicum students were able to apply molecular biological techniques such as PCR and gel electrophoresis to a real-world study.
- 5) **Introduce students to bioinformatics and databases:** The senior research practicum students were able to gain experience in using databases and bioinformatics as part of a scientific study.

This project provided a way to demonstrate the power of DNA technology and DNA's importance to all forms of life. It efficiently bridges the gap between broad areas of biology. Because my interest was to facilitate community building between lower-level and upper-level students, I focused on using this activity for that purpose. However, it is easy to adapt for many scenarios, and works between different courses in multiple fields of biology. Because DNA is a unifying feature of life and is of perpetual interest to students, this is a powerful learning activity to use for biology students.

### References

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