Supplemental Material

CBE—Life Sciences Education

Gin *et al*.

Contents pgs.

1A

Sample Class Plan for One Class Session

First Class: Introduction to Seafood Forensics and DNA Barcoding Technology, DNA extraction

After today you will be able to...

- Identify at least 2 things you have in common with a classmate
- Pipette specific amounts of sample into microcentrifuge tubes and agarose gels
- Extract DNA from seafood and define the significance of each step of the protocol used to extract seafood DNA
- Measure the concentration and quality of your extracted DNA
- Explain the key findings of Baker and Palumbi 1994 and discuss the broader implications for whaling
- Outline three ways DNA barcoding can be applied to fisheries management and marine conservation
- Keep a lab notebook

To do before class:

Read:

1) Baker and Palumbi 1994 (attached: this is very short!)

2) Two background articles on seafood mislabeling and work by Baker and Palumbi and others:

- (https://www.nytimes.com/1994/09/13/science/dna-tests-find-meat-of-endangered-whales-for-sale-in-japan.html)
- (http://www.slate.com/articles/health_and_science/doers/2013/01/steve_palumbi_seafood_identification_molecular_forensics_of_whale_meat_and.html)

3) The pdf on lab notebooks (attached)

4) DNA extraction protocol (attached)

5) Willette et al. 2017 (attached)

Obtain:

6) A lab notebook (you will take notes in this, we will grade it often - it can be any kind of notebook, but you will have to turn it in, so please don't use it for another course)

Complete:

7) Online tutorial on DNA extraction (http://learn.genetics.utah.edu/content/labs/extraction) and Gel electrophoresis (http://learn.genetics.utah.edu/content/labs/gel/)

8) Complete the Sakai quiz (copy of quiz attached)

In-class lab activities:

class intro, ice-breaker, learn how to pipet, load agarose gels, extract DNA from fish, start keeping lab notebooks, discuss Baker and Palumbi, discuss Willette et al. 2017, and discuss the application of seafood forensics

References:

Baker, C. S., & Palumbi, S. R. (1994). Which whales are hunted? A molecular genetic approach to monitoring whaling. Science, 265(5178), 1538-1540.

Willette, D. A., Simmonds, S. E., Cheng, S. H., Esteves, S., Kane, T. L., Nuetzel, H., ... & Barber, P. H. (2017). Using DNA barcoding to track seafood mislabeling in Los Angeles restaurants. Conservation Biology, 31(5), 1076-1085.

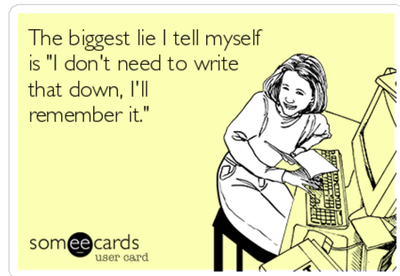
1B

Sample Lab Notebook Instructions

Science is coming

Tips for keeping a lab notebook & your sanity

Lab Notebooks. Why bother?



When you play the game of science, you write it down or you forget

What makes a good lab notebook?

Could someone else use your notebook to repeat your work and get similar results?

Organized
Accurate & detailed
Indicates what was done, why, and when
Easy to reference

Example entry

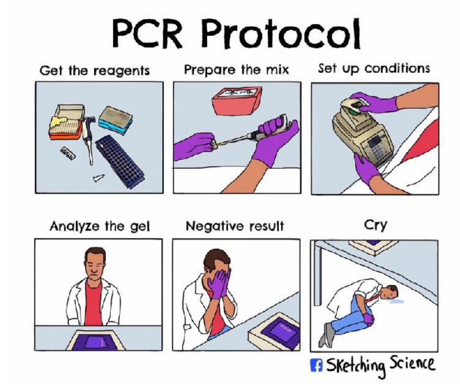
Date(s)
Title: relates to purpose of experiment/entry
Methods
- full protocol
- *or* changes to a previous one (reference page #)
- sample details!!!!!!

Results
- description or figure of gel/bands
- DNA concentrations
- sequence quality/barcoding results

Reflections
- if results successful: jot down next steps to take
- if not: write down possible reasons/solutions to get better results

Organization Tips

- Organize entries by experiment, not date (or make sure to mark what page the entry continues on)
- Save a couple pages when you start a new entry to keep methods/results/reflections together
- Add date and number to each page
- Draw (or print and paste) pictures of gels/bands
- keep track of sample details: the fish the tissue was extracted from, the location, the date, and your sample identification code for it



Get back up, write a reflection, try again

More Organization Tips

For keeping track of tissue, DNA, PCR samples

- Throw away samples that have been fully processed/didn't work
- Rewrite labels when they start to fade

1C

Sample DNA extraction protocol

1) Cut off ~20mg fish tissue (pea size) and place in a 1.5 mL microcentrifuge tube.
2) Add 180µl Buffer ATL.
3) Add 20µl proteinase K, mix, and incubate at 65 degrees C for at least 1 hour. Mix/shake samples often during incubation.
4) Add 200µl Buffer AL. Mix thoroughly by vortexing. Incubate samples at 55 degrees C for 10 minutes.
5) Add 200µl ethanol. Mix thoroughly by vortexing
6) Pipet the mixture into a DNAeasy Mini spin column placed in a 2 ml collection tube. LEAVE ANYUNLYSED FISH TISSUE BEHIND or it will clog the membrane. Centrifuge at 8,000rpm for 1 minute.
7) Discard the flow-through.
8) Add 500µl Buffer AW1. Centrifuge for 1 minute at 8,000 rpm. Discard the flow-through.
9) Add 500µl of Buffer AW2, and centrifuge for 3 minutes at 14,000rpm. Discard the flow through andcollection tube.
10) Transfer the spin column to a new 1.5ml or 2ml microcentrifuge tube
11) Elute the DNA by adding 20µl of diH20 (preferably heated to 55 degrees C) to the center of thecolumn membrane. Incubate for at least 5 minutes at room temperature and then centrifuge for 1minute at 8,000rpm.

1D

Sample Quiz

<u>QUIZ #1 – Seafood Forensics</u>

1) DNA released from cells when lysis solution is added to an eppendorf tube containing tissue/cells and the sample is placed in a warm water bath. Lysis solution contains detergent. Why?

a) Detergent breaks open cells by disrupting the cell membrane
b) Detergent digests the proteins that DNA is wrapped around releasing it
c) Detergent preserves the cells
d) Detergent causes DNA to clump together making it easier to extract

2) What is the role of proteinase K in the DNA extraction protocol?

a) It breaks open cells by disrupting cell membranes
b) It releases DNA from histone proteins
c) It causes DNA to clump together, separating it from solution
d) All of the above

3) Once cells have been lysed and DNA and proteins have been released into solution during DNA extraction, ________ is added prior to the first round of centrifugation to promote clumping of DNA and proteins in solution.

a) Proteinase K
b) Detergent
c) Isopropyl alcohol
d) Salt solution

4) A microcentrifuge is used multiple times in a DNA extraction protocol to separate various components of the sample from one another. What is the most important thing to remember to do when you use the microcentrifuge?

a) Make sure to set the speed such that it does not exceed 15,000rpm
b) Balance the centrifuge with another sample
c) Label your samples prior to loading them
d) Close the lids of the eppindorf tubes

5) Gel electrophoresis is used to separate and visualize strands of DNA. During electrophoresis a current is applied to a porous gel and fragments of DNA snake through the matrix toward a positive charge. As a result, ____________ strands of DNA move further down the gel than ____________ strands of DNA.

a) Larger, smaller
b) Smaller, larger

6) We can visualize single strands of DNA on a gel.

a) True
b) False

7) When using a pipette to draw up a volume of liquid, you place the tip in solution and press the plunger down to the _______ stop to draw it up.

a) First
b) Second

8) To dispose of tips between samples, press the _______ on the pipette.

a) Plunger
b) Plastic shaft
c) Ejector

9) The first digit on the volume indicator of a P20 is:

a) Thousands
b) Hundreds
c) Tens
d) Ones
e) Tenths

10) Where did Baker and Palumbi go to get their whale meat samples?

a) Japan
b) Whole Foods in San Diego
c) Russia
d) Ecuador

11) What year did the IWC moratorium on commercial whaling go into effect?

a) 1942
b) 1986
c) 1982
d) 2012
e) 1995

12) The results of Baker and Palumbi suggest that:

a) Whales have been illegally hunted, e.g., humpback whales.
b) Whale meat has been illegally imported into Japan.
c) All of the above.

Supplementary Results

Below we present results discussing the logistical and academic challenges students encountered, and also the outcomes of positive interactions with faculty and peers and increased communication skills. While these were not as prevalent as the central themes contained in the paper, we feel that they were important enough to merit inclusion in a supplement as they may be of interest to other CURE researchers or instructors.

Logistical Challenges Logistical challenges reflected challenges that arose from timing challenges, instructional difficulties, and organizational constraints. Students in both courses reported logistical challenges, but more students discussed them in the low-challenge offering than in the high-challenge offering (33% as opposed to 12%, Figure 1). Overall, students perceived that logistical challenges, such as the time allotted for the course, to interact with research challenges to limit their productivity in both offerings.

> "Because the class was only once a week, we would have to wait a whole week to resolve [problems]." (Student H4, High-challenge offering).

Yet, they recognized that timing was a difficult problem to solve saying "[the instructors] did as best as they could for the time that they had." (Student 4, High-challenge offering) Along with broader time limitations, students in both offerings expressing that they spent time "sitting around", but that they didn't know how to fix this challenge.

> "There would be periods of dead time where it does get a little slow, like you're either waiting for your reaction to – like your extraction to run, and you're not really doing anything. So again, I'm not sure how that's an issue that can actually be fixed, but that's just something that I run into many times." (Student L12, Low-challenge offering)

Both classes experienced challenges with the course organization, though their foci were different. The high-challenge offering expressed that although the "collaborative nature of the course was one of the highlights… it was also part of the challenges" (Student 4, High-challenge course) and more organization was needed to assist with effective communication among the entire groups of students.

> "I think if we had more accountability in the Google Doc maybe. I mean, it is hard to keep so many people in line and on the same page. But, yeah, I also found it a little bit of a challenge to share pipettes and things, like handing them around if there were limiting factors." (Student H12, High-challenge offering)

This perceived lack of coordination resulted in students feeling disorganized and confused.
In the low-challenge offering, students felt that expectations were not clear and "it seemed like some things were sort of under planned or spontaneously put together." (Student 3, Low-challenge offering) In reflecting on why they felt this way, one student mentioned how the expectations of the professors may have been shaped by the previous offering, resulting in expectations that were lower than necessary for their offering.

> "I would definitely say I think we were far more successful than [the instructors] ever expected with, like, getting DNA sequencing to work 'cause they said, like, a third of the class maybe less got it last time…. I mean, I don't think, like, from the past class they were really prepared for us to like, need as much as we did. Because with us getting ten samples, boom, we're done…. I guess now, moving forward and seeing how much we did, like, the expectations or the bar may need to be set way higher for the next group." (Student 9, Low-challenge offering)

Academic challenges Very few students expressed academic challenges associated with the course (Figure 1). However, when they did express these challenges, they typically highlighted challenges associated with the new course format in comparison with what they had experienced in other courses

> "…when you have a lot of students who are used to taking these very traditional courses where you go in and lecture every day, it's like a difficult adjustment to come into a class that's more organic learning. Like, you don't have to take notes on it; you're just learning it throughout the whole year." (Student L12, Low-challenge offering)

This student above expressed that during class there were "a lot of things we had generally touched on but not a lot of detailed information," which left her underprepared for exams or unsure of which information was important.

Positive interactions with faculty were expressed by students in both offerings but more students independently reported this outcome in the high-challenge as compared with the low-challenge offering (47% of vs. 27% of respondents, Figure 3). In general students expressed a sense of ease in discussing both personal and class matters with professors and an appreciation for the opportunity to develop these relationships.

> "The instructors made themselves very open and easy to talk to, and that definitely helped me feel more comfortable going up to them and asking them for help or when I was seeking an answer to my question. I got to know the instructors on a somewhat personal level, and I think it was great to be able to develop that type of relationship with some of the faculty, because it is not something every student gets to experience." (Student H14, High-challenge offering)

Students perceived that the small class size provided them opportunities to get to know their professors.

> "I have never been in a small science class before, so it was nice to have one-on-one time with my professors and to get to know them better." (Student H8, High-challenge offering)

A few students also highlighted the role of the class design feature discovery in how they viewed their professors and related to them.

> "And so seeing [the professors] approach the problems, you know, they didn't really know the answers either and so it was cool seeing them being so motivated to solve them because they were coming from really kind of a similar place to us." (Student H4, High-challenge offering)

Finally, for the students in the high-challenge offering, the experience of sharing challenges shaped students' view of professors as more approachable and human.

> "I feel like going in to college, at least a lot of freshmen, they kind of view their professors as sort of infallible and kind of distant and like unapproachable. But seeing them try to do these experiments and also fail just like us was very good because you see your professors more than just some figure. You can see them as a human being, which I thought was nice, especially coming from like one of them was like literally a distant figure at the front of a huge lecture hall for me from the previous semester. (Student H6, High-challenge offering)

Professor relationships were often discussed in combination with students increased sense of belonging in the classroom.

Positive interactions with peers were often mentioned in concert with statements of sense of belonging, but differed in that they expressed specific positive relationships only with peers and did not include statements of membership (e.g., being on a team, camaraderie, statements of relating to the class as a whole). These statements were present and similar in both offerings (29% and 27% of respondents in the high- and low-challenge offerings). Students in both offerings expressed that they developed friendships in this class.

> "The most memorable aspect was the relationships I built with my fellow classmates. I really enjoyed how we all became friends and it made the overall experience of attending lab more enjoyable." (Student L7, Low-challenge offering)

Like sense of belonging, students often attributed this to the collaborative nature of the course.

> "I think for me the most valuable thing was having something to look forward and having friends because it is hard to make friends so easily. It's a lot easier in this class because of the way it's set up and the teamwork and collaboration." (Student H12, High-challenge offering)

Communication skills were reported independently by many students in the low-challenge offering but not many in the high-challenge offering (47% of responses and 12% respectively). Most students who discussed communication reported that their writing and presenting had improved.

> "I also feel that this class allowed me to sharpen my communication skills as we presented our findings on a weekly basis and collaborated with other students to present our final projects." (Student L3, Low-challenge offering)

This outcome was not directly connected to challenges or any of the measured course design features. The higher incidence of this outcome in the low-challenge offering could be because the instructors asked students to present more frequently in that course since they were quicker to obtain DNA extraction and PCR results.

Supplementary Tables

Table S1: Laboratory Course Assessment Survey (Corwin *et al.*, 2014)

Discovery scale

In this course I was expected to…	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
generate novel results that are unknown to the instructor and that could be of interest to the broader scientific community or others.						
conduct an investigation to find something previously unknown to myself, other students, and the instructor.						
formulate my own research question or hypothesis to guide an investigation.						
develop new arguments based on data.						
explain how my work has resulted in new scientific knowledge.						

Iteration scale

In this course …	Strongly disagree	Disagree	Somewhat disagree	Somewhat agree	Agree	Strongly agree
I was expected to revise or repeat work to account for errors or fix problems.						
I had time to change the methods of the investigation if it was not unfolding as predicted.						
I had time to share and compare data with other students.						
I had time to collect and analyze additional data to address new questions or further test hypotheses that arose during the investigation.						
I had time to revise or repeat analyses based on feedback.						
I had time to revise drafts of papers or presentations about my investigation based on feedback.						

Collaboration scale

In this course I was encouraged to…	Weekly	Monthly	One or two times	Never
discuss elements of my investigation with classmates or instructors.				
reflect on what I was learning				
contribute my ideas and suggestions during class discussions.				
help other students collect or analyze data.				
provide constructive criticism to classmates and challenge each other's interpretations.				
share the problems I encountered during my investigation and seek input on how to address them.				

Table S2: Open ended questions

Question #	Question	Code category targeted
OE1	What has been the most memorable aspect or experience of this course for you?	Course challenges, Course design features, and Student outcomes
OE2	Describe any challenges you encountered during the course. What did you do when you encountered these challenges?	Course design features and Course challenges
OE3	If If you encounter challenges in science or science courses in the future, how will you approach these challenges?	Specific outcome: Ability to navigate scientific obstacles
OE4	Consider your thoughts and opinions about science and research prior to the start of the class. Describe how your thoughts and opinions have changed over the semester, if at all.	Specific outcome: Understanding of the nature of science
OE5	Describe any skills or knowledge you developed during this course and whether you feel these will be relevant or applicable outside of the course. How will these be relevant?	Student outcomes
OE6	Describe your relationships with both your peers and instructors. Did these help you to achieve your goals? If so how? Did these hinder your achievement of goals? If so how?	Course design features and Student outcomes

Table S3: Focus group questions

Question #	Question	Code category targeted
FG1	Why did you choose to take the Seafood Forensics Course?	-
FG2	Describe what you did in the course – what did a ‘day in the life’ look like?	Course design features
FG3	What are some of the especially memorable moments during this research experience?	Course challenges, Course design features, and Student outcomes
FG4	What were some of the challenges in this course, and how did they get resolved?	Course design features and Course challenges
FG5	How might dealing with these challenges change your approach to future obstacles and challenges you may encounter?	Student outcomes: Ability to navigate scientific obstacles
FG6	Consider your thoughts and opinions about science and research prior to the start of the class. Have they changed over the semester? If so, how?	Student outcomes: Understanding of the nature of science.
FG7	What has been the most important outcome of participating in this course?	Student outcomes
FG8	Has participating in this course changed your academic plan moving forward? If so, how?	Student outcomes
FG9	Did you find anything about the course particularly rewarding? Please describe.	Student outcomes
FG11	Is there anything you would like to add or anything I missed?	General information

Table S4: Code definitions and examples

Code	Definition	Example
Course challenges		
Research challenge	Challenges arising from executing research in the lab including technical difficulties and difficulties in data collection, analysis and interpretation.	*I had a lot of failures when trying to isolate the DNA. Over many trials and asking other people, I got to improve each time and finally graduate with real results.* – LC15
Logistical Challenges	Challenges arising from the course logistics and organization including limitations imposed by the course structure such as time limitations or availability of equipment.	*It would have been nice if the timeline for the class had been better laid out (start presentations/posters earlier than 4 days before they are due) but I understand the class is still a work in progress and it will get better every year."* –LC14
Academic Challenges	Challenges arising from the academic aspects of the course including learning new information, performing well on course assessments, and understanding course material.	*I definitely agree on the test thing 'cause, I mean, I will say at least on the molecular biology side was more difficult for just about everybody in the class, and there was something we had to do on the test, like converting something to something... There wasn't a time in front of the actual class where that was talked about. I overheard it to someone else and I did it before a couple years ago, but I completely knew I was gonna screw that question up on the test just 'cause I didn't practice it or we didn't practice it in class.* –LC9
Social Challenges	Challenges associated with building or maintaining relationships within the class or working in a social environment.	*It was kind of a challenge to work with people of different skill levels. Some people will have worked in a lab and other people wouldn't have. You know what I mean. It's hard if you want to make a suggestion or something. You don't want to be rude like oh, know it all or something.* –HC4
Personal Challenges	Challenges associated with students' personal lives or status that affect their class experience.	*Yeah, the biggest thing about it was we didn't have a textbook or any online anything, so it's not like we were dropping $200 for some textbook that you barely read, but if I would have known that I was spending X amount of dollars, it would just be cool to have had that, to be able to put aside money from the beginning of the class.* –LC9

Code	Definition	Example
Course Design Features		
Collaboration	Descriptions of how students together to make progress toward achieving a common goal.	*Because in this class we all worked on – you know, we all had one project and all the class worked together to accomplish it instead of just, like, in chem lab. It's just, you know, complete Lab 1, complete Lab 2, just turn it in.* –LC7
Iteration	Description of the iterative processes students engaged in during the course including repeating procedures when experiments did not work, revising work, re-analyzing data, troubleshooting, etc.	*Each time I experienced this (it probably occurred over 10 times) I would assess how I carried out the DNA extraction and PCR protocols to make sure I hadn't done anything wrong and would usually slightly modify my protocol (incubation time, tissue sample size, etc.)* –LC3
Autonomy*	Descriptions of instances in which individual students described themselves as responsible and in control of their own actions and decisions within the classroom.	*I felt incredibly challenged by the level of independent work in this class--never before have I had the opportunity to make so many of my own decisions about an experiment. It was intimidating but as the class continued, I was really able to adapt to the pressure.* –LC1
Relevance	Description of work done in the class that had relevance to a community outside the classroom.	*After two or three semesters they're going to actually be able to give their presentations with real results. I know Dr. Bruno was talking about trying to publish something and I mean we probably could if they got solid results which we're well on our way to doing.* –HC3
Discovery	Descriptions of work done in the class to build unknown knowledge, generate novel information, or work toward solving a problem with an unknown answer. Information had to be new or unknown to students and their professors.	*Everything we were supposed to do [in our other class] was giving to us and our research paper at the end was always pre structured. We always knew what the research was ""supposed"" to result in and if we didn't get the expected result you were wrong. With this course, I have learned that research does not work that way. There is no pre manual and ""expected"" research result. So, we had to learn in process.* " –LC8

*Inductive code generated during coding.

Code	Definition	Example
Course Design Features		
Productive	Instructor actions described by the student as having a positive cognitive, behavioral, research or emotional outcome for the student	*So basically Dr. Steinwand and Dr. Bruno were just like, "Well there's got to be a paper on it, just Google it."* *So you know just Googled around trying to find some and eventually found a paper, Fuller et all, which described a universal bi-valve primer, forward and backward primer, that we ended-up using and then looking at and reading what they did and they tested it on multiple of the like clams, oysters, a lot of what we'd been working with. And it seemed to have worked." –HC3*
Neutral	Instructor actions described by the student without a comment on the student outcome of the action	*Then usually it would start with just kind of waiting for those to settle and then Dr. Steinwand or Dr. Bruno would bring us together and kind of go over what we wanted to accomplish today. –HC3*
Counter-productive	Instructor actions described by the student as having a negative or counterproductive cognitive, behavioral, research, or emotional outcome for the student	*I wish we had spent more time discussing it just because I think there could be a really cool like strong connection between what we were doing and application. But they did as best as they could for like the time that they had. But I'm sure we did read a lot of papers that we ended up just taking a quiz on but not really talking about.. –HC4*

Code	Definition	Example
Student outcomes		
Increased ability to navigate scientific obstacles	Becoming better equipped (cognitively or emotionally) to work through a future scientific problem or demonstrating successful progress through a problem to arrive at a solution or resolution.	*It was challenging when I didn't get any results. I have a hard time accepting failure and it was just something that I had to learn that failure is part of science. You just have to keep trying until you get results, trying different things until it works.* – HC11
Increased access to positive faculty interactions	Experience of positive interactions with faculty or development of positive relationships with faculty.	*I was nervous that [my instructors] would be intimidating and unapproachable, but they are the complete opposite! I can ask them any question, whether it is related to science or not. Having down-to-earth, friendly professors was so valuable in helping me to develop my confidence as a scientist.* –HC10
Increased Sense of Belonging	Expressing a sense of belonging to or feeling a member or part of a community.	*I have this running joke with my mom that with a biology major, they're just kind of – like [The University] has been planning on telling me that I can't be in the biology major anymore but they just keep forgetting and letting me through to the next class, which is really hard, but then this class reminded me that, like, I belong here. Like, I can actually do this. It was very encouraging, and I think that was the best outcome for me.* –LC1
Increased understanding of the Nature of Science	Expressions of understanding or realizations of the various aspects of the nature of science.	*It definitely made me understand that research is a process of trial and error. Research is not going into an experiment knowing exactly how best to test everything and knowing that you will get a positive result.* –LC14
Increased Research Skills	Development or improvement of one's technical skills, analytical skills, or other skills associated with successful execution of research. Social skills (e.g., communication skills) are not included here.	*For a good portion of the course, loading DNA into a well was very nerve-wracking for me; I would actually be shaking. One week, however, I took a couple of deep breaths and made myself relax as I prepared to inject the DNA. I was able to inject the well successfully without having DNA splash out, and although I didn't end up getting results, at least I got liquid into the gel.* –HC14
Increased Self-Efficacy	Increases in one's belief in their ability to do science.	*But then I took this class and well, I mean, learning from the textbook is really hard, but once you do application science and are actually doing research, I suddenly realized, oh my gosh, I can explain everything. Like, all my friends who were 202, they're like what is PCR. I'm, like, listen. I'll break it down for you. 'Cause even when I just can't grasp the things that are in the textbook or just the lecture classes just don't make sense, I can remind myself, like, hey, this is really hard, but you can do science.* –LC1
Increased Intentions to Persist in Science	An increase in one's interest in or intentions to take actions associated with furthering their career or path in science.	*Yes I have become much more excited about conducting future scientific research. This course made an otherwise intimidating prospect (conducting my own scientific research in the future) much more tangible.* –HC5

Development of positive relationships with peers.	Development of positive and meaningful relationships with peers.	*I have made friendships in this course, which is really rare! I don't think I've made a friend in class since freshman year just because lectures are so big and it's difficult to make a friend without a lot of active effort.* –HC12
Increased Motivation	An increased sense of drive or will to accomplish something related to the course or science in general.	*Science doesn't need to be boring and if you're genuinely interested in your work and surrounded by people that feel the same way you'll be motivated every step of the way.* –LC12
Increased Collaboration Skills	Development or improvement of one's ability to work productively with others toward a common goal.	*I learned how to work on teams with people I wouldn't choose to work with myself. It will be applicable to any job because there are always coworkers you are not best friends with.* –HC12
Increased access to future research	Likely or realized opportunities to participate in future research experiences as a result of participating in the class.	*I learned a lot of molecular biology techniques that actually helped me to secure an internship at a plant molecular biology research lab this summer.* –HC6
Career Clarification	Greater understanding and assurance of what one wants to do for one's career. Increased intentions to persist in Science is not included here; it has its own code.	*I guess I would agree because I wasn't sure where biology degree would – where I wanted to go with that, and so it's just opened up my eyes to some opportunities and things I enjoy where I could go with it.* –LC5
Increased Communication Skills	Development or improvement of one's ability to successfully convey scientific information via writing, speaking, or other means.	*I learned how to better write a scientific paper. I learned how to read other scientific papers and discuss them.* –HC11
Increased Project Ownership	Identification of the project as belonging to the student or the student taking ownership and responsibility for their project.	*I have learned how rewarding it is to take ownership of a project and see how that project I can actually make a difference in the world.* –LC7
Enhanced Scientific Identity	A sense of belonging to the community of scientists or statements of seeing one's self as a scientist or as the same as other scientists.	*And I almost never felt that way when [my instructors] asked questions. A lot of times it didn't even seem like they necessarily knew what they were looking for and so, yeah and that made me feel very respected. It was like a fellow researcher on our team.* –HC4
Increased Content Knowledge	Development or improvement of one's knowledge in a specific scientific content area. This does not include knowledge of how to do skills.	*We would talk about like the topics and stuff that we needed to learn. And a lot of that was like [my instructor's discussions on like marine ecology. So a lot of the lab work we were actually doing was molecular biology so it kind of brought the marine ecology into it to combine the two.*-HC8
External Validation from the Scientific Community	Descriptions of formal recognition of students' work from the scientific community	Discussion of a publication or presentation at a professional conference would constitute this code. However, we did not find this in our data.