FUTURELAB+

AG/ENVIRONMENTAL

Solution Seeking Microbes

Microbes to the Rescue

In this Lesson Plan:

Print the **Teacher Section** → 🖨

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Follow the tips below in the Range field of your Print panel to print single pages or page ranges:

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Cover Image
Lactobacillus casei is one of many friendly bacteria in your gut microbiome.

AG ENVIRONMENTAL / SOLUTION SEEKING MICROBES

Microbes to the Rescue

DRIVING QUESTION

How can we use microbe superpowers to solve our local and global problems?

OVERVIEW

It is exciting to be a part of a community that shares a common understanding or passion. Across the United States, people gather in groups to celebrate, connect, and learn more about subjects that interest them by attending conferences. People often dress in cosplay (costume play), dressing as their favorite characters or superheroes in the field. These subject-matter conferences have fun names, such as e Comic-Con (con is short for convention). Other examples include Anime-Con, Sci-fi Con, Gaming-Con, Tech-Con, etc. We will celebrate the superheroes of the microbe world, whether those be the microbes themselves, the tools gathered from them, the scientists who discovered or worked with them, or the community members who will be impacted by them in an event called "Micro-Con."

Students have just identified a local or global problem in Lesson 9 and will begin this lesson by ideating solutions. Once students have an exhaustive list, they will select the option that best addresses the problem and stakeholders. After a few work days, students will be presenting their ideas at Micro-Con. The event will last three days, one day for students to be on a panel to share their ideas, and two days

Continues next page >

ACTIVITY DURATION

Six class sessions
(45 minutes each)

ESSENTIAL QUESTIONS

What criteria should we use when analyzing potential solutions to determine the best option?

How can we engage our audience to keep them interested and excited for our solution?

How can empathy be built with community members driving and designing solutions?

OBJECTIVES

Students will be able to:

Evaluate a local or global problem and **select** the best option for addressing the issue.

Create a solution to a local or global problem using microbes.

OVERVIEW

for them to be attendees. The first day will focus on projects based around human health, the second day will focus on food production, and the third will focus on the environment. When students are attendees, they will have a passport that will need to be completed by visiting each booth. Presenting groups will also be creating "swag" to pass out to their attendees.

Materials
Construction paper
Markers
Poster/Butcher Paper
15 different ink pads and stamps (optional for passport stamping)
Swag bag: Recyclable bags would be best, but plastic sandwich or quart ziplock bags could be used (this is where students will keep their swag)
Optional: 3D printer
Optional: Disposable Lab Coats (students can design)
Optional: Disposable aprons as a more cost effective solution than lab coats (student design cosplay)
Toolkit
Micro-Con Project Tuning Capture Sheet
Career Profiles from Lessons 1 (Holly Lutz), 2 (Celeste Allaband), 5 (Kevin Solomon), 6 (Lydia Contreras), 8 (Ryan Tappel), and 9 (Aditya Kunjapur)
Elevator Pitch Capture Sheet
Micro-Con Passport Capture Sheet
Micro-Con Grading Rubric

Have you ever wondered…

What would it be like to a panel member or presenter at a big convention, such as Comic-Con?

Conventions are exciting events that engage with the community. People of all backgrounds come together to celebrate and experience a themed convention. It is important that presenters are engaging and excite the attendees with their booths and information.

MAKE CONNECTIONS!

How does this connect to the larger unit storyline?	How does this connect to careers?	How does this connect to our world?
This is the final product and directly answers the overall question of the unit "How can we use microbe superpowers to solve our local and global problems?"	*Scientists* play many roles; they complete field and lab research, they write their findings in journals, and they present at various conferences. At a conference or convention, scientists might present a poster session, do a longer talk, or present a short presentation on a recent area of research, in addition to attending sessions presented by other researchers. *Costume designers* create outfits or costumes that fit a character, and the specific situation they are in (TV or movie, conference, other events). They use skills, such as researching a particular person or time period, creating visual design, and using technology or paper-based tools to create their products.	Students will be addressing real local or global problems identified in their interviews from Lesson 9.

Pedagogical Framing

Instructional materials are designed to meet national education and industry standards to focus on in-demand skills needed across the full product development life cycle—from molecule to medicine—which will also expose students and educators to the breadth of education and career pathways across biotechnology.

Through this collection, educators are equipped with strategies to engage students from diverse racial, ethnic, and cultural groups, providing them with quality, equitable, and liberating educational experiences that validate and affirm student identity.

Units are designed to be problem-based and focus on workforce skill development to empower students with the knowledge and tools to be the change in reducing health disparities in communities.

SOCIAL-EMOTIONAL LEARNING

Students will self-manage as they set out to achieve self-directed goals. They will practice managing stress, self-motivation, and setting personal and collective goals each day as they work with their partner to create a "booth" for Micro-Con. They will take initiative and demonstrate personal and collective agency in presenting meaningful solutions as they collaborate with the local community. Their social awareness will expand as they take the perspectives of the community members they are engaging with, demonstrating empathy and compassion to find microbe-influenced solutions to local and global struggles.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

Students will collaborate with families and the local community as they design and present solutions to their local/global problem, identified previously in Lesson 9. Students will learn about their diverse community and the problems they face as they attend Micro-Con.

ADVANCING INCLUSIVE RESEARCH

During Micro-Con, students will pitch their own designs to solve a local or global problem using microbes, and hear and reflect on other groups' pitches. These presentations will showcase the process students used to connect with a community, highlight the ways they incorporated opinions from diverse stakeholders, and develop a solution to the challenge faced. By highlighting the ways they developed trusted relationships with their community to co-develop these solutions, they are working to repair past injustices.

COMPUTATIONAL THINKING PRACTICES

In this lesson, students simulate the role of event planners who are developing a conference around microbes. Event planners use computational thinking in their day-to-day work in several ways. For instance, planners utilize the computational thinking strategy of developing algorithms to design project management tools, such as tuning protocols. Planners also rely on the computational thinking strategy of abstraction to develop concise and engaging marketing assets. Through a series of exercises, students gain hands-on experience with both of these skills.

CONNECTION TO THE PRODUCT LIFE CYCLE

This lesson showcases students' understanding of microbes throughout the unit, combining biotech content with science communication skills to touch on multiple phases involved in the product life cycle. For groups that are proposing a clinical trial for their Micro-Con product, they are engaging in the **discover** phase; for groups that are thinking more deeply around the safety and target audience of their microbes, they are in the **development** phase; and the elevator pitch from all groups prepares students for the communication aspect of the **manufacture** phase, even if their products are not yet developed to that level.

Day 1

Procedure

Develop solutions to a local or global problem.

Explain how their solution will best address the issues faced by their client or patient.

Whole Group (5 minutes)

To prepare, teachers may wish to modify the *Micro-Con Passport Capture Sheet* to incorporate some of the cartoons or comic strips that students designed in Lesson 2, and/or the menu items that students developed in Lesson 3 throughout the passport. Another option would be to draw or project a "Food Truck"on the board with the Menu items printed out or pasted on.

1   Ask students if they have ever heard of a "Con," short for *convention*, or if they have attended one themselves. Comic-Con may come up as an example, or you may wish to show students photos from a conference. Ask students if they could attend a "Con," what would it be? Allow students to talk to their partners before sharing ideas. Students may say "Ice Cream-Con", or "LEGO® CON." Ask them what they might want to see at these conventions? What would make it worth attending? Students might say free gifts, demonstrations, key speakers, dressing up, etc.

2   Ask students why conventions would be useful for different fields. What might be learned or shared at these conventions? Allow students to share their thoughts. Students might say that by learning from other scientists or people in the field, one's own career could move forward, or they might say that the camaraderie experienced and networking is important to working with people to create new and exciting products in the field.

3   Tell students to keep these ideas in mind, because they will now use microbes to help solve the challenges identified in Lesson 9, and will have a chance to showcase their designs at an event called Micro-Con.

Small Group (10–15 min)

1   Tell students to sit with their partners from Lesson 9. Students will work in these groups of two for the remainder of the lesson.

2   Give student groups time (five minutes) to focus on identifying and reiterating the challenge they identified in Lesson 9 during the interview process, assisting students in identifying their challenges if they have not yet done so. You may wish to circulate the room and check-in with student groups.

Day 1
Continued

Procedure

3   Direct students to their **Toolkit** and ask them to highlight which lesson(s) relate to their topic and indicate where they might use information and resources to help solve the problem or challenge.

4   Now, tell students to work through scaffolding their plan in order to be ready to present and attend Micro-Con at the end of the week. To help them, pass out the *Micro-Con Project Tuning Capture Sheet*.

Small Group (25–30 minutes)

1   After students have had a chance to review the *Micro-Con Project Tuning Capture Sheet*, tell them to start a brainstorming session (similar to what they did in Lesson 9) to identify as many solutions as possible, using their **Toolkit** and researching as necessary. Students should use the *Micro-Con Grading Rubric* as a guide to completing their projects. Encourage students to push through to really exhaust as many solutions as they can before stopping the brainstorm session. You may wish to provide struggling students with the following list of global problems: climate change, food scarcity, access to healthcare for new treatments (if you know of any local problems, that would also be also be a great resource to share with students, e.g., we live near the ocean and there is plastic pollution on the beach and in the water).

2   Students will choose a solution to the problem, and start to ideate how this might help the client they interviewed in Lesson 9, or the more global issue identified above.

3   Tell students they will have two to three days to complete their projects and create booths for Micro-Con and that they will need to complete all project components listed on planning Day 1 in the Micro-Con project tuning protocol before moving on to planning Day 2 components. Teachers should review work as students bring their information to receive a stamp and tell students to revise if necessary.

Day 2

Develop solutions to local and global problems.

Explain how their solutions will best address the issues faced by their client or patient.

Procedure

Small Group (45 minutes)

1.   At the beginning of class, students reflect on what they accomplished yesterday and what they need to accomplish by today, coming back to their *Micro-Con Project Tuning Capture Sheet*. Have students continue to work on their projects, checking off items to make sure each component is included.

2.   Tell students they should use the *Elevator Pitch Capture Sheet* to come up with the first iteration of their "*elevator pitch*" today (what the problem is, who the client is, how the microbe solves the challenge). You may wish to give them an understanding of how to deliver their elevator pitch by showing the following image.

Characteristics of an Effective Speaker

Confidence	**Excitement**
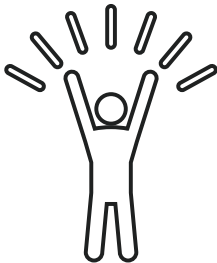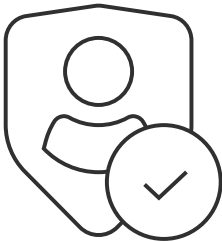
Authenticity	**Passion**

Teacher Note > *If students need additional time to complete their projects, teachers may want to include an additional workday. This can also be a day for groups who are finished to practice their presentations or make additional swag or improve upon what they have.*

Day 3

Procedure

LEARNING OUTCOMES

Students will be able to:

Create costumes (cosplay) to represent a microbe superhero or real scientist.

Develop communication strategies for presenting solutions to a local or global problem.

Design a creative "booth" to illustrate and communicate their solutions.

INDUSTRY AND CAREER CONNECTION

Invite students to dress as their favorite microbe or person who works with microbes at the Micro-con (refer back to the Career Profiles throughout the Unit). By doing so, they will be playing the role of a costume designer whose job it is to create outfits or costumes that fit a character. As students have done throughout this Unit, costume designers use skills such as researching a particular person or time period, visual design, and the use of technology or paper-based tools to create their products.

Teacher Note > *You or your students may also wish to find a local guest speaker willing to speak for ten minutes as a "Micro-Con Kickoff" keynote speaker. You may wish to have this person speak at the beginning or end of today's activities, or wherever fits best in the schedule for the presenter.*

Whole Group (10 minutes)

1 Micro-Con Kickoff! Tell students that as a part of a conference, there is usually a keynote speaker. Find a profile (or a few) in the *IF/THEN Heros* collection to show your students as a Kickoff speaker for the Micro-Con event. Alternatively, you or your students may wish to reach out to local community experts in microbes as real-life superhero scientists or citizens.

Small Group (35 minutes)

1 Tell students to practice their elevator pitches with their partners, getting ready for their presentation day. Remind them that they will be repeating this pitch multiple times as attendees circulate around the room so an effective and well-rehearsed pitch is important.

2 Tell students they may now have additional practice by presenting to groups that are focused on the same category of a community challenge (health, food, or environment). This will also allow them to hear from other groups they would otherwise not be able to observe on their presentation day, as each day will have a theme: health, then food, and then environmental challenges.

3 After students practice with each other, encourage them to give feedback in a way similar to how they practiced in Lesson 9 with the starter sentences of "I noticed…I wonder…I wish…" Presenters will record the feedback on their *Micro-Con Project Tuning Capture Sheet*.

4 Inform students that if they are not finished with the development phase, they should finish by the end of the day or complete the research as homework. If time permits, students may also decide to design name tags to wear on their presentation day and on their attendance day to differentiate the presenters from attendees during the Micro-Con event.

Day 4

Procedure

Students will be able to:

Engage an audience while sharing their microbe solutions.

Listen respectfully as an audience member.

Ask relevant clarification questions while attending Micro-Con.

Teacher Notes > *Prior to instruction, you may wish to make a side of the room themed to "Microgub" where you can hang student posters from Lesson 3, which illustrate microbe-influenced foods. This will be a fun way to celebrate student work and get students excited about the feel of Micro-Con.*

Small Group (10 minutes)

1   Tell students that today, groups with Human Health Connections will be presenting. Have students who are presenting get ready as other groups socialize as normal convention attendees would, waiting for the doors to open. If you are providing bags for attendees to place their "swag" in, these can be passed out at this time. You may wish to have students wear the name tags to differentiate the presenters from the attendees.

2   Give students ten minutes to set up their projects/presentations/boards/booths/costumes etc.

3   Pass out the *Micro-Con Passport Capture Sheet*, explaining how it will be used as evidence for engagement in today and tomorrow's Micro-Con. Explain to students that they will be visiting the various booths around the room, collecting swag in their swag bags, engaging in the elevator pitches from the groups they visit, and taking notes on their capture sheets. After visiting each booth, the presenters will provide a sticker, stamp, or signature indicating that each group visited and engaged in their presentations.

4   Ask students if they have any questions before beginning the event.

Whole Group (25 minutes)

1   Tell students that today, groups with Human Health Connections will be presenting. Tell students who are attendees to fill out their passports and collect swag in their swag bags. Remind students to be respectful when listening and presenting, and that this is meant to be fun and exciting so get energized!

Small Group (10 minutes)

1   Tell students to fill out the daily reflection, either as a presenter or an attendee.

Day 5

LEARNING OUTCOMES

Students will be able to:

Engage an audience while sharing their microbe solutions.

Listen respectfully as an audience member.

Ask relevant clarification questions while attending Micro-Con.

Procedure

Small Group (10 minutes)

1. Tell students that today, groups with Food Production Connections will be presenting. Have students who are presenting get ready as other groups socialize as normal convention attendees would, waiting for the doors to open, getting their *Micro-Con Passport Capture Sheet* ready. If you are providing bags for attendees to place their swag in, these can be passed out at this time. You may wish to have students wear the name tags to differentiate the presenters from the attendees.

2. Give students ten minutes to set up their projects/presentations/boards/booths/costumes etc.

Whole Group (25 minutes)

1. Tell students that today, groups with Food Production Connections will be presenting. Tell students who are attendees to fill out their *Micro-Con Passport Capture Sheet* and collect swag in their swag bags. Remind students to be respectful when listening and presenting and that this is meant to be fun and exciting so get energized!

Small Group (10 minutes)

1. Tell students to fill out the daily reflection, either as a presenter or an attendee.

Small Group (10 minutes)

1. Tell students that today, groups with Environment Connections will be presenting. Have students who are presenting get ready as other groups socialize as normal convention attendees would, waiting for the doors to open, getting their *Micro-Con Passport Capture Sheet* ready. If you are providing bags for attendees to place their swag in, these can be passed out at this time. You may wish to have students wear the name tags to differentiate the presenters from the attendees.

2. Give students ten minutes to set up their projects/presentations/boards/booths/costumes etc.

Day 6

LEARNING OUTCOMES

Students will be able to:

Engage an audience while sharing their microbe solutions.

Listen respectfully as an audience member.

Ask relevant clarification questions while attending Micro-Con.

Procedure

Whole Group (25 minutes)

1 Tell students that today, groups with Environment Connections will be presenting. Tell students who are attendees to fill out their *Micro-Con Passport Capture Sheet* and collect swag in their swag bags. Remind students to be respectful when listening and presenting and that this is meant to be fun and exciting so get energized!

Small Group (10 minutes)

1 Tell students to fill out the daily reflection, either as a presenter or an attendee.

Teacher Note > *As an Optional Reflection Piece, students reflect, in their Passports, on the experience with a new partner noting the highs and lows (similar to the interview in Lesson 9). Each time a Micro-Con event takes place, what might make it better. Use "I liked...I wished...I wonder.."*

National Standards

Next Generation Science Standards

LS1-1 Structure and Function
Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

LS3-3 Science is a Human Endeavor.
Technological advances have influenced the progress of science and science has influenced advances in technology. Science and engineering are influenced by society and society is influenced by science and engineering.

Science and Engineering Practices
Asking questions (for science) and defining problems (for engineering)
Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations.

Constructing explanations (for science) and designing solutions (for engineering)
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.

Career and Technical Education (CTE)

A1.0
Define and assess biotechnology and recognize the diverse applications and impact on society.

A2.0
Understand the ethical, moral, legal, and cultural issues related to the use of biotechnology research and product development.

3.2
Evaluate personal character traits such as trust, respect, and responsibility and understand the impact they can have on career success.

3.4
Research the scope of career opportunities available and the requirements for education, training, certification, and licensure.

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National Standards

Career and Technical Education (CTE)

3.5
Integrate changing employment trends, societal needs, and economic conditions into career planning.

3.6
Recognize the role and function of professional organizations, industry associations, and organized labor in a productive society.

3.7
Recognize the importance of small business in the California and global economies.

4.1
Use electronic reference materials to gather information and produce products and services.

4.3
Use information and communication technologies to synthesize, summarize, compare, and contrast information from multiple sources.

5.1
Identify and ask significant questions that clarify various points of view to solve problems.

5.6
Read, interpret, and extract information from documents.

7.2
Explain the importance of accountability and responsibility in fulfilling personal, community, and workplace roles.

7.4
Practice time management and efficiency to fulfill responsibilities.

7.7
Demonstrate the qualities and behaviors that constitute a positive and professional work demeanor, including appropriate attire for the profession.

7.8
Explore issues of global significance and document the impact on the Health Science and Medical Technology sector.

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National Standards

Career and Technical Education (CTE)

9.5
Understand that the modern world is an international community and requires an expanded global view.

9.7
Participate in interactive teamwork to solve real Health Science and Medical Technology sector issues and problems.

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Micro-Con Project Tuning Capture Sheet

Directions:
Working with your partner, fill in the information below as you plan for your booth at Micro-Con. Remember to focus on the client interview from Lesson 9 and to reference your Toolkit! Suggested time for discussion and research with your partner is listed on the far left column. You may wish to set a timer to help you progress each day to accomplish the goals listed.

Suggested Time	Day 1 Planning Priority List	Information
5–10 mins	☐ Area of Focus (Environmental, Health, Food production)	
	☐ Who is the client/patient?	
	☐ Problem to be solved with microbes (Reference the annotations from you client interview.)	
20–30 mins	☐ What microbe are you using or which microbe did the product come from?	
	☐ How will microbes solve the problem (what is the science behind it) and how will it best help the client? Reference your Toolkit.	
	☐ What will be your physical representation in the booth? Prototype design/model (digital, physical, poster)	

Teacher approval to proceed to Day 2 topics
(must have stamp or signature)

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Micro-Con Project Tuning Capture Sheet
Continued

Suggested Time	Day 2 Planning Priority List *(must be finished with Day 1)*	Information
10 mins	☐ Vision/Superhero Mission Statement	
	☐ What past lessons are similar? (Remember to reference your Toolkit!)	
15 mins	☐ Completion of prototype design/model (digital, physical, poster)	
10 mins	☐ Elevator pitch for attendees to hear	Connection to listener: Explain your problem/why your solution matters: How your solution helps solve the problem:
10 mins	☐ What swag will be given to attendees	
	☐ Cosplay-will you be a microbe/scientist representation of something else?	

Note: *When you have finished researching and planning each topic listed above, you may start constructing your booth (which may include visuals, such as posters, presentations, interpretive dance, song).*

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Micro-Con Project Tuning Capture Sheet
Preparation for Micro-Con

Record the feedback you received after practicing your presentation below:

What worked?	
What could be improved?	
What questions does your partner have about the prototype?	
What ideas does your partner have about the prototype?	

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Elevator Pitch Capture Sheet

An elevator pitch is a short summary of your research. Considering that most elevator rides are about a minute long, an ideal elevator pitch is about 60 seconds. The main goal of an elevator pitch is to get your listener interested in learning about more. The longer an elevator pitch, the more you risk your audience losing interest.

It can often be easiest to express the relevance of your research in terms of a disease.

— If you are studying the function of a protein that has a connection to a health condition—deliberately state this in your elevator pitch.

— Start by asking your listeners a simple question, such as "Have you heard of disease X?" The answer will allow you to gauge the listeners' level of understanding of your research area. This is critical to delivering a message your audience will remember.

— How to proceed with your elevator pitch depends on the response you receive.

  • If the answer is "YES," then follow by explaining your research.

  • However, if the response is a "NO," it is an opportunity for you to concisely describe the disease, the statistics on people affected by the disease, and whether a cause or cure is known.

— Proceed by describing how your research will bring us closer to an understanding of either the cause or cure for the disease.

The following is an example of an scientific elevator pitch
Do you know that 32 million Americans are taking statins for their high cholesterol? While statins have been shown to improve the heart function by reducing blood cholesterol levels, one of the major side effects associated with long-term use of statin is the development of muscle pain. My research focuses on separating the cellular pathways leading to the beneficial effects and muscle toxicity mediated by statins in order to identify new drug molecule(s) that only activate the pathway good for the heart. Using various cell-based assays, we have identified a drug combination that mimics the good effects of statins but is devoid of the muscle toxicity associated with their use.

Paraphrased from: *Elevator Pitches for Scientists: What, When, Where and How*

Please write your own elevator pitch below.

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Micro-Con Passport Capture Sheet

Directions:
Take this passport around with you as you learn about other groups' problems and proposed solutions. Make sure you visit each booth so you do not miss out on any of the fun!

Booth Name	Group Members	Problem	Proposed Solution	Presenter Stamp/Signature

Final Reflection/Takeaways
Presentation Day (when you are presenting)
One thing I learned about presenting was…

One thing I wish I would have done (or observed in another group) to improve my presentation was…

_____

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Micro-Con Passport Capture Sheet
Continued

First day attendee (when you are not presenting):
One thing I learned from another group today was... ⟶

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One thing I learned about the world around me was...

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Second Day attendee (when you are not presenting):
One thing I learned from another group today was... ⟶

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One thing I learned about the world around me was...

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Final Reflection
I was able to showcase my strengths in this project by... ⟶

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I showed improvement and growth through...

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Micro-Con Passport Capture Sheet
Continued

Directions:
Place a checkmark in the box that most closely states your feelings:

Project Component	Strongly Disagree	Disagree	Agree	Strongly Agree
I felt like my voice was heard and ideas were respected.				
I felt like I listened and respected the ideas of others.				
I felt like the work was evenly distributed between myself and my partner.				
I learned about microbes by participating in the Micro-Con event.				

Potential career(s) I have gained interest in or want to learn more about in the course of the unit:

_____

_____

Each time a Micro-Con event takes place, what might make it better?
I liked…

_____

_____

I wish…

_____

_____

I wonder…

_____

_____

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Micro-Con Grading Rubric
Rubric Unit 5 , Lesson 10
Micro-Con Project and Presentation

Component	Meets Expectations 8–10 points	Progressing 5-7 points	No attempt 0 points
1. Problem			
a. Describes the Area of Focus and importance.			
b. Identifies the client or patient.			
c. Explains the problem to be solved.			
d. Identifies microbe being used and how the microbe will solve the problem.			
2. Solution			
a. Explains how the solution will help the client.			
b. Contains clear vision or superhero mission statement.			
3. Presentation			
a. Contains clear vision or superhero mission statement.			
b. Prototype model designed.			
c. Elevator pitch delivery contains all points mentioned in the capture sheet.			
Total Score Grade			
Comments			

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Lesson 1 Career Profile

Holly L. Lutz, PhD
Research Associate
Field Museum of Natural History's Integrative Research Center
———
Project Scientist
UC San Diego's Center for Microbiome Innovation

What do you do and how did you get here?

I am currently a project scientist at UCSD and an associate with the Field Museum. After doing my undergraduate work at the University of Chicago, I worked as a research assistant in the museum, and got to do field work, going into caves to observe bats in their natural environment. I got really interested in the skin microbiome, and wrote a proposal to study this with Jack Gilbert's lab. Since then, I've been able to do field work in Africa, where I collected samples from birds, shrews, rodents, and bats. Now I analyze all that data from those field expeditions!

What was your favorite subject in high school, and why did you love it?

I enjoyed my science classes, but I believe my favorite subject was English Literature – I was lucky to have teachers who encouraged critical engagement with the literature we read, and at the time I felt like traveling through stories and time and trying to understand the historical and social contexts in which novels, poetry, etc. were written was really empowering and helped me view the world in a much more engaging way.

If you could give a piece of advice to your younger self, what would it be?

Learn how to establish boundaries for yourself—with your work, your family, your peers, yourself. If you don't learn how to set your own boundaries, something or someone else will set them for you.

What skills do you use on a daily basis?

Active listening. If you are going to interact with others, it is critical that you truly listen to what they are telling you— whether that is with their words, body language, etc. Perhaps another word for 'active listening' is caring. I have found listening to be the most efficient way to identify problems, find pathways forward, discover new areas for research, and to form meaningful relationships with people both inside and outside of my work. The other, more technical skill I rely on for my research is computer programming. I suppose both are communication skills—the latter is just for machines, while the former is for more sentient beings.

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Lesson 1 Career Profile

Continued

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What's most fulfilling about your job?

The complexity and unpredictable nature of the problems
I address in my research make it incredibly fulfilling. There
are infinite unknowns in the natural world, and I get to play
around in what feels like a candy shop of biological novelty.
These features also make my work challenging, as new
discoveries typically lead to new questions, and working
with "big data" means that you have to move between hands-
on biology in field conditions (as I practice in my field work
with bats and other animals) and working with data files
you cannot open or visualize because they are too large.
The mental leaps from "this is a bat in my hand" to "these
are the genomes of all the microbial symbionts of that bat
that was in my hand" can be exhausting, but they are
certainly never boring!

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If you could have any superpower, what would it be?

I truly, deeply wish that I can morph into any animal I choose,
so that I could have the ability to communicate with all
different types of intelligence that exist in this world!

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Lesson 2 Career Profile

Celeste Allaband, DVM
Small Animal Veterinarian and PhD Candidate
University of California, San Diego

What do you do and how did you get here?

I am currently a PhD candidate at UCSD. I collect and analyze data to examine the fundamental properties of the microbiome and how it applies to both human and animal health. After working as a small animal veterinarian, I was able to find this position, where I am able to combine my undergraduate interest in medical microbiology with my understanding of animal health.

What was your favorite subject in high school, and why did you love it?

My favorite subject in high school was physics. I had a really great teacher who was enthusiastic about the subject and we got to do a bunch of fun in-class experiments with springs, paper airplanes, etc.

If you could give a piece of advice to your younger self, what would it be?

My advice for my younger self would be to worry less. I was always measuring myself against others and how far "behind" I was compared to some people. Now, I love all of the detours my life has taken.

What skills do you use on a daily basis?

One of my core skills that I use every day is writing - whether that's writing a formal scientific paper or grant, an email to a colleague, or a friendly text message. Knowing who your audience is and how to make sure both parties are effectively talking about likes, dislikes, expectations, problems, etc is really important. Remember to be kind as much as possible—assume positive intent from every message. Maybe they are just having a bad day. Give them the benefit of the doubt that you would want. And, yes, people sometimes do want to hurt you with their words, but they get really frustrated when you don't.

What's most fulfilling about your job? What's most challenging?

The most fulfilling part of my career is having great conversations with other scientists who are passionate about their specialties. I learn so much all the time! I also like knowing that I am helping to make the medicine of the future. The most challenging thing is when you are trying to make sense of all of the data you collect. There is no one there to tell you how to do it right or better, you have to figure that out yourself. Although, being the first person on the planet to know something is so cool!

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Lesson 2 Career Profile

Continued

If you could instantly learn any language, which would you choose and why?

If I could instantly learn any language, I would probably pick either Mandarin or Cantonese. There are so many people in the world who speak the language, including some close friends of mine. The written characters are gorgeous and have such a rich history, too. Plus, I am absolutely terrible at it. I cannot hear the different tones at all to even get started. Sigh.

What is your most used phone app?

My most used phone app is Webtoon, which has online comics. I love exploring new stories, genres, and art styles!

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Chelsey Spriggs
Research Fellow Tsai Lab
Virology researcher | Postdoc
University of Michigan
——
Diversity Advocate

What do you do and how did you get here?

I am a scientist at the University of Michigan where I study how cancer-causing viruses get into cells to cause infection. I always loved science in school, but I had no idea that I could do science when I grew up! I worked in a research lab in college as a part of a degree requirement and learned about viruses and how they can cause cancer. Although I loved science, I thought that the only career options were doctor or veterinarian. I actually went to medical school, but was unhappy and made the difficult decision to leave and pursue biomedical research. My professor helped me to apply for graduate school and the rest is history! I will soon be starting my own lab studying how viruses cause cancer and how they can be used to treat cancer.

What skills do you use on a daily basis?

The skills that I use most are critical thinking and communication. In science, you come up with hypotheses to test and sometimes they work and sometimes they don't. It's VERY cool when they do work, but more often than not, you don't get the result you expected. At that time, it is very important to think critically about what to do next and how to interpret your data. Doing this, you come up with another hypothesis to test and eventually, you get it right! Communication is also extremely important in my daily activities. I have to be able to clearly communicate my findings to others because science is meant to be shared.

What's most fulfilling about your job/career? What's most challenging?

The most fulfilling part about my job is getting good data. If I find something new, for a few minutes, I may be the only person in the world that knows what I know! As a microbiologist, I study things too small to see so figuring out how they work through science is gratifying. The most challenging thing about my job is that 75% of my experiments fail or do not reveal what I expected them to. At these moments it is important to persevere instead of giving up—eventually I get it right.

If you could give a piece of advice to your younger self, what would it be?

My advice to my younger self would be to follow your passion. Don't do something because you think that is what is expected of you and don't shy away from challenges because people say that it can't be done. You can do what you put your mind to even if you have to be the first one to ever do it!

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Lesson 3 Career Profile

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If you could have any superpower, what would it be?

I would love to be able to fly! Seeing the world from that vantage point would be so awesome…and I'll never be stuck in traffic again!

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What is your most used phone app?

My music app. I love listening to music that matches my mood. It can also help me to feel at peace or uplift my spirit. I am always playing music!

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Lesson 4 Career Profile

Ariangela J. Kozik, PhD
Research Fellow
University of Michigan Medical School:
Division of Pulmonary and Critical Care

What is your current role, and how did you get there?

I am currently a research fellow at the University of Michigan Medical School, in the division of Pulmonary and Critical Care. I analyze samples from the airways of asthma patients to understand how the respiratory microbiome is involved in the presentation and pathogenesis of asthma. As a kid, I loved any and all school projects. I was also very curious, always asking questions about everything and always reading. I loved to do mini-experiments like making homemade slime, lava lamps, and growing crystals. The science fair was one of my favorite times of the school year. During my research for a science project in elementary school, I read a lot of books and articles about bacteria and antibiotics, and that was when I first started to really get interested in microbiology. When I started college, I planned to major in psychology and minor in gender studies, with the intent to go into neuropsychology in graduate school. However, during freshman year I had the opportunity to apply to a discovery-based science research course called SEA-PHAGES (Science Education Alliance-Phage Hunters Advancing Genomics and Evolutionary Science). The program involves looking in the soil for bacteriophage (viruses that infect bacteria), and teaches concepts of microbiology and genomics through hands-on learning experiences. I was fascinated by phage biology, the concept of microbiomes— being surrounded by a universe of microorganisms we depend on but can't even see without technology, and the hands-on approach to learning. I switched my major to biotechnology, added some computer science and microbiology classes, and started to learn basic programming skills. In graduate school I decided that microbiome research was what I wanted to devote my career to, and that led me to where I am today.

What skills do you use on a daily basis?

One of the most important skills I use daily is my knowledge of the programming languages R and Python. I use them every day in my work as I analyze genome sequence data. Another important skill is time and project management. I have a lot of projects at a lot of different stages going on at the same time. I also participate in several project teams. Each has its own goals, resources, and timelines so being able to schedule my workday around the needs of each project/team, prioritize when necessary, and plan my efforts in advance is really critical to sustained productivity and keeping stress levels down.

What skills do you use on a daily basis?

I LOVE asking questions to find answers to what we don't know. I think it is the most thrilling thing to be working on the edges of current biomedical knowledge. To be able to come up with ideas about how we think something works and then test whether or not that is true, to be able to look at what we think we know and why we think we know it, and see if we come to the same conclusion—that is fascinating to me and I LOVE that aspect of what I do. The most challenging thing is pushing through times with limited resources and constantly thinking about funding to keep your research going. It takes a lot of mental and creative energy to prepare funding proposals, navigate feedback and make revisions. Having a supportive mentorship team to help work through those issues and improve proposal-writing skills is really important.

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Lesson 4 Career Profile

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What was your favorite subject in high school, and why did you love it?

This is hard because I enjoyed school in general. I loved science, but I think my favorite subject was music. I was in Orchestra and Band. I am a very creative person so it was a nice change from the rest of the things I was learning in school. Music is its own language, with notation and rules and distinct ways different instruments participate to create a blended sound that can evoke emotion or change a mood in a matter of moments. It teaches you to listen in a different way, and some of the skills I developed as a musician have been important to my career as a scientist.

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If you could have any superpower, what would it be?

Teleportation.

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If you could instantly learn any language, which would you choose and why?

IMandarin. I studied Mandarin in college, and the hardest part was getting the tones right. If I could have snapped my fingers and instantly known them, I absolutely would have. For now, I will keep practicing.

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Lesson 5 Career Profile

Kevin V. Solomon, PhD
Assistant Professor
University of Delaware
Chemical and Biomolecular Engineering Department

What is your current role, and how did you get there?

I am a professor of Chemical & Biomolecular Engineering at the University of Delaware where we engineer bacteria to produce medicines, fuels, and materials. After getting my undergraduate degree in bioengineering, I used synthetic biology tools to work on metabolism with *E. coli* bacteria. From there, I studied fungi and other microbes. I really enjoy the freedom and ability to build things that address problems and am fascinated by the things that biology can do. Simple microorganisms can do so much including make basic medicines (e.g., *penicillin*), foods, and even fix cracks in concrete (when engineered to do so).

What skills do you use on a daily basis?

I interpret data, forming connections between disparate pieces of information, by reading scientific journals, programming computers, and even just making simple plots. I also need to communicate this information clearly to others, without jargon, such that others may benefit.

What's most fulfilling about your job? What's most challenging?

The most fulfilling part of my job is the freedom to work on jobs that I choose and help students learn to be similarly independent. The most challenging aspect is how to pick the 'right' kind of problems to work on—some problems are harder than others and may be more difficult to solve.

What was your favorite subject in high school, and why did you love it?

My favorite subject was chemistry—I found it fascinating that simple innocuous items could be changed into life saving drugs, or high energy explosives by understanding how atoms worked and making appropriate calculations.

What is your most used phone app?

Youtube—there's a lot of great content to teach me about the world (e.g. CrashCourse, Armchair Historian, VSauce) as well as 'fun' videos with wacky pranks, music videos, etc.

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Lesson 6 Career Profile

Lydia M. Contreras, PhD
Associate Professor of Chemical Engineering
The University of Texas at Austin

What is your current role, and how did you get there?

I was born in the Dominican Republic, so my first language is Spanish. I moved to New York City at about 11 years old, and learned that people would think of me as an Afro-Latina. When I was young I really liked science, so people told me I should be a doctor. But I really liked to create and build things so I was blessed to have people encourage me to go into engineering, even though it is a male-dominated industry. Actually, when I heard I wouldn't have to wear dresses all the time, and that it was a profession to wear a hard hat and get dirty (my perception of engineering as a child), I got even more excited about it!

When I was an undergrad student, I got involved in doing research with one of my professors. Biomedical engineering appealed to me because I wanted to help people. I was able to see how biotechnology can translate fundamental science into real products to solve a need. And the idea of being the first person in the world to figure out the answer to a question was so exciting. Growing up, becoming a professor was a pretty illusive idea for me. I never had a Latina or Black professor. In fact, I only had three women in science that I interacted with: my postdoc advisor, who was amazing, and two professors, one at Princeton and one at Cornell. So that research experience in college really impacted me.

My current lab studies the chemistry of biological materials like DNA and RNA to understand how they are regulated, with the ultimate goal of learning how the environment impacts health.

What skills do you use on a daily basis?

Clear and concise written and verbal communication- I write clearly to communicate new ideas and help others understand the importance and value of what we do. This includes oral presentations, writing, creating clear and helpful figures to help others see what I see etc.

Ability to bounce back and learn from failures—good science is about risk taking to explore the most exciting ideas and things don't always work. There are a lot of failures in my work. Learning quickly from mistakes and not letting them compromise the excitement of moving forward is key.

What's most fulfilling about your job/ career?

Learning something new everyday is extremely fulfilling, especially when at times it could be that my research team might be the only one in the world to understand a given phenomenon—that is very exciting!

What was your favorite subject in high school, and why did you love it?

I loved chemistry in High School. It was fascinating to learn about the properties of molecules and understand how those properties relate to the reactions that the molecules can most likely undergo.

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Lesson 6 Career Profile

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If you could give a piece of advice to your younger self, what would it be?

I have always loved music and Salsa dancing has always been my escape. My advice would be to create and seek out those positive moments that you enjoy to help you get through the tough times.

If you could instantly learn any language, which would you choose and why?

Sign language, to be able to be truly inclusive of everyone in a room.

What's a social cause you care about?

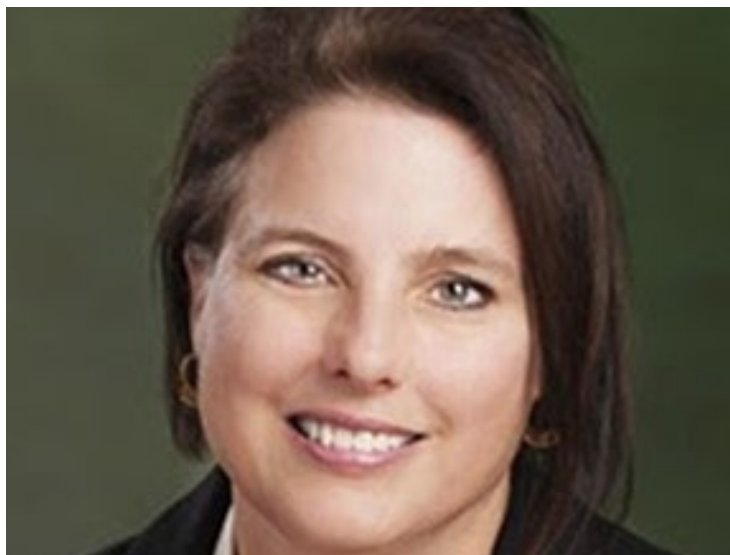Equal access to clean environmental resources (water, air, etc.).

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Lesson 7 Career Profile

Dr. Rusty Lowe
Lead Scientist
GO Mosquito Habitat Mapper

Where are you from?

I grew up in Maryland in the United States. I completed my BA at the University of Maine, did PhD work at the University of Munich and completed my dissertation at the University of Minnesota. My first job was as a professor at the University of Maryland, Munich. So you can see how easy it was for me —I have one "UM" tee shirt that describes most of where I've lived and most of my academic life!

What do you do?

I am a Senior Scientist at the Institute for Global Environmental Strategies in Arlington, VA. I work with scientists, communicators and teachers—some of the most dynamic people you will ever meet.

How do you plan to use GLOBE Observer in the future?

I am very interested in seeing how the GO Mosquito Habitat Mapper data correlates with GO Land Cover data. I have been working for 2 weeks describing the vegetation in Barbuda using a Land Cover app, as well as doing vegetation descriptions of floral formations. Once the snow melts in my home in the mountains of Boulder Colorado, I am planning to do a land cover survey of Lefthand Canyon, the canyon where I live in the Front Range of the Rocky Mountains. That is my "at home" citizen science project!

How do you use GLOBE Observer?

I am one of the lead scientists who developed the key used in the Mosquito Habitat Mapper app. I have used the app in an USAID project with teachers and students in Brazil and Peru, mapping mosquito habitats around their schools and in their communities. Reporting mosquito habitats and mitigating them so they can't be used for breeding sites can make a big difference and decrease disease transmission in a community. Where I live in Colorado, it is semi-arid so there are only container habitats near my home. I saw firsthand the importance of not storing my winter tires outside in the back of the barn—I had inadvertently created a perfect little mosquito nursery! Lots of larvae! Right now I am doing field research in Barbuda, a small island in the Caribbean, where we first tested the GO Mosquito Habitat Mapper app concept.

Why is citizen science important to you?

The essence of science is sharing data and discovery—for the greater good. I feel like every time I take a measurement, I am doing something that helps the world in a very small way. Not in a big, obvious, tangible way, like my husband who is a volunteer fireman and actually saves lives. But as one of millions of people reporting data, what can emerge is a better understanding of the world around us, an understanding whose meaning and utility is not yet known. I love that I am a tiny part of something much, much bigger than me.

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Lesson 7 Career Profile

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What advice do you have for people just getting into citizen science?

I'd say find a citizen science project that really excites you and matches your interests. For me, I studied plant taxonomy and forest ecology in graduate school as part of climate change studies and it's fun to return to this work as a volunteer citizen scientist, just for fun. It's especially exciting because my paid work is with the GO Mosquito Habitat Mapper, so I am interested in seeing how my hobby citizen science work (Land Cover citizen science) can help us understand patterns in the mosquito data.

What do you do for fun?

I live in the mountains and like to kayak, hike and cross-country ski. I'm always identifying plants when I walk.

I have a mandolin and banjolin, and like to play music with friends. I used to foster rescue dogs, but I wanted to adopt too many of them, it just wasn't sustainable! We live with our "failed foster" dog, Harrold, a massive St. Bernard.

What inspires you?

Volunteers who work to make the world a better place. Every one of them. That includes luminaries such as Jane Goodall, the volunteer firefighters in my mountain district, and the citizen scientists and professional scientists working with them around the world.

Any favorite quote(s) that you would like to share?

If you think you are too small to make a difference, try sleeping with a mosquito." The Dalai Lama.

The following video interview is also available: *video*.

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Lesson 8 Career Profile

Ryan Tappel, PhD
*Senior Scientist of Synthetic Biology
and Entomology
LanzaTech*

What do you do and how did you get here?

The thing that motivated me to pursue science in general was my love of the environment and wanting to do something that feels meaningful to help address global climate change. During my PhD, I worked on creating new plastics that bacteria could degrade, but afterwards it was hard to find a job in environmental related research. I kept in touch with a friend who happened to start work at LanzaTech, and when he told me that they were hiring I said I would definitely love to interview. I love the mission of LanzaTech—to renew waste material. In this case, the waste is gasses like carbon monoxide and carbon dioxide. Instead of pumping them into the atmosphere, we capture them and use bacteria to eat those gasses to make different things. My role in the company is to engineer the bacteria to perform better and make new products.

What was your favorite subject in high school, and why did you love it?

Science! (Chemistry and Physics). I loved it because I had an excellent teacher whom I was comfortable with. I enjoyed the hands-on approach of the classes. Followed closely by History where I had another excellent teacher who pushed me to develop numerous adult/college-level skills that served me well.

If you could give a piece of advice to your younger self, what would it be?

To my high school self: first some comfort. It's okay that you don't know what you are doing, but keep trying new things. I did a lot of "wandering around" in college, not really knowing what I wanted to do. And that's ok! I'd remind myself to strive to be hardworking and kind.

What skills do you use on a daily basis?

I use chemistry, algebra, and organizational skills on a regular basis while doing DNA and protein sequence analysis. I also use conversational skills when presenting at conferences, meeting new people and conducting meetings, for example. There's just so much science to talk about!

What's most fulfilling about your job/ career? What's most challenging?

I hoped for a long time I would get to work in a setting where addressing global climate change was a core value, and I have found that at LanzaTech. What is challenging is managing the fast-pace and intensity of the projects we work on.

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Career Profile

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If you could have any superpower, what would it be?

I'd love to be able to bioengineer myself to have spider-like abilities. I want to crawl up walls!

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If you could instantly learn any language, which would you choose and why?

Chinese. It is the most-spoken language along with English, and I'd love to be able to communicate with more people.

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Favorite place to go?

I live in Chicago, and love visiting The Field Museum!

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Lesson 9 Career Profile

Aditya Kunjapur, PhD
Assistant Professor of Chemical and Biomolecular Engineering
University of Delaware

What is your current role, and how did you get there?

I'm a professor of chemical and biomolecular engineering at the University of Delaware. I actually didn't like biology as a kid because it seemed like memorization and I didn't want to be a medical doctor. But I loved math, chemistry, and physics in the classroom, and I really liked making things, so I chose to major in chemical engineering.

I also did that because I wanted to help decrease our reliance on fossil fuels for energy. I grew up in Houston, Texas—the capital of the oil and gas energy industry. I picked chemical engineering because I knew it could help me make an impact in the energy industry. Eventually I realized that microbes can be used to make biofuels, and that they can be engineered. Suddenly everything that felt like memorization before now felt like information I could use to design an engineered process to make something useful. (If you're more interested in my journey, here's a *YouTube video* where I talk about this.)

What's most fulfilling about your job/ career? What's most challenging?

It's really fulfilling to be an educator and scientist. I get to help advance the scientific frontier to tackle some of society's most pressing needs, all while working with incredibly talented and motivated students who I train to be the next generation of leaders. It's also a very challenging job, because our work takes a lot of resources, and securing those resources requires a lot of effort, skill, and luck.

What skills do you use on a daily basis?

One of the most useful technical skills that I use on a daily basis that is hard to describe is the ability to creatively connect the dots between two different things that people are talking about or doing. In my job, there's a high priority on doing something "innovative" or new, so I find that some of the best ideas come from drawing relationships between two different concepts, sometimes from very different areas. My favorite example of this is how Steve Jobs took a calligraphy class at Reed College before he dropped out to start Apple. Because of Steve's experience many years earlier at Reed College, Apple pioneered the concept of having different text fonts. This skill isn't strictly technical but can lead to lots of new approaches in science.

The soft skill that I use the most is listening to, and not just hearing, what people have to say. For the graduate students who do research in my lab, carefully listening to what they tell me and asking the right questions has been really instrumental in keeping everyone happy and productive.

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Lesson 9 Career Profile

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If you could give a piece of advice to your younger self, what would it be?

I would encourage my younger self to recognize that my local community/school might not have everything that I might be interested in, especially from a knowledge perspective (in other words, most high schools wouldn't even mention that microbes can be engineered to do various things). And so my advice would be to not be afraid to search on my own for other programs/opportunities to complement my school curriculum, especially during the summers. In modern times, I think the internet helps a lot with this, so it may not be as helpful advice now, but when I was growing up I definitely remember getting bored a lot at school and a little complacent because for a while I thought I knew everything.

If you could have any superpower, what would it be?

My superpower would be to read other people's minds. There's two big reasons I can think of.

1. I'm around a lot of smart people and would love to know what they're thinking and learn how they think.
2. I think I'd be a much more effective manager, colleague, mentor, husband, father, etc. if I could understand what other people were thinking.

If you could instantly learn any language, which would you choose and why?

I'd choose the programming language Python, because it's a versatile coding language and coding is such an important part of society now and for the future. That includes thinking about microbes because a lot of interesting genetic sequence data is available online and easier to find/manipulate if you are skilled at coding.