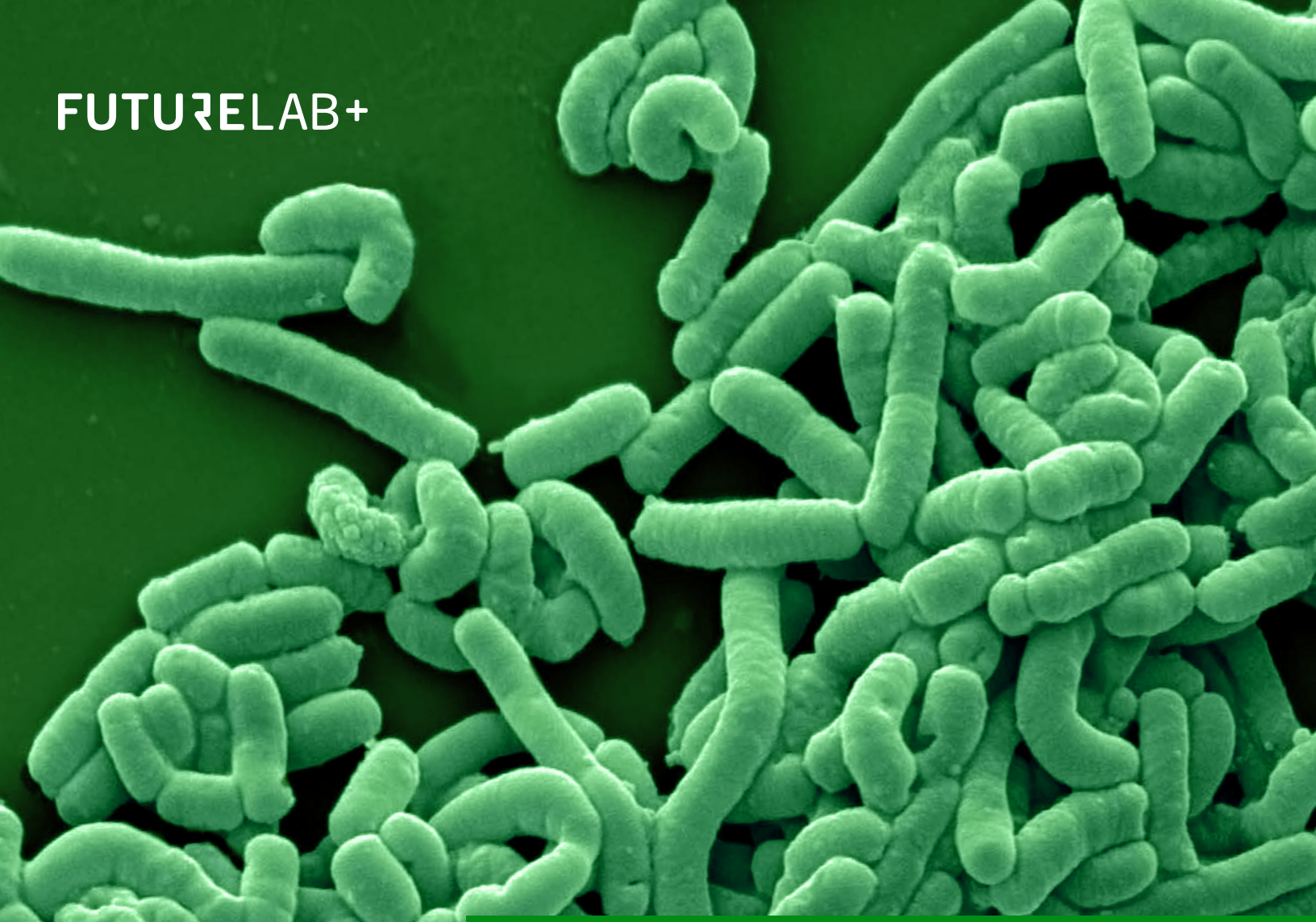
FUTURELAB+



AG/ENVIRONMENTAL

Solution Seeking Microbes

Unit Overview

Developed in partnership with:

Discovery Education and Ignited

AG/ENVIRONMENTAL / SOLUTION SEEKING MICROBES

Unit Overview

FINAL PROJECT PRODUCT

Micro-Con, a microbe superhero convention

OVERVIEW

In this unit, students will showcase how microbes might be used to provide solutions to local and global problems. Students will identify relationships between the microbiome and health through their own cultural lens, then design a menu where microbes are utilized in the production of food. They will investigate how antibiotic resistance arises, and explain the importance of using antibiotics appropriately. Students will understand the various techniques microbes use to defend against phages and examine the impact the phage-microbe relationship has on the environment, food production, and human health. They will then justify the choice of whether or not to utilize microbial defenses, such as CRISPR, for human benefit. Using an empathy interview, students will identify a problem involving climate change, disease, pollution, or food production. For their final project, students will research and prototype options on how to use microbes to solve issues surrounding health, the environment, or another community problems. These prototypes will be showcased in a culminating conference event called Micro-con.

STUDENT-FACING UNIT TASK

You 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 at “Micro-Con.” After identifying a local or global problem, you will ideate solutions, then select the option that best addresses the problem and stakeholders. You will research and prototype options on how to use microbes to solve issues surrounding health, pollution, or another community problem. You will present your ideas at Micro-Con, a three-day event where you will be on a panel to share your ideas and hear from your classmates about theirs. 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.

Lesson 1: Superhero Microbes

DRIVING QUESTION

Why are some microbes considered superheroes?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Explain why studying microbes is important to humans and the sustainability of the environment. **Identify** how microbes maintain their relationships with other living things. **Describe** how microbes are diverse due to their genetic components. **Analyze** how microbes have influenced human culture. **Evaluate** microbial metabolic processes (anaerobic, aerobic), enzymes, biosynthesis, chemo/autotrophs, gene regulation, and how these add to their microbial superpower. **Create** a model illustrating the structure and function of microbial components. **CTE**: 4.1, 4.3, 5.6, 7.4, A4.1, A5.1, A5.2	Students will be introduced to careers in the fields of **digital artistry**, **microbiology** and **marketing**. Students will explore the **discovery** phase of the product life cycle, which explores areas of promise.	Computers Modeling clay Blocks Microscopes (optional) Colored pencils/markers/pens Construction paper Prepared slides of different types of microbes String Toolkit Which Superhero Are You? Career Profile: Holly Lutz, PhD Bacteria Size Capture Sheet Microscope Slide Capture Sheet SEM Bacterial Pictures Superhero/Anime/Fantasy Creature Analogy Capture Sheet Superhero Microbe Storyboard Superhero Microbe Comic Rubric	In this lesson, students will choose and research specific microbes known to have an impact on the environment, food production, or human health. Students will create a cartoon/comic strip illustrating their microbes as superheroes.	Ultimately students will attend “Micro-Con” where they will showcase how they might use microbes to solve a real-world problem. This lesson highlights “superhero” microbes that already use their superpowers for the good of the environment, human health, or food production.

Lesson 2: Yogurt Fermentation

DRIVING QUESTION

How do microbes influence food and human health?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Design and **conduct** an investigation to determine how a particular variable affects kefir yogurt fermentation using scientific data and text. **Make** a claim about how the variable they changed affected the characteristics of their kefir yogurt and support it with evidence and reasoning using scientific text and experimental results. **Explain** the role of microorganisms in fermentation and the connection between the microbiome and probiotics using scientific text. **Ask** a testable question relating to the microbiome using SMART goals. **CTE:** A3.3, A4.2, A4.3, A8.1, 2.5, A8.7	Students will be introduced to careers in the fields of **microbiology** and **food science**. Students will explore the **discovery** and **manufacturing** phases of the product life cycle, which includes scaling up a new product for mass production and distribution.	Lab Preparation Phenomenon: Food Chart Background Reading: Effects of Variables on Yogurt Production Background Reading: Fermentation Background Reading: The Microbiome Background Reading: SMART Goals for Scientific Research Career Profile: Celeste Allaban, DVM Vocabulary Tool Student Protocol Student Guide Kefir 2% dairy milk and various plant based “milks” and/or animal milk Clean containers with lids Transfer pipette P1000 micropipette and tips can be used in place of transfer pipette 100-mL graduated cylinder Microwave Incubator and/or fridge Permanent marker and lab tape Dry waste beaker Sink or wet waste beaker	In this lab, students will observe the process of fermentation by making their own kefir yogurt. They will begin by observing milk and kefir samples under the microscope, and then predicting which can be used as a yogurt starter culture using their understanding of microorganisms. Students will then analyze data from previous studies showing how different variables influence yogurt production and choose one variable to change in their kefir yogurt fermentation experiment. They will then collect observational and pH data over a 48-hour period in order to determine how their changed variable affected the characteristics of the kefir yogurt. Students will also be given an opportunity to learn about connections between the microbiome and probiotics, as well as to generate their own testable question based on a real-world example from a scientist.	This unit connects how we can utilize microbes for human health and food production. The microbial relationship humans have with food production will be expanded on in an upcoming lesson.

Lesson 3: Microbes and Food (Menu)

DRIVING QUESTION

How are microbes used in food production?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Describe traditional agriculture methods used to produce various food items. **Explain** values of various roles, including an environmentalist, a financial analyst, a non-governmental organization (NGO) worker, and a food scientist. **CTE:** 2.5, 4.1, 4.3, 4.5, 5.6, 7.6, 9.3, 9.5, A1.1, A1.3, A1.6, A5.1, A7.1	Students will be introduced to careers in **food science**, **environmental science**, and **financial analysis**. They will also learn about **Non-Governmental Organization (NGO) food aid employees**. As students are identifying a sustainable microbe product alternative to current food, this connects to the **development** phase of the product life cycle.	Poster paper Markers/colored pencils Internet access/ computers Example household goods to physically show students: lipstick, instant noodles, soap, detergent, cookies, chocolate, shampoo etc. Microgrub Research Capture Sheet Microgrub Research Capture Sheet Key Synthetic Biology Article Toolkit Microgrub Poster Checklist Career Profile: Chelsey Spriggs	In this lesson, students will learn about how microbes contribute to producing food and food alternatives, comparing and contrasting with traditional approaches. Ultimately, they will create a food item that will be featured on the menu that could be served at “Microgrub” and explain how microbes were used in the creation of their food on their menu poster. By advertising their product and explaining where it will be marketed and why, students will incorporate various stakeholders to ensure their product meets the needs of the community they aim to serve.	Microbes are being used to create alternative proteins and nutrients in foods for humans and feedstocks for animals. This is a way that microbes are contributing to human health, the environment, and food production.

Lesson 4: Antibiotics, Resistance, and Combating Disease

DRIVING QUESTION

How are new treatments and therapies safely tested on humans?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Understand the basic phage life cycle. **Identify** how antibiotic resistance arises. **Explain** how bacteriophages and antibiotics can be used in combination to combat superbugs. **Analyze** a clinical trial to determine if the trial is deemed safe for patients. **CTE:** 4.1, 4.3, 5.3, 5.6, 10.1, A2.4, A5.1, A6.4, A7.2	Students will explore the work of **clinical research coordinators**. The emphasis on treatment safety (and the earlier discussion of how phage therapy is a medical solution that avoids antibiotic resistance) connects to the **development** phase of the product life cycle.	Antibiotic Resistance Simulation Capture Sheet When the Virus is the Cure Capture Sheet Clinical Trials Gone Wrong Reading Phage Therapy Clinical Trial Overview Clinical Trials for a New Phage Therapy Capture Sheet Career Profile: Ariangela J. Kozik, PhD Toolkit	In this lesson, students will investigate these so-called "superbugs," which are bacteria that have become resistant to most antibiotics. While learning about superbugs, students will understand the role of improper use of antibiotics in the emergence of antibiotic-resistant bacteria. Students will then learn about phage therapy as a potential next step in attacking superbugs. In the end, students will analyze a proposed clinical trial and determine if it is safe for a patient to participate in this clinical trial, taking into consideration the risks and benefits. Students will point out where concerns or clarifications are needed in the clinical trial.	This lesson focuses heavily on solving health-related problems by using microbes. Although previous lessons have focused on superhero bacteria, this lesson shifts to highlight that some bacteria have negative effects and can be combated using microbes, including antibiotics and phage therapy. This lesson builds toward students analyzing a clinical trial, which would be an important step in any microbe-related solution to human health problems.

Lesson 5: Bacterial Defense

DRIVING QUESTION

How do bacteria defend themselves against pathogens?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Describe the impact phages have on our food, global nutrient cycling, and human health. **Identify** specific bacterial defenses and weapons against invading phages. **Apply** the understanding of the evolutionary "arms race" between phages and bacteria to their own "superhero/ supervillain." **Explain** how restriction enzymes and CRISPR-Cas9 work as bacterial defense mechanisms. **CTE:** 4.1, 4.3, 4.5, 5.6, 7.8, 9.5, A1.1, A1.3, A1.6, A3.3, A3.5	Students will explore the careers of **molecular biologists** and **science writers**. In this lesson, students will learn about how bacteria and our human immune systems protect themselves from invading viruses, and use this to launch research focused on how restriction enzymes and CRISPR-Cas9 have been used in gene editing. This connects to both the **discovery** aspect of the product life cycle, as students learn about how and why novel products are designed, and to the **development** aspect of the product life cycle as students learn about the technologies and methods used in creating new products.	Poster paper (drawing models) Tape Modeling clay Construction paper Pipe cleaners Toothpicks Building blocks Popsicle sticks Scissors Duct tape Bacterial Defense Strategies Capture Sheet Career Profile: Kevin V. Solomon, PhD Restriction Enzymes Capture Sheet Toolkit Restriction Enzyme Capture Sheet History of CRISPR-Cas9 Reading History of CRISPR-Cas9 Capture Sheet CRISPR-Cas9 Capture Sheet CRISPR-Cas9 Interview Capture Sheet What is Sickle Cell Disease Reading What is Sickle Cell Disease Capture Sheet CRISPR-Cas9 Model mRNA Codon Chart Barriers to CRISPR-Cas9 Therapies Capture Sheet Microbe Phage Scenario Articles	In this lesson, students will be introduced to the various ways bacteria defend against viruses, including restriction enzymes and CRISPR-Cas9. Students will initially brainstorm and observe different types of strategies for phage defense, and then focus specifically on the structure and mechanism of restriction enzymes and CRISPR-Cas9. Curiosity and observation are key characteristics of the scientists who discovered and studied CRISPR-Cas9. Also, students will be asked to create a "tweet" based on their understanding of one of the researchers. This helps students identify with the scientists.	As the intention is for students to identify problems and how microbes might solve them, it is important for students to first see how microbes have solved their own problems in the form of defense against viruses. Furthermore, humans have harnessed the power of microbial defense mechanisms, such as restriction enzymes and CRISPR-Cas9, and utilized them in an engineering "toolkit." Additionally, as the opening lesson involves yogurt, it is a great tie back to the initial lesson on microbes, as CRISPR-Cas9 has been in yogurt all along!

Lesson 6: Uses of CRISPR and Bioethical Decision-Making

DRIVING QUESTION

Why are bioethical considerations important when making decisions about biotechnology?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Identify the components of bioethics: stakeholders, morals, and values. **Make** a justified decision based on facts from the case and the values of all stakeholders. **Understand** why the principles of bioethics are used in decision-making processes. **CTE:** 4.1, 5.6, 7.4, A2.1, A2.2, A2.4, A4.1	Students will explore the careers of **bioethicists**. In this lesson, students use an ethical decision-making framework to consider the implications of CRISPR technology around embryonic development. This discussion relates to both the **commercialization** phase of the product life cycle, as government agencies and other bodies are involved with regulating new technology, and to the **development** phase of the product life cycle when industries are considering the safety and ethics (cost/benefit) of new potential products.	Computers with internet access Career Profile: Lydia M. Contreras, PhD Decision-Making Framework Capture Sheet Ethical Case Study Values and their Definitions CRISPR Twins: Bioethical Decision-Making Article Bioethical Decision-Making Capture Sheet Example Ethical Justification Toolkit	In this lesson, students will consider the principles of bioethics and how difficult decisions are made using a decision-making framework. An example case study (or case studies) that are focused on the historical context of bioethics and the Belmont Report will be explored as small groups and whole class discussion with teacher scaffolding. Students will then apply the principles to CRISPR technology (connecting to the previous lesson) in small groups. Students will analyze other groups' decisions using a rubric.	Any time new scientific information or techniques emerge, the question of "should we do this?" can be explored. A class in biotechnology is an ideal course to learn the bioethical decision-making process. The previous lesson focuses on CRISPR-Cas9 genome editing as a tool derived from microbes. As much as this tool has tremendous potential, there are difficult questions that need to be answered surrounding its use, especially when thinking about embryonic or germ-line genome editing. Furthermore, the next lesson in this unit will focus on using microbes (*Wolbachia*) to eradicate disease. CRISPR gene drives could also do the same. Bioethics can be explored again in the next lesson when the ethical question of "Should we eradicate certain disease-transmitting insects?" will be explored.

Lesson 7: Detecting *Wolbachia*—A Microbe to Control Disease

DRIVING QUESTION

How can infection with *Wolbachia* impact insect populations and be used to solve problems, such as insect-borne disease?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Ask questions and **make observations** about how *Wolbachia* bacteria can be used as a tool to control mosquito-borne disease using a video. **Describe** the reproductive effects of *Wolbachia* on insects using scientific text. **CTE:** A3.3, A3.5, A8.1, 2.5, A8.7, A8.8, A8.9	Students will be introduced to careers in the fields of **microbiology**, **research associates**, and **entomology**. This connects to the **discovery** part of the product life cycle. Before developing a new product or process, scientists often first look in nature to identify and research potentially useful organisms and compounds.	Lab Preparation (for teacher) — Thermal Cycler Grid — Background Reading: *Wolbachia* (Jigsaw) — Background Reading: What is Polymerase Chain Reaction (PCR)? — Background Reading: Analyzing *Wolbachia* PCR Results — (1 per student) Career Profile: Dr. Rusty Lowe Vocabulary Tool Student Protocol, Part 1: Insect DNA Extraction and PCR Student Protocol, Part 2: Gel Electrophoresis Student Guide Reagents Lab Part 1: DNA Extraction and PCR — Lysis Buffer — 5M NaCl — TE/RNase — 91–100% Isopropanol — *Wolbachia* Master Mix — *Wolbachia* Primer Mix — Positive control DNA (15 µL PCR product per gel) — dH2O (15 µL PCR product per gel) Lab Part 2: Gel Electrophoresis — 1X TAE running buffer — 2% agarose gel with DNA stain — 10X loading dye — 100 bp ladder Lab Part 1: DNA Extraction — P1000 micropipettes — P1000 tips — P200 micropipettes — P200 tips — P20 micropipettes — P20 tips — 1.5 mL microtubes — PCR tubes — Microtube rack — PCR tube rack — Centrifuge — Thermal Cycler — Heat block set at 99˚ C — Cap locks — Permanent marker — Dry waste beaker — Sink or wet waste beaker — Ruler with millimeters — Crushed ice — Plastic micropestles Lab Part 2: Gel Electrophoresis — P20 micropipettes — P20 tips — Microtube rack — Dry waste beaker — Sink or wet waste beaker — Electrophoresis gel setup — UV light source and UV safety goggles (if needed)	In this lab, students first collect an insect from their local environment and extract its DNA. They then use PCR (Polymerase Chain Reaction) to detect the presence or absence of the Wspec gene of *Wolbachia* in the DNA sample. After visualizing their PCR results using gel electrophoresis, they collect class data to determine the *Wolbachia* infection rates among the local insect populations they sampled. Finally, they conduct further research to explain how *Wolbachia* impacts insect populations and how it might be used to mitigate an insect-associated problem.	An important part of using microbes to solve real-world problems is to first understand their role in nature. This allows us to identify mechanisms that we can then exploit for a particular purpose. This lab provides students with an opportunity to detect a particular microbe in their environment (*Wolbachia*) and to explore how it might be used to solve a problem.

Lesson 8: Microbes and Balance in the Environment

DRIVING QUESTION

How can we engineer microbes to convert waste products into something useful?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Identify the connection between greenhouse gas levels (CO_2) and climate. **Analyze** sources of CO_2 emission and prioritize sources that need to be addressed. **Explain** how microbes can be engineered to transform waste products. **CTE:** 2.4, 4.1, 4.3, 4.5, 5.6, 7.8, A1.3	Students will be introduced to the career fields in **environmental science, sustainability engineering, bioprocess engineering,** and **biochemical engineering**. In this lesson, students learn about how new technologies utilizing microbes are being implemented in facilities to reduce CO_2 emissions and identify local facilities with high emissions to hypothetically persuade them to incorporate these technologies. This relates to the **commercialization** phase of the product life cycle as new technologies are incorporated throughout the world.	CO_2 Data Extrapolation Capture Sheet Climate Change Simulation Capture Sheet Using Microbes for CO_2 Emissions Reading Greenhouse Gas Emissions from Large Facilities Capture Sheet Microbes to the Rescue Capture Sheet Career Profile: Ryan Tappel, PhD Toolkit	Students will review greenhouse gases, specifically carbon dioxide (CO_2) emissions, and their effects on climate in order to understand the problem and the urgency to address it. Once students have grasped the importance of dealing with these emissions, they will explore the emissions' sources, focusing primarily on industry. Students will analyze a case study modeled after a United States-based company that is using engineered microbes to convert CO_2 emissions from a steel mill into useful products, such as biofuel.	One of the possible main topics students will be addressing in their final project is using microbes to positively impact the environment. In this lesson, students will be learning how microbes are currently being used to reduce pollution and emissions. The main goal is for students to understand that microbes can be modified to complete the reactions that will transform something harmful to the environment into something less harmful, reducing human impact.

Lesson 9: Design Thinking to Identify Challenges

DRIVING QUESTION

How can we use the principals of design thinking to identify local and global challenges that can be solved with microbes?

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
Apply the principles of design thinking to **develop** solutions to a simple challenge for a partner in class. **Develop** empathy for the people they are interviewing. **Identify** local and/or global challenges using the principles of design thinking. **CTE:** 2.1, 2.2, 4.1, 4.3, 5.1, 5.6, 7.4, 7.8, A1.3, A1.5	Students will be exposed to careers in **product design** and **journalism.** Through surveying and interviewing users, and developing an understanding of empathy and human driven design principles, students engage deeply in the **development** and **discovery** phases of the product life cycle. They begin defining a problem that microbial engineering can solve (**discovery**) and begin to create surveys and feedback mechanisms for their target audience (**development**).	Poster paper (drawing models) Tape Modeling clay Construction paper Pipe cleaners Toothpicks Building blocks Popsicle sticks Scissors Duct tape Pens Pencils Career Profile: Aditya Kinjapur, PhD Design Thinking Capture Sheet Example prototype/ student sample Micro-Con Challenge Topic Research Capture Sheet Designing and Revising Interview Questions Capture Sheet Interview Guidelines Resource Toolkit	In this lesson, students will be introduced to the concepts of design thinking with an informal practice day where students will interview each other to identify generic challenges and design solutions to each other's challenge. Once students have a general idea of how to interact with the process of design thinking, they will use these concepts to design interview questions, research themed local and global challenges (climate change, disease, pollution, or food production), and conduct interviews of self-sought community participants. Students will showcase their design solutions in the next lesson in an event called "Micro-Con."	By this lesson, students have learned the structure of microbes, where microbes are found, the diversity of microbes, how to take care of them, microbe superpowers, and how humans have utilized microbes. This lesson connects to the larger storyline by teaching students how to connect with their community, design interview questions, and identify challenges in order to solve a challenge using microbes. By identifying a challenge, students will then be able to identify a potential microbe that will be their superhero, what superpowers the microbe will need to solve the challenge, or how the weapons or shields of this superhero microbe might be able to be used by humans to solve their challenges.

Lesson 10: Microbes to the Rescue

DRIVING QUESTION

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

Student Objectives and CTE Standards	Connections to Careers and the Product Life Cycle	Lesson Materials	Lesson Overview	Phenomena and Connection to the Unit Storyline
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. **CTE:** 3.4, 4.1, 4.3, 5.1, 5.6, 7.4, 7.7, 7.8, 9.5, 9.7	Students will explore careers as **scientists** and **costume designers**. 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 **discovery** 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 **manufacturing** phase, even if their products are not yet developed to that level.	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 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 Allaban), 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	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 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.	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?"

Career and Technical Education (CTE) Standards

Anchor Standards

2.0 Communications
Acquire and accurately use Health Science and Medical Technology sector terminology and protocols at the career and college readiness level for communicating effectively in oral, written, and multimedia formats.

2.1
Recognize the elements of communication using a sender–receiver model.

2.2
Identify barriers to accurate and appropriate communication.

2.4
Demonstrate elements of written and electronic communication, such as accurate spelling, grammar, and format.

2.5
Communicate information and ideas effectively to multiple audiences using a variety of media and formats.

3.0 Career Planning and Management
Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans.

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

4.0 Technology
Use existing and emerging technology to investigate, research, and produce products and services, including new information, as required in the Health Science and Medical Technology sector workplace environment.

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.

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Career and Technical Education (CTE) Standards

Anchor Standards

Continued

4.5
Research past, present, and projected technological advances as they impact a particular pathway.

5.0 Responsibility and Flexibility
Conduct short, as well as more sustained, research to create alternative solutions to answer a question or solve a problem unique to the Health Science and Medical Technology sector using critical and creative thinking, logical reasoning, analysis, inquiry, and problem-solving techniques.

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

5.3
Use systems thinking to analyze how various components interact with each other to produce outcomes in a complex work environment.

5.6
Read, interpret, and extract information from documents.

7.0 Responsibility and Flexibility
Initiate and participate in a range of collaborations demonstrating behaviors that reflect personal and professional responsibility, flexibility, and respect in the Health Science and Medical Technology sector workplace environment and community settings.

7.4
Practice time management and efficiency to fulfill responsibilities.

7.6
Demonstrate knowledge and practice of responsible financial management.

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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Career and Technical Education (CTE) Standards

Anchor Standards

Continued

9.0 Leadership and Teamwork

Work with peers to promote divergent and creative perspectives, effective leadership, group dynamics, team and individual decision-making, benefits of workforce diversity, and conflict resolution as practiced in the Cal-HOSA career technical student organization.

9.3
Understand the characteristics and benefits of teamwork, leadership, and citizenship in the school, community, and workplace setting.

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.

10.0 Technical Knowledge and Skills

Apply essential technical knowledge and skills common to all pathways in the Health Science and Medical Technology sector, following procedures when carrying out experiments or performing technical tasks.

10.1
Interpret and explain terminology and practices specific to the Health Science and Medical Technology sector.

Health Science and Medical Technology Standards

A1.0

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

A1.1
Use data to explain how biotechnology fields such as pharmaceuticals, agriculture, diagnostics, industrial products, instrumentation, and research and development are impacting human life.

A1.3
Recognize the role of innovation in creation of emerging biotechnology careers, including those in nanotechnology, biofuels, and forensics.

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Career and Technical Education (CTE) Standards

Health Science and Medical Technology Standards

Continued

A1.5
Evaluate the impact of biotechnological applications on both developing and industrial societies, including legal and judicial practices.

A1.6
Explore and outline the various science and non-science fields and careers associated with biotechnology.

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

A2.1
Know the relationship between morality and ethics in the development of biotechnology health care products.

A2.2
Know the difference between personal, professional, and organizational ethics.

A2.4
Understand the critical need for ethical policies and procedures for institutions engaged in biotechnology research and product development.

A3.0
Demonstrate competencies in the fundamentals of molecular cell biology, including deoxyribonucleic acid (DNA) and proteins and standard techniques for their purification and manipulation.

A3.3
Employ standard techniques of DNA extraction, purification, restriction digests, bacterial cell culture, and agarose gel electrophoresis and document and evaluate results.

A3.5
Predict outcomes of DNA and protein separation protocols.

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Career and Technical Education (CTE) Standards

Health Science and Medical Technology Standards

Continued

A4.0
Recognize basic concepts in cell biology and become familiar with the laboratory tools used for their analysis.

A4.1
List and describe the structure and function of cellular organelles.

A4.2
Describe conditions that promote cell growth under aseptic conditions in the laboratory and workplace.

A4.3
Use various methods to monitor the growth of cell cultures.

A5.0
Integrate computer skills into program components.

A5.1
Use the internet and world wide web to collect and share scientific information.

A5.2
Use a variety of methods, including literature searches in libraries, computer databases, and online, for gathering background information, making observations, and collecting and organizing data.

A6.0
Implement use of the metric system, orders of magnitude, and the pH scale in preparation of reagents, analysis of data, and graphing.

A6.4
Create data tables and graphs using Excel to collect and analyze data.

A7.0
Understand the function of regulatory agencies for the biotechnology industry and the lasting impact of routine laboratory and communication practices on product development and manufacturing.

A7.1
Identify agencies at the local, state, and federal levels.

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Career and Technical Education (CTE) Standards

Health Science and Medical Technology Standards

Continued

A7.2
Be aware of the role of agencies in promoting patient safety, quality control, and entrepreneurship.

A8.0
Follow sustainable and safe practices with high regard for quality control.

A8.1
Follow written protocols and oral directions to perform a variety of laboratory and technical tasks.

A8.6
Properly and safely use and monitor a variety of scientific equipment, including pH meters, microscopes, spectrophotometers, pipettes, micropipettes, and balances.

A8.7
Determine which equipment is appropriate to use for a given task and the units of measurement used.

A8.8
Perform specimen collection, label samples, and prepare samples for testing.

A8.9
Handle, transport, and store samples safely.

Third Party Evaluator Evidence/Findings

Completed by: American Institutes for Research

Sponsored by Genentech, Futurelab+ brings together a coalition of partners to develop an innovative, modular, two-year biotechnology curriculum, including instructional materials, to expose students and educators to the breadth of education and career pathways across biotechnology. To increase adoption and access to such curricula in California and beyond, the modular curriculum was designed to align with the *California Career Technical Education (CTE) Model Curriculum Standards for Biotechnology*, meet at least one year of the *University of California science (D) subject requirement*, and incorporate some of the three-dimensional learning innovations of the *Next Generation Science Standards* (NGSS).

The two-year biotechnology curriculum provides four core units per year; each core unit has nine lessons and a lab that each take approximately one week to complete, or 9–10 weeks for the full unit. In total, the biotechnology curriculum has 72 lessons and eight labs that span two full instructional years. Because the Futurelab+ biotechnology curriculum is modular, teachers can select specific units and materials to design biotechnology courses that are relevant and appropriate for their students and teaching environment.

Unit 5: Solution Seeking Microbes

Version Reviewed/Date: May 31, 2022

California (CTE) Model Curriculum Standards for Biotechnology

Full Report

[Futurelab+... priority to meet California CTE Biotech Standards...] Evidence of which California CTE Biotechnology standards are addressed within the curriculum and where they are addressed is included in the *full report*.

University of California Science (D)

Full Report

Because teachers and schools can choose which portions of the curriculum to include in their final course designs, this *report series* provides evidence of where each unit meets specific criteria for the UC science (D) subject requirement and, when incorporated into a full year-long course, where the curriculum could meet at least one year of the UC science (D) subject requirement, contingent upon review and approval by UC. Subsequently, the evidence provided within the report can be used by teachers for submitting Futurelab+ course materials for UC science (D) subject approval.

The purpose of this report is to provide evidence for alignment of Unit 5 of the Futurelab+ Biotechnology Curriculum with the UC science (D) subject requirement. To help educators submit their final courses for UC science (D) subject review, the American Institutes for Research (AIR) also provides a sample unit and lab summaries, which follow the guidelines for writing a UC science (D) course (March 17, 2021).

Specifically, AIR reviewed each unit for evidence of the extent to which they meet the eight Course Content Guidelines for the UC science (D) subject requirement. This report provides specific examples to demonstrate where and how materials satisfy these criteria. Based on our review, we believe there is a strong body of evidence that will translate to Unit 5 meeting the UC science (D) subject matter requirement.

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Third Party Evaluator Evidence/Findings

Continued

Next Generation Science Standards (NGSS)

Full Report

As an organizational partner, the American Institutes for Research (AIR) provided external feedback on alignment to the three sets of standards to Futurelab+ curriculum developers during the formative period of the biotechnology curriculum. AIR is now providing external feedback and evidence on the final curriculum's alignment to each set of standards: CTE, UC science (D) subject requirement, and NGSS in a series of three reports. The eight reports in the NGSS series provide feedback on aspects of NGSS in a sample of the curriculum (one lesson from each unit). Developers selected the lab activity, Yogurt Fermentation, from Unit 5 (Solution Seeking Microbes) for this report.

Of note, because the primary design element of the curriculum was alignment to CTE, AIR used the NGSS Lesson Screener (not the Educators Evaluating the Quality of Instructional Products [EQuIP] Rubric) to identify aspects of the curriculum that incorporate NGSS. The EQuIP Rubric is typically used to determine whether a unit was designed for the NGSS. Because the curriculum was designed to align primarily to CTE standards, it was not expected that the curriculum would meet all NGSS criteria. Nevertheless, in their current form, the materials from Unit 5 Laboratory Investigation: Yogurt Fermentation meet four and approach two of the six criteria. AIR created the approaching rating to indicate where a modification to materials would increase the rating to adequate. For more information, please see the *full report*.