LESSON

Emerging Tech

Grade Levels: 7-12

Duration: 3 Sessions (60 min each)

PRESENTED BY Ford

In this lesson, students examine environmental issues through the lens of four emerging technologies. They consider the challenges these technologies might face if they were adopted in their own communities. Working in teams, students will develop both a potential solution and a pitch to address possible challenges.

Outline

Session 1: Define the Problem	60 min
In this first session students are introduced to the four emerging environmental technologies. Teams begin researching the challenges and potential impacts of one of the technologies.	
Session 2: Develop Solutions	**60 min**
Teams brainstorm potential solutions and prepare for their pitch.	
Session 3: Pitch Ideas	**60 min**
The project culminates as teams pitch their ideas and give feedback. Students evaluate how their impressions of the technologies have changed.	

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Duration: 3 Sessions (60 min each)

Concepts/Skills

Sustainability, problem-solving, systems design, presentation skills

Objectives

Students will:

- Evaluate four emerging technologies and the impact they could have on their community and the broader environmental crisis.
- Identify problems facing one of the technologies based on background information and research.
- Work in groups to develop a solution to these challenges.
- Present their solution to their peers with a short pitch.

Materials and Preparation

Per class	*Per team*	*Per student*
□ Device to play videos □ 8 sheets of chart paper □ **4 Emerging Tech Videos:** • **Blue Planet** (*1:38 min*) • **Mango Materials** (*1:29 min*) • **SkyCool** (*1:32 min*) • **UPSIDE Foods** *(formerly Memphis Meats)* (*1:30 min*)	□ 3 sheets of chart paper □ 1 set of markers □ **Emerging Tech Profiles** • Blue Planet • Mango Materials • SkyCool • UPSIDE Foods *(1 copy for each student on the team)* □ Presentation tools (see **Pitch Options**)	□ **Emerging Tech Project Guide** □ 2-3 sheets of scratch paper □ Pen, pencil or other writing utensil □ 20 sticky notes □ *Optional*: 4 small stickers for ranking (ex: stars, dots or money) □ 2-3 copies of **Pitch Feedback Form** (Session 3 only)

Tech Tips

See our **educator guides and videos** for more design challenge facilitation techniques.
For this lesson check out:

- Innovation Design Process
- Brainstorming
- Sharing Solutions

Preparation

1. Review all of the resources to become familiar with the material:
   - 4 **Emerging Tech Videos**
   - 4 **Emerging Tech Profiles**
   - **Emerging Tech Project Guide**
   - **Pitch Feedback Form**
2. Divide students into teams of 3-6 and assign each team one of the four technologies. (If possible, have at least two teams working on each of the technologies.)
   - Prepare one **Emerging Tech Profile** for each student based on their team assignment.
3. Prepare for the Community Vote in Sessions 1 and 4 by writing the names of each of the technologies on four different chart papers. Place them around the room.
4. Set up and organize materials for student brainstorming.
5. Determine the format, tools, process and audience for student presentations. See **Pitch Options** (on the next page) for specific ideas. You will introduce students to the presentation tool(s) and format in Session 2.

Pitch Options

There are a number of options for pitch presentations which can vary from an informal class discussion to a formal event. Choose a style and tools that fit your resources and focus. When possible, involve students in the planning and process, especially if you are able to invite special guests to attend.

Presentation Tools

- Posters
- Slide decks
- Videos
- Online tool (document, web page, etc.)
- Solution prototypes (storyboards, 3D models, diagrams, etc.)

Audience

With any of these options, consider inviting special guests to attend as representatives from the community:

- Another group of learners
- Family and friends
- Professionals or community stakeholders (*For example*: city council members, engineers, environmental groups, etc.)

Process

- **Pair Share:** Pair up groups and have them take turns presenting and giving feedback.
- **Quad Share:** Four groups, each focused on a different emerging technology, take turns presenting and giving feedback.
- **Gallery Walk:** Teams stand by their materials and present. Teams can take turns walking around as "audience members" and presenting.
- **Shark Tank:** A panel of special guests (adults/community members or other students) serves as the audience, hears ideas and gives feedback.
- **Asynchronous:** Teams share their work online (web page, documents or videos) and receive feedback via an online form.

Consider combinations of these options as well. *For example:* Shark Tank followed by a gallery walk while the panelists discuss and prepare their feedback.

Adaptations for Distance Learning

- Have students research their technologies asynchronously.
- Use an online collaborative tool for brainstorming and creation (Jamboard, Slides, Padlet, Seesaw, etc.) (synchronously or asynchronously).
- Have teams or students develop their solutions asynchronously and come back together for feedback and pitches.
- Invite special guests to a virtual pitch and celebration.

For more tips on adapting Design Challenges to a virtual setting, see our **Educator Tips for Remote STEM Learning**.

Background Information

The **Solve For Earth** exhibition at The Tech Interactive explores the connections between technology and living sustainably on Earth. The Emerging Technologies section of the exhibition features videos about the work of innovators on the forefront of science and engineering who are developing solutions for how we live sustainably in the face of climate change. These forward thinkers asked questions about the world around us and then worked to find the answers to those questions.

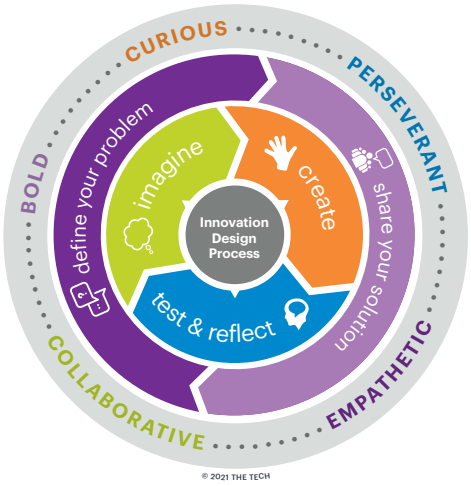
The simplest things inspire innovators to investigate the most complex problems: How do people living without electricity in the desert keep water cool? How can we make use of bacteria as tiny little factories? Put together, these stories of inventors and their solutions share the spirit of innovation and act as sources of inspiration. Students will see that anyone and everyone is a problem-solver.

This lesson examines four of these Emerging Technologies:

- **Blue Planet Ltd.** has developed a process to permanently store CO_2 coming from power plants and factories by incorporating it into building materials like aggregate and concrete.
- The three women entrepreneurs behind **Mango Materials** are making bioplastics using methane gas from landfills and wastewater treatment plants.
- **SkyCool** panels use the heat absorbing power of the sky to make any cooling system more efficient.
- **UPSIDE Foods**' lab grown beef, chicken, and duck reduce water and land use along with CO_2 emissions.

Systems Design Challenges

Systems Design Challenges present students with a real-world problem that is part of a complex system. Students examine the intricate parts of that problem as they design potential solutions. By the end of a systems design challenge, students will be able to articulate a potential solution, the real-world problem it addresses, and the effects their idea might have on other components of that larger system. Systems Design Challenges use the **Innovation Design Process** and the **Innovator Mindsets**. This focus on the process builds students' problem-solving capacity and self-confidence, preparing them for careers of the future and empowering them to create change in the world.



Frame the Challenge

Frame the Challenge	22 min
Activate Prior Knowledge	5 min
Introduce Emerging Technologies	10 min
Initial Community Vote	7 min
Systems Design Challenge	**38 min**
Introduce the Challenge	5 min
Researching	18 min
Sketch Success	10 min
Debrief	5 min

Activate Prior Knowledge *(5 min)*

1. Lead students in a discussion about their existing knowledge of some of the larger environmental issues facing the world today.
2. Use some of these **Guiding Questions**:
   - *What are some of the problems facing our environment?*
   - *What are some of the environmental issues affecting you or your community?*
   - *What are some technologies that try to address environmental issues?*
3. It may be useful to make a list or mind map of some of the issues students mention on the board.
   - Point out the interconnections of some of these issues and the complexity of solving these problems. *For example:* Students may mention pollution and plastic waste; these issues are interrelated as factories that generate plastics also create pollution.

Introduce Emerging Technologies *(10 min)*

1. Let students know that during this project they will examine four technologies that aim to create sustainable solutions to some of these problems.
2. Distribute the **Emerging Tech Project Guide** for students to take notes during the videos.
3. Play the videos for the class. Pause after each video to briefly discuss the issues/solutions introduced and add to your mindmap.
   - **Blue Planet**: Carbon sequestration (*1:38 min*)
   - **Mango Materials**: Bioplastics (*1:29 min*)
   - **SkyCool**: Rooftop radiative cooling panels (*1:32 min*)
   - **UPSIDE Foods**: Lab grown meat (*1:30 min*)

Initial Community Vote *(7 min)*

1. Tell students that you'd like to get a sense of their initial impressions of these technologies.
2. Have them silently consider and take notes on this prompt:
   - *Imagine you could choose two of these technologies to bring to your local community. Which ones would you pick and why?*
3. Refer students to the 4 different chart papers with each of the technologies.
   - *Students should "vote" for the two technologies they would choose by placing a tally mark (or sticker dot) on that chart paper.*
   - *Once everyone has voted, have volunteers help total the responses. Together notice and reflect on the top two technologies that the class thought the community should adopt.*

Note: Save these results to revisit in Session 3. At the end of the challenge, students will do this exercise again and notice if their personal opinions and those of the larger group have changed.

Systems Design Challenge

Introduce the Challenge *(5 min)*

1. Introduce the **design scenario**:

> *You are the Research and Development team for one of these emerging technologies and you want to convince your community to adopt this sustainable technology. The community is only adopting two new initiatives/ technologies this year, and you need to convince them that yours is worth implementing and investing time and resources in. Your team will need to research the issues that might prevent the technology from being adopted and determine a solution to help it succeed within your community. You will then pitch your solution to the community, who will vote on two technologies to adopt.*

2. Share that, in tackling this challenge, they will use the **Innovation Design Process**.
   - Explain that students will examine a complex systemic design problem, develop solutions to the problem, and then share and present their ideas.
   - Note that the design process is iterative and they will revisit phases throughout.
3. Explain the design problem and pitch. Address any questions students have:

Design Problem	New technologies can run into numerous problems during the implementation process. Imagine the barriers to adoption your technology might face in your community and develop a solution to help your technology succeed.	
Pitch	• General information about the technology, including implementation/ adoption challenges it might face in your community. • Your team's solution to those challenges. (including what successful adoption of this technology looks like) • How this technology would positively impact your community.	

4. Divide students into teams, then assign and distribute the **Emerging Tech Profiles**.
   - **Blue Planet**
   - **Mango Materials**
   - **SkyCool**
   - **UPSIDE Foods**
5. In addition, provide teams with scratch paper, writing utensils, chart paper and sticky notes as needed.

Scenario Adaptation

Choose a specific audience for the pitch. Focus on one aspect of the local community (school, city, county, state). *For example*: You want to convince your school to adopt this technology.

- During the Pitch Presentations, the audience will take on these professional roles. (*Depending on the focus this might include*: school board member, city council member, community action group, local corporation on the sustainability council, county officials, state legislators).
- Invite local community members who have these roles to participate as the authentic audience.

Researching *(15 min)*

1. Have students read the background information about their technology.
   - Try a jigsaw reading in which they divide the reading between team members and share what they have learned with each other.
   - Students should use the information and questions in the **Emerging Tech Profile** to guide their discussion.
2. During the research process, ask teams questions to help facilitate deeper understanding. **Sample Questions** include:
   - *What would it take for your technology to be widely adopted?*
   - *What are some problems that would affect the growth of this technology and how would you address them?*
   - *How would your technology help your community? What aspects of the technology might be difficult to implement in your communities?*
   - *What are some of the possible consequences of not adopting the technology?*
   - *What questions might community members have about this technology? How might you address these concerns?*
   - *Are there other technologies out there that already address a similar need?*
3. By the end of their research, teams should have written down:
   - Summary/overview of the technology
   - Several challenges it might face being implemented in their community

Additional Research

Encourage teams to conduct additional research on the topic throughout the entire design process. This can be done through background information and **Resources** you provide or their own research online.

Sketch Success *(10 min)*

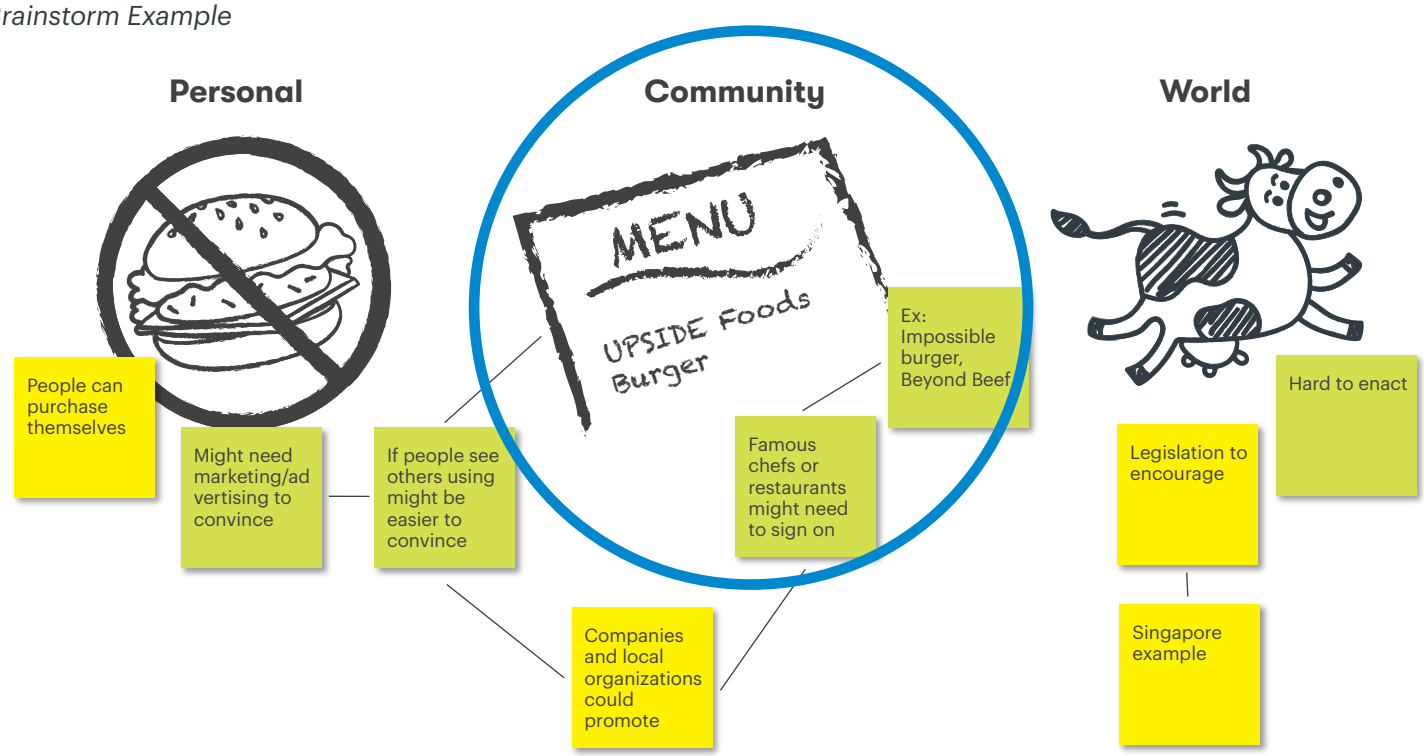
1. Before teams can brainstorm how to overcome these challenges, they will need to visualize what success looks like. This activity will help them deconstruct some of the complexity of the problem.
2. Hand out three sticky notes to each student. On each sticky note they will sketch one of the following prompts: **What does a future with this technology look like...**
   - For me?
   - For my community?
   - For the world?

For example:

A vegetarian student considering UPSIDE Foods may draw these sketches to demonstrate that although the success of the technology may not affect them personally, its global impact will.

3. Students should spend five minutes on sketches before sharing what they have drawn with their team. As a group, they will need to look at these potential futures as starting points for determining what success looks like for this technology.
4. Some **Sample Questions** for this brainstorm are:
   - *What about our sketches seemed realistic, feasible, interesting, exciting?*
   - *At what scale (personal, community, global) would this technology resonate with people? At what scale would it start to impact the environment?*
   - *Who can adopt the technology (individuals, communities, nations)? How does that affect its success?*
   - *Who/what would benefit most from this technology?*

Brainstorm Example



Success looks like product sold in local supermarkets and on restaurant menus in the community.

Debrief *(5 min)*

1. Teams will share their visions of success with the class. Options for share-out:
   - Share their favorite sketch.
   - An idea that was sparked by their team's discussion.
2. After the share-out, ask students if they notice any patterns or similarities with the ideas that were shared.
3. Let teams know that in the next session they will have an opportunity to develop solutions to the implementation problems they have brainstormed.

Session Two 2
Develop Solutions

Preparation Reminder

1. During this session, students will begin to prepare their pitches, so review the **Pitch Options** and determine the tools they will be using.
2. Make sure teams have their research and brainstorming materials from the previous session and provide additional sticky notes and chart paper as needed.

Session Two	60 min total
Review Design Process	3 min
Brainstorm Solutions	15 min
Develop Solutions	20 min
Prepare for Pitches	20 min
Debrief	2 min

Review Design Process *(3 min)*

1. Remind students that their final pitch will include challenges that their technology will face to being adopted or implemented in their community, solutions to those challenges, and what success would look like if it were adopted.
2. Let students know that during this session they will brainstorm and develop their solutions and prepare their pitches.
3. Remind them that they are working on a systems design challenge, so both the problem and solutions can be multifaceted.
   - *For example:* Their solution could be a plan that addresses the process for production, distribution, informing the community, marketing or funding. It could even combine one or more of these categories into a comprehensive plan.
4. Therefore, the design product they create in their solution will vary depending on the problem they are trying to solve. It could be a technology, event, space, marketing campaign, or business.

   For example:
   - If they need to raise awareness about the benefits of lab-grown meat, then they may develop a commercial.
   - If they need to solve for lack of production, then they may develop a plan for government incentives or funding for manufacturing infrastructure.

   Note: Keep this variety of solutions in mind, but wait to provide teams with specific examples until they are struggling to come up with ideas on their own.

Tech Tip: Authentic Assessment

For more details on how to assess students as they create real-world authentic solutions, see our **Tech Tip** on **Design Challenge Assessment**.

Brainstorm Solutions *(15 min)*

1. First, have teams revisit their end goal or "success" that they decided on in the previous lesson and the problems they noticed that might prevent that success.
2. Once they have had a chance to review the problems they identified in the last session, lead the entire class in a timed sticky note brainstorm.

- **Individual Brainstorm** (*5 min*): Give each student a pack of 10 sticky notes. If possible, each student in a group should have a different color or write with a different color pen.
  - Their goal is to think of as many creative solutions to overcome these problems as they can. Encourage them to fill ALL their sticky notes.
  - They should write each idea (sketch, word or phrase) on a different sticky note.
- **Team Brainstorm** (*10 min*): After the time is up, students should share their ideas with their team, organize, discuss and generate new ideas.
  - Encourage them to group similar ideas together on chart paper as they are shared.
  - As new ideas come up during the share-out, students should also write these down. Sometimes the best ideas can come up during discussion!

Brainstorming Tech Tip

Remind teams to encourage anything and everything during brainstorming.

- Think of wild ideas.
- Go for quantity over quality.
- Be creative!

For suggestions on structuring a brainstorm session see **Tech Tip: Facilitating Brainstorming** (**PDF** and **Video**).

Develop Solutions *(20 min)*

1. Next, teams will need to pick the solution (or solutions!) they will be moving forward with. Remind them that the design process is iterative, so their solution does not need to be polished or detailed.
2. As they pick their solution, teams can consider:
   - *How will this solution help the technology be adopted or effectively implemented?*
   - *How would this solution address the challenges you highlighted earlier? How would it address community members' questions about this technology?*
   - *What does success look like for the technology? How does your solution help the technology reach that goal?*
   - *Is this a quick fix or a long-term solution? Would it take a long time to implement and how would you communicate this to the community?*

   Note: If a team thinks success for their technology happens at a global level, have them consider how that impacts their solution and pitch. They may show for example how actions at a community level can influence global change.
3. Remind teams that they can use **Resources** provided to do more research in order to refine their solutions.

Note: As individual teams seem ready, have them start preparing their pitch.

Prepare for Pitches *(25 min)*

1. Review the **design scenario**:

You are the Research and Development team for one of these emerging technologies and you want to convince your community to adopt this sustainable technology. The community is only adopting two new initiatives/ technologies this year, and you need to convince them that yours is worth implementing and investing time and resources in. Your team has researched the issues that might prevent the technology from being adopted and determined a solution to help it succeed within your community. ***Now you need to pitch your technology and adoption solution, so the community can choose two technologies to adopt.***

2. Describe the format and process for their pitches. (Reminder: See **Pitch Options**.)
3. Encourage learners to think about how they can both show and tell their ideas.
4. Address any questions regarding:
   - Presentation tools
   - Pitch process
   - Pitch timing (*For example: 2 minutes*)
   - Audience
5. Remind students of the content of the pitch.

Pitch	• General information about the technology, including implementation/ adoption challenges it might face in your community. • Your team's solution to those challenges. (including what successful adoption of this technology looks like). • How this technology would positively impact your community.	

6. Set expectations for all team members to participate in the pitch.
7. Support teams in developing pitch materials, planning and practicing their presentations.
8. As they work, have teams focus on being able to explain their ideas rather than having a polished pitch.

Debrief *(2 min)*

1. If there is time, have each student share one idea they are excited about from their project and one question that they still have.

Extension: Sharing, Research and Iteration

If there is available time to extend the lesson, provide opportunities for repeated iteration and further research:

- Teams can share out their solutions with another team for feedback and iterate on their solution. Use the **Pitch Feedback Form** or see The Tech's **Peer Feedback Protocol** for more tools and techniques.
- Provide asynchronous work time for students in addition to extended iteration. These moments of individual contribution may help them come up with unique solutions to spark their collaboration.
- Add in another class session where students work in groups to allow more time for research, fleshing out their ideas and pitches.

Preparation Reminder

1. Coordinate final details of the pitch process including inviting any additional audience members (See **Pitch Options** for more information.)
2. Make sure students have the presentation tools and resources they need for their pitches.
3. Print 2-3 copies of the **Pitch Feedback Form** for every student and any additional audience members.
4. Prepare for the Community Vote by writing the names of each of the technologies on 4 different chart papers. Place them around the room.

Session Three	60 min total
Check-in and Final Preparations	10 min
Pitches	40 min
Final Community Vote	5 min
Debrief	5 min

Check-in and Final Preparations *(10 min)*

1. Take a few minutes to review the process for the pitches.
2. Review audience roles. If there are special guests, introduce the teams and the overall challenge.
3. Review the feedback process and the **Pitch Feedback Form**.
   - Students will take notes and turn in forms about each team after their pitch.
   - Tell students they will also have opportunities to share their feedback and ask questions verbally after each pitch.

Pitches *(40 min)*

1. Have teams pitch their ideas.
2. Keep track of time to ensure that all teams have a chance to present and receive feedback.
3. If time allows, have teams respond to additional questions from the audience. **Sample Questions** include:
   - *What inspired you to develop this idea?*
   - *Why did you choose this particular solution?*
   - *What were some of the other solution ideas?*
   - *What questions did you have as you worked on this project? What do you still want to learn about this technology?*
   - *What is one thing you changed about your idea as you worked on it?*
   - *What is something you would change or want to improve if you had more time?*

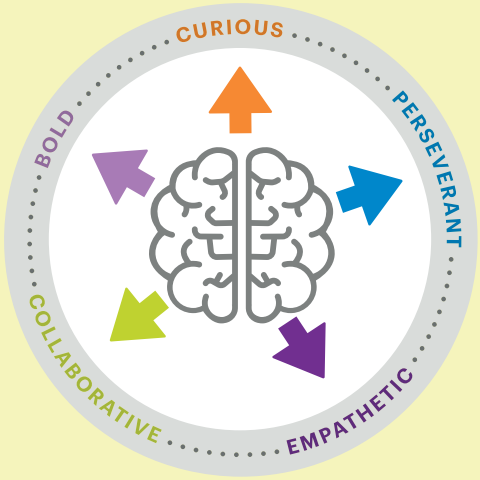
Tip: Share student solutions, photos and videos on social media using #SolveForEarth.

Final Community Vote *(5 min)*

1. As part of the reflection process, have the class rank the technologies once again.
   - Students should vote for the two technologies they choose by placing a tally mark (or sticker dot) on that chart paper.
2. After everyone has voted, have volunteers help total the responses and share the top two technologies that the class thought the community should adopt.
3. Compare the results with their initial vote and reflect on any changes both as a class and individually:
   - *How did you adjust your rankings after learning more about these technologies?*
   - *What influenced your decisions?*

Debrief *(5 min)*

1. Celebrate student work and reflect on the experience.
2. Debrief the project and concepts as a class. Discuss what students saw and learned from the process and each other's work.
   - Review their discussion about environmental issues from Session 1. Have them consider how their understanding of the complexity and interconnectedness of these problems has changed.
3. **Debrief Questions** can include:
   - *How did your understanding of the emerging technology change throughout this project?*
   - *How did your understanding of environmental issues change?*
   - *What part of the process did you like most?*
   - *What was most challenging?*
   - *What would you change?*
   - *How did this make you think about how you can impact your community, the world?*



Innovator Mindsets

Have students reflect on their innovator mindsets (bold, curious, empathetic, perseverant, collaborative).

Use one of the tools in the **Innovator Mindsets Tech Tip** or have students share verbally one mindset they are proud of using and one they want to try next time.

The mindsets can also be used for peer recognition activities throughout the project by having students give each other shout-outs for using different mindsets.

Standards Connections

Next Generation Science Standards

Grades	Standard	Description	3-Dimensional Focus
6-8	MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	**Defining and Delimiting Engineering Problems** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.
9-12	HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.	**Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system.
9-12	HS-ETS1-3	Engineering Design: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	

Common Core State Standards: English Language Arts

Grades	Standard	Description
7-12	CCSS.ELA-LITERACY.SL.[7-12].4	Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

Student Handouts

Resources

Blue Planet	• Website: ***Blue Planet***, www.blueplanet-ltd.com/. • Article: Emerson, Joe. "**Low Carbon Concrete – Starting from the Ground Up.**" *Zero Energy Project*, 3 Dec. 2020. • Video: "**Brent Constantz CEO Intro to Blue Planet May 2020**" YouTube, uploaded by Blue Planet Sep 2020. • Press Release: "**Press Room - 2020 - Use of CO2 in Concrete / Partnership with Blue Planet Systems Corporation.**" *Mitsubishi Corporation*, 23 Sept. 2020.
MANGO MATERIALS	• Website: ***Mango Materials***, https://www.mangomaterials.com/. • Article: Francesco, Emanuele Di. "**Mango Materials**." *Circular Conversations*, July 2020. • Webpage: "**Methane.**" *Climate & Clean Air Coalition*, UN Environment Programme, 6 May 2021. • Webpage: "**Basic Information about Landfill Gas.**" *EPA*, Environmental Protection Agency, 3 June 2021.
SkyCool Systems	• Website: ***SkyCool Systems***, https://www.skycoolsystems.com/. • TED Talk Video: "**How we can turn the cold of outer space into a renewable resource | Aaswath Raman**" YouTube, uploaded by TED June 2018. • Article: Kaplan, Sarah. "**Bringing the Chill of the Cosmos to a Warming Planet.**" *The Washington Post*, 7 Oct. 2020. • Webpage: "**SkyCool.**" *TomKat Center for Sustainable Energy*, Stanford University.
UPSIDE Foods *(formerly Memphis Meats)*	• Website: ***UPSIDE Foods***, https://www.upsidefoods.com. • Webpage: "**Methane.**" *Climate & Clean Air Coalition*, UN Environment Programme, 6 May 2021. • Webpage: "**Enteric Fermentation.**" *Climate & Clean Air Coalition*, UN Environment Programme. • Article: Ritchie, Hannah. "**Half of the World's Habitable Land Is Used for Agriculture.**" *Our World in Data*, 11 Nov. 2019. • Blog: Byrd, Emily. "**Farming Cells, Not Animals.**" *The Good Food Institute*, 20 Mar. 2018. • Article: Corbyn, Zoë. "**Out of the Lab and into Your Frying Pan: the Advance of Cultured Meat.**" *The Guardian*, 19 Jan. 2020. • Article: Watson, Elaine. "**Clean Meat: How Do US Consumers Feel about Cell Cultured Meat?**" *Foodnavigator*, 1 Aug. 2018.

Emerging Tech
Project Guide

Name(s): Date:

Take notes on your INITIAL impressions and rankings of these emerging technologies.

Blue Planet	Mango Materials

SkyCool	UPSIDE Foods

Take notes on your FINAL impressions and rankings of these emerging technologies.

Blue Planet	Mango Materials

SkyCool	UPSIDE Foods

Emerging Tech Project Guide

Emerging Technology: _____

(Write the name of the technology your team has been assigned for this project.)

As you complete this project you will use the Innovation Design Process.

Design Scenario:
You are the Research and Development team for one of these emerging technologies and you want to convince your community to adopt this sustainable technology. The community is only adopting two new initiatives/ technologies this year, and you need to convince them that yours is worth implementing and investing time and resources in. Your team will need to research the issues that might prevent the technology from being adopted and determine a solution to help it succeed within your community. You will then pitch your solution to the community who will vote on two technologies to adopt.

Design Problem	New technologies can run into numerous problems during the implementation process. Imagine the barriers to adoption your technology might face in your community and develop a solution to help your technology succeed.
Pitch	• General information about the technology, including implementation/ adoption challenges it might face in your community. • Your team's solution to those challenges. (including what successful adoption of this technology looks like) • How this technology would positively impact your community.

1. Research the Technology

- Review the design challenge and the background information in your Emerging Tech Profile.

2. Sketch Success

- Make a series of sketches of what a future with this technology would look like...
  - For you?
  - For your community?
  - For the world?

3. Brainstorm Solutions

- Be creative! Think of as many wild ideas as possible.
- As a team, share your ideas with each other. Categorize, group them and capture any new ideas.

4. Develop Solutions

- As a team, choose your favorite idea(s) to focus on.
- Think through some of the details of your idea.

5. Pitch your Ideas

- Review the goals for your pitch and prepare any accompanying resources.
- Get feedback on your solution by sharing your ideas with others.
- Take notes on ways to continue improving and iterating on your ideas.

Emerging Technology Profile

BLUE PLANET

Founded in 2013

Founder Dr. Brent Constantz

Location Los Gatos, CA

What is Blue Planet?

Blue Planet developed a CO_2 (carbon dioxide) capture and storage method that is more efficient and less expensive than traditional methods. Designed to help reduce CO_2 emissions and their impact on the planet, the company's technology captures carbon dioxide from flue gas and converts it into carbonate coated rocks (aggregate). This environmentally friendly building material can replace limestone rock and conventional concrete in construction.

Problems Being Addressed

- Human activities release CO_2 into the atmosphere, causing air temperatures to rise.
- Current CO_2 purification processes are expensive.
- Conventional CO_2 sequestration processes allow us to trap CO_2 within geological formations, but this is expensive, has potential negative effects and can only be done under certain conditions.
- Mining aggregate, which is used in creating conventional concrete manufacture, has significant environmental impact.

What is Blue Planet replacing?

- Materials in conventional concrete
- Current carbon sequestering efforts

Vocabulary

Aggregate: A material formed from smaller fragments or particles. *Ex. Gravel or sand*

Carbon capture: Collecting carbon that is produced as waste from industrial processes like cement production or burning gas or oil.

Carbon sequestering: To capture and store atmospheric carbon dioxide.

Concrete: Hard, strong building material made up mostly of aggregate (rocks), which are sealed together by a mixture of cement and water.

Flue gas: A mixture of gases produced when fossil fuels (ex: coal, natural gas) are burned.

Greenhouse gas: Gases, such as carbon dioxide and methane, that trap heat in the atmosphere to keep the Earth warm. Excess greenhouse gases produced by human activity have caused temperatures to rise beyond what is normal. This is commonly referred to as *global warming*.

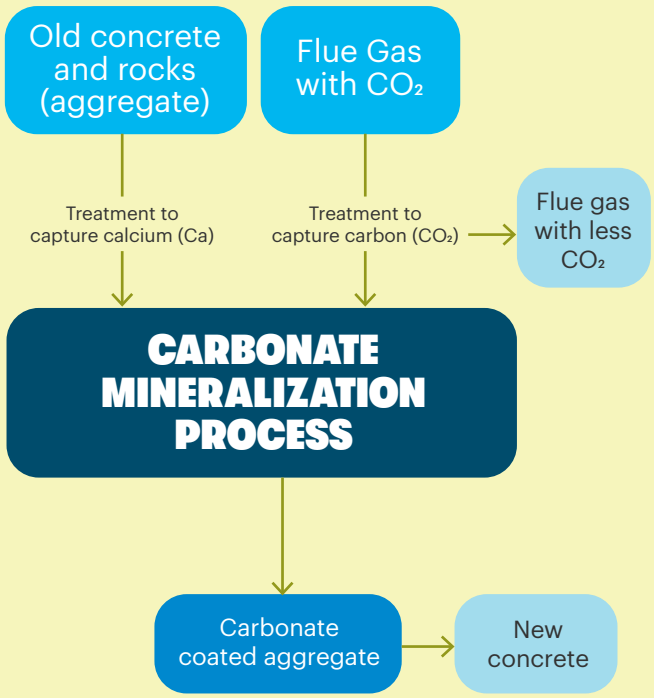
How do they do it?

CO_2 is captured from flue gas produced by industrial processes.

The captured CO_2 is converted to carbonate by putting the CO_2 containing gas in contact with a water-based capture solution.

The carbonate is then used to coat recycled concrete and rocks (aggregate). This carbonated aggregate is used instead of mined limestone in new concrete.

The Process



What's next?

As they look to expand their presence in the construction industry, Blue Planet needs to ensure that products made from their process are as strong and durable as traditional materials. They will also need to scale up their manufacturing in order to create enough aggregate to compete with conventional concrete.

This could be a great alternative to conventional concrete, but if we can capture CO_2 emissions and sequester it, will this give us a "pass" to continue our bad behavior and not reduce our carbon emissions?

Fun Facts

Blue Planet's limestone-coated light weight aggregate was included in the concrete poured at San Francisco International Airport in 2016 by Central Concrete.

Blue Planet is different from most CO_2 capture methods because it does not require a purification step, which uses a lot of energy, money and resources.

Questions to Consider

Benefits:

- How would this technology help your community?
- What would success look like for your technology? On a personal, community or global scale?

Challenges:

- What aspects of the technology might be difficult to implement in your community?
- What questions might community members have about this technology?

Emerging Technology Profile

MANGO MATERIALS

MANGO MATERIALS

What is Mango Materials?

Mango Materials produces bioplastic pellets that can be used to create a variety of products. In natural settings like the ocean, these materials biodegrade in about 6 weeks. The production of these bioplastics uses the methane waste gas from industrial processes.

Founded in	2010
Founders	Molly Morse Ph.D. Allison Pieja Ph.D. Anne Schauer-Gimenez Ph.D.
Location	Redwood City, CA
Slogan	The Future is Biodegradable

Problems Being Addressed

- Plastics are a major pollutant that take hundreds of years to degrade.
- Methane is the second most abundant greenhouse gas.
- Methane is emitted as a waste gas from both industry and natural sources.

Vocabulary

Greenhouse gas: Gases, such as carbon dioxide and methane, that trap heat in the atmosphere to keep the Earth warm. Excess greenhouse gases produced by human activity have caused temperatures to rise beyond what is normal. This is commonly referred to as *global warming*.

Methanotrophs: A type of bacteria used by Mango Materials that can use methane as their sole carbon source.

Polyhydroxyalkanoates (PHA): A type of biodegradable bioplastic.

P3HB: A type of PHA.

What is Mango Materials replacing?

Mango Materials bioplastics are a form of PHA and have similar properties to polypropylene. They can be used for:

Fiber extrusion

- For apparel and textiles

Injection Molding

- For jars, caps, and other rigid goods

Creating plastic films

- For thin packaging and goods

3D Printing

How do they do it?

METHANE GAS EMISSIONS

Mango Materials factories are placed next to existing methane production facilities.

Methane is captured and used to feed a specially selected bacteria.

MICROBIAL PROCESSES

These bacteria feed on the methane, then naturally produce a type of plastic and store it in their cell walls.

CREATION OF PHA BIOPOLYMER

The type of plastic that these microbes produce is called P3HB, which acts as a starting material for the bioplastics produced by Mango Materials.

BIODEGRADABLE PRODUCTS

Once these bioplastics are produced, they are integrated into conventional plastic supply chains.

WASTE FACILITY

If these plastic items are sent to a traditional waste facility, the methane produced can be recaptured to create more P3HB.

What's next?

Bioplastics have a lot of benefits to sustainability, but they also face challenges during the production process. Mango Materials' bioplastics are more expensive to make than conventional plastics and manufacturing plants need to be able to access a source of methane. This places certain limitations on the pricing and production of these plastic alternatives.

How would you address these restrictions? Are these limitations worth the cost of eliminating traditional plastics?

Fun Facts

The process that Mango Materials uses to create their bioplastics is an example of circular economy. In the case of Mango Materials, the waste produced when the product is disposed of can be used again to create more bioplastics.

Methane gas, which is used to produce Mango Materials' bioplastics, is emitted from a range of sources from landfills and animal agriculture to natural plant decay and gas deposits.

Questions to Consider

Benefits:

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Emerging Technology Profile

SKYCOOL SYSTEMS

SkyCool Systems

What is SkyCool?

SkyCool Systems is a clean energy company focused on energy-efficient solutions and new methods for cooling. Their vision is to improve the efficiency of all cooling systems by harnessing an untapped renewable resource: the sky.

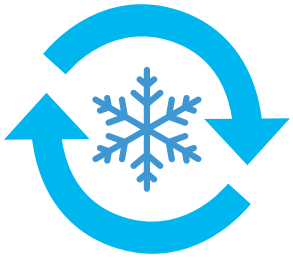
Founded in	2016
Founders	Eli Goldstien Shanhui Fan Aaswath Raman
Location	Mountain View, CA

Problems Being Addressed

- Rising global temperatures has led to an increased demand for cooling. Inefficient systems result in overburdened electrical grids, increased greenhouse gas emissions, and even higher temperatures!
- Air conditioning and refrigeration systems consume close to 25% of electricity generated worldwide and are responsible for 7% of global greenhouse gas emissions.

What is SkyCool replacing?

SkyCool is an addition to current cooling systems to maximize their cooling potential.



Vocabulary

Ambient temperature: The temperature of the air around an object or environment.

Optical film: Thin structured layers of materials used to affect the behavior of light. *Ex. anti-glare film on glasses.*

Passive: To be affected by an outside force without internal action.

Reflective: Able to throw back light or radiation without absorbing it.

Radiative cooling: The cooling of the earth's surface and adjacent air, primarily at night, caused by a loss of heat due to surface emission of infrared radiation.

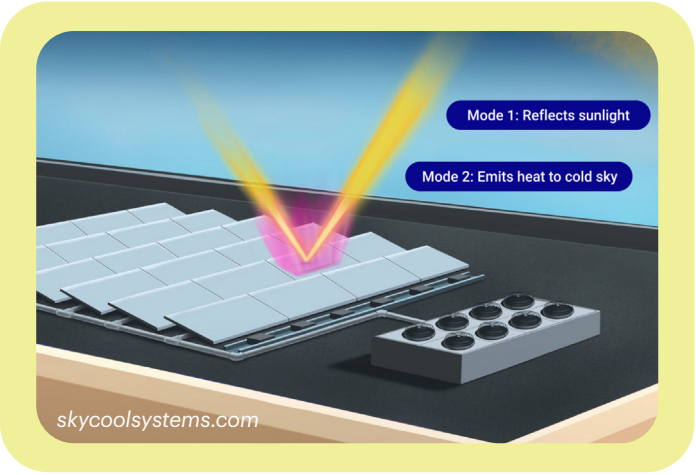
Thermal radiation: The electromagnetic waves given off by an object due to its temperature. Infrared radiation is a part of thermal radiation.

SkyCool's Dual-Mode Film has numerous applications, including outdoor batteries or electronic boxes, outdoor shaded structures, metal roofs and refrigerated trucks or other vehicles.

How do they do it?

SkyCool Dual-Mode Film

1. SkyCool Systems has repurposed the ancient technique of radiative cooling using modern technology. They use specially designed optical films that enable a passive approach to cooling throughout the day.
2. These optical films are highly reflective of sunlight, but also emit thermal radiation to cool the space, even during the hottest hours of the day.



SkyCool Radiative Cooling Panels

1. SkyCool Systems has developed a passive cooling panel that improves the efficiency of any air conditioning or refrigeration system.
2. They apply their Dual-Mode film to the top surface of each panel. The film reflects sunlight to prevent the panels from heating up during the day.
3. Panels also emit infrared heat to the cold sky, which keeps the panels and the fluid flowing in them cool 24/7/365. The panels' temperature can drop by up to 15°F below the ambient temperature with zero electricity input.
4. SkyCool's panels can be used as an add-on to air conditioning and refrigeration systems. In some circumstances, panels can even replace an air conditioning unit.
5. With this panel system, there will be a 10% and 40% improvement in efficiency depending on how it is paired with conventional cooling. When they can fully replace an air conditioning system, we could see an 80% to 90% energy reduction for cooling with SkyCool.

What's next?

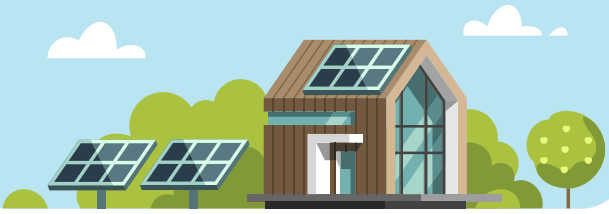
Heating and cooling make up a large chunk of electrical usage in homes and public buildings alike. Reducing the energy used for cooling could have major positive effects, but SkyCool's cooling panel system is expensive to produce and is still in the pilot phase, meaning it is not available to the public.

It will be a while before this technology could be available and affordable. Would you invest?

Fun Facts

The bulk of electrical consumption in buildings is attributed to heating and cooling — about 35%! Reducing electrical consumption is directly connected to electrical generation and CO_2 emissions.

Since SkyCool panels do not need to be south-facing, they can complement solar panels on the roof. Compared to solar panels, SkyCool Panels utilize roof-space more effectively by providing cooling 24/7 and save 2x-3x as much energy as a solar panel generates given the same area.



Questions to Consider

Benefits:

- How would this technology help your community?
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Challenges:

- What aspects of the technology might be difficult to implement in your community?
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Emerging Technology Profile

UPSIDE FOODS

Founded in	2015
Founders	Uma Valeti M.D (cardiologist) Nicholas Genovese Ph.D. (cell biologist)
Location	Berkeley, CA
Slogan	Real Meat. No Compromise.

What is UPSIDE Foods?

The UPSIDE Foods process uses cells to make meat! They start by sourcing high quality cells from animals. These cells are fed nutrients so they can grow and multiply into edible meat without needing to use an entire animal. At scale, cell-based meat could drastically reduce both the amount of land needed and the emissions produced during meat production.

Problems Being Addressed

- Animal agriculture uses up the most land of any agricultural industry.
- Animal agriculture produces large amounts of two major greenhouse gases, methane and nitrous oxide.
- Animals raised as a food source are often kept in unsafe, close quarters that promote the spread of disease, resulting in danger to humans and other animals.

What is UPSIDE Foods replacing?

UPSIDE Foods has created cell-based:

Chicken

Beef

Duck

Vocabulary

Animal agriculture: The branch of agriculture concerned with animals that are raised for meat, fiber, milk, eggs, or other products.

Cell: The basic membrane-bound unit that contains the fundamental molecules of life and of which all living things are composed.

Cell-based meat: Meat that is developed through cell cultivation, rather than through animal agriculture.

Greenhouse gas: Gases, such as carbon dioxide and methane, that trap heat in the atmosphere to keep the Earth warm. Excess greenhouse gases produced by human activity have caused temperatures to rise beyond what is normal. This is commonly referred to as *global warming*.

Micronutrient: A chemical element or substance required in trace amounts for the normal growth and development of living organisms.

How do they do it?

CELLS

UPSIDE Foods identifies and selects specific types of cells that are able to self-renew and grow to become meat.

FEEDING THE CELLS

The cells are fed essential micronutrients to aid growth and help create the highest quality product.

CULTIVATION

The cells continue their growth in a device called a "cultivator." During their growth, they follow their natural process to form muscle and connective tissue just like they would when growing in an animal.

MEAT

After the 4-6 week growing process, the meat is harvested from the cultivator and is ready to be used.

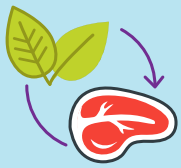
What's next?

Cell-based meats are no doubt a growing business, but they face some challenges in both production and perception. Cell-based meats are expensive to produce, leading to a higher retail price than meats from animal agriculture. Consumers may also have varied reactions to the idea of lab-grown meat.

How about you? Would you eat lab-grown meat? And would you be willing to pay more for an environmentally sustainable product?

Fun Facts

A 2018 survey of 1,185 American adults found that, when presented with information about how 'conventional' meat is produced at scale, 66% were willing to try cell-based meat.



Animal activists are divided on the development of cell-based meats. People for the Ethical Treatment of Animals (PETA) has been supportive on the grounds that animals' lives will be saved. Other activists are strong opponents because they think cell-based meats imply that eating meat is still desirable and that animals are a resource for humans.

Questions to Consider

Benefits:

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Emerging Tech
Pitch Feedback Form

Listen to each pitch about a sustainable emerging technology. Consider how the team's ideas address the challenges that technology might face in our community. Remember, our community can only invest in two of these technologies.

Team Name(s)	Technology

Write down 1-2 sentences of positive and constructive feedback.

I Liked...	I Suggest...

This proposal...	
☐ **is APPROVED to move forward.**	☐ needs further consideration.

Team Name(s)	Technology

Write down 1-2 sentences of positive and constructive feedback.

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