Lesson 1 - Biotechnology & Maker Microbes

Summary

In this lesson, students will be introduced to biotechnology by learning about microbes and the ways that scientists and engineers are using them to solve problems. After a quick introduction to ways microbes can be used to make environmentally friendly products, students will get hands-on experience with microbes by conducting an investigation with yeast. Students will add sugar water to two different types of yeast and record quantitative observations. By comparing the results between the two yeast types, students will see firsthand that scientists can modify living things for different purposes. Through a brief video, students will hear from local scientists about how they are designing bacteria to help the environment. Students will end the day by reflecting on this lesson using a graphic organizer that they will add to in subsequent lessons.

Experience Goals

- Biotechnology is a way to solve problems by understanding and changing the way living things work.
- Microbes are small living things that scientists and engineers can change to solve problems.
- Yeast consume sugar to create gas bubbles and other new substances like those that cause different smells.

Materials and Preparation

Materials

For the Class

- Projections: Lesson 1 slides
- Jar with 34 grams sugar
- Thermometer*

For Each Group of Four Students

- Instant yeast packet
- Active dry yeast packet
- Marker*
- Masking tape*
- Scissors*

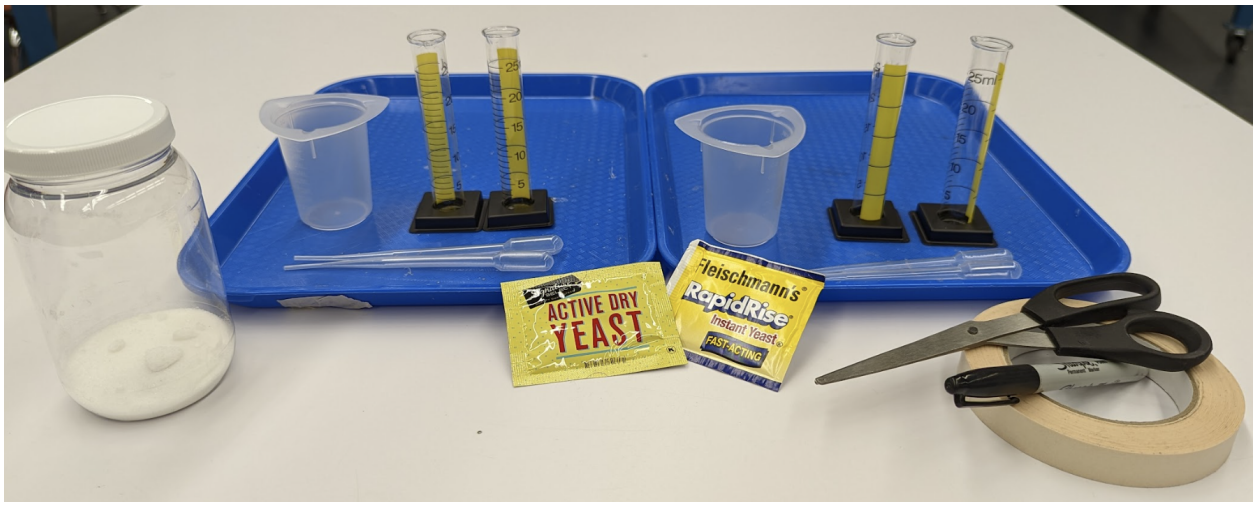
For Each Pair of Students

- 2 graduated cylinders (25 mL)
- 2 transfer pipettes
- 2 wooden stir sticks
- Small plastic beaker
- Materials tray or paper plate*

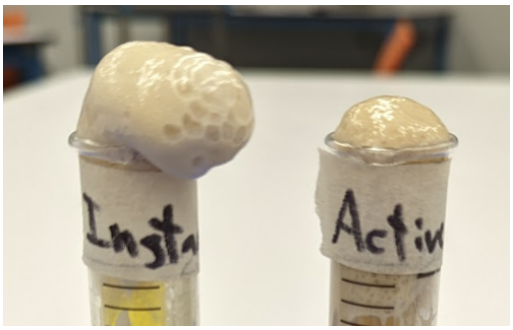
For Each Student

- 1 copy of these student sheets:
  - Biotechnology graphic organizer
  - Lesson 1 student sheet

* teacher provided



Preparation - Before the Day of the Lesson

- **Plan for partners and groups of four**
  - Partners will work together on the yeast activity
  - Groups of four will divide the contents of each yeast packet
- **Prepare yeast activity materials.** Review the materials list above. The yeast will overflow, so be sure to use materials trays or paper plates to contain the mess. See below:
  - 
- **Familiarize yourself with the videos.** Prepare to project the *Pivot Bio* and *Bayer* videos during Activity 1.4. The links can be found in the projections slide deck. Students are not intended to remember everything about the science in this and other biotech careers videos. Instead, these videos are meant to inspire students to consider the problems they could solve if they were to pursue a career in biotechnology.
- **Prepare Projection: Lesson 1 slides.** You might choose to download the projections file to your desktop so you can project during the lessons. If you don't have a computer

and a projector, print the projections and use a document camera to project.
- **Make a plan for warming sugar water.** The sugar water solution should be as close to 100-120 ℉ as possible when students add it to their cylinders. Make a plan for rewarming the sugar water if necessary before dispensing it to students.

Preparation - Immediately Before the Lesson

- **Prepare the sugar water solution.**
    - *[If you have access to a microwave - preferred option]*:
        - Add water to the jar so it is nearly full (~420 mL, ~1.75 cups). Cap and swirl to dissolve. Remove the lid and warm the water in the microwave to a maximum of 49 ℃ (120 ℉). Start by heating on high for 1 minute, then heat by 10 second increments until you reach 120 ℉.
    - *[If you have access to an electric kettle]*:
        - Warm water in the kettle to a maximum temperature of 49 ℃ (120 ℉). Make a plan to re-warm the kettle water to that temperature just prior to students needing the sugar water. At that time, add the warm water to the jar, and cap and swirl to dissolve the sugar.
    - Notes:
        - Above 120 ℉, the yeast will be killed. If you warm it past that temperature during heating simply ensure that the solution has cooled to 120 ℉ or below before students use it.
        - The solution should ideally be above 38 ℃ (100 ℉) when students add it to their cylinders, otherwise the activity will take too long to be completed in the allotted time.

Preparation - Between Lessons

- **Reset materials trays**. Transfer pipettes, graduated cylinders, and beakers are all meant to be reused by subsequent classes.

Instructional Guide

Activity 1.1: Warm-Up (5 minutes)

Students respond to the Warm-Up to activate their questions and ideas about biotechnology.

1. **Project slide 1.1.**
2. **Distribute copies of the Warm-Up student sheet.**
3. **Students work independently** to answer the Warm-Up questions.
4. **If time permits,** have students share their responses to the Warm-Up.

Science Note: Lab Grown Leather. To make lab-grown leather, VitroLabs takes a very small piece of skin from a cow to get a sample of skin cells. Then they give those cells all the nutrients they need to continue to grow and make more skin cells. This is where the lab-grown leather comes from. They just need one sample of cow skin cells to get this process started.

Activity 1.2: Project Introduction & Maker Microbes (5 minutes)

The teacher introduces microbes and the various ways they can be used in biotechnology.

1. **Introduce the Exploring Biotechnology Program.** Tell students they will be learning about an area of science and engineering called biotechnology in a program that will include two in-class lessons and one field trip to The Lawrence Hall of Science.
2. **Solicit ideas about Microbes.** Have students heard of them? What ideas do they have? Highlight ideas about microbes being made of just one cell.
3. **Introduce Cells.** *Project slide 1.2A*. Introduce or remind students of cells.
4. **Introduce microbes and their use in biotechnology.** Tell students these are just three kinds of microbes, though these three in particular are very important to biotechnology. Tell students you will introduce ways biotech professionals are using microbes to solve problems.
5. **Review each "Microbes can make:" slide.** The key information is on each slide, but you might find this additional information helpful
    - *1.2C - dyes and pigments*: Most dyes and pigments are made from petroleum or coal and thus contribute to climate change.
    - *1.2D - moisturizers:* Sharks play an important role in marine ecosystems, and many shark species are threatened with extinction. Amyris has many different beauty and health products marketed under different brands.
    - *1.2E - sports equipment:* While it is not clear that polyurethane made from algae oil is more sustainable than traditional methods, developing processes for making materials from algae could help transition the economy away from the use of fossil fuels.Polyurethane is one of the most widely used materials in the world. It has applications in areas ranging from medical devices to clothing to appliances to cars.
    - *1.2F - fertilizer:* Chemical fertilizers are often over-applied to fields, which leads to huge algae blooms and "dead zones" when they are rinsed into lakes and seas. Making fertilizer in soil could avoid this problem. Producing chemical fertilizers is a very energy intensive process, accounting for 1% of total global energy consumption.
    - *1.2G - fabrics:* Spider silk is one of the strongest materials on the planet–matching the properties of steel and kevlar. There are many other possible applications for this synthetic spider silk aside from clothing, including artificial tendons or ligaments, surgical thread, contact lenses, and body armor. However, spiders can't be farmed like silkworms, so there is currently no efficient method of producing large quantities of spider silk.
    - *1.2H - artificial meat:* Animal agriculture is a leading contributor to climate change. Changing diets from animal protein to plant protein would lead to a dramatic reduction in greenhouse gas emissions.Heme is the only ingredient in the impossible burger that is made by microbes. Other key ingredients in the impossible burger are protein from soy, fat from sunflower and coconut oils, and binders that help hold it together.

6. **Summarize with the idea of modifying living things.** Tell students that in most of these examples, the microbes originally didn't make the product they wanted it to make. Scientists had to make changes to the microbes.
7. **Highlight the Bay Area as a Biotech Hub.** The San Francisco Bay Area is where biotechnology began, and it has the highest concentration of biotech companies in the world.

Activity 1.3: Yeast Hands-On (20 minutes)

Students compare how quickly Instant and Active Dry yeast fill up graduated cylinders after they add warm sugar water to the dried yeast.

1. **Introduce the activity.** Tell students that yeast is one of the most important microbes to the field of biotechnology. Tell students they will be observing two kinds of yeast, and that one of the yeast varieties has been modified to come out of dormancy more quickly. Other key ideas you might care to introduce include:
    - Yeast are alive.
    - Yeast consume sugar
    - Yeast produce carbon dioxide
    - Carbon dioxide is a gas
    - Yeast are what create the tiny holes in bread by making carbon dioxide
2. **Introduce the materials.** *Project slide 1.3A* or show students an example activity tray with all the materials:
    - *Two graduated cylinders*. Students will place yeast and sugar water in the graduated cylinders and measure how fast the volume increases.
    - *Two types of yeast.* One labeled "instant" and the other "active dry." Each pair of students will share the yeast packets with another pair of students.
    - *Small beakers*. Teachers will add warm sugar water to these beakers.
    - *Transfer pipettes*. Students will use these to add warm sugar water to the graduated cylinders.
3. **Review the yeast activity instructions.** *Project slide 1.3B*. Emphasize the following points:
    - Cut a small part of the corner off the yeast packet to make it easier to pour.
    - Both students in each pair should add water to a cylinder at the same time.
        - The sugar water needs to be added to both cylinders at the same time. You might choose to ask students why this is important and use the opportunity to discuss only changing one variable (the type of yeast) and keeping all other variables (time, water temperature, yeast amount, water amount, etc) constant.
4. **Demonstrate how to use a transfer pipette.** *Project slide 1.3C*. Review the video. Encourage students to practice filling and dispensing sugar water into the beaker until they are confident. You might also choose to fill students' beakers with water first to give them a chance to practice.

5. **Review the data table.** *Project slide 1.3D*. Tell students they will be recording their observations in the data table. They should always record the volumes in both of their graduated cylinders, but they should also record other observations in the same row.
6. **Brainstorm other possible observations.** Ask students what else they might observe. Highlight or solicit ideas focusing on smells or sounds.
7. **Distribute activity materials.** Prompt students to gather their activity trays and begin working.
8. **Dispense warm sugar water.** If possible, re-warm the water prior to dispensing to students. Once students have divided their yeast and labeled their cylinders, divide the solution evenly between groups (each pair will only need approximately 10 mL, but the kit provides enough sugar water so that each pair can work with 25 mL solution).
9. **Prompt students to record the initial time and volume in their data tables** once they have added sugar water and mixed the contents of both cylinders.
10. **Circulate and support student observations.**
    - Make sure they record volumes every minute.
    - Make sure students notice that the two yeast varieties smell different. Tell students that smells are caused by molecules entering our noses, and different smells mean these yeast are making different molecules.
11. **When the first tube overflows, prompt students to record the time.** Each pair should record the final time their yeast varieties overflowed as the final row in their data table. It should take around 8 minutes for the yeast in both cylinders to overflow.
12. **Prompt students to clean up activity when finished**. Make sure students do the following:
    - Empty the sugar water from the beaker
    - Empty and rinse the graduated cylinders (yeast can go down the drain)
    - Empty the transfer pipettes
    - Clean up their activity trays (yeast mixtures will have overflowed)
    - Note: the beakers and transfer pipettes can be reused without rinsing, but should both be rinsed at the end of the day for reuse.
13. **Ask students to share observations and possible explanations for differences.** Did they notice differences between the two types of yeast? Since they are both the same species, yeast, what could explain the differences?
14. **Help students conclude that scientists can change yeast to solve problems.** Return to the idea that scientists modify living things to get them to do what they want. In this case, scientists have modified yeast to make it come alive and start producing carbon dioxide very quickly to make baking with yeast quicker and easier.

Teacher's Note: Possible Extensions. In addition to comparing the two different types of yeast, you might consider the following activity extensions:

- *Comparing food sources.* Try comparing sugar water to water alone or an artificial sweetener like stevia. This can provide compelling evidence that yeast are alive and need to take in food to grow and reproduce just like animals and plants.

- *Comparing water temperatures.* Try adding water at different temperatures. Yeast will activate very slowly at room temperature, and will be killed at temperatures above 120-140 ℉.

For any of these activities, you will need to obtain additional yeast and other supplies.

Teacher's Note: Lengthening Yeast Activity. If you think the yeast activity will take longer than 20 minutes in your classroom, you might consider planning to teach activities 1.4 or 1.5 in a subsequent lesson

Teacher's Note: How Can Yeast Come Back to Life? All known living things require water to life. Some microorganisms can enter an inactive, dormant state when conditions are not favorable (lack of moisture, nutrients, etc). When conditions become favorable again, like when you add warm sugar water to the dried yeast, the microorganisms restart their life processes.

Activity 1.4: Introduce the Final Project & Graphic Organizer (5 minutes)

Students begin to consider what problems and science ideas feel important to them.

1. **Introduce the final project.** *Project slide 1.4A.* Tell students they will be completing a project during the third lesson of this program where they share what they would do with a "biotech science wand."
2. **Introduce the graphic organizer.** *Project slide 1.4B.* Tell students they will help themselves prepare for the final project by recording their thoughts and ideas during these lessons.
3. **Distribute the graphic organizer.** Emphasize that this is their own space to record ideas that seem important to them.
4. **Circulate to support as students record their ideas.** Encourage students to record anything they remember from the activity, videos, or anything else. Tell them this is their space to record information and ideas that might be helpful during their final projects.

Activity 1.5: Biotech Careers Videos (10 minutes)

Students learn about a local company that is designing a microbe that will make fertilizer in the soil from nitrogen in the air.

1. **Introduce Biotech Careers videos.** Tell students that as a part of the program, students will be hearing from professionals in local biotech companies. They will be viewing their first video today.
2. **Remind students they can take notes in the graphic organizer.** Emphasize again that taking complete notes on everything is not important, but they should pay attention to what connections they are making, questions they have, or ideas that seem important.
3. **Show the Pivot Bio video**. *Project slide 1.5A.* Play the video.
4. **Show the Bayer video.** *Project slide 1.5B.* Play the video.

5. **Solicit reactions from students**. Ask students to share something they found most interesting from the video. Encourage students to record their ideas and thoughts in the graphic organizer.

Lesson 3 - How Would You Use Biotechnology?

Summary

Students will begin the lesson by reflecting on their experiences from the first two lessons by updating their graphic organizer. Students will then be introduced to the final "Biotech Science Wand" project for this sequence where they are tasked with showing what problem they would solve using biotechnology. After a brief small group brainstorming session, students will view two videos featuring local scientists who are using biotechnology to make animal-free meat and leather. Students will then continue to brainstorm and can refer back to graphic organizers as they create their own visual representation of the way they would use a *"Biotech Science Wand."*

Experience Goals

- Biotechnology is something that I could use to solve problems that are important to me.

Materials and Preparation

Materials

For the Class

- Projections: Lesson 3 slides
- Extra copies of the graphic organizer for students who lose theirs
- Art materials for *Biotech Science Wand* projects*

* teacher provided

Preparation - Before the Day of the Lesson

- **Plan and organize materials for student projects.** Plan what materials students will have access to when they're completing their Biotech Science Wand projects, such as markers, pencils, and paper.
- **Familiarize yourself with the videos.** Prepare to project the *Impossible Foods* and *Bolt Threads* videos during Activity 3.2.
- **Prepare Projection: Lesson 3 slides.** You might choose to download the projections file to your desktop so you can project during the lessons. If you don't have a computer and a projector, print the projections and use a document camera to project.

Preparation - Between Lessons

- **Refresh or clean up student activity materials as needed.**

Instructional Guide

Activity 3.1: Warm-Up & Lawrence visit recap (10 minutes)

Students update their graphic organizer and then discuss their reactions and recollections of the visit to the Lawrence.

1. **Project slide 3.1.**
2. **Make sure students have copies of their graphic organizers.**
3. **Students work independently** to update their graphic organizers.
4. **Lead a brief discussion** about the field trip to The Lawrence and students' updates to their graphic organizers. Tell students they will return to their graphic organizers after watching the videos.

Activity 3.2: Videos - Impossible Foods & Bolt Threads (10 minutes)

Students view two videos about local biotechnology companies to help spark ideas about how they would use their biotech science wand.

1. **Discuss previous Biotech Careers videos.** Ask students to share what they remember from the Pivot Bio and Bayer videos in Lesson 1 If necessary remind students of the following:
    - Pivot Bio is trying to design bacteria that will produce fertilizer in the soil, which will avoid the need for chemical fertilizers.
    - Bayer makes a wide variety of medicines. Bayer in Berkeley specializes in medicines that help people with certain blood disorders.
2. **Show the Bolt Threads video**. *Project slide 3.2A*. Play the video.
3. **Show the Impossible Foods video.** *Project slide 3.2B*. Play the video.
4. **Solicit reactions from students**. Ask students to share something they found most interesting from the videos. Encourage students to record their ideas and thoughts in the graphic organizer.

Activity 3.3: Biotech Science Wand Ideas (25 minutes)

Students discuss what problem they might solve if they had a *Biotech Science Wand* and sketch their ideas in a drawing.

1. **Remind students about the project.** *Project slide 3.3*. Tell students they will be creating a project that shows how they would use a Biotech Science Wand. Remind students that they will have their graphic organizer as a resource.
2. **Emphasize just sharing the problem they would solve, not a complete solution.** If students have ideas about solutions and how those would work, they are welcome to share them, but at this point students are only meant to be applying their understanding that biotech can be used to solve problems.
3. **Prompt students to discuss ideas in small groups**. Place students in groups of 2-4 to share their ideas about how they would use a Biotech Science Wand.

4. **Introduce the materials students will use to complete their projects.**
5. **Prompt students to choose an idea and begin working.** Circulate to support students in selecting an idea. Encourage students to select ideas that are important to them. Help them refer to their graphic organizers or any experiences from the Exploring Biotechnology program that might be helpful.
6. **Introduce plan for finishing projects.** If you will be allowing students to work on projects at home or again during class, let them know.

