# Sourdough For Science: Contents

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Sourdough For Science: Activity Overview

About the Activity
Humans have baked bread for over 10,000 years. All over the world, different cultures bake their own unique bread - and have for centuries - and yet we know almost nothing about the microbes that truly make a traditional sourdough bread. In this project, you will grow your own sourdough starter from scratch just by mixing flour and water. For two weeks, you will measure the height and pH of your starter to track the growth of your “microbial zoo” over time, and share your data with a scientist.

By participating in a real science project, you can help us solve the mysteries of bread. Your data will be compared with data from other participants, all over the world, who have completed the same experiment. Together we can use these data to learn how different flours affect microbial growth over time - and how those microbes affect the taste and texture of bread.

Here’s What You’ll Need
- Student Data Sheet (one per student)
- 6 half-pint wide-mouth jars (one per group)
- 6 tablespoon measuring spoons (one per group)
- 6 plastic spoons (to mix and scoop starter)
- 6 rulers (to measure the height of the starter)
- 6 Sharpie markers (one per group)
- pH paper (that will detect from 3.5-8.0 at the accuracy of at least one decimal place)
- 6 pH color keys (one per group)
- 6 different types of flour (one per group)
- Distilled water
- Paper towels
- Pencils for data recording
- Sourdough For Science Introduction video
- Sourdough For Science Demo video

Helpful Hints
- Organize 6 starter kits to include: one wide mouth jar, one spoon, one ruler, one sharpie, one pH paper key, pH paper (15 small strips), one type of flour, and a paper towel.
- Individual groups should focus on one type of flour.
- If you do not have access to distilled water, let water sit, uncovered, overnight in order to remove the chlorine.
- Starters should be kept in a cool area with limited access to light.
- Print out the Teacher Instructions with pictures for students who prefer visuals.
**Directions**

1. Warm up exercise (approx. 5 min) as students arrive to class (directions can be written on the board so that students can complete task while teacher takes roll or completes other administrative tasks):
   - Take out a blank sheet of paper and pen/pencil.
   - Make a list of all the different types of bread you can think of.
2. Watch “Sourdough for Science Introduction” video with students.
3. Divide students up into groups of 2-4, depending on how many mason jars/supplies you have on hand.
4. Assign each group one of the six types of flour: emmer, einkorn, Red Turkey wheat, rye, all-purpose and millet (millet is gluten-free if you have students with an allergy)
5. Follow *Sourdough for Science: Teacher Instructions*

**Calendar**

Use the following calendar as a guide for completing all the activities.

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
</table>
| ● Video: Welcome  
● Video: Make your starter  
● Data Collection | ● Feed your starter  
● Bread Tasting and Aroma Wheel | ● Feed your starter  
● Guided Reading | ● Feed your starter  
● Wonderbread Poetry Workshop | ● Feed your starter  
● Which Variable Matter |

<table>
<thead>
<tr>
<th>Day 6</th>
<th>Day 7</th>
<th>Day 8</th>
<th>Day 9</th>
<th>Day 10</th>
</tr>
</thead>
</table>
| Feed your starter  
Student Readiness | Feed your starter  
Who’s My’crobe | Feed your starter  
DNA ‘Recipe” | Feed your starter  
Map My Microbes | Feed your starter  
Map My Microbe |

<table>
<thead>
<tr>
<th>Day 11</th>
<th>Day 12</th>
<th>Day 13</th>
<th>Day 14</th>
<th>Day 15</th>
</tr>
</thead>
</table>
| Feed your starter  
Graphing Data | Feed your starter  
Graphing Data | Feed your starter  
Lab Report | Feed your starter  
Lab Report | Feed your starter  
Lab Report |
Sourdough For Science: Teacher Instructions

Day 0:

Step 1: Set Up
- Make sure students are with their lab group and have all their supplies.
- Hand out Sourdough Starter Lab Sheet to each group.
- Use a Sharpie to write your group name (in small type) and flour type near the top edge of your jar.

Step 2: Create the starter
- Measure 2 Tablespoons (Tbsp) of the flour assigned to your group, into your jar.
- Add 2 Tbsp of distilled water.
- Mix with a plastic spoon, and then use the spoon to scrape any flour-water paste back down the sides of the jar.

Step 3: Measure Height
- Measure and record the height of the flour-water paste (in cm) on your datasheet.
Step 4: pH Testing
● Scoop a small amount of your starter into a spoon, and touch one side of a strip of pH paper to
the starter. (This allows the starter to soak into the pH paper, but keeps the other side of the
paper clean and easy to read.) To measure the pH, match the color of the paper to the color
key on the package.

Step 5: Data Collection
● Smell your starter, and record a description on the data sheet (i.e. biscuity, fruity, floral, musty,
rotten eggs, sour, no smell, etc.)
● Record any other observations or mistakes made under the correct day.

Step 6: Clean Up
● Cover jar mouth with a paper towel and secure with lid ring or rubber band.
● Clean ALL tools.
● Place all jars and data sheets in a secure location away from direct sunlight with all clean
supplies.
Day 1-14:

Step 1: Measure Height
- Measure and record height of each sourdough starter. (Measure to the “high tide” mark, to record the maximum growth over 24 hours.)

Step 2: Data Collection
- Remove the paper towel cover.
- Record any additional observations: for example, is there a layer of liquid on top of the starter?
- Smell your starter, and record a description on the datasheet (i.e. biscuity, fruity, floral, musty, rotten eggs, sour, no smell, etc.)

Step 3: pH Test
- *Then* mix starter
- Scoop a small amount of your starter into a spoon, and touch one side of a strip of pH paper to the starter. (This allows the starter to soak into the pH paper, but keeps the other side of the paper clean and easy to read.) To measure the pH, match the color of the paper to the color key on the package.
**Step 4: Feeding**

- Remove 1 Tbsp of the starter. (This is called backslopping.) The backslop can be discarded in the trash.
- Add 1 Tbsp of your group’s flour and 1 Tbsp distilled water; mix well.
- Make sure all starter is pushed off the sides of the jar and off of the spoon.

**Step 5: Clean**

- Cover jar mouth with a paper towel and secure with lid ring or rubber band.
- Clean ALL tools.
- Place all jars and data sheets in a secure location away from direct sunlight with all clean supplies.

Repeat Day 1 instructions once a day, for 14 days.

- **IMPORTANT:** Starters must be fed every day to keep growing.
- *It must be fed over the weekend or put in a refrigerator to slow growth.*
Sourdough For Science: Frequently Asked Questions

Does sourdough smell as bad when baking in the oven as it does as a dough?

Sourdough in the oven tends to smell like bread baking, and even mature sourdough starters tend to smell more like bread than what you're smelling now. The reason your sourdough starter might not smell appetizing is because your sourdough starter’s community is still forming. Before a starter reaches its mature climax community, it can still contain opportunistic bacteria or yeasts that produce smells and flavors that are a bit “off”. When your starter reaches a stable, mature climax community, it will probably smell more like something you want to eat.

When I checked my starter this morning, there was a layer of liquid on top. What is that liquid?

Many bakers call this liquid “hooch”, because it contains alcohol. When the yeasts in the starter run out of sugar and starch to eat, they get stressed and start to produce alcohol. So, hooch is a sign that your starter is hungry.

If there is some alcohol in the dough, can a person become intoxicated from consuming it?

Nope. Remember, you bake bread before you eat it – and the heat bakes off all of the alcohol.

Are there any other microorganisms in our starters besides the yeast and bacteria?

It's possible, but we haven’t used DNA sequencing or microscopy to look.

If microbe reproduction slows down in the refrigerator, then why do people get sick in the winter?

There are a lot of differences between the microbes that live in sourdough starters and the microbes that make us sick; but here are a couple of reasons.

- In the winter, humans like to stay warm, so they tend to gather inside together. This means people are more likely to share germs with each other.
- Microbial reproduction slows down at low temperatures but remember that human bodies are warm — and the microbes that make people sick are only able to do that when they are growing in our bodies.

Are fungi antibacterial, or is that just mold?

Mold and yeast are actually both types of fungus, and many molds and yeasts are able to produce antibacterial compounds.
Can scientists determine the dominant bacteria or yeast in the climax community from the pH or aroma?

We know that bacteria lower the pH of your sourdough starter by creating acetic acid and lactic acid, and that yeasts are responsible for creating the aromas that contribute to the smell and flavor of bread. But we don’t yet know enough to be able to identify which bacteria or yeasts are present from the pH or smell of a starter. That is actually part of our ongoing research, and the data you are collecting may help us to answer that question!

Is the relationship between the yeast and the bacteria commensalistic, mutualistic, or are they competition?

Different types of yeasts and bacteria can have different types of relationships. For the global Sourdough Project, we are measuring which different bacteria and yeasts occur in the same starters, to infer what type of relationship they might have. Two microorganisms with positive co-occurrence tend to be found in high abundance together, and we think this means that they work together in a mutualistic relationship. Other microorganisms might compete with each other for nutrients, resulting in negative co-occurrence: the “winner” would be successful and common, while the “loser” would be rare because it was outcompeted. So far, it looks like several species of Lactobacillus bacteria have positive co-occurrence. These bacteria may “get along well” because they are similar: they all make acid and thrive in low-pH habitats.

Yeasts, on the other hand, don’t play so well with others: they tend to have negative relationships with other yeasts, as well as many types of bacteria, possibly because they are competing for the same nutrients. Sacchromyces cerevisiae, the same species of yeast that is used in commercial bread baking, is an exception: it has a positive relationship with a few types of Lactobacillus bacteria.

In a climax community is there one dominant microorganism yeast or bacteria, or are they equal and it is one of each?

The climax communities in mature sourdough starters tend to have one or two types of bacteria and yeast that are dominant.

At what temperature does the yeast and bacteria die? HOT? Does cold ever kill bacteria or yeast or are they just dormant?

Most bacteria and yeasts are killed by heating to 160F (71C), especially when the pH is low. Yeasts and bacteria can remain dormant in the refrigerator, but most will die if they are frozen unless we use a special storage technique.

What is the rate of reproduction?
When conditions are optimal (when there’s a lot of food and the temperature is just right), bacteria can divide in as little as 20 to 30 minutes. Yeast take a little longer (once every 1-2 hours). But that is when conditions are perfect; we don’t know the exact growth rates for sourdough starters.

**Sourdough For Science: Student Activity Sheet**

Name: _______________________________  Date:______________________________

**Objective:**
Observe how your sourdough starter will grow and acidify when being fed flour and water daily.

**Hypothesis:**
Will a change in your sourdough starter height result from a species of bacterium or yeast? (Circle the best response.)

If the ___________ (yeast/bacteria) grow within my starter, then the **height** of my sourdough starter will ___________ (increase/decrease).

Will a change in your sourdough starter pH result from a species of bacterium or yeast? Use the following template to help you.(Circle the best response.)

If the _______________ (yeast/bacteria) grow within my starter, then the **pH** of my sourdough starter will ______________ (increase/decrease).

**Procedure:**

**Day 0 (First Day):**
1. Label your name and flour type near the top edge of your jar.
2. Add 2 Tablespoons (Tbsp) of the flour assigned to you, into your jar.
3. Add 2 Tbsp of distilled water to your jar.
4. Mix flour and water mixture with a spoon, and then use the spoon to scrape any flour-water paste back down the sides of the jar. **This flour-water paste is your starter.**
5. Measure and record the height of the starter (in cm) on your data table.
6. Scoop a small amount of your starter into your spoon, and touch one side of a strip of pH paper to the starter. (This allows the starter to soak into the pH paper, but keeps the other side of the pH paper clean and easy to read). Measure and record the pH on your data table. **To measure the pH, match the color of the paper to the color key on the pH package.**
7. Smell your starter, and record a description of the smell in your data table (i.e. biscuity, fruity, floral, musty, rotten eggs, sour, no smell, etc.) **See Aroma Wheel for clarification.**
8. Cover mouth of jar with one paper towel and secure paper towel with lid ring or rubber band.
9. Place jar in a warm location, out of direct sunlight.

**Day 1 (Second Day):**

**Before feeding:**
1. Measure and record the height of your sourdough starter. **Measure to the “high tide” mark (the point of highest growth), to record the maximum growth over 24 hours.**
2. Record any additional observations of your starter in your data table. For example, is there a layer of liquid on top of the starter? What color is it?
3. Remove the paper towel cover and smell the aroma of your starter. Record the smell. See **Aroma Wheel for clarification**.

4. Mix your starter and measure the pH (before feeding). Record your pH on the data table.

**Feeding:**
5. 1. Remove 1 Tbsp of the starter and dump into a waste container. (This is called *backslopping*.)
6. Add 1 Tbsp of flour into jar.
7. Add 1 Tbsp of distilled water into jar. Mix well with spoon.
8. Cover the mouth of the jar with the paper towel and secure with lid ring or rubber band.
9. Return jar to the location where it was stored previously.

**Days 2-14:**
Repeat Day 1 instructions once a day, for 2 weeks.

*IMPORTANT: Starters must be fed every day to keep growing!*

**Data Table**

**Flour Type:**

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Height (cm) before mixing</th>
<th>Temp (°C)</th>
<th>Aroma</th>
<th>pH (after mixing, before feeding)</th>
<th>Other observations (i.e., color, presence of liquid, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 0</td>
<td></td>
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<td></td>
<td>N/A</td>
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<td>Day 1</td>
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<td>Day 5</td>
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<td>Day 6</td>
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</tbody>
</table>
Questions - Checkpoint (Answer after collecting your data for Day 7):

1. Thus far, do you notice a change occurring in your sourdough starter height? If so, explain.

2. Is there a change occurring in your sourdough starter pH? If so, explain.

3. Are there other changes or trends you are seeing in your sourdough starter? If so, explain.

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Height (cm) before mixing</th>
<th>Temp (°C)</th>
<th>Aroma</th>
<th>pH (after mixing, before feeding)</th>
<th>Other observations (i.e., color, presence of liquid, etc.)</th>
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<td>Day 8</td>
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<td>Day 9</td>
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<td>Day 10</td>
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<td>Day 11</td>
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<td>Day 12</td>
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</tbody>
</table>
Questions - Conclusion (Answer after collecting your data for Day 14):

1. What final observation(s) did you notice with your sourdough starter height? 
   ______________
   ___________________________________________________________________________
   ___________________________________________________________________________
   ___________________________________________________________________________

2. What final observation(s) did you notice with your sourdough starter pH? 
   ______________
   ___________________________________________________________________________
   ___________________________________________________________________________
   ___________________________________________________________________________

3. Are there any additional changes or trends that occurred over the last few days of your data collection? If so, explain. 
   ___________________________________________________________________________
   ___________________________________________________________________________
   ___________________________________________________________________________

4. Was your hypothesis supported or rejected? Why? 
   ___________________________________________________________________________
   ___________________________________________________________________________
   ___________________________________________________________________________
**Aroma Wheel: Teacher Instructions**

**About This Activity:**
Students will explore the chemistry of bread through smell. They will learn how to use an aroma wheel while detecting a scent or smell from four different types of bread. An aroma wheel is a circular chart that acts as a word bank to help make aromas and flavors easier to describe. The four words at the center of the aroma wheel (sour, grainy, bold, fruity) are major aroma categories. The outer ring contains more detailed scents that extend out from each major category.

**Here’s What You’ll Need:**
- Aroma Wheel Student Activity Sheet (one per student)
- Aroma Wheel (below)
- Sticky Notes
- Processed Wheat Bread
- Processed White Bread
- Gluten Free Bread
- Homemade or Bakery Sourdough Bread (from a starter)
- Marker

**Helpful Hints**
- You may bring in some of the items on the aroma wheel to provide references of smell for your students.
- For each group, place one piece of each type of bread into a separate bag and label

**Directions**
1. Ask Students “How can we collect data on smell?”
2. Give each student an Aroma Wheel Student Data Sheet.
3. Give each group of students a piece of each type of bread, some sticky notes, and a marker.
4. Have students complete Part I on their Student Data Sheet
5. After students have each smelled the bread, have them share their “smell” of each bread. As a class, decide what aroma will be recorded for each bread. Students will record their aroma in the chart 1.

6. Give each student an aroma wheel

7. Explain "An aroma wheel is a circular chart that acts as a word bank to help make aromas and flavors easier to describe. An “aroma” is another word for a scent, or smell. The four words at the center of the chart (sour, grainy, bold, fruity) are major aroma categories. The outer ring contains more detailed scents that extend out from each major category. You can use the aroma wheel to describe the smell of your sourdough starter by thinking about each major category, one at a time. For example, you might first consider “What sour scents do you smell?” Look at the detailed words extending from the “sour” category (vinegar, yogurt, cheese, buttermilk) and select the words that best describe the smell of your starter. Continue around the wheel until you have considered all four categories. You might not detect scents from all four categories, but it is important that you only record aromas that you see on the aroma wheel"

8. Students should complete Part II of their activity sheet

9. When student’s finish remind students that they will use the same technique that they just learned to identify the aroma of the sourdough starter.

Aroma Wheel
Objective: Learn how to use an aroma wheel and discover the scents and smells of different types of bread.

Materials:
- Sticky Notes
- Processed Wheat Bread
- Processed White Bread
- Gluten Free Bread
- Homemade or Bakery Sourdough Bread (from a starter)
- Marker
Directions:

Part I

1. Label each bread with the following letter
   a. Processed Wheat Bread - A
   b. Processed White Bread - B
   c. Gluten Free Bread - C
   d. Sourdough Bread - D

2. Take four sticky notes and give each sticky note one letter (A,B,C,D).

3. Smell the processed wheat bread and write down how you think it smells on the “A” sticky note.

4. Smell the processed white bread and write down how you think it smells on the “B” sticky note.

5. Smell the gluten free bread and write down how you think it smells on the “C” sticky note.

6. Smell the sourdough bread and write down how you think it smells on the “D” sticky note.

7. Wait for the teacher’s instructions.

Part II - Aroma Wheel

8. Smell the processed wheat bread again and use the aroma wheel to document the smell on Chart 2. Remember you might not detect aromas from all four categories.

9. Smell the processed white bread again and use the aroma wheel to document the smell on Chart 2.

10. Smell the gluten free bread again and use the aroma wheel to document the smell on Chart 2.

11. Smell the sourdough bread again and use the aroma wheel to document the smell on Chart 2.

---

Chart 1

<table>
<thead>
<tr>
<th>Possible types of bread</th>
<th>Aroma (how does it smell?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Processed Wheat Bread</td>
</tr>
<tr>
<td>B</td>
<td>Processed White Bread</td>
</tr>
<tr>
<td>C</td>
<td>Gluten Free Bread</td>
</tr>
<tr>
<td>D</td>
<td>Sourdough Bread</td>
</tr>
</tbody>
</table>

Chart 2

<table>
<thead>
<tr>
<th>Possible types of bread</th>
<th>Aroma (how does it smell?)</th>
</tr>
</thead>
</table>
### Guided Reading: Teacher Instructions

**About the Activity**
Students will explore the background and science of bread making through literacy. They will dive into vocabulary, reading comprehension, and writing, while focusing on the relationships of microbes.

**Estimated Time to Complete**
- 30-45 minutes

**Here’s What You’ll Need**

<table>
<thead>
<tr>
<th></th>
<th>Processed Wheat Bread</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Processed White Bread</td>
</tr>
<tr>
<td>C</td>
<td>Gluten Free Bread</td>
</tr>
<tr>
<td>D</td>
<td>Sourdough Bread</td>
</tr>
</tbody>
</table>
Directions

- Ask Students “What do you know about bread?”
- Pass out a Guided Reading: Student Activity Sheet to each student. Instruct students to work with their partner to discuss what they believe the six vocabulary words mean. Ask students to share their ideas about the words with the class. Go over the definitions as a class.
  - Sourdough - bread that is naturally leavened with wild bacteria and yeast.
  - Microorganism – living, often single-celled, that are only visible under a microscope - too small to see with the naked eye.
  - Bacteria - living, but without a nucleus, and generally unicellular - Prokaryote.
  - Yeast - living, a member of the Kingdom of Fungi, have a nucleus, and thus eukaryote like animal, plant, and protista kingdoms
  - Succession - how a biological community changes over time. Primary succession is when the first species, in this case bacteria and yeast, colonize a previously lifeless habitat
  - Climax Community - the final stage of succession, the starter ecosystem can live for centuries remaining relatively unchanged until destroyed by an event such as human interference - like baking
- Pass out a Guided Reading to each student. As the students read have them highlight ten words that they believe are the most important words. Each student may pick different words.
- As students complete the reading have them answer the five questions on the activity sheet.

Helpful Hints

- This lesson is available in English and Spanish.

**Guided Reading: Student Activity Sheet**

**Before You Read**

What do you think the following words mean?

**Sourdough** -

**Microorganism** -
As You Read
Highlight ten words that you think are the most important.

After You Read
Answer the following questions in complete sentences.

1. When was the earliest bread baked and where was it found?
2. What happens when a starter is not fed for a long period of time?
3. What truly makes bread?
4. Explain how the first loaf of bread was formed.

5. Using the ten highlighted words write a summary of the article.

Guided Reading

Background
Humans have a long history of baking bread. In fact, bread has played an important role in human cultures and histories all over the world. The bread we eat and buy from the store today is typically made with commercial yeast, which was developed in the 1860s. But before that, all bread was made with sourdough starter. Instead of adding a packet of dried yeast, bakers would mix flour and water together – and
then leave that sticky glob out, to be colonized by wild bacteria and yeast from the environment. The earliest known sourdough bread was found in Egypt, and was baked over 10,000 years ago – which is incredible, considering that microorganisms weren’t even discovered until the 1660s! So how did humans bake bread for thousands of years, without knowing about the bacteria and yeasts that truly “make” bread?

Microbiology

The first sourdough starter was probably created completely by accident, possibly by leaving a bowl of porridge out. Bacteria and yeast would have settled from the air into the porridge, and started to digest the sugars and starch from the grain to produce different products of fermentation: vitamins, acid, and carbon dioxide. Bacteria and yeast both digest sugar and starch, but produce different fermentation products. Bacteria make acids, which prevent the growth of other (food-spoiling) microorganisms that are not acid-tolerant. Yeast produce carbon dioxide, which similarly prevents the growth of other microorganisms that require oxygen to live. Together, the bacteria and yeasts that colonize the sourdough starter early create compounds that (1) change their environment and (2) prevent harmful microorganisms from moving in. Both of these actions push the succession process forward toward a mature climax community. Along the way, some types of bacteria and yeast might compete for the same resources. When this happens, one type of microorganism typically outcompetes the other, which is why we only find one or the other in the mature sourdough starter’s climax community. When starters are not fed for a long time, the bacteria and yeast use up all of the sugar and starch from the flour. When this happens, the yeast switch to a different digestive process: instead of fermenting sugar and starch to make carbon dioxide, they ferment acetic acid (made by bacteria) to produce alcohol. This alternate digestion strategy is not ideal, which is why you only see or smell alcohol in “hungry” starters.

Mechanics of Baking

Back to the first sourdough starter… Whoever found that old bowl of porridge might have tasted it. The acids would give it a sour taste (hence, the name “sourdough”) and the carbon dioxide might have made it a little fizzy – NOT your typical porridge. Whoever tasted it probably would have thrown it into the fire to burn, as garbage. The heat from the fire would have baked the fermented porridge (the first bread dough), causing a crust to form on the outside. That crust would have trapped the carbon dioxide bubbles inside, even as
the heat from the fire caused the air bubbles to expand, causing the loaf of bread to rise. The heat eventually kills the bacteria and yeast, leaving behind the vitamins, acid, and air pockets filled with flavor. That first loaf of bread might have been a mistake, but it’s not surprising that humans continued to make sourdough bread! The vitamins and aromatic compounds that make bread so tasty, are also highly nutritious; and the acids that give sourdough its characteristic sour flavor, also keep the bread from getting moldy as quickly as store-bought breads do. In addition to the sour “tang”, the yeasts also produce a lot of other flavors – not all sourdough breads are super-sour. Sourdough and modern, store-bought breads even grow differently when you make them: commercial (“rapid rise”) yeast is really good at digesting sugar to produce a lot of carbon dioxide, quickly. In contrast, all of the different types of bacteria and yeasts that live in sourdough starter produce different compounds (in addition to carbon dioxide). These different compounds make sourdough bread more flavorful and nutritious – and last longer!

**Sourdough for science**

Surprisingly, for all the work that has gone into commercial bread production, we know almost nothing about the microbes associated with traditional sourdoughs. Here’s where you come in: you can help us study sourdough as a citizen scientist. Citizen science doesn’t require any formal education (like a college degree) – just an interest in exploring the world around you. By growing your own starters in the classroom and taking a few simple measurements, you can help add to what we know about bread!

**Lectura Guiada**

**Antecedentes**

Los humanos tienen una larga historia de hornear pan. De hecho, el pan ha jugado un papel importante en las culturas e historias humanas en todo el mundo. El pan que comemos y compramos en la tienda hoy en día se hace típicamente con levadura comercial, que se desarrolló en la década de 1860. Pero antes de eso, todo el pan estaba hecho con masa madre. En lugar de agregar un paquete de levadura seca, los panaderos mezclaban la harina y el agua, y luego dejaban esa mezcla pegajosa para ser colonizada por bacterias y levaduras silvestres del medio ambiente. El primer pan de masa fermentada conocido se encontró en Egipto y fue horneado hace más de 10.000 años, lo cual es increíble, ¡teniendo en cuenta que los microorganismos ni siquiera se descubrieron hasta la década de 1660! Entonces, ¿cómo los humanos horneaban pan durante miles de años, sin saber
Microbiología

El primer iniciador de masa madre probablemente fue creado completamente por accidente, posiblemente al dejar afuera un tazón de avena. Las bacterias y la levadura se habrían asentado del aire en la papilla y comenzaron a digerir los azúcares y el almidón del grano para producir diferentes productos de la fermentación: vitaminas, ácido y dióxido de carbono. Tanto las bacterias como la levadura digieren el azúcar y el almidón, pero producen diferentes productos de fermentación. Las bacterias producen ácidos, que impiden el crecimiento de otros microorganismos (que estropean los alimentos) que no son tolerantes a los ácidos. La levadura produce dióxido de carbono, que de manera similar previene el crecimiento de otros microorganismos que requieren oxígeno para vivir. Juntas, las bacterias y las levaduras que colonizan el iniciador de masa madre temprano crean compuestos que (1) cambian su ambiente y (2) evitan la entrada de microorganismos dañinos. Ambas acciones impulsan el proceso hacia una comunidad climax madura. En el proceso, algunos tipos de bacterias y levaduras pueden competir por los mismos recursos. Cuando esto sucede, un tipo de microorganismo generalmente supera al otro, por lo que solo encontramos uno u otro en la comunidad climax del iniciador de masa madre madura. Cuando los iniciadores no se alimentan durante mucho tiempo, las bacterias y la levadura usan todo el azúcar y el almidón de la harina. Cuando esto sucede, la levadura cambia a un proceso digestivo diferente: en lugar de fermentar azúcar y almidón para producir dióxido de carbono, fermentan ácido acético (producido por bacterias) para producir alcohol. Esta estrategia alternativa de digestión no es ideal, por eso solo se ve o huele el alcohol en iniciadores "hambrientos".

Mecánica de hornear

Volver al primer plato de masa madre ... Quienquiera que haya encontrado ese viejo tazón de avena podría haberlo probado. Los ácidos le darían un sabor agrio (de ahí el nombre de "masa agria") y el dióxido de carbono podría haberlo hecho un poco efervescente, NO su papilla típica. Quien lo haya probado probablemente lo habría arrojado al fuego para quemarlo, como basura. El calor del fuego habría horneado la papilla fermentada (la primera masa de pan), causando que se forme una costra en el exterior. Esa corteza habría atrapado las burbujas de dióxido de carbono en el interior, incluso cuando el calor del fuego hizo que las burbujas de aire se expandieran, provocando que la barra de pan creciera. El calor finalmente mata las bacterias y la levadura, dejando atrás las vitaminas, el ácido y las bolsas
de aire llenas de sabor. ¡Esa primera barra de pan podría haber sido un error, pero no es sorprendente que los humanos sigieran haciendo pan de masa fermentada! Las vitaminas y compuestos aromáticos que hacen que el pan sea tan sabroso, también son altamente nutritivos; y los ácidos que le dan a la masa madre su sabor ácido característico, también evitan que el pan se enmohezca tan rápido como los panes comprados en la tienda. Además del “sabor” ácido, las levaduras también producen muchos otros sabores, no todos los panes de masa fermentada son súper ácidos. La masa madre y los panes modernos comprados en la tienda incluso crecen de manera diferente cuando los haces: la levadura comercial (“crecimiento rápido”) es realmente buena para digerir el azúcar para producir mucho dióxido de carbono, rápidamente. Por el contrario, todos los diferentes tipos de bacterias y levaduras que viven en la masa madre producen compuestos diferentes (además del dióxido de carbono). Estos diferentes compuestos hacen que el pan de masa fermentada sea más sabroso y nutritivo, ¡y dure más!

Masa madre para la ciencia

Sorprendentemente, por todo el trabajo que se ha dedicado a la producción comercial de pan, no sabemos casi nada sobre los microbios asociados con las masas madre tradicionales. Aquí es dónde vienes tú: puedes ayudarnos a estudiar la masa madre como científico ciudadano. La ciencia ciudadana no requiere ninguna educación formal (como un título universitario), solo un interés en explorar el mundo que te rodea. ¡Cultivando tus propios iniciadores en el aula y tomando algunas medidas simples, puedes ayudar a incrementar lo que sabemos sobre el pan!

Wonderbread: Teacher Instructions

About the Activity
Students will understand the meaning of tone in literacy through poetry.

Estimated Time to Complete
● 20-25 minutes

Here’s What You’ll Need
● Wonderbread Student Activity Sheet
● Highlighter (1 per student)

Directions
● Ask students: Why do you think Wonderbread is called Wonderbread?
● Establish a discussion protocol with students (ex. think pair share, talking stick, round table).
● Give each student a Wonderbread Student Activity Sheet
● Review with students the following terms
  ○ Tone: The author’s attitude toward the subject.
  ○ Pun: usually the humorous use of a word in such a way as to suggest two or more of its meanings.
● Closing discussion or exit ticket: Why should we know the science of sourdough bread?

Resources
● Alfred Corn bio https://www.poetryfoundation.org/poets/alfred-corn

Wonderbread: Student Activity Sheet

Name: _______________________________  Date:______________________________

Before You Read:
Discuss the following questions:
What is your earliest memory of homemade bread?
Describe what you see when you are looking at the shelves full of bread at the grocery store?

As You Read
Highlight words that indicate the author’s tone toward Wonderbread.

After You Read
Answer the following questions in complete sentences.
  1. What words are used to describe Wonderbread? ____________________________________________

  2. What does the author mean by, “a pun for bread.”? _________________________________________
3. Would the author support your sourdough research? Explain your answer. _______________________
__________________________________________________________________________________
__________________________________________________________________________________

**Wonderbread**
By Alfred Corn (1977)

Loaf after loaf, in several sizes,
and never does it not look fresh,
as though its insides weren’t moist
or warm crust not the kind that spices
a room with the plump aroma of toast.

Nothing! Nothing but air, thin air ....
Oh. One more loaf of wonderbread,
only a pun for bread, seductive
visually, but you could starve.
Get rid of it, throw it in the river—

Found on the table; among shadows
next to the kitchen phone; dispatched
FedEx (without return address, though).
Someone, possibly more than one
person, loves me. Well then, who?

Beyond which, grain fields. Future food for the just
and the unjust, those who love, and do not love.

Amazing that bread should be so weightless,
down-light when handled, as a me
dying to taste it takes a slice.
Which lasts just long enough to reach
my mouth, but then, at the first bite,

**What’s the Limit: Teacher Instructions**

**About the Activity**
Students will learn about the four different limiting factors in an ecosystem (food, water, space, shelter), and explore what other factors impact a population. They will also determine which factors are abiotic and biotic. Students will understand that ecosystems can be large, like a pond, or small, like their Sourdough jar.

**Estimated Time to Complete**
- 45-60 minutes

**Here’s What You’ll Need**
- What’s the Limit Student Activity Sheet
- Pencils
Directions

- Ask students “When you hear the word limit, what do you think of?”
- Hand out What’s the Limit Student Activity Sheet
- Have a student read the introduction on the What’s the Limit Student Activity Sheet. Have students do a “Think, Pair, Share” on what they believe the four major limiting factors are. Students should have written down **Food, Water, Space, & Shelter** as the four main limiting factors, while discussing as a class.
- As a class have students brainstorm what other factors could limit a population.
  - Some answers may include competition, predation, disease, etc
- Students will now look at the picture of the pond. Have students work with a partner to determine how the four main limiting factors would impact that population. Have a couple groups share.
- Say “Limiting factors can be categorized into two different categories: abiotic and biotic. Does anyone know what those two words mean?” If students do not know the answer, have them read the paragraph on their activity sheet.
- Students will now work together to draw the sourdough ecosystem and complete the rest of the student activity sheet.

Helpful Hints

- This can be done as partners or small groups.
- If students are struggling with creating the sourdough ecosystem, this can be done as a whole class.

---

**What’s the Limit: Student Activity Sheet**

Name: _______________________________  Date:______________________________

Did you know that ecosystems have limits? Each ecosystem can only support a certain amount of a specific organism depending on its limiting factors. A *limiting factor* can change the animal and plant populations in an ecosystem. The four major limiting factors are

____________________________________________________________________________

Other limiting factors:

**Directions:**

Look at the picture below. Pick an organism and identify how the four main limiting factors could affect the population.
Food -

Shelter -

Space -

Explain one other factor that could limit that population.

Factors can be classified into two different categories: abiotic and biotic. Abiotic factors are nonliving parts of the environment and biotic factors are living parts of the environment. For example in the pond ecosystem, the Sun is a very important abiotic factor that helps provide plants with food and the plants themselves are important biotic factors that provide food to other organisms.

Look at the pond picture. List all abiotic and biotic factors below.

<table>
<thead>
<tr>
<th>Abiotic</th>
<th>Biotic</th>
</tr>
</thead>
</table>

Now let's look at our sourdough starters! Draw your sourdough ecosystem below. Pick an organism and identify how the four main limiting factors could affect the population.

Water -

Food -

Shelter -

Space -

Explain one other factor that could limit that population.
Think about your ecosystem. Think about all the factors that are part of that ecosystem. List all abiotic and biotic factors below.

<table>
<thead>
<tr>
<th>Abiotic</th>
<th>Biotic</th>
</tr>
</thead>
</table>

Questions (Please answer in complete sentences):

1. What are the four main limiting factors? __________________________________________________________

2. Were there similar abiotic and biotic factors for the pond ecosystem and the sourdough ecosystem? If so what were they? _______________________________________________________________________________
   _______________________________________________________________________________________

3. Were there any different abiotic and biotic factors for the pond ecosystem and the sourdough ecosystem? If so what were they? _______________________________________________________________________________
   _______________________________________________________________________________________

4. In the sourdough ecosystem, which limiting factor do you think has the greatest influence? Explain your answer. _______________________________________________________________________________________
   _______________________________________________________________________________________
   _______________________________________________________________________________________
   _______________________________________________________________________________________

Student Readiness: Formative Assessment

Name: _______________________________ Date:______________________________

Over the last five days you have gotten to explore different aspects of growing a sourdough starter. Answer the following questions in complete sentences.

1. How did you create your starter? __________________________________________________________
   ____________________________________________________________________________________
   ____________________________________________________________________________________

2. How has your starter changed since Day 0? ______________________________________________
   ____________________________________________________________________________________
   ____________________________________________________________________________________

3. What organisms are you feeding? ______________________________________________________
   ____________________________________________________________________________________
   ____________________________________________________________________________________
4. How has pH changed over time? ______________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

5. What causes the pH to change over time? ______________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

6. How has the height changed over time?________________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

7. What causes the height to change over time?____________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

8. What happens when you feed your starter? _____________________________________________
__________________________________________________________________________________
__________________________________________________________________________________

9. How is sourdough bread different from commercial bread? ________________________________
__________________________________________________________________________________
__________________________________________________________________________________

10. Is your starter a living organism or an ecosystem? Explain. ________________________________
__________________________________________________________________________________

Who’s My’crobe: Teacher Instructions

About the Activity
Students will explore the different traits of the most common bacteria and yeast found in the international citizen science project Sourdough for Science. Through collaborations with their peers, students will form their own bacterial and yeast colonies and become the class “experts” on their individual colony. After becoming experts on their colony, students will share out their findings and teach the rest of the class about their microbe.

Estimated Time to Complete
● 45-60 minutes

Here’s What You’ll Need
● Who’s My’crobe Trading Cards
● Who’s My’crobe Student Activity Sheet
● Whiteboard

Directions
● Print out all of the My’crobe Trading Cards (There are four cards for each microbe, making a total of 40).
● Pass out one trading card to each student.
● Ask the students “Who can tell me what a microbe is?” Students should answer with “an organism or agent that is too small to be seen with the naked eye.”
● Ask the students “Why are microbes important to the breadmaking process?” Students answers may vary.
● Pass out My’crobe Student Activity Sheet and say “Congratulations! You have now become a microbe. These microbes are the most common bacteria or yeast found in the Sourdough for Science citizen science project. Each of you has been given either a bacteria or a yeast with one fact on it. Find your microbe on your activity sheet and fill in the name and your fact.”
● Have students find the other students that share the same microbe to form a colony. They must check their picture and name (If you printed them out in color, each microbe has its own color). Students are to share their fact with their colony and fill in their activity sheet.
● Once students have finished recording their individual data, have students share their information with the class. Students should write the name of their microbe on the board so that students will have accurate spelling.
● After every group has shared, have students answer the questions. This can be done in their colony or on their own. You can choose to go over the answers as a class discussion or collect individually.

Helpful Hints
● Laminating the trading cards allows them to be used over and over again.
● For smaller class sizes (<20), have students become experts on the yeast microbes and then duplicate the activity with the bacteria microbes.
● Students can do additional research on their individual colony if time allows.

Who’s My’crobe: Student Activity Sheet

**Directions:**
Congratulations you just became a microbe! Your first goal is to find your picture below, label it correctly, and add your fact.

**What type of microbe are you? (Circle one)**

<table>
<thead>
<tr>
<th></th>
<th>Bacteria</th>
<th>Yeast</th>
</tr>
</thead>
</table>

Your second goal is to find your colony. A colony is many of the same bacteria or yeast in an area. Make sure you check your name and picture as some microbes can look very similar or even have a similar name. Take turns with your other colony members to share facts about your microbe. Record your information below. Be prepared to share your information with the class.

Your third goal will be to present your information to the class. Record the information about the other microbes as your classmates present.

**Yeast**
<table>
<thead>
<tr>
<th>Name:</th>
<th>Name:</th>
<th>Name:</th>
<th>Name:</th>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size:</td>
<td>Size:</td>
<td>Size:</td>
<td>Size:</td>
<td>Size:</td>
</tr>
<tr>
<td>Habitat:</td>
<td>Habitat:</td>
<td>Habitat:</td>
<td>Habitat:</td>
<td>Habitat:</td>
</tr>
<tr>
<td>Use:</td>
<td>Use:</td>
<td>Use:</td>
<td>Use:</td>
<td>Use:</td>
</tr>
<tr>
<td>Fun Fact:</td>
<td>Fun Fact:</td>
<td>Fun Fact:</td>
<td>Fun Fact:</td>
<td>Fun Fact:</td>
</tr>
</tbody>
</table>

**Bacteria**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Name:</th>
<th>Name:</th>
<th>Name:</th>
<th>Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size:</td>
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<td>Size:</td>
<td>Size:</td>
</tr>
<tr>
<td>Habitat:</td>
<td>Habitat:</td>
<td>Habitat:</td>
<td>Habitat:</td>
<td>Habitat:</td>
</tr>
</tbody>
</table>
Questions (answer in complete sentences):

1. What two facts surprised you the most? ________________________________________
   _______________________________________________________________________
   _______________________________________________________________________

2. Take a look at the photos and names of the bacteria.
   a. What do you believe bacillus means? ___________________________________
      _______________________________________________________________________
   b. What do you think coccus means? ______________________________________
      _______________________________________________________________________

3. Lactobacillus paralimentarius was isolated in 1999. Do you believe that there could be other
   types of microbes that have not been discovered yet? Explain your answer. _____________
   _______________________________________________________________________
   _______________________________________________________________________
   _______________________________________________________________________

---

**Saccharomyces cerevisiae**

Size: 5–10 μm in diameter

---

**Saccharomyces cerevisiae**

Size: ________________________________
**Habitat:** widespread, pH 4-6, 32.3°C
**Use:** used in baking, winemaking, and brewing
**Fun Fact:** used as a genetic tool
**Alternaria**

**Size:** 23-34 μm x 7-10 μm

**Habitat:**

**Use:**

**Fun Fact:**

---

**Alternaria**

**Size:**

**Habitat:** soil/water, pH 5.5-7.5, 23-27°C

**Use:**

**Fun Fact:**

---

**Alternaria**

**Size:**

**Habitat:**

**Use:** plant pathogen, can cause hay fever/asthma

**Fun Fact:**

---

**Alternaria**

**Size:**

**Habitat:**

**Use:**

**Fun Fact:** help with decomposition
Gibberella zeae

Size: 10-14 x 3.5-4.5 µm
Habitat: ________________________________
Use: __________________________________
Fun Fact: ____________________________

Gibberella zeae

Size: _________________________________
Habitat: where crops are grown, pH 5-9, 26-28°C
Use: __________________________________
Fun Fact: ____________________________

Gibberella zeae

Size: _________________________________
Habitat: ________________________________
Use: plant pathogen found in wheat, barley, & corn.
Fun Fact: ____________________________

Gibberella zeae

Size: _________________________________
Habitat: ________________________________
Use: __________________________________
Fun Fact: causes vomiting, liver damage, & reproductive defects in farm animals.
**Mycosphaerella tassiana**

**Size:** 16-29 x 4.5-8 um

**Habitat:**

**Use:**

**Fun Fact:**

---

**Mycosphaerella tassiana**

**Size:**

**Habitat:** soil/wood, pH 6, 28-32°C

**Use:**

**Fun Fact:**

---

**Mycosphaerella tassiana**

**Size:**

**Habitat:**

**Use:** plant pathogen found in hemp, rye, & others

**Fun Fact:**

---

**Mycosphaerella tassiana**

**Size:**

**Habitat:**

**Use:**

**Fun Fact:** causes allergies in humans
**Naumovozyma castellii**

**Size:** 3-5.5 x 3.5-7um

**Habitat:**

**Use:**

**Fun Fact:**

---

**Naumovozyma castellii**

**Size:**

**Habitat:** pH 5-7, 25°C

**Use:**

**Fun Fact:**

---

**Naumovozyma castellii**

**Size:**

**Habitat:**

**Use:** wide distribution in nature.

**Fun Fact:**

---

**Naumovozyma castellii**

**Size:**

**Habitat:**

**Use:**

**Fun Fact:** easily genetically modified.
**Lactobacillus sanfranciscensis**

**Size:** 0.5-0.8 x 2-9 um

**Habitat:**

**Use:**

**Fun Fact:**

---

**Lactobacillus sanfranciscensis**

**Size:** ________________

**Habitat:** pH 4-6.5, 30-37°C

**Use:**

**Fun Fact:**

---

**Lactobacillus sanfranciscensis**

**Size:** ________________

**Habitat:**

**Use:** used in sourdough

**Fun Fact:**

---

**Lactobacillus sanfranciscensis**

**Size:** ________________

**Habitat:**

**Use:**

**Fun Fact:** grow & adapt quickly to sourdough environment

---

39
Lactobacillus brevis

Size: 0.5-0.8 x 2-9 um
Habitat: mostly in food, pH 4-6, 30°C
Use: used in beer, yogurt, & fermented products
Fun Fact: improves human immune function
Lactobacillus paralimentarius

Size: 4.0-7.0 pm x 0.7-1.0 pm
Habitat:
Use: 
Fun Fact:

Lactobacillus paralimentarius

Size: _____________________________
Habitat: pH 4.5, 37-45°C
Use: _____________________________
Fun Fact: ________________________

Lactobacillus paralimentarius

Size: _____________________________
Habitat: ___________________________
Use: used in sourdough
Fun Fact: ________________________

Lactobacillus paralimentarius

Size: _____________________________
Habitat: ___________________________
Use: _____________________________
Fun Fact: was isolated as own bacteria in 1999
**Lactobacillus plantarum**

**Size:** 0.9–1.2 μm x 3–8 μm long

**Habitat:**

**Use:**

**Fun Fact:**

---

**Lactobacillus plantarum**

**Size:**

**Habitat:** mammalian saliva/gastrointestinal tracts, pH 3.2, 15-45°C

**Use:**

**Fun Fact:**

---

**Lactobacillus plantarum**

**Size:**

**Habitat:**

**Use:** used in dairy, meat, and plant fermentations

**Fun Fact:**

---

**Lactobacillus plantarum**

**Size:**

**Habitat:**

**Use:**

**Fun Fact:** fights off pathogenic bacteria
Pediococcus

**Size:** 1–2.5 μm  
**Habitat:**  
**Use:**  
**Fun Fact:**

---

Pediococcus

**Size:**  
**Habitat:** plant material/fruits, pH 4-8, 12-40°C  
**Use:**  
**Fun Fact:**

---

Pediococcus

**Size:**  
**Habitat:**  
**Use:** used in beer, wine, & fermented products  
**Fun Fact:** can inhibit and kill similar species of bacteria
Sourdough DNA “Recipe”: Teacher Instructions

About the Activity:
Students will explore the DNA sequence of microbes and understand how phylogenetic trees show the genetic relationship among different species.

Estimated Time to Complete:
● 30-45 min

Here’s What You’ll Need:
● Blank paper (1 piece for each student)
● Yeast Trading Cards (from Who’s My’Crobe Activity)
● Pencil (1 for each student)
● Whiteboard
● Sourdough DNA “Recipe” Student Activity Sheet

Directions:
● Give each student a blank piece of paper.
● Ask students to draw out their family tree to the best of their ability. As the students are drawing, the teacher can draw out their own family tree on the whiteboard.
● Explain to students that as someone gets further away from the student on the tree, the less DNA they have in common with each other. Scientists use this same idea when looking at different organisms including microbes.
● Give each student a Sourdough DNA “Recipe” Student Activity Sheet and have them complete the activity.

Helpful Hints:
● Review nucleotides with students.
● Students may work in groups or independently depending on their skill level.
● Provide other examples of phylogenetic trees before doing the Sourdough DNA “Recipe” Student Activity Sheet
Overview:
Below is a phylogenetic (family) tree of some of the most common yeast species found in sourdough starters. By looking at the DNA sequence for each microbe, you can tell how closely related they are to each other. DNA is like a recipe for an organism, just like you need a recipe to create sourdough. Use the tree below and the yeast trading cards from the “Who’s My’crobe” activity to answer the questions below.

Questions:
1. Which two microbes are the most closely related to each other?
   ______________________________ & ______________________________
   a. How many nucleotides do they have in common? ______
   b. How many nucleotides are different? ______

2. Which microbes are the least closely related?
   ______________________________ & ______________________________
   a. How many nucleotides do they have in common? ______
   b. How many nucleotides are different? ______

3. Which species of microbe is essential in brewing, baking, and winemaking?
   a. Name of microbe: ______________________________
   b. What is the DNA sequence of this microbe? ______________________________
   c. What is the complementary gene sequence? ______________________________
4. Which species of microbe has a wide distribution in nature and can be easily genetically modified?
   a. Name of microbe: 
   b. What is the DNA sequence of this microbe?
   c. What is the complementary gene sequence?

5. Which microbial species’ cell is shaped like a banana and infects cereal grains?
   a. Name of microbe: 
   b. What is the DNA sequence of this microbe?
   c. What is the complementary gene sequence?

6. Describe how most yeast reproduce. 
   ____________________________________________________
   ____________________________________________________

7. Are fungi and yeasts classified as a Eukaryote or Prokaryote? 
   ____________________________________________________

8. What makes a cell a Eukaryote?
   ____________________________________________________
   ____________________________________________________

9. How do Eukaryotes and Prokaryotes interact within your sourdough starter?
   ____________________________________________________
   ____________________________________________________
   ____________________________________________________
   ____________________________________________________
Map My Microbes: Teacher Instructions

About the Activity:
Students will understand that the body is a diverse ecosystem, in which microbes play an important role. When you are healthy your body is homeostasis. When it is unhealthy some part is not in balance. The diversity is lost, and some part of your microbial population is dominant.

Estimated Time to Complete:
● 2 45-60 min classes

Here’s What You’ll Need:
● Map My Microbes Student Activity Sheet
● Computer, tablet, or device
● Pencil

Directions:
● Give each student a Map My Microbes Student Activity Sheet
● Make sure each student or group has a device.
● Inform students that they will be researching their body and its ecosystem.

Helpful Hints:
● Make sure there is a strong internet connection for research.
● Students may work in small groups or individually depending on individual levels.
Your body is a diverse ecosystem. When you are healthy your body is homeostasis. When it is unhealthy some part is not in balance. The diversity is lost, and some part of your microbial population is dominant.

**Directions:**
Use Google to research, fill in the charts, and answer the questions below:

1. There are two kinds of living cells in your body. It is important to know the difference.

<table>
<thead>
<tr>
<th>Living Cells</th>
<th>Prokaryotic Cell</th>
<th>Eukaryotic Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differences in Organelles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DNA and reproduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. What is a common gut microbe that helps your body?

<table>
<thead>
<tr>
<th>Gut Microbe</th>
<th>What does it do?</th>
<th>Picture</th>
</tr>
</thead>
</table>
3. Mold and yeast are both fungi. What are their differences?

<table>
<thead>
<tr>
<th>Fungi</th>
<th>Differences</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yeast</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Pathogens cause disease.

<table>
<thead>
<tr>
<th>CELLULAR (LIVING)</th>
<th>ACELLULAR (NON-LIVING)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parasites (e.g. helminthes)</td>
<td>Tapeworm</td>
</tr>
<tr>
<td>Protozoa (e.g. plasmodia)</td>
<td>Malaria</td>
</tr>
<tr>
<td>Fungi (e.g. tinea)</td>
<td>Athlete’s foot</td>
</tr>
<tr>
<td>Prokaryote (i.e. bacteria)</td>
<td>Leprosy</td>
</tr>
<tr>
<td>Virus (e.g. HIV)</td>
<td>AIDS</td>
</tr>
<tr>
<td>Prion</td>
<td>CJD</td>
</tr>
</tbody>
</table>

In each row find 2 more examples that can live in or on humans.

<table>
<thead>
<tr>
<th>CELLULAR (LIVING)</th>
<th>ACELLULAR (NON-LIVING)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eukaryotes</td>
<td>Prokaryote</td>
</tr>
<tr>
<td>Parasites</td>
<td>Protozoa protists</td>
</tr>
<tr>
<td>Fungi</td>
<td>Bacteria and Archaea</td>
</tr>
<tr>
<td>tapeworm</td>
<td>malaria</td>
</tr>
<tr>
<td>Athlete’s Foot</td>
<td>leprosy</td>
</tr>
<tr>
<td>HIV</td>
<td>CJD</td>
</tr>
</tbody>
</table>
5. Is your body an ecosystem? Explain your answer.
   ________________________________
   ________________________________
   ________________________________

6. Who or what lives on and in you? ________________________________
   ________________________________
   ________________________________

7. What is living and what is not living?
   ________________________________
   ________________________________
   ________________________________

8. Which microbes make you healthier?
   ________________________________
   ________________________________
   ________________________________

9. Which makes you sick?
   ________________________________
   ________________________________
   ________________________________

10. How are these microbes classified?
    ________________________________
    ________________________________
    ________________________________

11. Is your body a healthy ecosystem?
    ________________________________
    ________________________________
    ________________________________
Wait to Bake: Teacher Instructions

About the Activity:
Students will try their hand at analyzing data. To do so, they will use the data they collected in the Sourdough for Science experiment. This activity cannot be done unless Sourdough for Science has been completed and students have the Sourdough for Science data available.

Estimated Time to Complete:
● 45-60 min

Here’s What You’ll Need:
● Wait to Bake Student Activity Sheet
● Completed Sourdough for Science Data
● Computer, tablet, or device
● Pencil

Directions:
● Make sure you have your data from the Sourdough for Science experiment.
● Give each student the Wait to Bake Student Activity Sheet
● Discuss with the students that they are going to explore the role that bacteria and yeast play in a sourdough starter by analyzing data.
● Make sure students have a computer or tablet with access to Excel.
● Students will now visualize the data by creating a graph. Students should follow the directions on their Student Activity Sheet.
● You may discuss the questions on the Student Activity Sheet as a class or have students work independently.

Helpful Hints:
● Students can share their completed work with you. This will eliminate printing and allow you to give feedback easily.
Wait to Bake: Student Activity Sheet

Name: _______________________________  Date:______________________________

Directions:

1. Open up Excel
2. Select which flour data you would like to graph. We will be looking at height (cm) and pH. Copy the data into Excel. See the example below.

<table>
<thead>
<tr>
<th>Days Elap Height (cm)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>258</td>
<td>0</td>
</tr>
<tr>
<td>259</td>
<td>1</td>
</tr>
<tr>
<td>260</td>
<td>2</td>
</tr>
<tr>
<td>261</td>
<td>3</td>
</tr>
<tr>
<td>262</td>
<td>4</td>
</tr>
<tr>
<td>263</td>
<td>5</td>
</tr>
<tr>
<td>264</td>
<td>6</td>
</tr>
<tr>
<td>265</td>
<td>7</td>
</tr>
<tr>
<td>266</td>
<td>8</td>
</tr>
<tr>
<td>267</td>
<td>9</td>
</tr>
<tr>
<td>268</td>
<td>10</td>
</tr>
<tr>
<td>269</td>
<td>11</td>
</tr>
<tr>
<td>270</td>
<td>12</td>
</tr>
<tr>
<td>271</td>
<td>13</td>
</tr>
<tr>
<td>272</td>
<td>14</td>
</tr>
</tbody>
</table>

3. Select the column headers “Height(cm)” and “pH” along with the data in the columns underneath them.

   ● Proceed to the Insert tab on the control bar
   
   ● Go to the charts subsection and from the listed graph options
4. Now you should see a graph with two axes and see 3 axes. Right-click the “Height (cm)” line (likely blue) and select “Format Data Series” from the drop-down menu. This will open a “Format Data Series” sidebar on the right side of the screen. Select “Secondary Axis”

5. Click the arrow V by the “Series Options” in the “Format Data Series” sidebar

- You’ll see a drop-down menu
  - Click on the option “Secondary Vertical Axis”
- Now, click the far right icon
  - Set the max values to better reflect/illustrate your data’s maximum points
6. Labeling is of utmost importance. Click the + icon on the right of the graph. You’ll see “Axis Titles” appear on the drop-down menu, select it.

- Label your Axes
  - Horizontal Axis = Days Elapsed
  - Primary Vertical Axis (left) = pH
  - Secondary Vertical Axis (right) = Height(cm)

- Label your Graph
  - Chart Title = Flour type, replicate number if applicable
Questions:
Pioneer species (days 0-2) are the first organisms to colonize an ecosystem. They usually perform functions that change the environment, creating a niche space for additional types of organisms to thrive. For this reason, pioneer species are often known as ecosystem engineers. In the chart below:

1. Describe what is happening to the bacteria colony in days 0-2, 3-4, and 5-15 (increasing or decreasing).
2. Describe what is happening to the yeast population on days 0-2, 3-4, and 5-15 (increasing or decreasing).

<table>
<thead>
<tr>
<th>Pioneers Species</th>
<th>Succession</th>
<th>Climax Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 0-2</td>
<td>Day 3-4</td>
<td>Day 5-15</td>
</tr>
<tr>
<td>Bacteria (pH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yeast (height)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Succession is the process where some organisms are replaced by different types of organisms. These new organisms are better adapted for the changing environment.

3. In days 3-4 which microorganism population is dying? ______________
4. What is the environmental change in the environment? ______________

A community is made up of many different populations. In a climax community there is no more succession. Your starter is a climax community when populations are no longer being replaced. The starter’s populations remain stable over time. Succession may end at different rates for different populations.

5. Complete the table

<table>
<thead>
<tr>
<th>Stable Population</th>
<th>Which population bacteria or yeast?</th>
<th>Which day does it stabilize?</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. On which day does your starter become a climax community? Why? ______________

In the baking world a starter is considered mature (ready for baking) when it has reached its climax community.

7. Looking back at your graph of yeast and bacterial activity, why do you think it is important for a baker to wait to bake? ______________

_____________________________________________________________________________