Are All Bacteria in Food Harmful?

High School, Life Science

Task Overview

Because certain types of bacteria can make humans sick, many people believe that having bacteria in food is always harmful. Throughout this task, students will gradually analyze new sources of data to revise working explanations of whether all bacteria are harmful for humans or if some bacteria can be used to prevent food from spoiling. First, students explore the food ecosystems of two samples of yogurt with different bacteria to figure out which types are harmful and then explore the environmental conditions that allow harmful and less harmful bacteria to thrive. Next, students investigate how the presence of a bacteria called *lactobacillus* can actually prevent harmful bacteria from forming on food, which they use to construct a final argument about how bacteria can actually be beneficial to humans by making food safer.

Background Information

Food can be thought of as an ecosystem. Bacteria, of many types, are the primary living organisms interacting in food ecosystems. Some food bacteria are safe for humans to eat while others are harmful. When bacteria consume sugars in the food, they release waste products that can be neutral, beneficial, or harmful. Harmful bacteria, for example, produce toxic waste products, which make us sick when they are in our digestive system.

One bacteria that is safe for humans to consume is *lactobacillus.* When *lactobacillus* feeds on sugars in food, it produces lactic acid and carbon dioxide through a process called lacto-fermentation. Lactic acid and carbon dioxide reduce the pH in food ecosystems to the point that harmful bacteria (that spoil food and make people sick) have a hard time growing in the ecosystem. *Lactobacillus* can continue to survive in the low pH (acidic) food ecosystems it helps create. Therefore, humans are able to use the unique characteristics of *lactobacillus* to help keep harmful bacteria out of food without any negative impacts to our digestive systems. Sometimes humans even add *lactobacillus* starters to food to encourage growth. This makes the food ecosystem unfavorable for other harmful bacteria to grow and can increase the shelf life of food.

Next Generation Science Standards

Three-Dimensional Claim

Evaluate the impact of new data on a working explanation to construct an argument for how the population of one species can affect the carrying capacity of another species in the same ecosystem by

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

changing environmental conditions.

This task is intended to elicit student learning of the following **NGSS elements** for each of the three dimensions:

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems (HS)

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem (HS-LS2-1).

Science and Engineering Practices

Analyzing and Interpreting Data (HS)

- Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.

Engaging in Argument from Evidence (HS)

- Construct, ~~use, and/or present an oral and~~ written argument ~~or counter arguments~~ based on data and evidence.

Crosscutting Concepts

Cause and Effect (HS)

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Suggestions for Use

This task is intended to be used for formative assessment purposes — to identify students' strengths and needs with the above dimensions in order to provide feedback to students and guide shifts in instruction.

Assumptions

Students should have engaged with instructional experiences that ask them to analyze and interpret various types of data. They should also have experience with using patterns in data to identify cause and effect relationships among populations of organisms in an ecosystem. In addition, students should have an understanding that ecosystems have carrying capacities that affect the abundance of species present,

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

which result from the availability of resources and other challenges (e.g., competition). It is not necessary for students to understand the process of fermentation for this task.

Materials Needed

- Are All Bacteria Harmful? Student Task

Assessment Guidance

Introduction

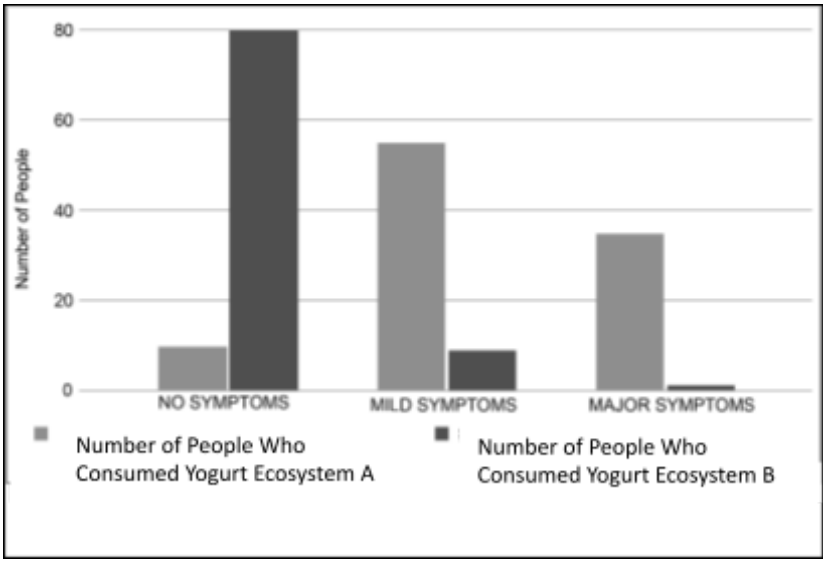
Certain types of bacteria are known to make humans sick, including through food. For centuries, humans have tried to find safe and effective ways to preserve food so humans don't get sick from bacteria. Many people think that having bacteria in our food is always harmful. Are all bacteria harmful for humans, or can some bacteria actually *prevent* food from spoiling and making humans sick?

In this task, you will be investigating two samples of yogurt that have different bacteria ecosystems. You will analyze these samples to figure out which types of bacteria in those ecosystems are harmful.

Prompt 1

One group of people consumed Yogurt Ecosystem A and a different group consumed Yogurt Ecosystem B. Look at Source 1 below to compare the symptoms people experienced after eating each food (e.g., stomach cramps, vomiting, and diarrhea).

Source 1. Negative Digestive Symptoms From Consuming Yogurt Ecosystem A and B



These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

a. Which yogurt ecosystem causes the most negative digestive symptoms and which yogurt ecosystem causes the least negative digestive symptoms?

Prompt 1a is not assessed and is used as a scaffold to better understand the phenomenon and gather data to use as evidence in 3-dimensional prompts later in the task.

b. Make an initial prediction for why there are differences in the digestive symptoms for those who consumed Yogurt Ecosystem A and Yogurt Ecosystem B.

Prompt 1b is not assessed and is used as a scaffold to make an initial prediction that will be revisited with additional data throughout the task.

Prompt 2

Now that you know which yogurt ecosystem caused more negative digestive symptoms, analyze more data to help you figure out why. We consider these yogurt samples "ecosystems" primarily because of the presence of various types of living bacteria that consume the sugars in the food. The data table below shows the number of each bacteria present in Yogurt Ecosystem A and Yogurt Ecosystem B.

Source 2. Number of Each Bacteria Present in Yogurt Ecosystem A and B

Type of Bacteria	Number of Bacteria Present in Yogurt Ecosystem A	Number of Bacteria Present in Yogurt Ecosystem B
Salmonella	100 million	20 million
Coliform	400 million	50 million
E. coli	200 million	30 million
Lactobacillus	0	600 million

a. First look at the total number of bacteria in the two yogurt ecosystems. Why are the total number of bacteria the same in the two yogurt ecosystems? Use what you know about ecosystems and their resources to support your response.

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

b. Next, compare the bacteria that make up Yogurt Ecosystems A and B. Cite data from the table to describe differences in the numbers of various bacteria between the two yogurt ecosystems.

c. Based on the data, which of these bacteria are more harmful and which are less harmful to humans? Use data from **both** Source 1 and Source 2 to support your response.

Prompt 2 Performance Outcome:
Evaluate the impact of new data on a working explanation for the abundance and types of bacteria in different ecosystems.

SEP	Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
DCI	Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

Prompt 2 Rubric

	Emerging	Developing	Proficient
Sample Student Response	a. Because they have been left out for the same amount of time for bacteria to grow. b. There are smaller amounts in Yogurt A and some big and some really small amounts in Yogurt B. c. *Lactobacillus* in Ecosystem B and *coliform* in Ecosystem A seem more harmful to humans because of the	a. Because they both have similar ingredients. b. There is no *lactobacillus* in Yogurt A but lots in Yogurt B and the other bacteria have larger numbers in Yogurt A then in Yogurt B. c. Ecosystem A is more harmful because there are more *salmonella* and *E. coli* in the ecosystem, but Ecosystem B is less harmful	a. Both yogurt ecosystems have the same amount of sugars for the bacteria to eat so there is the same amount of resources for the bacteria populations; that's why there are the same total number of bacteria, just different types. b. There is no *lactobacillus* in Yogurt A but there is 600 million in Yogurt B. There is

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

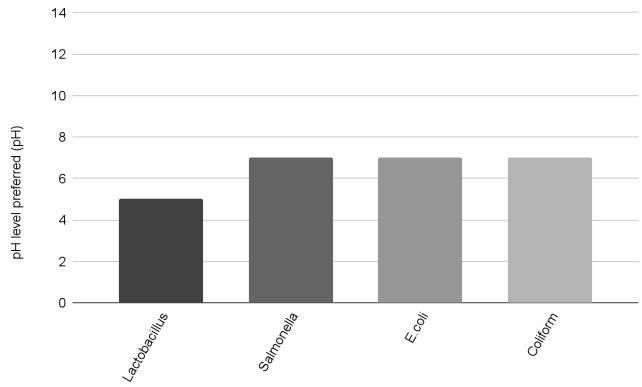
	high natural levels of it.	because there is only *lactobacillus*.	lots of *coliform* and *E. coli* (400 and 200 million) in Yogurt A and a small amount in Yogurt B (50 and 30 million). c. I think that *lactobacillus* is the least harmful and *coliform* and *E. coli* are the most harmful because the data shows that there is a lot of *lactobacillus* in Yogurt B, which does not cause bad digestive symptoms, and there is more of the other ones in Yogurt A which does cause bad symptoms.
Look-Fors	• Describes **irrelevant** similarities between the two ecosystems • Makes **irrelevant**, **inaccurate or insufficient** comparisons about the numbers of various bacteria in the two ecosystems citing **limited to no** data • Explanations of which bacteria are more and less harmful are **inaccurate**	• Describes **general** similarities between the two ecosystems • Makes **sufficient** comparisons about the numbers of various bacteria in the two ecosystems citing **limited to no** data • Explains which bacteria are more and less harmful, **implicitly** using data from the source(s)	• Describes role of availability of resources in the ecosystem (e.g., sugars) on bacteria population size • Makes **sufficient** comparisons about the numbers of various bacteria in the two ecosystems, citing **relevant** data • Explains which bacteria are more and less harmful, **explicitly** using **and combining** data from **both** sources

Prompt 3

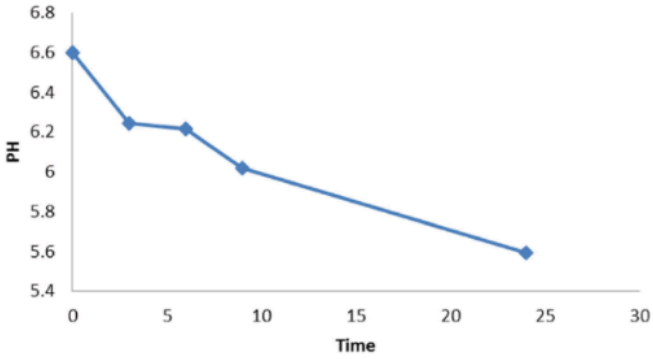
Now that you know which bacteria are more and less harmful to humans, let's investigate conditions that allow each of these types of bacteria to survive. The bacteria in the yogurt ecosystems require certain pH to survive, as shown in Source 3. Source 4 shows what happens to pH when *lactobacillus* is present.

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

Source 3. Preferred pH Level for Each Bacteria



Source 4. pH Level Over Time When *Lactobacillus* is Present in Yogurt Sample



a. Use Source 3 to describe the differences in the pH levels that each bacteria prefers.

b. Use Source 4 to describe how *lactobacillus* affects the yogurt ecosystem.

c. Based on new evidence from Sources 3 and 4, why do you think there aren't high numbers of harmful bacteria in <u>both</u> yogurt ecosystems? *Use what you know about factors that affect carrying capacity to support your response.*

Prompt 3 Performance Outcome:
Make a claim based on data about how the population of one species of bacteria affects the carrying capacity for other species in the same ecosystem.

SEPs	Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. Construct a written argument based on data and evidence.
DCI	Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
CCC	Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

	system.

Prompt 3 Rubric			
	Emerging	**Developing**	**Proficient**
Sample Student Response	a. The higher the pH levels, the more harmful the bacteria is. For example, *E. coli* and *coliform*. b. *Lactobacillus* makes the pH levels go down. c. There aren't high levels of harmful bacteria in B because it is the healthier option with less harmful chemicals.	a. The *lactobacillus* has a lower amount than the rest of them. b. The pH level is very low. c. Ecosystem B isn't as high with harmful bacteria because the pH level is low.	a. *Lactobacillus* prefer pH level under 6 so it can survive but the other prefer a pH above 6 so they wouldn't survive in the same environment. b. *Lactobacillus* pH goes down c. *Lactobacillus* makes the harmful bacteria go away because when it causes the pH to go down, which changes the environment and causes other bacteria to die.
Look-Fors	• Analyzes sources of data **(may be vague or have minor inaccuracies)** • Cause-and-effect claim about difference in number of harmful bacteria between ecosystems **is missing, irrelevant, or inaccurate** • Reasoning describing how one bacteria (*lactobacillus*) affects other bacteria in the ecosystem **is missing, irrelevant, or inaccurate**	• Analyzes sources of data **(may be vague or have minor inaccuracies)** • Makes a claim for a relevant cause in the difference in number of harmful bacteria between ecosystems (e.g., because pH level is low or because *lactobacillus* is present) • Reasoning **partially** describes how one bacteria (*lactobacillus*) affects the conditions of the ecosystem by lowering pH (i.e., changing carrying capacity), which affects other bacteria in the ecosystem	• **Accurately** analyzes sources of data • Makes a claim for a relevant cause in the difference in number of harmful bacteria between ecosystems (e.g., because pH level is low or because *lactobacillus* is present) • Reasoning **sufficiently** describes how one bacteria (*lactobacillus*) affects the conditions of the ecosystem by lowering pH (i.e., changing carrying capacity), which affects other bacteria in the ecosystem

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

Prompt 4

Many people think that having bacteria in our food is *always* harmful, but that isn't true. Construct your own argument to explain how certain bacteria can actually be used to make food safer for humans to eat. Include the following in your argument:

- A claim for why certain bacteria can be helpful to humans
- How one type of bacteria can change the conditions of the food ecosystem and impact the carrying capacity for other types of bacteria present
- Specific evidence to support your argument

Prompt 4 Performance Outcome:
Use data to support an argument about how increasing the population of one species of bacteria in food (*lactobacillus*) can affect the carrying capacity of other harmful species of bacteria in the same food ecosystem by changing environmental conditions (pH).

SEP	Construct a written argument based on data.
DCI	Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
CCC	Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Prompt 4 Rubric

	Emerging	Developing	Proficient
Sample Student Response	I think certain bacteria can be helpful to humans because they all aren't bad. We should include bacteria such as *E. coli*	Certain bacteria can be helpful to humans. If we were to allow bacteria in food, the best would be *lactobacillus*. Lower pH can	I think certain bacteria can be helpful to humans. *Lactobacillus* makes it less harmful. It decreases the carrying capacity

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.

	and *coliform* in foods. These two bacteria have a low pH level which is better than a high pH level. It could make food better. **OR** Most bacteria are harmful. But there are some bacteria that help in different ways. Some can help with digestion.	decrease the amount of bad bacteria in an ecosystem. **OR** Some bacteria in food are good for humans like *lactobacillus* because it could make it so that there are less dangerous bacteria in food because it would make it harder for other bacteria to survive while not harming us.	of other types of bacteria because they can't survive in an acidic place. **OR** Certain bacteria can be helpful to humans. Some bacteria are necessary to keep food safe. We should have bacteria like *lactobacillus* because it makes our food safe to eat. Like in the lab the yogurt without the *lactobacillus* is unsafe to eat because the pH is too high but once it is added it brings down the pH and makes it safe to eat. This is because it affects the carrying capacity of the ecosystem because one bacteria outcompetes the others.
Look-Fors	• Identification of *lactobacillus* as a good bacteria to have in food **is missing** • Cause and effect relationships between bacteria in the ecosystems **are general, irrelevant, or inaccurate** • Reasoning explaining the relationships between the bacteria **is missing, irrelevant, or inaccurate**	• **Accurately** identifies *lactobacillus* as a good bacteria to have in food • Uses data from sources to describe **some** cause and effect relationships between bacteria in the ecosystems • Reasoning **partially** explains the relationships between the bacteria by describing how one bacteria (*lactobacillus*) affects the ecosystem conditions (by lowering pH) and thus the carrying capacity of other bacteria	• **Accurately** identifies *lactobacillus* as a good bacteria to have in food • Uses data from sources to describe **all** cause and effect relationships between bacteria in the ecosystems • Reasoning **sufficiently** explains the relationships between the bacteria by describing how one bacteria (*lactobacillus*) affects the ecosystem conditions (by lowering pH) and thus the carrying capacity of other bacteria

These materials are made freely available by the American Farm Bureau Foundation for Agriculture, a 501(c)3 nonprofit organization through generous support from the National Dairy Council.