Science

Winogradsky Columns

Grade Level
3+

Length of Lesson
45-60 minutes to set up, then 15 mins, 1x/week for 6-10 weeks

Objective
By the end of this lesson, students will having a better understanding on how soil microorganisms live together in communities, continuously recycling nutrients.

Materials
- See full materials list on "Student Directions" page of student packet
- Copies of student packet

Standards
Common Core
CCSS.ELA.SL.1-8.4; R.ST.6-8.3-4,7,9

NGSS
3-LS4-3-4; 5-LS2-1; MS-LS1-1-2,5-7; MS-LS2-1-5; MS-ETS1-1-2

Lesson Summary
This lesson is a fun and unique way to see how microorganisms survive and interact with one another and the compounds in a self-contained environment that mimics their natural environment. After the initial set up, this activity will take place over the course of 6-10 weeks as students records their observations each week.

Suggested Sequence of Events:
1. Set Up: Gather enough materials so that each student can create their own column. **Please read through the Teacher Troubleshooting page for more information and helpful tips before doing this activity with your class.**
2. Read *Tiny Creatures: The World of Microbes* by Nicola Davis to introduce students to microorganisms.
3. Read through the IAITC Soil Ag Mag to learn more about the importance of soil. Interactive online versions can be found on our website.
4. Complete the activity following the procedures:
    - Give each student a copy of the student packet. Then, read through the "Observing Soil Microorganisms" page together as a whole class.
    - Explain that they will be creating a small-scale environment that mimics a natural environment. By doing this, they will be able to observe how microbes in that environment live interdependently in communities.
    - Pass out materials to students.
    - Have students use their "Student Directions" sheet to create their columns.
    - Have students label their column for identification. Then have students fill out the first page and "week 1" of their "Student Observation Log" in their student packet.
    - Have students continue recording observations in their log, weekly.
5. Whole class discussion and reflection of activity. How did their columns change over the course of 6-8 weeks? Do any of the columns look the same? Why aren't they identical?

TEACHER RESOURCES

Background Information

Microbes are everywhere! And just like humans, microbes live in communities. Isolating microbes is a crucial part of studying which microbes cause particular infections and diseases and has allowed us to come such a far way with medical practices. But we know that microbes do not live in isolation in the natural world, or even within our own bodies, and so these columns allow us to observe how soil microbes behave in their natural habitat with their natural microbe communities and competitors.

**Although your sediment/soil sample should generally not contain any pathogenic microbes, it's best to practice safe science. Make sure to provide gloves and hand sanitizer/hand soap while setting up the columns.

Extension Ideas

- Encourage scientific inquiry and play around with variables. Here are some examples:
  - Allow students to bring in their own sediment/soil samples.
  - Allow students to choose which nutrient sources they want to add to their columns.
    - If they are all using the same nutrient sources, allow them to use different amounts.
    - They can also read through the list of microbes and research other nutrients that would be a source of nutrients for specific microbes they want to try to grow more of (microbe species will depend on the location of the soil source).
  - Use different types of lighting: bright sunny windowsill, dimly lit room, different color light bulbs, adding black strips of paper to different places on the outside of the container, etc.
- Watch some kid-friendly videos about soil microbes, or microbes in general.
- Learn about the similarities and differences between different types of microbes: bacteria, fungi, algae, archaea. Which can be found in their column?
  - Have students create fake Instagram posts for their microbe of choice. Create a fun handle, 1-4 "posts" that each include a picture, a caption, and hashtags that are appropriate for their chosen microbe.
  - For grades 5+, read through *Rotten!: Vultures, Beetles, Clime, and Nature's Other Decomposers* by Anita Sanchz
  - Which microbes are autotrophs or heterotrophs? What about phototrophs or chemotrophs? Discover what these mean and then categorize each type of identified microbe into one of 4 categories: photoautotrophs, photoheterotrophs, chemoautotrophs, or chemoheterotrophs.
- Compare soil microbe communities to the microbe communities in their own guts! Based on what they learned about the microbes in their columns, why do they think it's important to eat healthy and nutritious food?
  - For grades 3-8, read *A Garden in Your Belly* by Masha D'yans to introduce students to gut microbes.
- Broaden the scope and learn more about various soil food webs/chains. How is energy transferred?
- Go to agintheclassroom.org to contact your County Ag Literacy Coordinator for free classroom sets of our Ag Mags.

Below are sources used to help create this lesson. They are all beneficial in helping you become more familiar with Winogradsky Columns.

- How to Make a Winogradsky Column by Heather Flanagan
- A Window into the Microbial World: The Winogradsky Column by Justine Dees, Joyful Microbe
- Make a Home for Microbes from the American Museum of Natural History
- Winogradsky Columns: Microbial Ecology in the Classroom from HHMI BioInteractive

WINOGRADSKY COLUMN

Teacher Troubleshooting

Most of the information is included in the student packet, but you'll find any extra information or tips on this sheet.

Materials

- Source of soil/sediment: While microbes are found in many types of environments, sediment from a pond or creek have a more diverse community of microbes than most backyard soils (depending on the location, of course). If you have access to a pond or creek, that is the suggested source. If not, backyard soil will work just fine, there just may not be as many different types of microbes that will grow and be observed. You can collect enough soil from one single location for all students to use **or** you can have students collect soil from their backyards. If soil sources are from different locations, make sure they don't share mixing bowls.
- Source of water: If you are collecting sediment from a pond or creek, collect the water from this location as well to create the muddy mixture. If you are collecting backyard soil, use distilled water (you can buy gallons at the grocery store) to create the muddy mixture. Tap water is fine to use, just make sure to let it sit out for several days for dechlorination.
- Source of Nutrients: There is a list of nutrient sources in the student packet. Choose your sources that are easy to access/budget friendly. You can have all students create their columns with the same nutrients (i.e. all contain shredded newspaper and a raw egg) or have them individually pick what nutrients they would like to add.
  - The amount of nutrients used will depend on the size of container you are using for the column. There aren't really any right or wrong measurements, but you want to make sure that there is enough sediment for the inoculum and the space isn't being taken by the nutrient sources. For example, roughly 1/2-3/4 cup of shredded newspaper for 16 oz. container. The nutrient sources are only there to rapidly increase population sizes. Once populations are settled, they can survive on the cycling of nutrients that are produced during metabolic processes.
- Container for Column: You can use just about any type of transparent container for this and is best if it's 16oz or larger. Examples: 16 oz. water bottle with label removed and top cut off (this should be done by an adult to reduce chances of students getting hurt), mason jar, tennis ball container, etc.
  - No matter the type of container, do NOT seal it with a lid. Gases will build up inside and if they cannot escape, the column will explode. This is why it is suggested to use a piece of plastic wrap on top with a rubber band secured around to hold in place. You could also drill a few holes in the top of a lid if preferred, or leave the lid loosely twisted on. Drilling holes will lead to faster evaporation of water. In this case, you can add source/distilled water if you notice the level getting too low in the column.
- Mixing Bowls: The large bowl is to mix the soil/sediment with the water to make mud. The mud should be the consistency of cake batter so have students add water in slowly. If it gets too watery, students can add more of their soil/sediment to the mix. The small bowl is for students to mix some of their mud (from bowl 1) with their nutrient sources.

Student Packets

- Observing Soil Microorganism Colonies: Background information and overview of Winogradsky columns. Suggested to read out loud together as a whole class.
- Vocabulary: Words used throughout the lesson that students should be familiar with and can refer back to. One page is blank and the other includes the definitions. It is up to you which page you decide to include. For 7th grade and up, it is suggested to have students use a dictionary to fill out the definitions in their own words.
- Student Field Guide and Research: This section includes a short description of the microbes that might grow in their columns. The microbe colonies will depend on the location that the sediment/soil was collected. This section also includes a diagram of the column, labeled with source gradients along with a table that shares the nutrient source options.
- Student Directions: Once students have familiarized themselves with all the information, they can use this page to complete the activity.
- Student Observation Log: Collecting and recording data is a HUGE part of science! Have students record their observations each week and practice using descriptive language.

Disposal

- As long as there is ~1 inch of water as the top layer, your columns will continue living for quite some time and you can continue making observations throughout the year. However, when you're ready to dispose of them, they can either be placed in trash bins or dumped back at the location where the soil/water sources were collected.

Here are two examples of columns made in different size/types of containers.

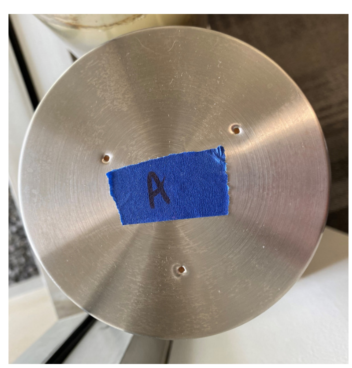
- Both have a strip of black construction paper taped around the very bottom to block sunlight, encouraging microbe populations that require no sunlight.

12 OZ. PLASTIC WATERBOTTLE

- 1/2 cups shredded newspaper
- 1/4 cup shredded cheese
- 1 tsp salt
- 1 tbsp sand
- 2 dissolved antacid tablets

72 OZ. GLASS CANISTER

- 1.5 cups shredded newspaper
- 1 raw egg
- 1 tsp salt
- 1 tbsp sand
- 5 dissolved antacid tablets



**One of the byproducts from the metabolic reactions taking place is hydrogen sulfide. This can smell like toots or rotten eggs.

WINOGRADSKY COLUMN

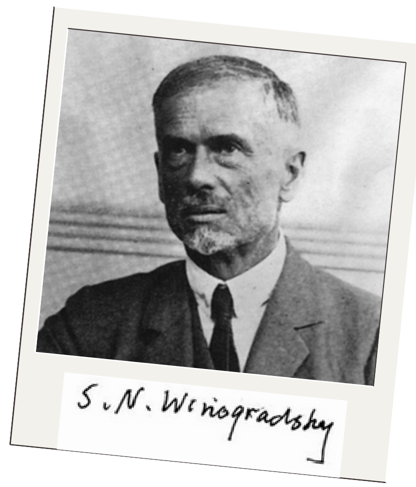
Student Packet

Name: ______________________________

WINOGRADSKY COLUMN
Observing Soil Microorganism Colonies

Bacteria and other microorganisms can be found in almost every environment. They are small but mighty and while some are just a part of the food chain in their environments, others can cause diseases in plants and in animals. Microbiology is the branch of science that focuses on studying organisms that are too small to see with the naked eye. There are many ways to study these organisms, but they are often studied as individual species that are grown in a laboratory in a container like a petri dish or test tube.

Sergei Winogradsky (1856-1953) was a microbiologist from Russia. Early in his career he studied bacteria that use inorganic compounds to create energy for themselves. He did this by isolating certain bacterium to grow and study. He was heavily influenced by the work of other microbiologists like Ferdinand Cohn and Louis Pasteur, which in turn encouraged him to study the behavior of many microorganism species all together in conditions as close to their natural environment as possible rather than in a petri dish.



Using sediment and water from a pond, he created a small-scale environment as a way to observe and study large communities of varying microorganisms, their modes of metabolism, and nutrient cycles all together. This would allow him to also study how these microorganisms affect one another.

Sergei Winogradsky is considered a father of microbiology because he was one of the first scientists to research microorganisms with an environmental context rather than medical.

There are different kinds of microbes all around us. The types of microbes found in a location depend on the type of environment (soil, sediment, woods, intestines, manure, etc.). Although microbes are not visible to the naked eye, when they grow in massive populations they can appear as different layers of colors or as a film or bubbles below and on the surface of water and sediment!

Making your own Winogradsky Column is a fun and unique way to see how microorganisms survive and interact with one another and the compounds in a self-contained environment that simulates their natural environment.

WINOGRADSKY COLUMN
Student Vocabulary

Aerobic	
Anaerobic	
Anoxic	
Ecosystem	
Fermentation	
Metabolism	
Microorganism	
Organic	
Oxidation	
Sediment	

WINOGRADSKY COLUMN

Student Vocabulary

Aerobic	Requiring, living, or occurring only in the presence of free oxygen.
Anaerobic	Requiring, living, or occurring only in the absence of free oxygen.
Anoxic	Requiring, living, or occurring with deficient levels of free oxygen.
Ecosystem	The interactions between all living and non-living things in their environment.
Fermentation	A metabolic process which uses enzymes to produce a chemical change to break down substances.
Metabolism	Chemical reactions that happen in cells of living things that turn compounds and nutrients into energy.
Microorganism	An organism that is of microscopic size and requiring a microscope to be seen. Microbe for short.
Organic	Matter which was once part of a living organism or was produced by a living organism.
Oxidation	A chemical reaction in which a molecule loses electrons or a chemical reaction in which oxygen is released.
Sediment	The matter which falls to the bottom of lakes and oceans.

WINOGRADSKY COLUMN
Student Field Guide and Research

While you might find many, many different types of microorganisms in different environments, here is a short list and description of common microbes that might be found in most water and sediment environments, similar to the environment found in a Winogradsky Column.

Biofilm Formers
These bacteria form in large groups called 'biofilm' instead of exploring freely in their environment. As they group together, they form a slimy film-like cover that serves as a protective layer and allows them to stick to a surface. They are aerobic, meaning they need oxygen to survive.

Bioluminescence
These bacteria can make molecules that glow when they react with oxygen in their environment. When they are in massive groups, they can actually create a large glowing mass on the surface of the water.

Cyanobacteria
These bacteria are versatile and can be found in almost all environments that have light and water. They are photosynthetic bacteria and in giant populations they most often appear green but can also appear gooey-reddish orange floating mass, brown-yellow films floating on the water, or even brown/black patches.

Halophiles
These microbes are named after the Greek word meaning "salt loving" and flourish in environments that have high salt, or saline, concentrations. When salt water evaporates, the water vapor rises and leaves behind salt crystals. Enormous populations of halophiles can grow on these salt crystals and appear as pink, red, or even orange.

Fermenters
These bacteria live in anaerobic environments. They use enzymes to break down and digest carbohydrates in order to make their own energy. This is a chemical reaction that produces hydrogen, alcohols like ethanol, and carbon dioxide in the form of bubbles (like we see when bread is rising).

Methanogens

These are categorized as archaea and not bacteria. When they take in compounds like hydrogen, carbon dioxide, or acetate, a chemical reaction takes place and they produce and release the gas methane. They can live in anoxic environments, such as the sediment under stagnant water. In this case, the sediment would be a deep black color and would produce bubbles (from the methane gas being produced) if the water and sediment were agitated.

Iron Oxidizers

These microbes most often appear over black sediment in an anoxic environment. They use the oxygen and iron from minerals in their environment to create their source of energy. When this chemical reaction occurs, it will produce a rust color.

Sulfide Oxidizers

These bacteria live in environments rich in hydrogen sulfide, like black sediment, because this is their food source to create energy and breathe. When they are in gigantic colonies, they will be seen as white fuzz/scum. These little bacteria require both oxygen and sulfide to survive, so they would be found where both those gradients overlap, usually somewhere below green cyanobacteria.

Sulfate Reducers

These bacteria breathe sulfate and eat sugars and hydrogen which causes a chemical reaction to create energy. Then, they release hydrogen sulfide which smells like rotten eggs. When found in a massive colony, they appear as a black layer of sediment below the photic zone, where there is little to no sunlight.

Green Sulfurs

These bacteria can be found in anoxic environments where there is both light *and* high sulfur levels. When found in massive colonies, they appear as a thin layer of green just above the black sediment, and under their purple sulfur bacteria neighbors.

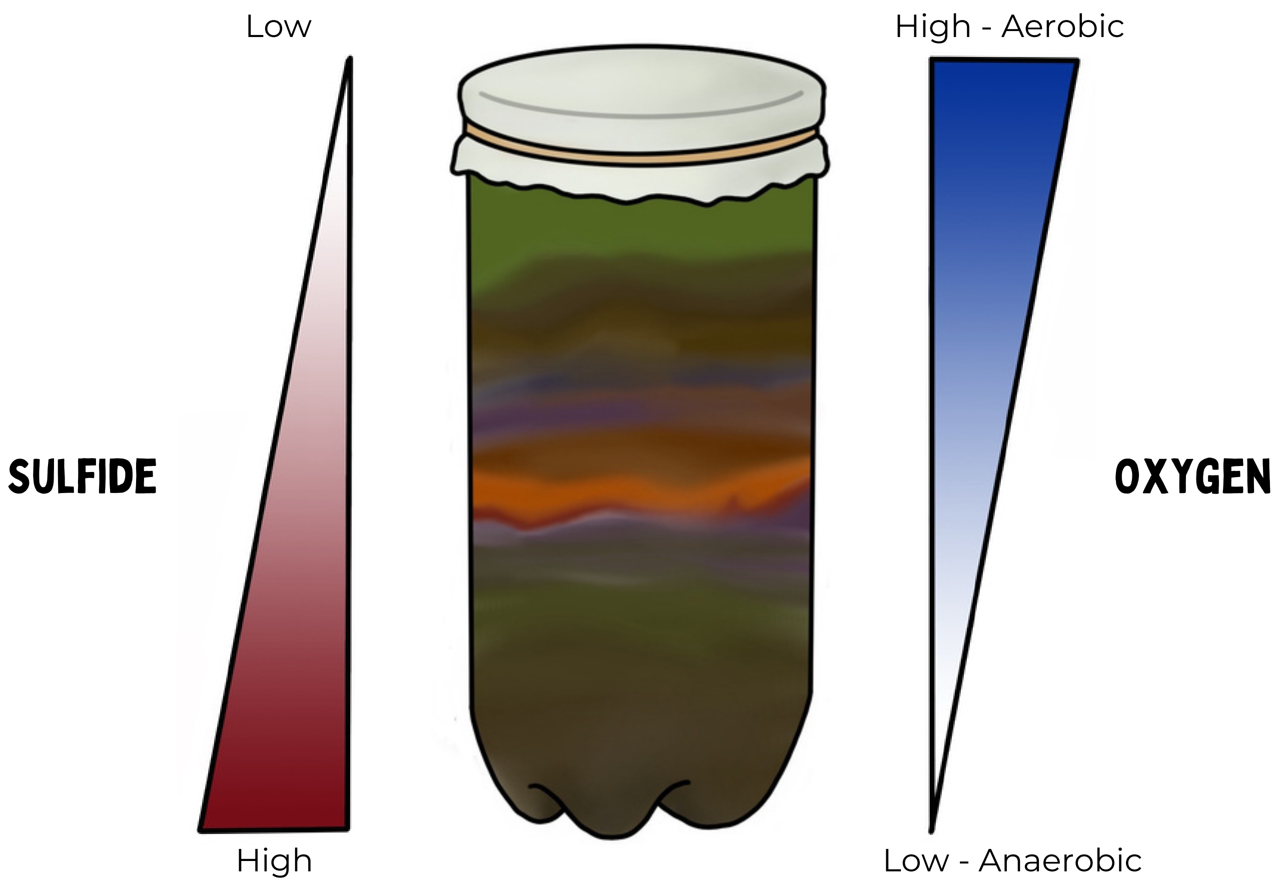
Purple Sulfurs

Just like green sulfurs, these bacteria live in environments where there is both light *and* high sulfur levels. But purple sulfurs **also** rely on oxygen, as it is an important part of their metabolic process to create sugar as their source of energy. In huge colonies, they appear as a purple or pink layer beneath green cyanobacteria, similar to the sulfide oxidizing bacteria.

Purple Non-Sulfurs

These bacteria live in anaerobic environments, but where sunlight can still reach (in the photic zone) because they use photosynthesis as their process to produce energy.

WINOGRADSKY COLUMN
Student Field Guide and Research



NUTRIENT SOURCE OPTIONS

Carbon Sources	shredded newspaper, dried leaves, oatmeal, corn starch, grass clippings, sawdust
Sulfur Sources	egg (hardboiled or raw), plaster of Paris, Epsom salt, shredded cheese
Phosphorus	liquid fertilizer (4-12-4)
Calcium	dissolved antacid tablets, non-fat dry milk
Sodium Choloride	table salt

WINOGRADSKY COLUMN
Student Directions

MATERIALS

- Large container to collect sediment
- Sealed container to collect water
- Sediment
- Water
- Container for column (16oz or larger)
- Large bowl
- Small bowl
- Hand trowel
- Large spoon for mixing and transferring sediment
- Nutrient sources (find these options on the Student Field Guide and Research sheet)
- Plastic wrap
- Rubber band
- Permanent marker
- Latex/vinyl gloves

WHAT TO DO

1. Collect your sediment and water from a pond, lake, puddle, or backyard. You will want enough sediment to fill your bottle about 3/4 full.
2. Using a permanent marker, draw two short lines on the bottle. Draw the first line about 1/4 from the bottom and draw the second line about 1/4 from the top.
3. Remove any rocks, twigs, and other solid matter from the sediment.
4. In a large bowl, mix some of the water into the sediment and mix it up. This should be a similar consistency to a milkshake so keep adding water a little bit at a time.
5. Transfer about 1/4 of the milkshake-sediment into the small bowl and mix in your carbon and sulfur sources. If you are adding more nutrient sources, add them in now.
6. Use a large spoon to put the mixture from the small bowl into the bottom of your column container. **Gently** tap the container on your desk/table to remove any air bubbles in the sediment.
7. Use the large spoon to add the remaining milkshake-sediment from the large bowl into your container. Fill to the top line you drew in step 3. **Gently** tap the bottle on your desk/table to remove any air bubbles.
8. Add about 1 inch of water to the top. There should be at least an inch of air between the water surface and the top of your container.
9. Cover the top of your bottle with a piece of plastic wrap. Put a rubber band around the plastic wrap to keep it on your bottle. Now you have your very own Winogradsky Column!
10. Place your column into a bright location, wash your hands and clean up, and then wait patiently. Observe and record the changes of you column each week over the next 6-10 weeks.

WINOGRADSKY COLUMN

Student Observation Log

Recording your process, observations, and data during an experiment is an extremely important part of the scientific process. Scientists use their recorded information to compare their results to multiple trials or to each others' work, to provide evidence in their conclusion of the experiment, and for many more reasons. Use the following sheets to record the information for your experiment.

STUDENT NAME

DATE CREATED

MATERIALS USED

Container:

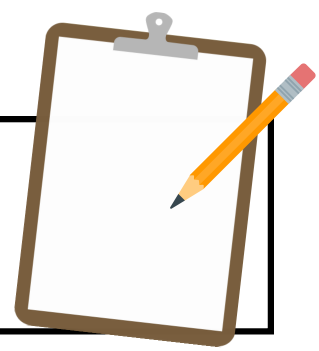
Mud Source Location:

Sulfur Source:

Location of Column:

Carbon Source:

NOTES



Based on the information in your student research sheets, what do you think your column will look like in 6-8 weeks?

HYPOTHESIS

Make observations each week to keep track of any changes your column undergoes. Were there any changes from the previous week?

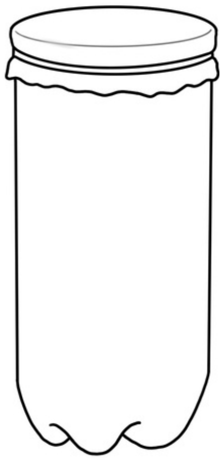
Record the date of the day you made observations!

Color what your column looks like!

Describe what your column looks like!

WEEK 1

Date:



WEEK 2

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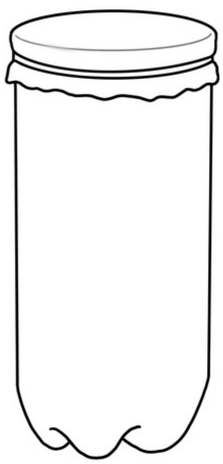

WEEK 3

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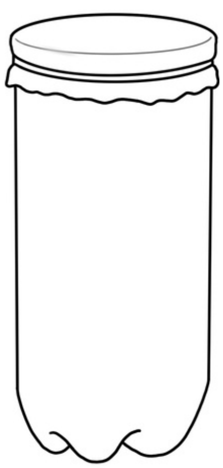

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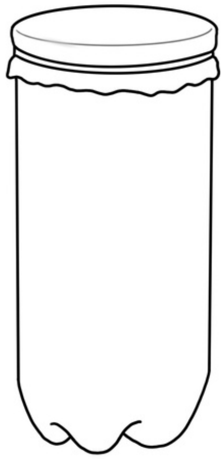

WEEK 5

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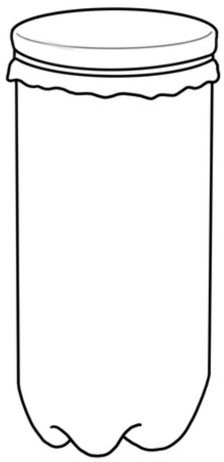

WEEK 6

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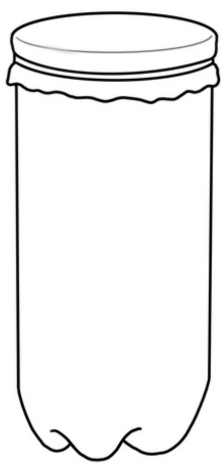

WEEK 7

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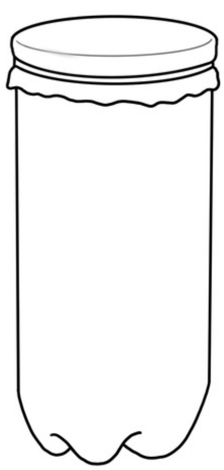

WEEK 8

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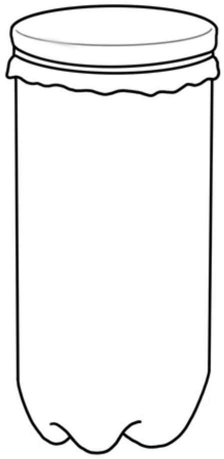

WEEK 9

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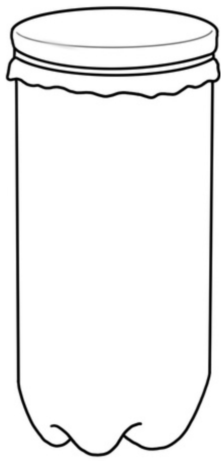

WEEK 10

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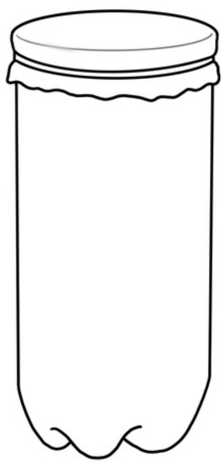

CONCLUSION

Was your hypothesis correct? Explain below: