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**Beneficial and Harmful Microorganisms**

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| **Estimated Time:** 45 minutes – 1 hour; 2-3 days to observe | |
| **GSE Standard(s) and Element(s):**  **S5L4. Obtain, evaluate, and communicate information about how microorganisms benefit or harm larger organisms. (Clarification statement: Possible microorganisms could include Tardigrades, Lactobacillus, Probiotics, Rotifers, Salmonella, Clostridium botulinum (Botox), E-coli, Algae, etc. Students are not expected to know these specific organisms. This list is provided to give teachers examples.)**   1. Construct an argument using scientific evidence to support a claim that microorganisms are beneficial. 2. Construct an argument using scientific evidence to support a claim that microorganisms are harmful. | |
| **Science and Engineering Practices:**  **Analyzing and Interpreting Data**  Analyze and interpret data to make sense of phenomena using logical reasoning. | **Disciplinary Core Idea:**  **Variation of Traits**  Different organisms vary in how they look and function because they have different inherited information. |
| **Crosscutting Concepts:**  **Patterns**  Patterns of change can be used to make predictions. |
| **Authentic Scenario (Phenomena):**  Bakers’ Yeast: A Helpful Microorganism <https://www.bakerpedia.com/wp-content/uploads/2015/08/baking-ingredients-yeast-nutrient-e1483927750233-400x400.jpg> | **Vocabulary:**   * microorganisms * membrane * wall * cytoplasm * nucleus * chloroplasts |
| **Guiding Questions:**  What type of microorganisms can be found in a hay infusion drop of water?  How are microorganisms similar and different from other multi-celled organisms we have observed? |
| **Materials:**   * water samples from various sources * clear containers * hay or dried grass * pipette or eye dropper * microscope slides * slide covers * microscopes * permanent maker for labeling * Microorganisms PowerPoint * Harmful & Helpful Microorganisms Sort | **Safety Considerations:**   * Be sure that students wash their hands after working with all water samples. |
| **Technology Integration:**   * Students will use microscopes to view microorganisms. * Students will need a device with Internet access   Nikon Microscopy U site: <https://www.microscopyu.com/galleries/dic-phase-contrast/pond-life> |

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| **5E Stage** | **Student Activities**  How will students engage actively in the three dimensions throughout the lesson?    **Teacher Activities**  How will the teacher facilitate and monitor student learning? |
| **Engage** | ***BEFORE STARTING THIS LESSON: You must have water sample (s) from nearby water sources. Having more than one source makes this lesson more interesting, be sure to label where the source was from.***  Show students some Bakers’ Yeast or a photo of it: <https://www.bakerpedia.com/wp-content/uploads/2015/08/baking-ingredients-yeast-nutrient-e1483927750233-400x400.jpg>  Ask students what they notice and/or wonder.  Explain that Bakers' yeast is a fungus that is a helpful microorganism. When mixed with flour and water, the yeast will ferment sugars out of the flour and produce carbon dioxide, which is responsible for making bread rise.  Go through the Microorganisms PowerPoint presentation with students so that they can gain some background knowledge on harmful and beneficial microorganisms.  Have students complete the Beneficial and Harmful Microorganisms Sort in small groups to assess their understanding of the PowerPoint. |
| **Explore** | Ask students how many of them have ever swam or walked in a stream, creek, pond, or lake. Brainstorm on the board what living things they saw in the water. Show the students the water sample(s) and ask if they see any living things in the water (add any new organisms to the brainstorm). Tell the students that they will be growing the microorganisms in the water to be seen under a microscope.  Directions for hay infusion:  (This can be done as a whole class or in groups, it depends on how many you want to make.)   * Go to your nearest body of water and collect a water sample(s). Any natural water will work but tap water will not. Tap water is chlorinated to remove microbes and the water out of your tap will have enough chlorine in it to kill or inhibit the growth of microbes. * Pour the water into a clear glass, or clear disposable cup, and add a handful of hay or dried grass to the water. A glass you do not care about should be used, as it is going to get scummy. * Let the mixture incubate at room temperature or above for several days. A light source (either the sun or a lamp) will encourage the growth of photosynthetic microbes. * During the incubation, check the infusion and add more water as it evaporates. * In a few days the culture should turn dark and cloudy. Examination under a microscope will reveal a large number of microorganisms. * Make a wet mount slide using one drop of water from your water culture. It is best to take samples from the top, middle, and bottom of the culture.   Have students draw a microorganism they saw and label the organelles, if possible (applied from previous cell lessons). A good site to identify the microorganisms is the Nikon Microscopy U site: <https://www.microscopyu.com/galleries/dic-phase-contrast/pond-life>  The site has videos of each microorganism.  Differentiation:  Provide pictures with bacteria common to your area identified, giving the student a smaller field of possible answers. |
| **Explain** | As needed emphasize that a **microorganism** or **microbe** is a living organism that is so small that it is invisible to the naked eye. Normally, they can only be seen with a microscope that magnifies the image of the organism. **Microorganisms** include bacteria, fungi (yeasts and molds), algae, protozoa, and viruses. While most microorganisms are single-celled, some are multicellular. The study of microorganisms is called microbiology.  Microorganisms are found almost everywhere. Most of them are beneficial but some are harmful and can cause disease or even death. Beneficial or helpful bacteria include many species that live inside the bodies of living things. **Lactobacillus** is a type of bacteria found within our digestive tract that helps with the digestion of certain foods. Beneficial microorganisms are used in the production of fermented food and beverages like yogurt and wine. Other beneficial microbes have the ability to break down toxic materials like oil, petroleum, and plastic waste products. Finally, microorganisms have evolved as a potential alternate source of energy and are now used to produce biofuels like biodiesel and bioalcohol. |
| **Elaborate** | As an extension, students can use their drawings of the microorganisms to identify the group or species to which they belong. They can use Google images to see which microbes most closely match their drawings. Once identified, they can learn more about these amazing microorganisms. |
| **Evaluate** | Using the C-E-R Method, have students explain why the microorganism(s) they saw in their water sample were beneficial or harmful. |

**Teacher Notes:** A hay infusion is a culture of microbes made from a pond, lake, stream, or puddle. If you examine pond water without culturing it, you'll probably find the protozoa are somewhat difficult to find because they are not present at high density. To increase the protozoa density, make a hay infusion by putting the water in an open jar and adding cut, dried grass or hay. The grass or hay should be green when it was cut and dried and be free of herbicides and pesticides. You may also wish to add a few grains of yeast and a few drops of skim milk (this is not necessary though). The sugars in the dried grass or hay and the nutrition provided by the yeast and milk provide food for the bacteria. If the jar is kept at room temperature for a few days, the bacteria proliferate (and make quite a smell!). The bacteria are food for the protozoa, so the bacteria population boom will create a corresponding protozoan population boom.

Be careful to not add too much hay, grass, yeast, or milk. This will overfeed the bacteria and they'll poison the water with their waste products before the protozoan population gets a chance to catch up. Protozoa are oxygen breathers. Give them oxygen by using a pipette to bubbling air into the water at least once a day.

Taking samples with a pipette near the surface of the water, near floating debris, and near the bottom of the jar will often give you different types of microzoa to examine. The hay infusion population will peak about a week after making it. If you want to keep it going, get more fresh water from the original source, add hay, etc., and inoculate the new culture with several pipettes filled from the old culture.

Remember that the hay infusion has a very high bacteria count. While the vast majority of bacteria are not harmful to humans, there may be bacteria in the culture that could cause infection on contact. **Be sure to wash with soap and water if the culture gets on your skin. Rinse out your eye with lots of clean water if any of the culture liquid contacts it. If you get any of the water in a cut be sure to wash it out and sterilize it with hydrogen peroxide or iodine.**

The site below shows a hay infusion and what you will be looking for <https://instruction.bact.wisc.edu/instr/book/displayarticle/2>.