Bacteria and Protists Oh My!

Below is an adaptation of the Oh Deer! (Project Wild K-12 Curriculum and Activity Guide, Council for Environmental Education 2006) lesson plan to be about microbes and to incorporate information learned from Dr. Kerkhof’s presentation and subsequent discussion.

Lesson Overview

Students role-play species of microbes with different nutrient needs and how predators select them.

Lesson Rationale

Some of the fundamental questions in ecology relate to how the community composition is created. Scientists study the whether the community composition is controlled by bottom-up forces, the amount of available resources, or top-down forces, predators. This activity explores each of these questions in ecology through the marine microbes.

Key Concept

The community composition of microbes may be determined by the ability of species to use different resources and/or by the selective pressure of different predators.

Time Required

40-minute class period.

Overview

Microbes make up 98% of the biomass in the oceans. There are almost countless species of microbes in the ocean, many living in the same area at the same time. How can they all survive? A variety of factors affect the ability of species to successfully reproduce and to maintain their populations over time. Some of the most fundamental nutrients that bacteria need are: nitrogen, phosphorus, and carbon. Without these essential nutrients bacteria, and in fact all living organisms, cannot survive.

However, even if all nutritional requirements are met, some naturally caused limiting factors serve to prevent populations from reproducing in greater numbers. For example, the types and selectivity of different predators within the system may limit the success of bacteria populations.

In this activity, students role-play the nutrient needs of microbes and the predators that graze them. The activity illustrates that: access to necessary resources is key to survival, a population will continue to increase in size until some limiting factors are imposed, and limiting factors contribute to fluctuations in populations.

Students are transformed into different marine bacteria for the simulation. They each need multiple nutrients to survive and divide (reproduce). Through many rounds of gathering nutrients they will they graph their results and compare their population success over time. Then a predator, a type of protist, will be added to the system and the students will repeat the simulation. Students discover that populations of bacteria fluctuate based upon both the available nutrients (**bottom-up control**) and the presence and abundance of predators (**top-down control**).

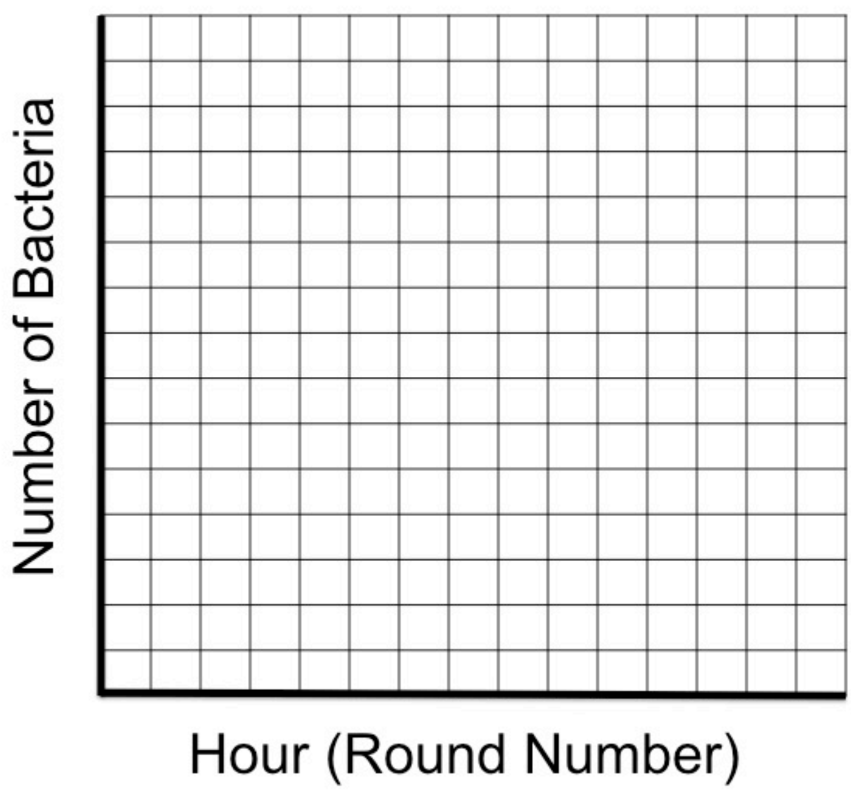
Materials Needed

For the class:

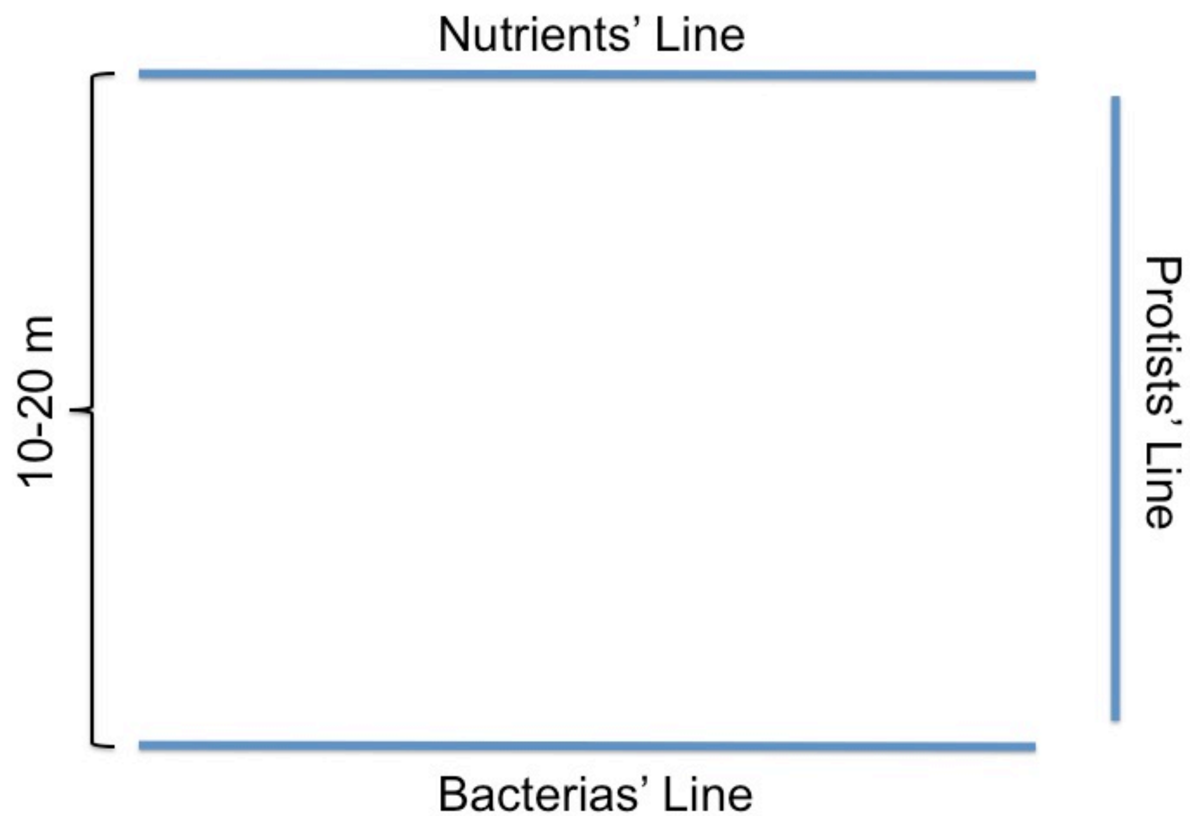
- An area – indoor or outdoor – large enough for the students to run around
- Flipchart with graphs
- Writing utensils (at least two colors)

Preparation

1. Prepare the flipchart graph for the class data. You should make two copies, the first with Number of Bacteria and the second with Population Size for the x-axis.



2. Mark two parallel lines about 10-20 meters apart in the space that you will use for the activity (see image below). Mark a third line perpendicular to the two parallel lines and off to the side in the same space.



Procedure

Introduction to Simulation

1. Tell students that they will be participating in an activity that emphasizes some of the most essential things bacteria need to survive. Review the essential nutrients with the students: nitrogen, phosphorus, and carbon.
2. Ask the students to count off in fours. Have all of the ones line up behind one line; the rest of the students (2s-4s) line up behind the other line, facing the ones.
3. The ones become "bacteria." All bacteria need nutrients to survive. Again, ask the students what the essential nutrients are (nitrogen, phosphorus, and carbon). The bacteria (the ones) need to find nitrogen, phosphorus, and carbon to survive and reproduce. When a bacteria is looking for nitrogen, it should stand with its hands by his/her side. When it is looking for phosphorus, it should put his/her hands on his/her hips and stick out his/her elbows. Finally, when it is looking for carbon, it should make a giant "C" above his/her head with his/her arms. A bacteria can choose to look for anyone of these nutrients each round of the activity. The bacteria cannot change what it is looking for within a round

(e.g., when it sees what is available during that round). It can only change what it is looking for in the next round, if it survives. Bacterial cells in fact need all three of these essential nutrients for survival, so the students acting as bacteria must change which nutrient they choose between each round.

4. The twos, threes, and fours are the nutrients. Each student should choose at the beginning of each round what nutrient component he or she will be during the round. The students depict which nutrient they are in the same way as the bacteria show what they are looking for (i.e., placement of hands).
5. The activity starts with all players lined up behind their respective lines (bacteria on one side and nutrients on the other) – and with their backs facing each other.

The Simulation Scenario 1 – Only Bacteria

1. Record the number of bacteria at time 0 (start of the activity) on the flipchart graph.
2. Begin the first round by asking all of the students to make their signs – each bacteria deciding what it is looking for and each nutrient deciding which it will be for that round. Give the students a few moments to put their hands in place.
3. When the students are ready, say, "Bacteria Oh My!" Each bacteria and nutrient should turn to face each other while holding their hands in place.
4. When bacteria see the nutrient that they need, they should run (or walk) to it. Each bacteria must hold the sign of what it is looking for until getting to the nutrient student with the same sign. When the bacteria reaches a nutrient that it needs, he/she should take the nutrient back to the bacteria line. "Capturing" a nutrient represents the bacteria successfully meeting its needs and successfully reproducing as a result. Any bacteria that fails to find a nutrient, dies and becomes part of the nutrient pool. That is, any bacteria that died will be a nutrient in the next round and so available as a nutrient to the bacteria that are still alive.
5. Record the number of bacteria at the end of the round on the flipchart graph. Continue the activity for approximately 10-15 rounds.

Making Sense of the Data

1. At end the of 10-15 rounds, bring the students together to discuss the activity. Encourage them to talk about what they experienced and saw.
2. Use the flipchart graph to have the students look at the data from the activity. The number of bacteria at the beginning of the activity and at the end of each round represents the number of bacteria in a series of hours. That is, the beginning of the activity is hour one; each round is an additional hour. The students will see this visual reminder of what they experienced during the activity: the bacteria population fluctuated over a period of hours. This process is natural as long as the factors that limit the population do not become excessive to the point where the bacteria cannot successfully reproduce. The populations will tend to peak, decline, and rebuild; peak, decline, and rebuild – as long as there are enough nutrients and sufficient numbers of bacteria to reproduce.

3. Ask your students, what is realistic and unrealistic about this simulation? (Bacteria that do not survive **do** become recycled as nutrients but not instantaneously. Bacteria need **all** three nutrients to survive. Other environmental conditions can affect the survival rate of bacteria.)

The Simulation Scenario 2 –Bacteria & Protists

1. Introduce the protist as a predator in the system (choose one student in the class to be the first protist). The protist starts in the designated "predator" area off to the side of the game space (behind the line perpendicular to the other two lines). The protist needs living bacteria, so he/she can tag a bacteria only when the bacteria is going toward the nutrients and are between the bacteria and nutrient lines. Once a bacteria has been tagged by the protist, the protist escorts the bacteria back to the "predator" area. Because the protist was able to get a bacteria he/she was able to reproduce, so the bacteria becomes another protist. Protists that fail to tag a bacteria die and become nutrients. That is, in the next round the protist that died joins the nutrient line. They will become available to surviving bacteria.
2. Record the number of bacteria and the number of protists at time 0 (start of the activity) on the flipchart graph.
3. Repeat the simulation like in the first scenario, but also allowing protists to tag the bacteria.
4. Record the number of bacteria and protists at the end of the round on the flipchart graph. Continue the activity for approximately 10-15 rounds.

Wrap-Up

1. Use the flipchart graph to have the students look at the data from the activity. The students will see this visual reminder of what they experienced during the activity: the bacteria and protists populations fluctuated over a period of hours. Ask the students if they see a pattern in the data between the bacteria and protists populations (the peaks and declines in the protist population will be delayed from the bacteria population).
2. In discussion, ask the students to summarize some of the things they learned from this activity. What nutrients do bacteria need to survive? How does the availability of these nutrients affect the population size of bacteria over time? What are some "limiting factors" that affect the survival of bacteria? How do these factors affect competition within a species and among species? What is the affect of predators on the population size of bacteria? Are populations of organisms static, or do they tend to fluctuate?