Unit: Oceans of Energy
Lesson 6: *Bacteria and Viruses*

Summary: This lesson contains two sections: 1) a discussion about the role of bacteria and viruses in the ocean and 2) a classification activity.

Lesson type:	Discussion, sorting model
Grade level:	Presented to grade 4; appropriate for grades 2 – 12 with age appropriate modifications
Duration of lesson:	50 min
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Developed for:	Sir William Van Horne
School Year:	*2015-2016*
Notes:	• For the candy diversity, make sure to avoid all candies with possible allergens.

Objectives

Students will:

- understand that bacteria are present in all marine waters.
- understand bacterial community stages and reproduction
- get a sense of what diversity means
- be introduced to the process of taxonomy

Materials (Classification Activity)

- Large Bowl
- Sampling devices, e.g.
  - Slotted spoon
  - Ladle
  - Tea strainer
  - Pasta server
  - Tongs
- Class set of napkins or place where candy can be placed and organized
- Small candy
  - Cake sprinkles (Virus)
  - Nerds (Bacteria)
- Medium candy (Diatoms and phytoplankton)
  - Skittles
  - M&M
  - Mike & Ike
  - Sweet Tarts
  - Whoppers
- Large Candy (zooplankton)
  - Gummy bears
  - Gummy worms
  - Licorice
- How much of each candy? Depends on your goal. Generally, you want ~¼ – ½ cup of candy per student. Above candies are not all required, but suggestions to help you get a variety. If aiming for a marine community, there should be about 10x the number of individuals each time you represent a smaller organism.

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Background Information

Bacteria and Viruses

Bacteria and viruses are omnipresent in marine waters and serve a very important role as they are crucial to recycling the organic material into inorganic nutrients that can again be utilized for the growth of phytoplankton. Bacteria are present in marine waters at ~10^7-10^9 per litre and viruses are even more abundant (10^9-10^{11} per litre). While a typical virus is ~1 nm (10^{-9} m) and a bacteria is ~1 µm (10^{-6} m) across, if all bacteria in the ocean were to be stacked end to end, the resulting line would be ~10^{24} m long (for some perspective on the size of that, see http://htwins.net/scale2/). (Assume 1.35 x 10^{21} L in the ocean.) If all the viruses in the ocean were to be stacked end to end, the line would be ~10^{30} m long which is 1000 times longer than the size of the observable universe!

While incredibly abundant and diverse, these organisms are largely harmless to humans. The principle role of bacteria is to degrade organics. Viruses largely infect bacteria and keep bacterial populations under control.

As with all bacteria, marine bacteria grow their cell slightly prior to replication by division. On average marine bacteria divide hourly, though some may have a replication time as short as 4 min or as long as thousands of years. Many resources are available describing bacterial growth and life cycle stages (lag phase, log phase, declining growth phase, and endogenous respiration phase) online.

While scientific culturing techniques are able to bring about 3% of bacteria into culture, the remaining 97% of bacterial species we know about through the use of genomic techniques. These techniques allow scientists to examine the DNA of the 16S gene that is a unique fingerprint of living organisms on the planet and differentiate between species. However, this is a rather new system of classification and for centuries, the Linnaean taxonomy was considered standard. Resources online can provide a better history and role of taxonomy.

The main thrust of this lesson was to introduce students to bacteria in the ocean and that they are very diverse with many species filling roles in each known niche on the planet.

Lesson Detail

Discussion - Bacteria and Viruses

1. Explain that bacteria are in every litre of seawater in large numbers. So large that if you had a typical sports bottle of seawater and stacked all the bacteria inside it end on end, the bacterial line would stretch over a kilometer.
2. Explore the bacterial life cycle and ask students to do the math on how many bacteria would exist in a petri dish if it were left for X days assuming a doubling time of 1 hour. This is an easy way to introduce students to exponential growth since the numbers quickly get very large. Can students think of a reason why there might not be that many individuals present after the given amount of time? What about death?

Activity - Classification

1. While there is incredible diversity in the microbial communities on earth, using bacteria as a model group may be challenging for students to get excited about. You may wish to consider using photos from http://www.boredpanda.com/strange-animals/ to help students understand the challenge of classifying all life on earth. If shown a range of animals such as those in the link, how would students propose classifying life?
2. Tell students that they are going to use different sampling devices to collect a sample from a population of diverse candy. Using different typical kitchen spoons, students will get different sample compositions that they will then have to classify. Depending on the quantity and variety of candy that was purchased, students should have roughly about a ¼ - ½ cup of candy each.
3. Students should have some time to develop some classification system of their own design to break their sample into groups. They should sort their categories into any arrangement they choose as long as they can justify their thinking.
4. After a reasonable amount of time on their own, have students compare their classification system with that of a partner or as a small group. Have them discuss the merits and drawbacks of each system. Engage the class into a discussion about the different systems used and have them report how many classes there are in their system. What are the advantages and disadvantages of each system? In hearing the methods of the rest of the class, can they arrive at a "best" system?

Closure Discussion

Examples of questions to help students share their results and observations…

1. Ask the students how the different sampling devices influenced their sample. Was one device better or worse at getting the smaller organisms? If there was a particularly small sampling device, was it hard to get the bigger organisms? Was there one device that got a "representative" sample? Similar issues with sampling occur in the ocean depending on if sampling was conducted using a phytoplankton net (smaller mesh size), zooplankton net (larger mesh size), CTD (closing PVC pipe), or a direct seawater pump.
2. Now that the students have explored taxonomy and classification systems with things that they can see, how might they classify things like bacteria that they can't see? Introduce DNA and explain that DNA is in every living thing and viruses. The current tree of life is based on genomic techniques that break all life from a last universal common ancestor, or LUCA, into the three domains of life, Bacteria, Archaea, and Eukaryota.

References

This lesson was created using the following resources:

Pomeroy, L.R. P.J.L. Williams, F. Azam, and J.E. Hobbie (2007). The Microbial Loop, *Oceanography*. 20(2):28-33, http://dx.doi.org/10.5670/oceanog.2007.45 [High school accessible overview of the microbial loop]

<https://en.wikipedia.org/wiki/Linnaean_taxonomy> Linnaean taxonomy. Website hosted on Wikipedia (Accessed 27 April 2016).

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