Bacteria, Friends or Foes?

This unit integrates molecular biology techniques with the role of bacteria in our environment, specifically in the marine environment. The unit starts with introductory activities to familiarize students with microbes. Through the unit there are key words written in bold to emphasize their importance. These words are used frequently in the AP Biology examination and it is important for the students to practice them through the school year. Below is a list of keywords with their definitions.

Key Words
Describe - To give a picture of something in words
Justify - Give a good reason for something, show to be right
Predict - Say or estimate what will happen in the future
Create/Design - graph data, generate an equation, an experiment or model
Support - Back up your answer with data or evidence
Analyze - Break into parts, tell about the parts
Evaluate - Judge it tell the good and the bad
Explain - Tell how to do, give the meaning of, give reasons for
Identify - Name, list, or give an example
Define - Give a meaning for a word or phrase
Propose - To suggest something
Indicate - To show something

The importance of microbes

http://learn.genetics.utah.edu/content/gsl/microbes/
Describe how microbes can be beneficial to us. Use examples of two different organisms.

The size of bacteria

http://learn.genetics.utah.edu/content/cells/scale/
In a short paragraph **describe** the size of bacteria when compared to other cells.

The role of bacteria in the evolution of cells

http://learn.genetics.utah.edu/content/cells/organelles/

Justify the idea that chloroplast and mitochondria evolved from bacteria cells as described in the Endosymbiotic theory.

Describe the importance of mitochondrial DNA.

http://learn.genetics.utah.edu/content/astrobiology/environments/

Identify two reasons why scientists are using Archaea as models for Astrobiology. Based on the"Tree of Life" found in the above link **explain** the relationship between the three domains. Using table 27.2 in your book **justify** your response.

Techniques used to study microbial diversity

http://learn.genetics.utah.edu/content/gsl/diversity/

Propose a procedure to identify a single species of bacteria from a water sample.

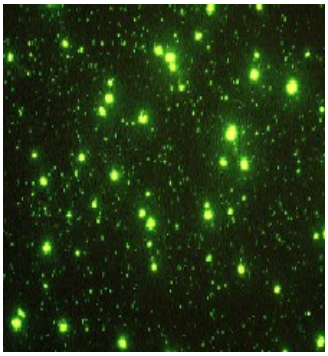
DNA extraction: http://learn.genetics.utah.edu/content/labs/extraction/
Gel electrophoresis: http://learn.genetics.utah.edu/content/labs/gel/
PCR: http://learn.genetics.utah.edu/content/labs/pcr/
Link to Biodiversity of Marine Bacteria Lab.
Link to sequences (Sapelo 2014)

The importance and role of microbes in the marine environment

Marine Bacteria

http://www.teachoceanscience.net/teaching_resources/education_modules/marine_bacteria/learn_about/

Symbiotic relationships of microbes



http://learn.genetics.utah.edu/content/microbiome/symbiosis/
-Prokaryotes (big) and viruses (small) in a seawater sample. These two microbes are the most abundant organisms in marine environments (©Ruth-Ann Sandaa)

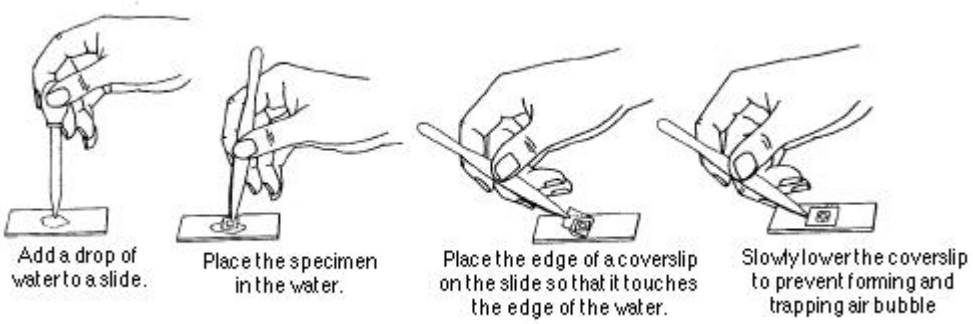
Roseobacter and Phytoplankton

Students will read Geng and Belas 2010 "Molecular Mechanisms Underlying roseobacter-phytoplankton symbiosis". Students will:

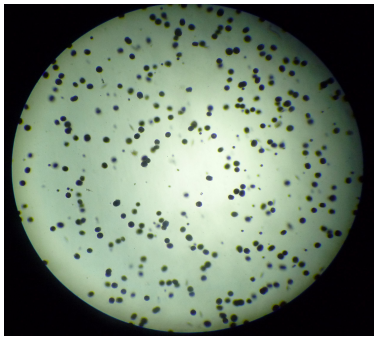
- **Describe** the type of symbiosis that the paper suggests is happening between the bacteria and the dinoflagellate.
- **Identify** the molecules produced and used by each organism.
- **Indicate** the molecular mechanisms used by the bacteria to maintain the symbiotic relationship.
- http://media.hhmi.org/biointeractive/click/Quorum_Sensing/13.html
- **Explain** how bacteria communicate during Quorum Sensing (QS).

Making observations

Students will make wet mounts of a phytoplankton culture to make observations under the microscope of the dinoflagellate and record the presence or absence of bacteria.

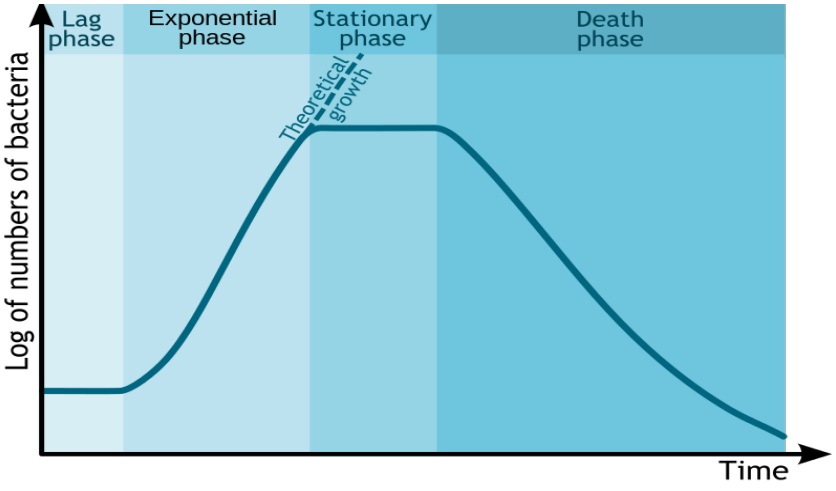


Students will focus first with the low power objective (10X), then move to (40X) and re-focus only using the fine adjustment, if necessary. Finally students will add a drop of oil immersion on top of the coverslip and move the objective to (100X). ONLY USE FINE ADJUSTMENT.
Make a table to record your data.
Record the number of dinoflagellates present in ten fields of view, and indicate if they are associated with bacteria or not.



Field of view

Lab Activity: Measuring bacterial growth under increasing nutrient concentration using a spectrophotometer



Bacterial growth curve\Kinetic Curve From Wikipedia, the free encyclopedia

Bacteria depend on different sources of carbon for their growth. Marine bacteria in the Roseobacter group can live in association with phytoplankton and are able to get

their carbon from these organisms. Under laboratory conditions the growth medium used for this group of bacteria is 1/2YTSS medium (half-strength yeast, tryptone, and sea salts medium).
In this activity we will grow bacteria in a 1/2YTSS medium diluted with a sea salt solution (see table below). The density of bacteria will be measured using a spectrophotometer based on % absorbance. **Procedures to make 1/2YTSS**

Table 1. Volumes of sea salts and medium to be added to each tube.

TUBE #	SEA SALT VOL.	½ YTSS VOL.	TOTAL VOL.
1	30 mL	0 mL	30
2	24 mL	6 mL	30
3	18 mL	12 mL	30
4	12 mL	18 mL	30
5	6 mL	24 mL	30
6	0 mL	30 mL	30

1µL of bacteria (DSS3 strain) is added to each tube. The tubes are then kept at room temperature until growth is visually detected (the medium will change from clear to cloudy).
Students will record the % absorbance for each tube and will **create** a graph using this data.

Food webs

Read: Oceans, The Mighty Oceans
http://wwf.panda.org/about_our_earth/ecoregions/about/habitat_types/habitats/oceans/

Students will get familiar with organisms inhabiting oceans.
Students will **create** a food chain and **indicate** the flow of energy among the different trophic levels.
Students will click and read the content of the following link.

Read: http://cordis.europa.eu/inco/fp5/acprep8_en.html

Students will click on the **Fig. 1** link to see a simplified ocean food web. Based on this food web they will address the following:

1. Geng and Belas 2010 "Molecular Mechanisms Underlying roseobacter-phytoplankton symbiosis". This article describes the interaction of bacteria (Roseobacter) and dinoflagellates. According to the information in this paper, **propose** a trophic level in the food web diagram in **Fig.1** where Roseobacter should be inserted. **Predict** what would happened to the food web if no bacteria are associated with the phytoplankton
2. Looking at Fig. 1, **explain** the trophic level position of the top predators.

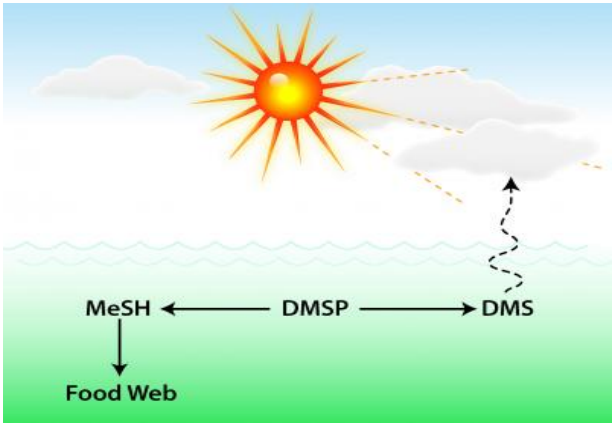
3. **Predict** what would happened if the large zooplankton are removed from the food web.
4. Click on **Fig. 2** and **analyze** the trend of mean trophic level in both oceans.

Bacterial effect on global climate

DMS: The Climate Gas You've Never Heard Of (Woods Hole Oceanographic Institution)
http://www.whoi.edu/page.do?pid=7342&tid=1061&cid=40305&cl=28372&article=45946&print=this

Students will click on the link above and complete the multimedia activity "How tiny ocean plants help make clouds"
Based on what they learn in the multimedia presentation and the paper by Geng and Belas 2010**,** students will **explain** in a paragraph why scientists who study global warming should be closely monitoring microbial activity in the oceans.

Biogeochemical cycles



Simplified version of sulfur transformation by marine bacteria living in the surface ocean.

Cycling of nutrients is critical for all life on earth. The element sulfur is found in proteins that are essential in living organisms. Students will **create** a model for the sulfur cycle in the ocean incorporating the organisms that produce and breakdown DMSP

Recommendations for implementing this unit

This unit can be implemented as a whole in conjunction with the bacteria chapter (Chapter 27, Campbell and Reece 8th edition) or as a series of separate activities related to materials in chapters 25 (The History of Life on Earth), chapter 20 (Biotechnology), chapter 54 (Community Ecology), chapter 53 (Population Ecology), and chapter 55 (Ecosystems).

Big Ideas, Enduring Understanding and Essential Knowledge Addressed in This Unit

Big Idea 1: The process of evolution drives the diversity and unity of life.

Enduring Understanding 1.B: Organisms are linked by lines of descent from common ancestry.

Essential Knowledge: 1.B.1, 1.B.2

Enduring Understanding 1.D: The origin of living systems is explained by natural processes.

Essential Knowledge: 1.D.1, 1.D.2

Activities: "The Role of bacteria in the evolution of cells"

Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Enduring Understanding 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.

Essential Knowledge: 2.D.1, 2.D.4

Activities: "Food webs"

Big Idea 3: Living systems store, retrieve, transmit, and respond to information essential to life processes.

Enduring Understanding 3.A: Heritable information provides for continuity of life.

Essential Knowledge: 3.A.1

Activities: "Techniques used to study microbial diversity"

Big Idea 4: Biological Systems interact, and these systems and their interactions possess complex properties.

Enduring Understanding 4.A: Interactions within biological systems lead to complex properties.

Essential Knowledge: 4.A.4, 4.A.5, 4.A.6

Enduring Understanding 4.B: Competition and cooperation are important aspects of biological systems.

Essential Knowledge: 4.B.3, 4.B.4

Enduring Understanding 4.C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

Essential Knowledge: 4.C.3, 4.C.4

Activities: "Symbiotic relationships of microbes", "Lab activity increasing nutrient concentration to compare bacterial growth using the spectrophotometer", "Bacterial effect on global climate", "Biogeochemical cycles"

Science Practices (SP)

SP1, SP2, SP3, SP4, SP5, SP6, SP7