Some Background Concerning Life Science Content Standards for Fourth-Grade Teachers:

Microscopic Organisms

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Contents

Introduction

The background information for teachers in this document addresses the following life science content standards[1] for fourth-grade teachers:

3. Living organisms depend on one another and on their environment for survival. As a basis for understanding this concept:
d. *Students know that most microorganisms do not cause disease and that many are beneficial.*

Biological Overview: Classification of Organisms on Earth

Biologists describe and study all life on Earth. Through observation and experimentation, biologists study and describe the basic structure of each organism, and determine which biological kingdom each organism belongs in. Table 1 shows the five biological kingdoms and their basic ecological functions (producer, consumer, and decomposer).

[1] As specified in *Science Framework for California Public Schools Kindergarten Through Grade Twelve.* Sacramento: California Department of Education, 2003, p 62.

Table 1. **Five biological kingdoms of life on Earth and their functions in ecosystems.** Note that viruses are not included in this table because they are not cells (they are free-ranging molecules), and life is usually defined as being cellular.

Kingdom	Description	Examples	Ecological Function
Animals	Multicellular organisms that eat food	Insect Cougar Starfish	Consumer
Plants	Multicellular organisms that make food	Flower Moss Tree	Producer
Fungi	Multicellular consumers that absorb food	Mushroom Mold Yeast	Decomposer
Protists	Single-celled organisms that make food or eat food	Diatoms Algae & seaweed* Amoebas Protozoa	Producer Consumer
Bacteria	Tiny single-celled organisms that absorb food or make food	Blue-green bacteria Soil bacteria	Producer Decomposer

* Algae and seaweed are sometimes classified as plants because many species are multicellular.

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Life Science Topic: Microscopic Organisms

Science Framework[2] for California Public Schools

Grade 4: Standard Set 3. Life Sciences: 3.d. "*Students know that most microorganisms do not cause disease and that many are beneficial."*

> *"Microorganisms play a vital role in the environment. This standard helps students to look beyond the common misconceptions that bacteria are responsible only for diseases and that microorganisms are responsible only for decomposition. Some bacteria and single-celled organisms called protists are photosynthetic, and their contribution as primary producers of biomass in the ocean far exceeds that of the "visible" plants. Food chains and food webs may be based on bacteria and protists; therefore, a microscope will help students to observe microorganisms."*
>
> *"Growing cultures in the classroom provides students with opportunities to study bacteria and protists. A hay infusion is relatively safe to grow in a classroom. Within a few days students will be able to see numerous types of microorganisms through a microscope. Teachers and students should not culture soils and meat broths as some microorganisms can cause serious illness."*

Background for Teachers

Some microorganisms cause disease in plants and animals; however, most microorganisms play vital, beneficial roles in our environment and in our bodies! Microorganisms are microscopic, single-celled organisms (bacteria and protists).

Microorganisms are microscopic organisms.

In this background material, we will discuss bacteria, protists, and viruses. Viruses are not usually categorized as living organisms. Viruses are microscopic, but they are not cells – they are free-ranging molecules (that invade and reproduce inside the cells of other organisms).

[2] As specified in *Science Framework for California Public Schools Kindergarten Through Grade Twelve.* Sacramento: California Department of Education, 2003, p. 62.

Bacteria

Bacteria are very tiny cells and are usually difficult to see even with a microscope (Figure 1). They are much smaller than protists (about the size of chloroplasts and mitochondria[3]), and have a simple cell structure.[4]

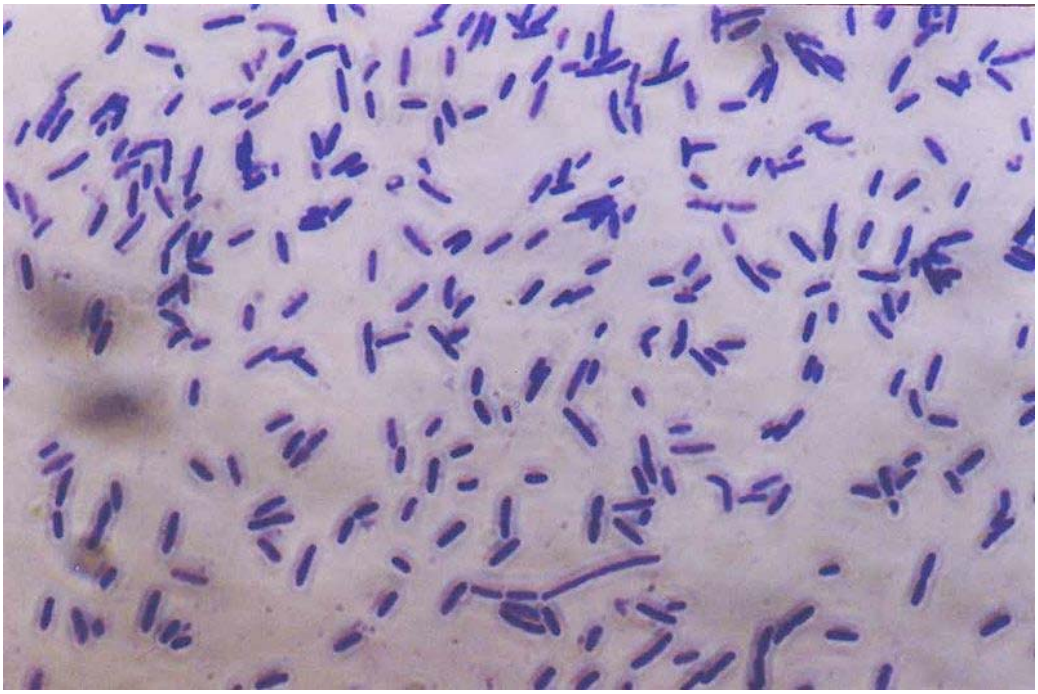

Figure 1. Microscopic photograph[5] of bacteria. These cells usually can only be seen at very high power (200x power) on a microscope (with an oil immersion lens).

Some bacteria absorb food and excrete mineral-nutrients; other bacteria can make food through photosynthesis. We shall discuss important groups of bacteria by their ecological function:

Blue-green Bacteria

Cyanobacteria (blue-green bacteria[6]) contain molecules of chlorophyll; therefore, these bacteria can make food (sugar) and release oxygen (O_2). Blue-green bacteria can often be found free-living in ponds and lakes (Figure 2).

[3] In fact, mitochondria and chloroplasts are thought to have once been free-living bacteria that were engulfed by larger, amoeba-like cells!
[4] Bacteria are prokaryotes (small cells with two cell membranes and no nucleus).
[5] Photograph on website: http://commons.wikimedia.org/wiki/File:Bacteria_photomicrograph.jpg
[6] Also known as *blue-green algae.*

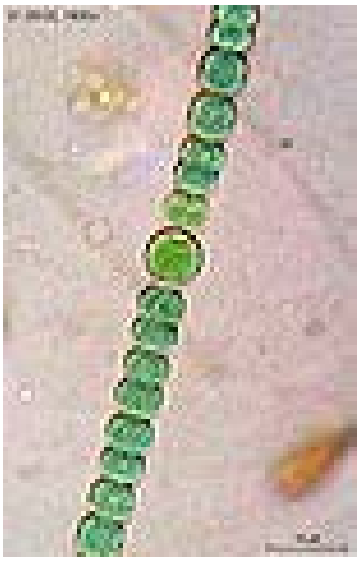

Figure 2. Microscopic photograph[7] of blue-green bacteria. Blue-green bacteria often live in pond water. These chains of cells can be seen at high power (100x power) on a microscope.

Nitrogen-Fixing Bacteria

Some species of beneficial bacteria live inside round organs (nodules) on the roots of legumes (Figure 3). The bacteria inside these nodules absorb nitrogen molecules from the air and make nitrate and ammonium molecules, which plants then use as fertilizer. Nitrogen-fixing bacteria are an important source of nitrogen-based mineral-nutrients in our soils!

[7] Photograph by Markus Dubach. Website: http://commons.wikimedia.org/wiki/Category:Cyanobacteria

Figure 3. Photograph[8] of a plant root with nodules. Nodules are spherical structures on the roots of legume plants that contain special bacteria that can take nitrogen molecules from the air and make nitrate and ammonium molecules, which plants use as fertilizer.

Soil Bacteria

Many beneficial bacteria are free-living decomposers in soil. These bacteria breakdown dead material and release mineral-nutrients (such as, phosphate molecules and potassium ions), which plants can then use as fertilizer. Soil bacteria are an important source of mineral-nutrients in our soils!

Symbiotic Bacteria In and On Our Bodies

Some beneficial bacteria live on our skin and inside our digestive tracts. The "good" bacteria on our skin forms a protective community that outcompetes most "bad" (disease-causing) bacteria that may land on our skin; we need these beneficial bacteria to maintain skin health.

The beneficial bacteria in our digestive tract (gut) provide us with natural vitamins, and help protect us from disease-causing bacteria. Some important foods (such as yogurt) contain beneficial bacteria, which help our digestive tract. Symbiotic bacteria are important for our health!

Pathogenic Bacteria

Pathogenic bacteria (germs) can be found in spoiled food, contaminated water, rusty nails, dirty clothes, etc. Pathogenic bacteria are the cause of some diseases in plants and animals. Human infections include tuberculosis, pneumonia, strep

[8] Photograph on website: http://www.ars.usda.gov/is/graphics/photos/aug05/d152-1.htm

throat, and some forms of dysentery. The easiest way to prevent infection by most pathogenic bacteria is by eating fresh food, drinking clean water, bathing daily, and washing our hands before eating. The immune system of the human body can fight off most harmful bacteria. In severe cases, proper use of antibiotics can successfully treat most bacterial infections.

Although some bacteria cause disease,
most bacteria play vital, beneficial roles in our environment
and in our bodies!

Protists

Protists are free-living, single-celled organisms that can be seen with a microscope. They are much larger than bacteria, and have a complex cell structure[9]. Some protists are producers (algae, phytoplankton), while other protists are consumers (protozoa). Figure 4 shows a common protist called an amoeba; this protist eats by surrounding and engulfing its food.

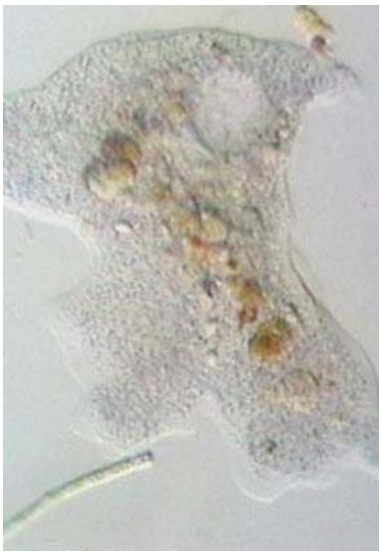

Figure 4. Microscopic photograph[10] of a protist. This free-living cell is called an amoeba.

Single-celled Algae

Algae are protists that are producers (Figures 5 and 6). Single-celled algae that float in water are called phytoplankton. Most of the oxygen in our atmosphere comes from marine phytoplankton!

[9] Protists are eukaryotes (cells have one cell membrane, a nucleus, and several organelles) Eukaryotes comprise 4 kingdoms: Protists, Animals, Plants, and Fungi.
[10] Photograph on website:
http://commons.wikimedia.org/wiki/File:Asymmetrical_and_Spherical.JPG

Figure 5. Microscopic photograph[11] of fresh-water green algae. The cells of Spirogyra are found in long strands (note the spiral chloroplast within each cell).

Figure 6. Microscopic photograph[12] of single-celled algae. These free-living cells are called diatoms. They have outer shells made of glass!

Protozoa

Protozoa are protists that are consumers (Figures 4 and 7). Protozoa that float in water are called zooplankton. Small fish and clams eat zooplankton!

[11] Photograph by Keisotyo (2006) Website: http://upload.wikimedia.org/wikipedia/commons/f/f5/Spirogyra_sp.jpg

[12] Photograph on website: http://commons.wikimedia.org/wiki/File:Diatoms.jpgvaccinat

Figure 7. Microscopic photograph[13] of a protist. This free-living cell is a Paramecium.

Pathogenic Protists

Pathogenic protists (germs) can be found in red tides[14], contaminated water, mosquitos, etc. Pathogenic protists are the cause of some diseases in plants and animals. Human diseases include giardia, malaria, and some forms of dysentery. The easiest way to prevent infection by most pathogenic protists is by avoiding shellfish during red tides, drinking clean water, sleeping under mosquito nets while in the tropics, and avoiding vectors of parasitic protozoa.

Although some protists cause disease,
most protists play vital, beneficial roles in our environment!

Viruses

Viruses are free-ranging, non-cellular molecules (of genetic material). They are much smaller than bacteria, and can be seen only with electron microscopes (Figure 8). All viruses are parasitic; they invade and reproduce inside the cells of other organisms.

[13] Photograph by Barfooz (2003) Website:
http://commons.wikimedia.org/wiki/File:Paramecium.jpg
[14] Dinoflagellates in red tides infect shellfish and poison people who eat the shellfish

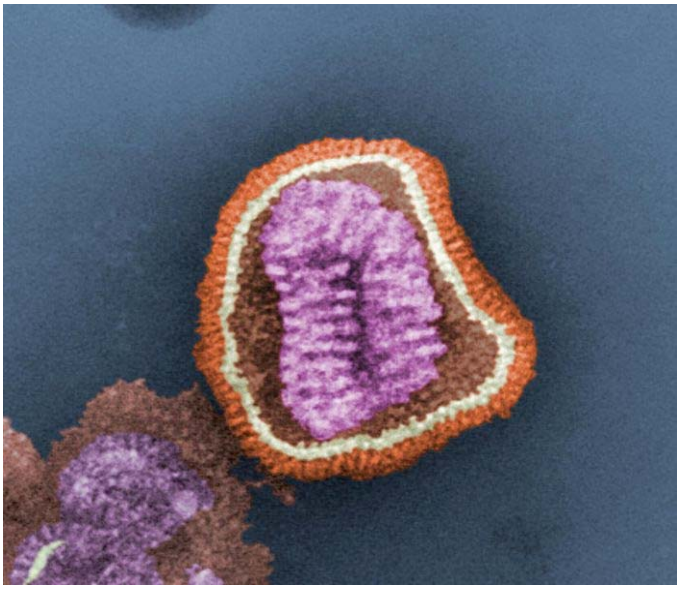

Figure 8. Electron microscope image[15] of a virus. This image of an influenza virus has been false-colored to show the different molecules inside.

Viruses (germs) can be passed person to person via body fluids, skin-to-skin contact, coughing, etc. Viruses are the cause of some diseases in plants and animals. Human diseases include warts, cold sores, colds, flu, polio, small pox, and AIDS. The easiest way to prevent infection by most viruses is through vaccinations, washing our hands before eating, and avoiding contact with infected people. The immune system of the human body can usually fight off most viruses.

[15] Image by Goldsmith, C (1981) Website: http://commons.wikimedia.org/wiki/File:Influenza_virus_particle_color.jpg1981g

Websites

1. Bacteria

A British website that has a link called “the smallest page on the web” with fabulous photographs of pond organisms, including blue-green bacteria!
http://www.microscopy-uk.org.uk/mag/indexmag.html?http://www.microscopy-uk.org.uk/mag/wimsmall/smal1.html

2. Protists

The microbe zoo -- interactive website with useful information on algae.
http://commtechlab.msu.edu/sites/dlc-me/zoo/zwpmain.htm

The YouTube website has several videos of microscopic organisms that live in ponds. This particular link shows moving protozoa (like amoeba), tiny multicellular animals (like rotifers), and tiny plants (green algae).
http://www.youtube.com/watch?v=CpkdvITDaWQ

A video of Vorticella, a protozoan.
http://www.youtube.com/watch?v=YHb2JaujIPo&feature=related

3. Viruses

A comparison of bacteria to viruses for teachers:
http://www.mansfieldct.org/schools/mms/staff/hand/Immunebacteriavsviruses.htm