Teacher's Supplement for
Time for Slime
A microscope connected to a digital projector helps students make connections between the microscopic and macroscopic world.

The purpose of this supplement is to provide teachers with a greater familiarity with the microorganisms they will encounter in this activity, give them a basic understanding of the roles they play in aquatic food webs, and give additional tips on performing the activity described in the article in *Science and Children*.

Microbial Food Webs in Aquatic Ecosystems

In aquatic food webs there are two main contributors that form the food base for aquatic communities: **algae** and **bacteria**. Algae are responsible for the majority of primary production that occurs in aquatic ecosystems. Much of the algae is microscopic in size and is consumed by large protozoa and by small animals, such as amphipods and zooplankton (i.e. "microcrustaceans;" daphnia or "water fleas"). **Protozoa** are largely single-celled organisms with cell structures similar to human cells. Because protozoa also consume bacteria they will be discussed in more detail below. The microcrustaceans consume both algae and large protozoa, and are then consumed by larger animals, such as fish. Figure 1 illustrates a simplified food web showing the basic feeding connections among these organisms.

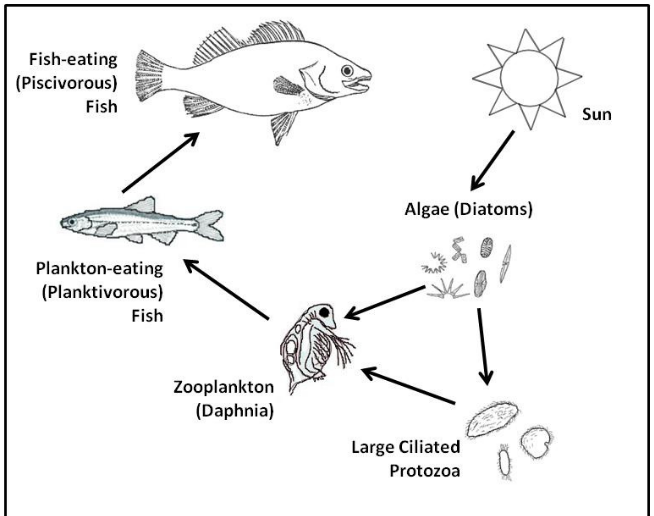

Figure 1. A basic aquatic food web that illustrates the contribution of algae to the food base and how large organisms are supported by small ones. Black arrows show the energy/feeding connections. Drawing not to scale.

When viewing the slide preparations of "mud" that you scrape from the stream or pond rock, you will likely see a diversity of microorganisms. These will include ciliated and flagellated protozoa that are described in more detail below, as well as a diverse assemblage of **diatoms**, a large group of microscopic algae. A key feature of diatoms is the ornate glass case they produce that houses the cell and gives each cell its shape. The number of different shaped diatoms is large and some examples are given in Figure 2. The distinct shapes and the presence of pigments for photosynthesis make it difficult to mistake diatoms for anything else.

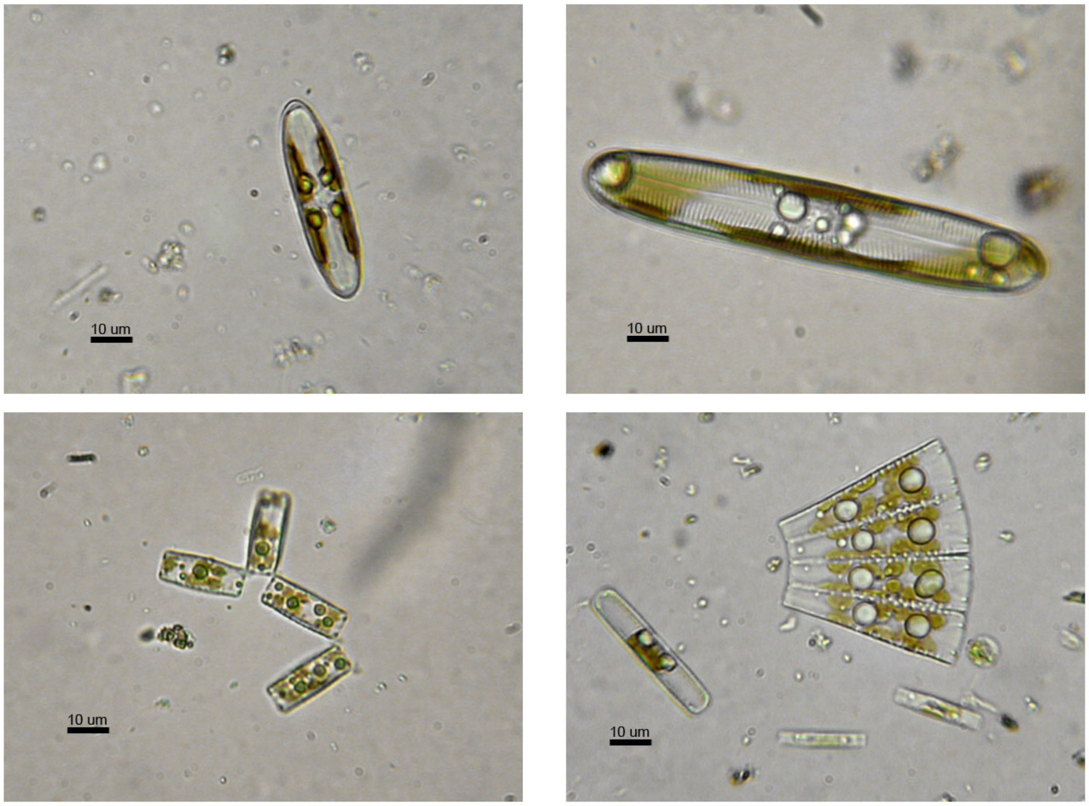

Figure 2. Different types of diatoms. *http://en.wikipedia.org/wiki/File:Diatomeas_w.jpg*

The Role of Bacteria in Aquatic Ecosystems

Although the food web illustrated in Figure 1 is likely sufficient at the elementary level, bacteria also play an important role in the function of aquatic food webs. As decomposers of dead, organic matter they serve to recycle nutrients needed by algae for photosynthesis. The density of bacteria in aquatic systems is staggering, ranging from 100,000 to 1,000,000 cells per milliliter, and they serve as an abundant food source for large protozoa that were discussed briefly above. The protozoa have a cell structure similar to human cells but they exist largely as single cells in aquatic environments, swimming around and feeding on bacteria and each other. The two main groups of protozoa are flagellates and ciliates (Figure 3). Flagellated protozoa ("flagellates") have one to several long appendages called flagella that they use for movement and eating. Ciliated protozoa ("ciliates") have several to many short hair-like appendages called cilia that they also use for movement and feeding. Flagellates are generally smaller than ciliates and thus serve as food for them. The bacteria break down the dead organic matter for food, grow in number and are fed upon by flagellates and small ciliates. These small protozoa become food for larger protozoa, who are also important consumers of algae as described above. Figure 4 shows an elaborated version of the food web presented earlier, with algae and bacteria together forming the food base. The figure also shows the decomposition pathways, with all producers and consumers contributing to a pool of organic matter (either as waste materials or by mortality) that serves as food for bacteria. Note the key role that protozoa play in mobilizing the energy in bacteria into higher consumers.

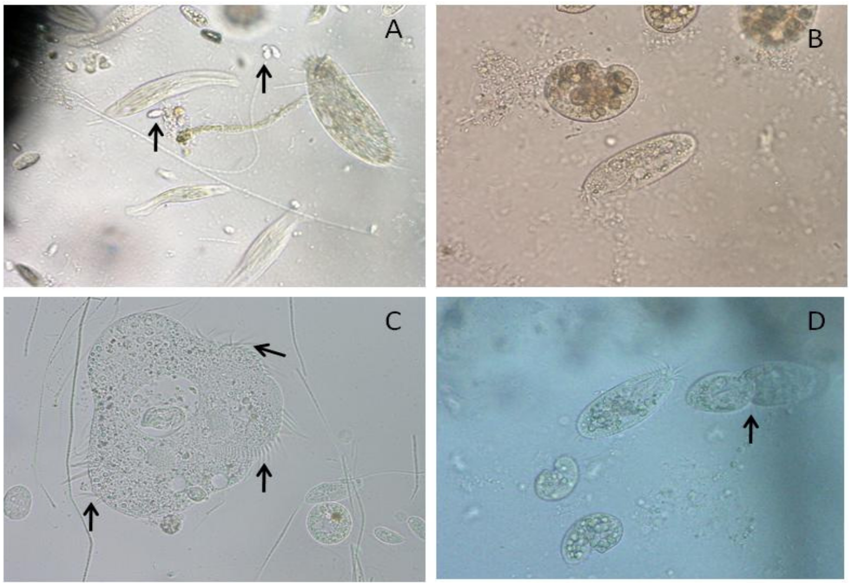

Figure 3. Protozoa at 400X magnification. A, large ciliates and small flagellates denoted by arrows. B, two different large ciliates; the small grainy objects are bacteria. C, a large ciliate with the cilia denoted by arrows, together with smaller protozoa. D, large

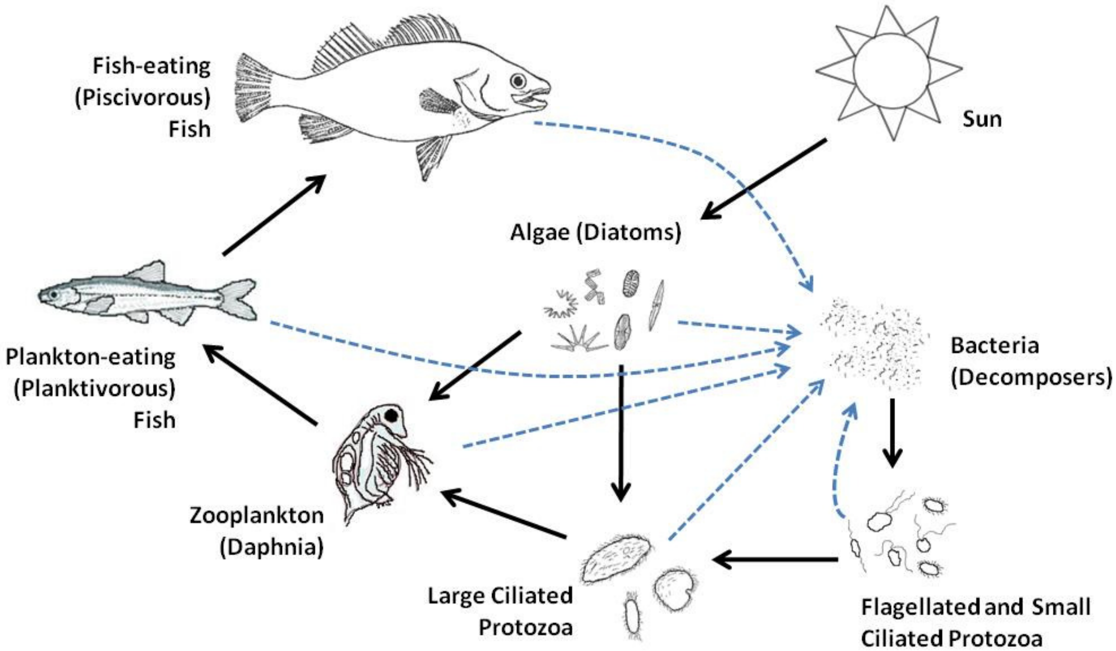

Figure 4. A basic aquatic food web that illustrates the contribution of bacteria and algae to the food base in aquatic and how large organisms are supported by small ones. Arrows with black solid lines show the energy/feeding connections; arrows with blue dotted lines show the decomposition pathways. Drawing not to scale.

Preparing and Viewing Slides

Achieving success with the activity is dependent on the quality of the microscope slide preparation. It is important for the rock to be wet but not submerged. Locate a spot on the rock that is covered by the most “mud” and scrape the surface at an angle with a sharp-edged instrument; a razor blade is best but a butter knife is sufficient. Scrape enough material so that an area at the center of the slide about the size of a nickel is covered. If the “mud” appears wet, then place a glass or plastic cover slip directly over it. If it appears dry, then add a drop of water and stir it into the material. Cover with a cover slip and you are good to go.

When viewing a preparation, it is important to start at the lowest magnification; for most compound microscopes this is 40X. Move the slide so that a spot with an abundant amount of material is beneath the objective lens. Bring it into focus and allow the students to view and make hypotheses about what they see. No doubt they will be able to see some things moving around, like large ciliated protozoa, and they will begin to question the initial observation that this is just “mud”. Switch to an objective lens with a higher magnification; typically, this achieves a 100X magnification. Most compound microscopes have parfocal lenses and the image will stay in relatively good focus when you change between lenses of different magnification. At 100X, the students will begin to make out the busy lives of microscopic life. Large protozoa will be the most obvious but smaller moving objects, such as small ciliated and flagellated protozoa, will be swimming around like mad. Many long diatoms will be seen moving around like ocean liners. A great way to get the students involved is to have them count the number of different shapes of the ciliates and diatoms they can see.

Having a microscope with a magnification of 200X or higher can really enhance this activity. Projected images of microbes can be 1-2 feet in length or diameter and provide students with a unique encounter of cellular life. As shown in Figure 3, the full view of large ciliated protozoa at 400X can take up most of the screen.