

Naked to the Eye

Wyoming Science

Objectives:

- Explain how magnification technology enables us to see a world invisible to the naked eye.
- Compare characteristics common in observed organisms (e.g., color, movement, appendages, shape) and infer their function (e.g., green color found in organisms that are producers, appendages help movement).
- Examine and illustrate size, shape, and structure of organisms found in an environment (such as pond water and/or food).

Background:

When scientists began to study microorganisms it wasn't because they could see them (they are too small for the naked eye), it was because they observed things that were happening in the world around them. Why did some people contract certain diseases or get sick after they ate a particular food? Why did milk sour and sometimes sour into something tasty that didn't make you sick (yogurt)? What caused the bread to rise? Microorganisms need water, oxygen, and food, they thrive in our food and environment, and we need them, most of them.

Students need to understand how a lens and microscope works. The microscope your school has may still have the literature that came with it, but probably not. One of the best resources for learning about how a microscope works can be found in your school library in most encyclopedias. The lens activity in this lesson plan will help your students to understand magnification so that students know what it means when an object is magnified 10x, 40x, or 400x.

Microorganisms are everywhere, they are ubiquitous. Microscopes make it so we can see microorganisms, but they are not a requirement for observing or learning about microorganisms. If you have one or two microscopes, they can be used for either demonstration or in a work station setting. Prices for microscopes begin at \$50. Cheap microscopes equal poor images, and yes you might see your eyelash flutter; this may frustrate students and cause them to lose interest. If your school is in a position to purchase good quality microscopes, about \$450, you might consider purchasing a microscope with a video camera, \$670 - \$1,200, or another option would be to buy a "virtual microscope" CD (vendors are listed in the resource section). This technology allows you to view microorganisms on a computer screen that may also



Standards

Science

Life Systems: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6

Science As Inquiry: 2.1, 2.2, 2.3, 2.4, 2.5

Materials

Activity 1: Magnification

- Glass slides
- Quarter-inch (US) washers
- Petroleum Jelly
- Toothpicks
- 15 magnifiers (Hand lenses, 2 students per)
- Microscope (at least one)
- Video Microscope or "Virtual Microscope" CD
- Magnification Worksheet
- 15 pipettes
- Materials for Activity 2 on page 6
- Materials for Activity 3 on page 7

Estimated Time

3- (50) Minute Sections

Grades 5-6

notes:

be projected or displayed through a television screen. Your entire class can view microorganisms at the same time. The Internet offers yet another way to view microorganisms, but you need an Internet connection in your room to make this possible (see web sites noted in the resource section).

Begin by studying scientists that have used “crude” microscopes. What led them to use this tool? Was it an innate desire to see what was floating in our environment? No. Men and women of science observed the world around them and then from their observations, experimentation, and study deduced that perhaps something they could not see was causing the phenomena.

Lenses to correct poor vision were the first “eye magnification devices.” It wasn’t long after that people discovered that they could change the thickness, curve, and type of glass to see the “microscopic world.” Microscopes in a crude form have been around for nearly 4,000 years! Credit for the first compound microscope (meaning more than one lens) is usually given to Zacharias Jansen, in Middleburg, Holland, around the year 1595. Few improvements in the microscope occurred until the early 1800s, when better glass-making methods produced lenses that provided undistorted images, allowing us to see the world of bacteria, protists, and to some extent, fungi.

Marcello Malpighi (1628-1694) was one of the first great microscopists, and even today is considered the father of embryology and early histology (the study of blood). He discovered capillary blood vessels. Another great scientist was Louis Pasteur. Louis Pasteur (1822-1895) is probably best known for his work in controlling bacteria through pasteurization (and how animals develop immunity and can fight off microbes with a vaccination, saving countless lives). Pasteurization is a method of preserving food by heating the product up and cooling quickly. Louis Pasteur developed this process to save the wine industry in France. Pasteurizing the wine kept out harmful microbes. Pasteurization is most commonly used in milk.

Just how small are microorganisms? Molds can be seen with only slight magnification and use of an ordinary magnifying glass. Yeasts must be viewed through a microscope that magnifies several hundred times. Bacteria can best be seen when studied with a more powerful microscope that enlarges 1,000 times.

Microorganisms have a direct impact on our daily lives, in fact, we couldn’t live without them. Some are helpful decomposers, that help make our food and plant life possible because of their necessary role in making the soil fertile and in some of our foods because of their fermenting properties etc. They aid our bodily processes by helping break down

complex foods into simpler substances. Some, called germs, are harmful to us by the role they play in causing diseases.

It helps to understand something about cells when studying microorganisms. All living organisms, large and small, have one thing in common, the cell. This is a tiny living factory capable of converting simple food substances into energy, and creating new cell material, making it possible for the cell to reproducing itself. If you understand the cell “factory” you can understand how tiny microorganisms live.

Large organisms, including people, are composed of billions of cells with many different roles. They make up your body’s parts from your brain to your big toe. Microorganisms, on the other hand, are made up of a very few or even a single cells capable of carrying on all of life’s processes. A basic understanding of cell structure and function is essential to understanding the actions of bacteria, protists, yeasts, and molds. The cell is complex in its makeup and its function. Many scientists have spent their lives studying it. The main parts of the cell are the nucleus, cytoplasm, and the cell wall. (There are other organelles found in the cell. But for this unit of instruction, knowledge of these main parts will suffice.)

The cell nucleus (plural, nuclei), is the control center and directs cell division or the formation of new cells (bacteria lack an organized nucleus). Cytoplasm is the watery material in the cell between the cell membrane and the nucleus it contains the parts which convert food material into energy and new cell material. The cell membrane, or plasma membrane, separates the cell from its surrounding environment. The membrane controls the movement of materials into and out of the cell, which makes it possible for the cell contents to be chemically different from the environment. The cell wall or membrane holds everything together and controls the passage of material into and out of the cell.

Animal cells do not have cell walls, just a cell membrane. The cell membrane and cell wall keeps the internal conditions of the cell constant.

Kingdom Monera

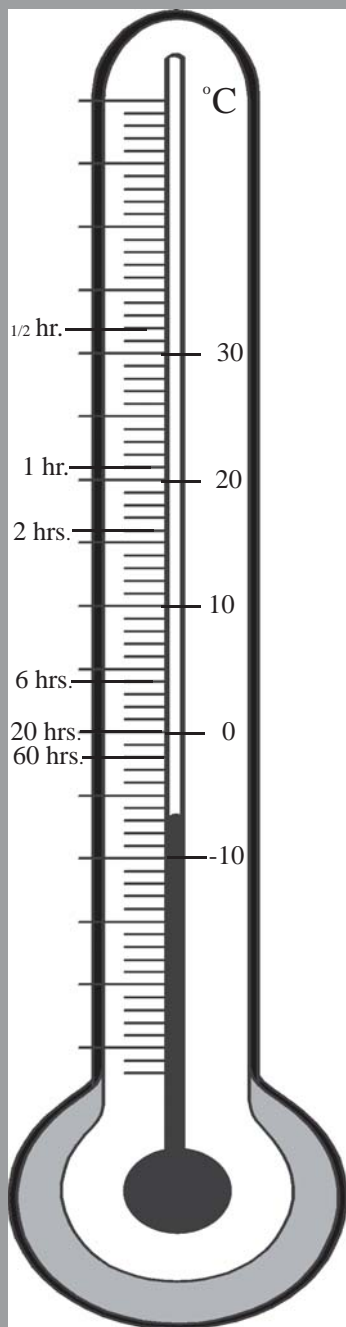
Bacteria (Monerans) make up the largest group of microorganisms. People often think of them only as germs and the harm they do. Actually, only a small number of bacteria types are pathogenic (disease causing). Most are harmless, and many are helpful.

There are thousands of different kinds of bacteria. Some differ only slightly, and it takes a highly trained person to identify them. There are also groups that differ greatly in growth habits and appearance and are quite easily identified. But regardless of minor differences, most bacteria can be

vocabulary:

- *organism*
- *environment*
- *ocular*
- *monocular*
- *binocular*
- *trinocular*
- *stereoscopes*

notes:



classified according to three basic cell shapes; bacillus (rod shaped), cocci (spherical shape), spirilla (long spiral rods).

In addition to their different shapes, their cell arrangement varies. For example, some cocci are always grouped in pairs (diplococci). Others are arranged in chains (streptococci). Still others are bunched (staphylococcal). Diplococci are the kind which cause pneumonia. Streptococci are often associated with “strep throat.” Staphylococci are familiar to many because of their role in “staph infections” and some types of food poisoning. Bacteria also vary somewhat in size, but average about $1/25,000$ inch. In other words, 25,000 bacteria laid side by side would occupy only one inch of space. One cubic inch is big enough to hold nine trillion average size bacteria—about 3,000 bacteria for every person on earth.

Bacteria multiply by binary fission or cell division. Bacteria double every $1/2$ hour at 32°C , 1 hour at 21°C , 2 hours at 16°C , 6 hours at 4°C , 20 hours at 0°C , and 60 hours at -2°C .

Microorganisms, including bacteria, can also be grouped according to their requirement for oxygen. Some grow only in the presence of oxygen (aerobes). Others grow only in the absence of oxygen (anaerobes). Some are able to grow with or without oxygen (facultative anaerobes).

Bacteria and other microorganisms need food in order to grow and multiply. They vary in their food needs, but nearly everything we consider as food can also be used as food by some types of bacteria (some bacteria can synthesize or make their own food). To be used by bacteria, a food substance must pass into the cell where it can be processed into energy and new cell material. Because most foods are too complex to move into a bacterial cell, they must be broken down into simpler substances. Enzymes do this by increasing the rate of biochemical reactions. Produced within the bacterial cell, enzymes move through the cell wall to break down the food on the outside into a form bacteria can use.

Kingdom Protista

Scientists estimate that the protists first evolved about 3 billion years after the monerans (bacteria) were established. Since most protists require oxygen, it is thought that the earliest protists could not have evolved until the “blue-green” bacteria had been producing oxygen for billions of years.

The kingdom Protista contains many species and a greater variation of organisms. Although most protists are unicellular, some are multicellular organisms and may be quite large. Some protists are heterotrophic (get their food from their environment) others are autotrophic (make their

own food). Protists may live on land or in water. Because they are so diverse, the members of the kingdom Protista are difficult to classify. They are divided into three main groups: the animallike, plantlike, and fungus-like protists.

Animal like Protists

The animal like protists are single-celled or colonial organisms called protozoans. They live in fresh and salt water, in the soil, and in the bodies of other organisms. All protozoans are heterotrophic. Some absorb nutrients through their cell membranes, whereas others engulf larger particles of food. Most protozoa are motile.

Amebas are unicellular organisms that continually change shape and engulf food particles. Amebas reproduce asexually by binary fission (cell division). They are commonly found in freshwater ponds, lakes, and streams.

Another group of the animallike protista is called zooflagellates. *Trypanosoma gambiense* is the protist responsible for African sleeping sickness in humans. These microorganisms are spread by the Tsetse fly.

Plasmodium is a protozoan that causes malaria, a serious, sometimes fatal, disease. The spores from this parasite invade the red blood cells of the human host, multiply there, then break out and invade new cells. The destruction of the red blood cells releases toxic cell wastes into the bloodstream. These waste products cause fever, chills, and other symptoms of malaria. Although malaria can be treated with drugs, one method of prevention is to eliminate the *Anopheles* mosquito. In spite of the widespread use of pesticides in many countries, millions of people are still infected with malaria, especially in tropical areas.

Plantlike Protists

The plantlike protists, commonly called algae, are photosynthetic like plants. Like the protozoa, algae are very diverse. Some are tiny, single-celled organisms with flagella. Others are large, multicellular organisms like seaweed. Like plants, algae have chloroplasts, which contain the photosynthetic pigment chlorophyll.

Another group in this category is called the euglenoids. These single-celled protists have both plantlike and animallike characteristics. Like plants, they contain chloroplasts. However, they do not have cell walls. Like some of the protozoa, euglenoids move by means of flagella. One typical euglenoid is *Euglena*, an organism common in pond water.

The *Euglena* is a single-celled organism having two flagella. The cell has a large, central nucleus and numerous chloroplasts which contain chlorophyll. Chlorophyll gives *Euglenas* their grassgreen color. *Euglenas* are primarily photosynthetic. However, in the absence of light, they live as

Questions for Investigation

1. What are six things bacteria need to survive? Food, water, proper temperature, proper acid (pH), no inhibitors present, host.
2. How does/do _____ affect the growth of bacteria?
light
infrared light
ultra violet light
temperature
moisture
antibiotics
salt
vinegar
sugar
air/oxygen/carbon dioxide
soap
(regular vs. antibacterial)
household
disinfectants

Materials

Activity 2: Growing Microorganisms

- 4 - Ziploc bags
- 4 - slices of bread
- permanent marker or pen
- water mister bottle
- papertowel

heterotrophs, absorbing dissolved nutrients from the environment.

Activity Procedures:

Microbe Observations

Activity 1: Magnification

1. Provide each student with a Magnification “m” Worksheet, hand lens, glass slide and three washers.
2. Instruct each student to look at the letter “m” with a 3x magnifier and then draw what they see, actual size in the appropriate box on the worksheet.
3. Ask the students to apply some petroleum jelly with a toothpick to one side of a washer and place it onto the glass slide (they will be able to maneuver the slide better if they apply the washer to one end of the slide). Have them add a few drops of water into the center of the washer using a pipette until the water is almost even with the top of the washer. Instruct them to use this “lens” to view the 1x letter “m” and then draw its actual size in the appropriate box on the worksheet. They should estimate how many times the letter has been magnified.
4. Repeat this same step using two more washers. **BE SURE TO ASK THEM TO PREDICT THE MAGNIFICATION OF THIS LAST LENS BEFORE THEY MAKE THAT OBSERVATION.**
5. If you plan to have student use microscopes in class, discuss the proper use and handling of the microscope (see microscope manual, encyclopedia, web sites noted in the Resources section)
6. Observe some microorganisms using either video, CD’s, or by looking at prepared slides at microscope work stations. Discuss the amount of magnification being used to view the specimens.

Activity 2: Growing Microorganisms on Bread-Media

Select four slices of bread, preferably from a loaf without preservatives (this will speed your mold growth). Give each piece the following treatment and then place the slice into a “treatment labeled” Ziploc bag. Store the bags in warm dark place for incubation.

1. Wipe an unwashed hand (pretend you are smearing on mayonnaise with your entire hand) on both sides of the slice, place it into a Ziploc bag.
2. Lick one piece on both sides with your tongue.
3. Wipe one piece on both sides on the floor.
4. **WASH YOUR HANDS.** Place the slice onto a paper towel. Moisten the slice with water from a mister bottle. Observe

the bread for microorganism growth every other day for the next week. (This may take longer if you are using bread that contains growth inhibitors, preservatives.)

5. Students need to record their observations.
6. At the end of 2 weeks review the results and make some class conclusions. Most of the growths on the bread will be fungal.

Activity 3: Pond Life

Protists live under almost all natural conditions where moisture is found. They may be found in fresh water ponds, soil, salty water, hot springs, or snow drifts. The most important piece of equipment for the study of protozoans is a microscope. The better the microscope the more you'll see. However, in 1675 Anthony van Leeuwenhoek discovered the first Protists known to man with a very primitive microscope that gave the magnification of only about 50 diameters.

If you have a standard microscope with a low power magnification of about 100 times (written 100x) and a high power of 400x you have the most important item of equipment. If you do not have microscopes, a video or CD that allows your students to view the movement, color, appendages, and shape of pond water microbes will suffice.

1. Collect protists from local pond water (or other source noted above) by scooping up (use the lid or your hand) the scum and algae on top of the water. Even in midwinter, protists may be scooped up in debris or vegetation on top or on the bottom of the pond.
2. Fill the jars 2/3 full with the pond water.
3. Keep the jars in a well-lit area, preferably one that is reached by moderate sunlight. You don't want the water to get too hot or you'll kill the creatures. Be careful about direct sunlight.
4. Observe your protists. Some protists can be found immediately (cyclops can be seen with the naked eye!). Within 24-48 hours others that were scattered through the jar will become concentrated at the top where they may be found more easily and in greater numbers. Others may become concentrated near the bottom of the jar.
5. Using an eyedropper suck-up some pond water from the top or the bottom of the jar, place a drop or two on a slide and then cover the drop with a coverslip.
6. Observe the slide, if no protists are found, make more slides.
7. Ask students to draw what they observed.
8. Ask students to compare the similarities and differences of

Materials

Activity 3: Pond Life

- quart or pint jars
- microscopes
- eyedroppers (or pipettes)
- slides
- cover slips
- Pond Life Identification Sheet

notes:

organisms they see growing on the bread and the microorganisms in the pond water. (Use the Kingdom and Characteristic Charts to aid in the discussion.)

9. Finally, see if they can identify what they saw using their drawing and the identification key. The jars should be kept for several weeks. The species that are most numerous one day may be absent the next day and be replaced by other species. The protozoa which feed on bacteria may be helped by adding a little hay infusion prepared by steeping in warm water a small amount of grass or alfalfa hay. The proportion of hay to water should be enough to produce a color similar to that of strong green tea. Two tablespoons added to a quart jar or one tablespoon added to a pint jar should be sufficient to revive your protozoa.

Extensions, Adaptations, Integration:

Activity 1a: More Observation Possibilities

This activity is a variation on bread media observations. Wash your hands and then slice two potatoes into four pieces. Give each piece the following treatment and then place the slice into a “treatment-labeled” Ziploc bag. Store the bags in a warm dark place for incubation.

1. Dip one potato piece into a 5% solution of chlorine bleach (5ml in 100ml). Remove the piece with sterilized tweezers and place it into a Ziploc bag.
2. Put fingerprints all over another piece, or pass it around the classroom for everyone to touch (unwashed hands).
3. Ask one student to wash hands and then touch a piece on both sides.
4. Wipe one piece on both sides on the floor.
5. Using a variety (use three potato pieces for this) of “antibacterial” wipes, lotion, and/or hand sanitizer, have a student use one product on their hands then touch both sides of the potato.
6. Use the last potato piece as a control, no treatment.
7. Observe the potatoes for microbial growth every other day for the next week. Have students to record their observations.
8. At the end of 2 weeks review the results and make some class conclusions. Most of the growths on the potatoes will be fungal.

Activity 1b: More Observation Possibilities

Obtain sterile agar petri plates and carefully label them with name, date, experiment and any other pertinent identification information. Do not open the lid until you are ready to inoculate (contaminate) the nutrient agar. Expose the petri dish of agar medium to microorganisms by performing one or more of the following:

1. Sprinkle some yeast on the medium
2. Using a cotton swab, rub across mold on cheese then rub on the medium in the petri dish
3. Using an eye dropper, deposit a drop or two of pond water/ditch water onto the medium in the petri dish
4. Rub your finger (after washing hand thoroughly) on your face and then rub same finger on medium in petri dish (being careful not to tear the surface of the agar)
5. Place strand of hair on the medium in petri dish
6. Place a fine layer of soil onto the agar Seal petri dishes with clear tape. Place the petri dishes in a drawer (or other warm dark place) overnight and observe the next day and after 3 and 7 days. This is the incubation period. Have students write on a piece of paper what they observed on each petri dish.
7. After incubation, observe the types of microorganisms that have grown on the surface of the plate. Many microorganisms will have formed visible colonies. A colony is a group of microbial cells resulting from the reproduction of one or more cells that were deposited on the medium surface and grew into a visible collection of cells.
8. Discuss with students what took place in the petri dishes.
9. Create a Venn diagram with your student to compare the microorganisms.

(Materials Adapted from Agriculture in the Classroom)

Resources:

History of the Light Microscope

www.utmem.edu/~thjones/hist/hist_mic.htm

How to use a microscope

www.usoe.k12.ut.us/curr/science/sciber00/7th/cells/sciber/intro.htm

Cells

www.clarityconnect.com/webpages/cramer/pictureit/cells.htm

www.purchon.com/biology/cells.htm

<http://personal.tmlp.com/Jimr57/index.htm>

<http://gened.emc.maricopa.edu/bio/bio181/BIOBK/>

BioBookCELL2.html#Table%20of%20Contents

www.nyu.edu/education/mindsinmotion/individual/bg243/

Guide to Microlife, Kenneth G. Rains & Russell.

Published by Franklin Watts Danbury, Connecticut, 1996.

Microorganism CD's, microscopes, and microbe videos are available from Carolina Biological; www.carolinabiological.com (order a catalog) and other Science Supply vendors.

Characteristics of the Five Kingdoms

| | Kingdom | | | | |
|----------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------|
| Characteristic | Monera (bacteria) | Protista (protozoa and algae) | Fungi (molds, yeast, mushrooms, rust, smut) | Plantae (non-microscopic, plants) | Animalia (non-microscopic, animals) |
| Cell type | prokaryotic (cells lacking distinct membrane-bound nuclei) | eukaryotic (cells containing membrane-bound nuclei) | eukarotic (cells containing membrane-bound nuclei) | eukarotic (cells containing membrane-bound nuclei) | eukarotic (thick cell wall) |
| Body form | most unicellular some conial | most unicellular; some multicellular | most multicellular | multicellular | multicellular; organs and organ systems |
| Cell wall composition | polysaccharides and amono acids | present in some | usually chitin | cellulose | no cell wall |
| Mode of nutrition | photosynthesis, chemosynthesis absorption | photosynthesis, ingestion, or absorption | absorption | photosynthesis | ingestion |
| Nervous system | absent | absent | absent | absent | present |
| Locomotion | present in some | present in some | absent | absent | present |

Magnification Worksheet

| | | |
|----------------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------|
| <p>M</p> <p>Actual Size, 1x letter M</p> | <p>Size when M is viewed with hand lens, 3x</p> | <p>Size when M is viewed with 1-washer lens</p> |
| <p><u>Predicted</u> size of M when viewed with 3-washer lens</p> | | <p>Actual size when M is viewed with 3-washer lens</p> |

Microscope Lingo

- ***Ocular***, microscope eyepiece.
- ***Monocular***, microscope with one eyepiece.
- ***Binocular***, a microscope with eyepieces.
- ***Trinocular***, three eyepieces, two for viewing one for a camera.
- ***Stereoscopes***, which are binocular, provide a three dimensional view of an object. Stereoscopes are usually lower magnification, but are great for viewing larger organisms, especially those found in pond water .

Great Microscope links for students:

www.geocities.com/EnchantedForest/Dell/5400/resources

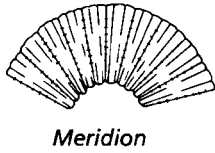
www.cellsalive.com

www.utmem.edu/personal/thjones/hist/hist_mic.htm)

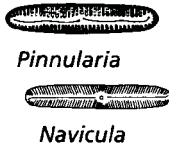
www.pfizerfunzone.com

Pond Life Identification

Diatoms: (golden-brown)

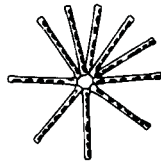


Meridion

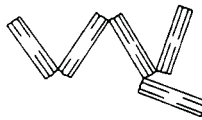


Pinnularia

Navicula



Asterionella



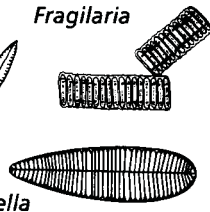
Tabellaria

Gomphonema



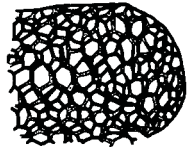
Gomphonema

Fragilaria

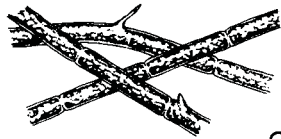


Fragilaria

Algae: (green)



Hydrodictyon



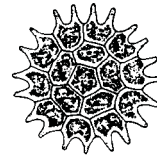
Rhizoclonium



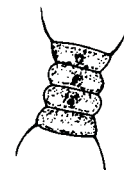
Chlamydomonas



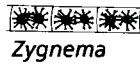
Chilomonas



Pediastrum



Scenedesmus



Zygnema



Cosmarium



Micrasterius



Closterium

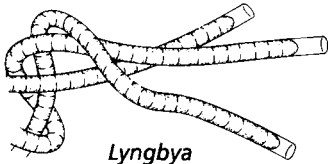


Euglena



Spirogyra

Single-celled forms, attached or swimming:



Lyngbya



Amoeba



Stylonychia



Vorticella



Tetrahymena



Stentor

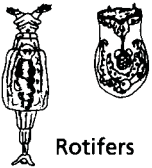


Paramecium

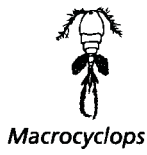


Anabaena

Larger organisms:



Rotifers



Macrocylops



Daphnia



Bosmina



Lymnaea



Physa



Helisoma



Campeloma



mosquito larva



Chaoborus
("phantom larva")



Gammarus
(amphipod)



damselfly nymph



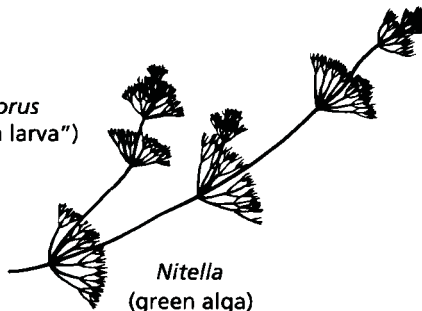
Gerris
(water strider)



Hydracarina
(water mite)



Tendipes
(blood worm)



Nitella
(green alga)



caddis fly larva



Tubifex
(red annelid)



whirligig beetle



dragonfly nymphs