Algal blooms and the water supply

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Great Lakes Region

Figure 1: Map of Great Lakes region. The city of Toledo is located at the most western end of Lake Erie.

Case studies: What happened to the water? - - - - - - - - - - - - - -

Excerpted from: weather.com Toledo, *Ohio Water Supply Contaminated by Algae From Lake Erie*, By Eric Zerkel, Aug 3, 2014

Toledo, Ohio city officials issued an urgent notice to residents to not drink or use the city's tap water after harmful levels of algae-related toxins were discovered at one of the city's water treatment plants.

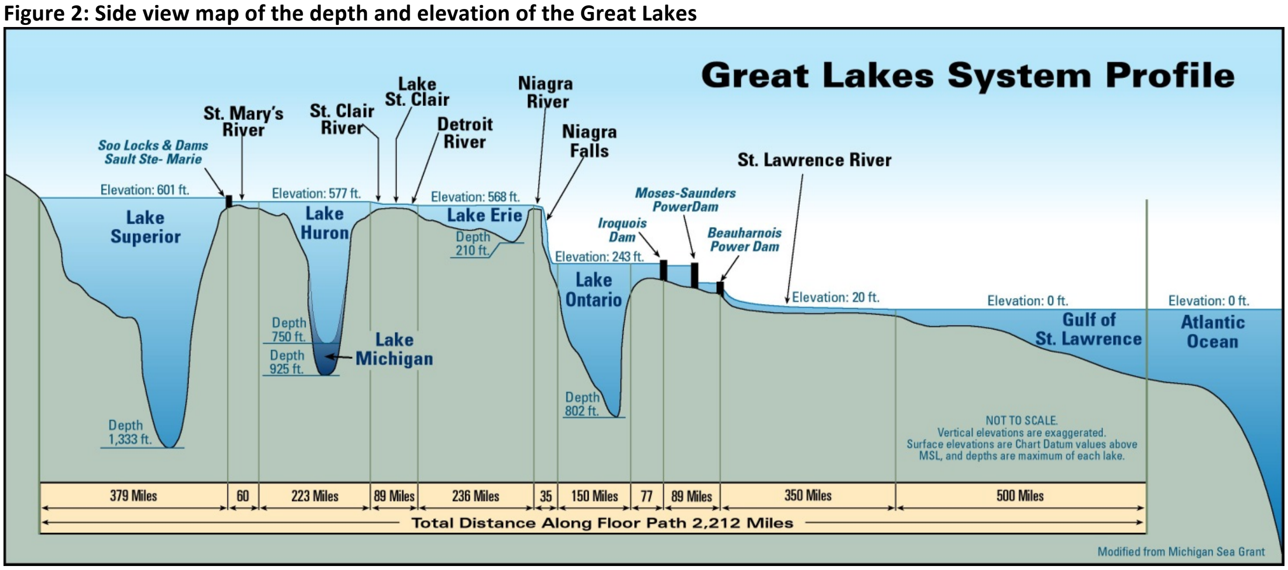
A post to the city's Facebook page urged the 400,000-plus residents of Ohio's fourth largest city not to drink or boil the water until the city cleared the water for consumption. Some Toledo, Ohio, suburbs along with areas of southwestern Michigan were also affected by the water ban.

The post went on to explain that consuming the water could lead to a series of health complications, including "abnormal liver function, diarrhea, vomiting, nausea numbness or dizziness." Attempting to boil and drink the water would only worsen those health effects because it would "increase the concentration of the toxins."

Those toxins are said to come from a growing algae bloom on Lake Erie. A recent bulletin issued by NOAA shows the harmful algae bloom growing in Maumee Bay near the mouth of the Maumee River, which runs through Toledo. Lake Erie provides water to more than 11 million people, including major cities like Toledo, Cleveland, Buffalo and Detroit.

Where does the water come from??? -

Figure 2: Side view map of the depth and elevation of the Great Lakes



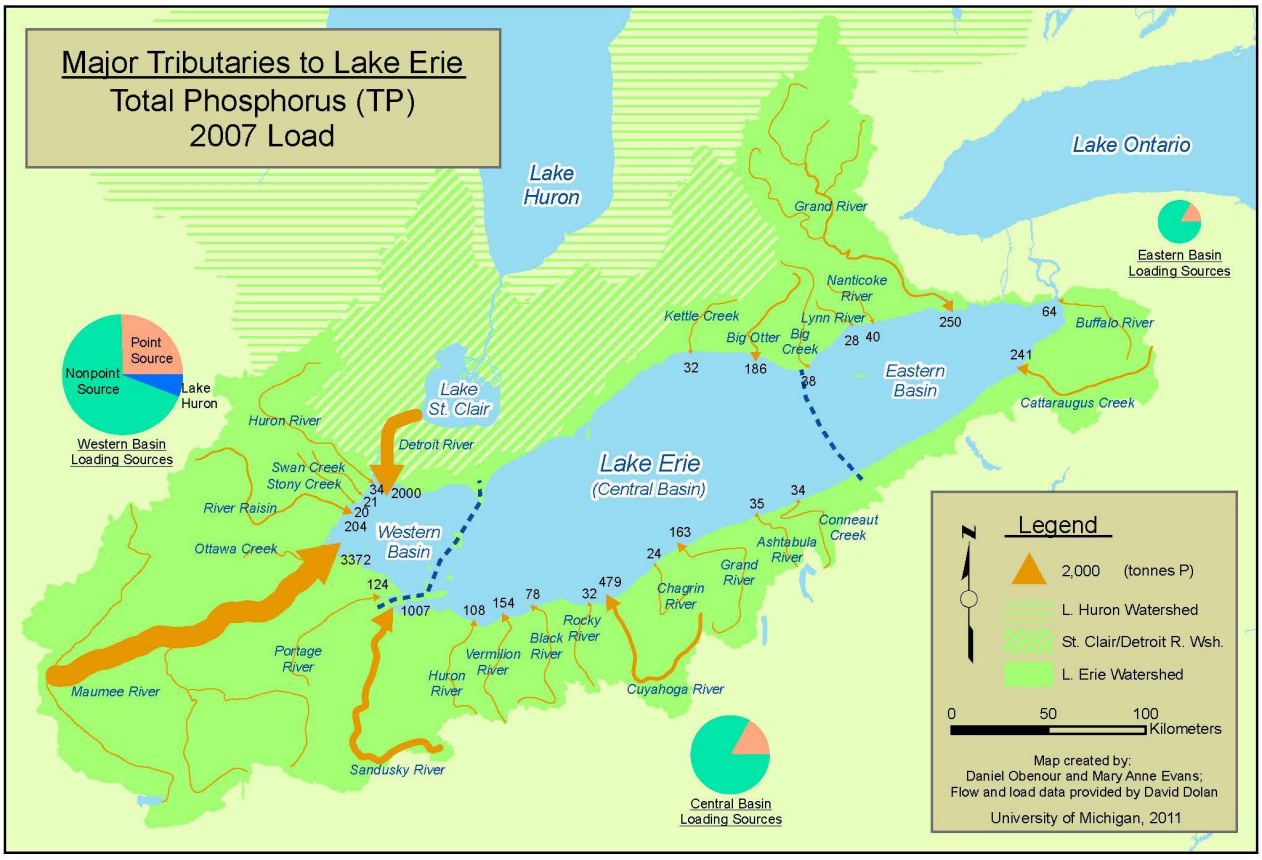
1. What is the elevation and maximum depth of Lake Erie?

2. What are the names and elevations of lake(s) higher in elevation than Lake Erie? Which lake(s) are lower in elevation than Lake Erie?

3. What do you think the sequence of the water flow is in the Great Lakes system? Give evidence from Figure 2 to support your reasoning.

4. How does water get from Lake Erie into Lake Ontario?

Figure 3: Local area drainage and phosphorus contributor map to regions of Lake Erie.



5. Which 3 watersheds are depicted in figure 3? Which one drains into Lake Erie?

6. Figure 3 is showing the watersheds in the Lake Erie area. Based on the direction of water flow and the size and distribution of the shaded regions, how might you describe what a watershed is?

7. Which statement correctly identifies the flow of water for Lake Erie?
   a. Lake Ontario → Eastern Lake Erie → Central Lake Erie→ Western Lake Erie → Lake Huron
   b. Lake Huron → Western Lake Erie → Central Lake Erie→ Eastern Lake Erie → Lake Ontario
   c. Lake Huron → Western Lake Erie → Central Lake Erie ← Eastern Lake Erie← Lake Ontario
   d. Lake Huron← Western Lake Erie ← Central Lake Erie→ Eastern Lake Erie → Lake Ontario

Compare your answer to #7 with other groups before moving on!

8. How much Total Phosphorus (TP) was contributed by the Cuyahoga River in 2007?

9. Which of the three basins of Lake Erie receives the largest amount of phosphorus? Provide evidence from Figure 3 to support your reasoning.

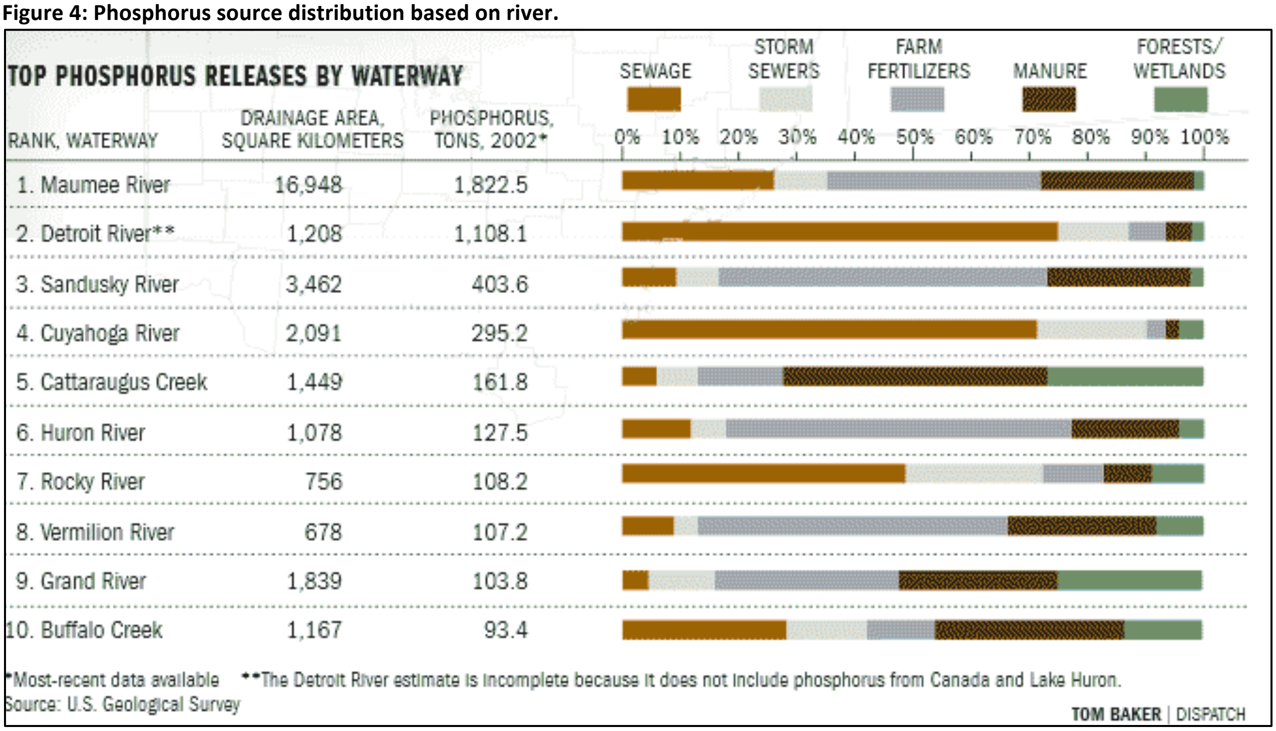
Why did this happen? -

Excerpted from *The NY Times* By Michael Wines, AUG. 4, 2014.

Flooded by tides of phosphorus washed from fertilized farms, cattle feedlots and leaky septic systems, the most intensely developed of the Great Lakes is increasingly being choked each summer by thick mats of algae, much of it poisonous. What plagues Toledo and, experts say, potentially all 11 million lakeside residents, is increasingly a serious problem across the United States.

Once the shining success of the environmental movement — Lake Erie was mocked as dead in the 1960s, then revived by clean-water rules — it has sunk into crisis again as urbanization and industrial agriculture have spawned new and potent sources of phosphorus runoff.

Figure 4: Phosphorus source distribution based on river.



10. Which river has the largest drainage area and what is it called?

11. What are the different sources of phosphorus that are shown in Figure 4?

12. Which sources of phosphorus would originate from urban areas?

13. Which sources of phosphorus would originate from rural or farming areas?

Compare your answer to #12-13 with other groups before moving on!

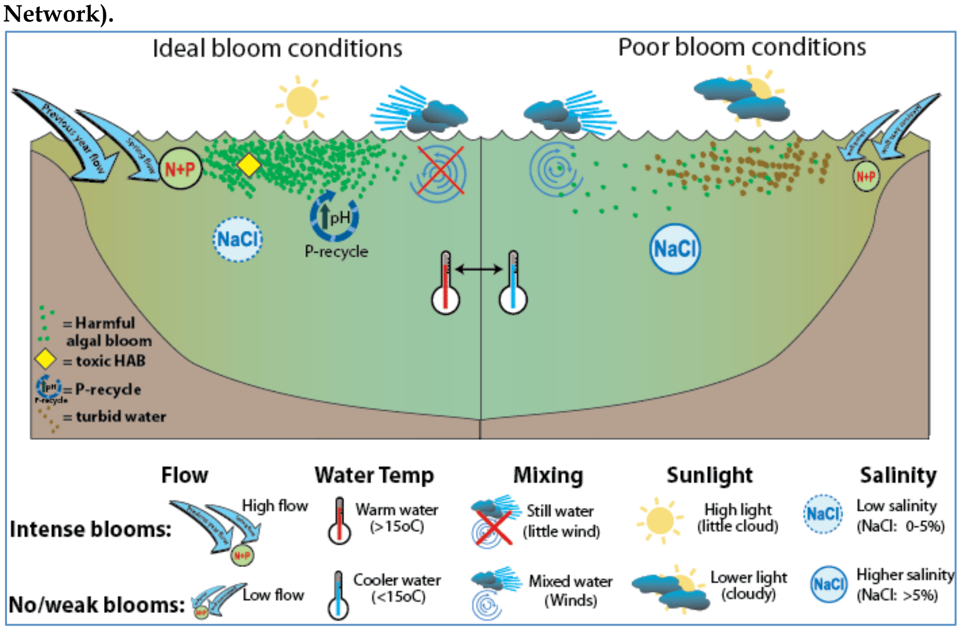
14. Figure 3 shows the Maumee River and Detroit River feeding into the Western Basin of Lake Erie. Use Figure 4 to examine the phosphorus contributions of both of these rivers. Based on this information, what would the land around the Maumee River drainage area most likely be used for?

15. Likewise, what do you think the area around the Detroit River is used for?

How does phosphorus cause algae blooms? --

Algae are natural components of marine and fresh water flora performing many roles that are vital for the health of ecosystems. However, when certain conditions are favorable, algae can rapidly multiply causing "blooms." When blooms (or dense surface scums) are formed, the risk of toxin contamination of surface waters increases especially for some species of cyanobacteria algae with the ability to produce toxins and other noxious chemicals. Cyanobacteria, also known as blue-green algae, are of special concern because of their potential impacts on drinking and recreational waters.

Figure 5: Comparison of conditions for algae bloom formation. (sourced from university of Maryland, Integration and Application Network).



READ THIS!

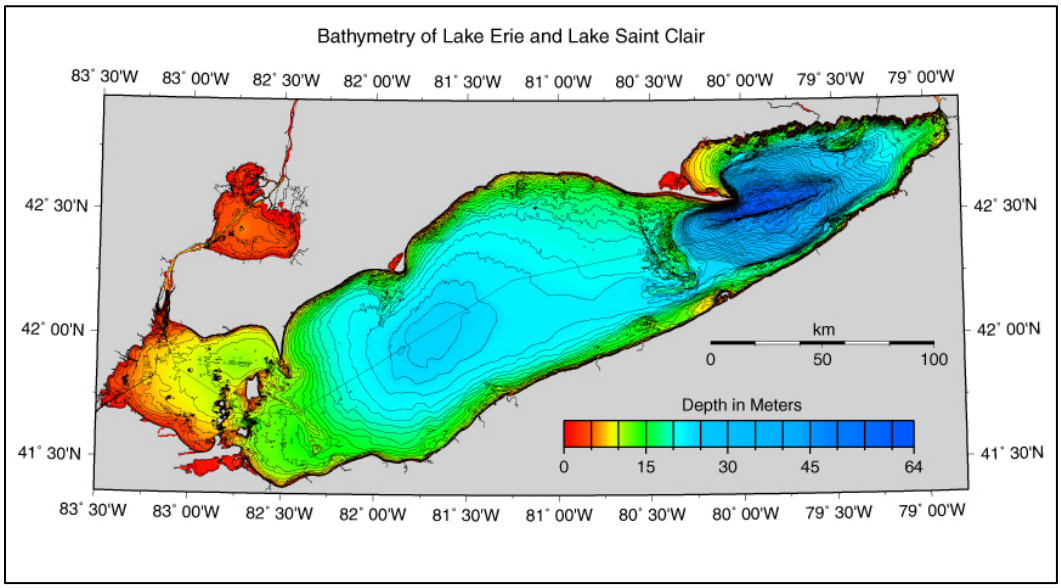
The arrows indicating "Flow" read previous year flow and Spring flow. This indicates the flow of Nitrogen and Phosphorus by mass, not the flow or amount of water.

16. Name the 5 conditions that are represented in Figure 5 which relate to algae blooms?

17. What does HAB stand for? What is the symbol for toxic HAB in Figure 5?

18. Choose 3 **specific** conditions that contribute to HABs?

Figure 6: Depth map of Lake Erie (sourced from NOAA)



19. Looking at Figure 6, what is the range of depth in Lake Erie? Include units in your answer.

20. Circle the shallower region of Lake Erie:
    a. Western Basin by Toledo
    b. Eastern Basin by Niagra falls

21. Using Figure 6, what do you think is the correct relationship between depth and temperature of the lake?
    a. The Western basin has cooler water.
    b. The Eastern Basin has cooler water.
    c. There is little to no temperature difference in Lake Erie.

Compare your answers to #20-21 with another group before moving on.

22. Refer back to previous figures- Which region of Lake Erie has the greatest phosphorus load?

23. What is the relationship between HABs and phosphorus (Hint- look back at figure 5)?

24. Why was the Western Basin and Toledo area the site for the HAB and not the Eastern Basin?

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WHERE DISCOVERIES BEGIN

Algae Detection - Chlorophyll Fluorescence Lab

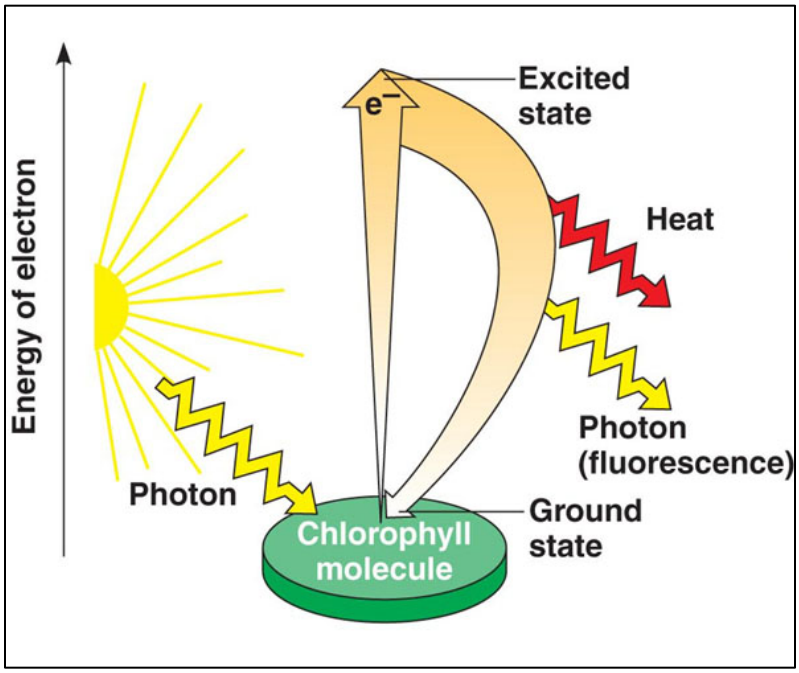
Name: _____

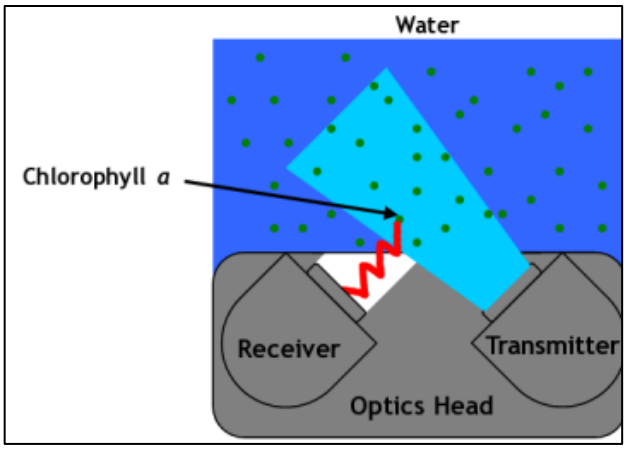
Period: _____

Objective: Determine the concentration of algae in various water samples

Addition of nutrients in water bodies (e.g., nitrogen, phosphorus) can cause eutrophication where algae blooms deplete oxygen and kill most aquatic life.

Chlorophyll is present in algae and can absorb light and then fluoresce red light that can be measured to indicate the algae concentration.





Supplies needed:

- Vernier spectrophotometer/fluorometer
- Plastic cuvettes with two "ridged" sides (1-cm), or all clear sides (not frosted)
- Transfer pipettes
- Algae standards or supplied graph of fluorescence versus algae concentration.
  *Purchase prepared algae *(http://www.reedmariculture.com/product_instant_algae.php)*

Notes:

- Prior to making chlorophyll measurements set the excitation wavelength to 405 nm (For the Vernier spectrovis go to Experiment, Change units, Spectrometer, Fluorescence 405 nm. If the fluorescence peak is >1 at ~686 nm, go to Experiment, Set up Sensors, Spectrometer: 1, and decrease the sample time, alternatively if the peak is too low increase the sample time.) (Set sample collection time to maximum of 1000 msec under set up sensors- spectrovis)

Procedures on how to create Algae standard graph:

1. Prepare a series of 10-mL algae calibration standards at # mg/L, by diluting the provided stock solution into DI H2O.
2. Fill a plastic cuvette more than half way full with the first standard.
3. Record the fluorescence reading on the Vernier spectrophotometer/fluorometer
4. Repeat this procedure for each of the other standards.
5. Use Microsoft Excel to prepare an x-y scatter plot of the measured values of absorbance for the standard solutions versus the concentration of algae in those solutions.
6. Select the data points for each plot, and using the "Add Trendline" function, select the "Linear" fit in the "Type" window to perform a linear regression of the data. Also, in the "Options" window of the "Add Trendline" function, be sure to select "Display equation on chart" and "Display R-squared value on chart".
7. Record the slope and y-intercept from your regressions, as you will use these to calculate algae concentrations from other samples

Procedures to collect algae concentration data:

8. Shake the retrieved local samples and then add them to the cuvettes
9. Place the cuvette in the Vernier spectrophotometer/fluorometer and record the fluorescence value
10. Use the calculated standard curve to determine the mass concentration of algae in each water sample

Algae mass concentration (cells/mL) = (*F*(Ex:405, Em:686 nm) – y-intercept)/slope

Data Table:

Sample location	Measured Fluorescence	Estimated algae concentration
Tap water		
Sample 1-		
Sample 2-		
Sample 3-		
Sample 4-		

Compare your results with other groups who measured the same water samples. If there are large differences in the same sample, come see the teacher.

Analysis Questions

1. Which water source sample resulted in the greatest algae concentration?

2. Open the "class web site" and follow the link to the Water Source Google Map. Examine where each sample originated. List some things you know about each area:
    a. Sample 1-

    b. Sample 2-

    c. Sample 3-

    d. Sample 4-

3. Based on the locations where the samples were retrieved, how might we explain the values we observed?

This lab was developed by:

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Microscope lab: Algae in the water

Name: _____

Period: _____

Fresh water sources are teaming with life. In addition to the fish, critters and bugs we can see with our eyes, there are many other forms of life we can't see with the naked eye. Some examples of these tiny life forms are:

- Protozoa - single cells organisms that are found in water.
- Bacteria and viruses - even smaller single celled organisms, found everywhere
- micro invertebrates - Multicellular organism that do not have a backbone , bugs and larva fall in this category, so do crabs, snails, worms and many more.
- Algae – single celled organisms found in water related to plants that perform photosynthesis.

Objective: Examine various water samples and try to identify several common species of algae found in fresh water.

Procedure:

1. Make a wet mount slide of a specific water sample (if you need help ask the teacher).
2. Examine slide under microscope using both low and high power objectives.
3. Consult with your lab partner and the algae field guide to help you identify what you see.
4. Record how many different species of algae you can see in each sample.
5. Draw one species that you feel confident in your identification.

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