WHO'S THAT PHYTOPLANKTON?

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Grade Level
High School

Subject Area
Biology

VA SEA is a collaborative project between the Chesapeake Bay National Estuarine Research Reserve, the Virginia Institute of Marine Science's Marine Advisory Program, and Virginia Sea Grant. The VA SEA project is made possible through funding from the National Estuarine Research Reserve System Science Collaborative, which supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is funded by the National Oceanic and Atmospheric Administration and managed by the University of Michigan Water Center.

Activity Title: Who's that Phytoplankton?

Focus: Harmful algal bloom diagnosis

Grade Level: High School Biology

VA Science Standards:

LS.1 The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems

- ask questions and develop hypotheses to determine relationships between independent and dependent variables

b) planning and carrying out investigations

- independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate and include the safe use of chemicals and equipment
- take metric measurements using appropriate tools and technologies including the use of microscopes

c) interpreting, analyzing, and evaluating data

- identify, interpret, and evaluate patterns in data
- construct, analyze, and interpret graphical displays of data

d) constructing and critiquing conclusions and explanations

- construct explanations that include qualitative or quantitative relationships between variables
- construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)

LS.2 The student will investigate and understand that all living things are composed of one or more cells that support life processes, as described by the cell theory. Key ideas include

b) cell structure and organelles support life processes;

d) cell division is the mechanism for growth and reproduction

LS.4 The student will investigate and understand that there are chemical processes of energy transfer which are important for life. Key ideas include

a) photosynthesis is the foundation of virtually all food webs; and

b) photosynthesis and cellular respiration support life processes.

LS.6 The student will investigate and understand that populations in a biological community interact and are interdependent. Key ideas include

a) relationships exist between predators and prey and these relationships are modeled in food webs;

b) the availability and use of resources may lead to competition and cooperation;

LS.7 The student will investigate and understand that adaptations support an organism's survival in an ecosystem. Key ideas include

a) biotic and abiotic factors define land, marine, and freshwater ecosystems; and

b) physical and behavioral characteristics enable organisms to survive within a specific ecosystem.

LS.8 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time. Key ideas include

a) organisms respond to daily, seasonal, and long-term changes;

b) changes in the environment may increase or decrease population size; and

c) large-scale changes such as eutrophication, climate changes, and catastrophic disturbances affect ecosystems.

LS.9 The student will investigate and understand that relationships exist between ecosystem dynamics and human activity. Key ideas include

a) changes in habitat can disturb populations;

b) disruptions in ecosystems can change species competition; and

c) variations in biotic and abiotic factors can change ecosystems.

Learning Objectives:

Students will obtain a knowledge basis of the dynamics of harmful algal blooms.

Students will demonstrate their understanding of harmful algal bloom dynamics by:

- Assessing biotic and abiotic factors of an aerial photograph of a bloom
- Formulating a hypothesis about which phytoplankton may have caused the bloom
- Differentiating between phytoplankton species
- Generating data by collecting cell counts of phytoplankton from a bloom sample
- Making inferences about the data they collected
- Inventing a new phytoplankton species

Total length of time required for the lesson: 1 to 1.5 hours

Key words, vocabulary:

Phytoplankton: Microscopic plant-like organisms that serve as the base for aquatic food webs. Through photosynthesis they play a key role for removing carbon dioxide from the air and contributing oxygen to the environment.

Hypoxic: Oxygen deficiency in a biotic environment.

Salinity: The concentration of salt in water.

Estuarine: Bodies of water usually found where river meets the sea, characterized by fluctuating salinity.

Marine: Bodies of water with high salinity.

Adaptation: A change or the process of change by which an organism or species becomes better suited to its environment.

Dinoflagellates: A single-celled phytoplankton with two flagella

Bioluminescence: A biochemical emission of light by living organisms.

Biotic: Relating to or resulting from living things, especially in their ecological relations.

Abiotic: Physical rather than biological; not derived from living organisms.

Temperate region: Area occurring in the middle latitudes of Earth, between the tropic and polar regions.

Polar region: Area occurring around the North Pole or the South Pole of Earth.

Tropical region: Areas of Earth surrounding the equator.

Cysts: Resting or dormant stage of a microorganism that helps the organism to survive in unfavorable environmental conditions.

Anthropogenic: Originating in human activity.

Bioaccumulate: (of a substance) to become concentrated inside the bodies of living things.

Background Information:

Phytoplankton, also known as microalgae, are single-celled, plant-like organisms, that live in water. Like land plants, phytoplankton are primary producers. They use sunlight, carbon dioxide, and nutrients from their environment to perform photosynthesis and create their own food. Through photosynthesis they release oxygen into the environment that other animals (and humans) need to breathe. For this reason, phytoplankton growth is usually considered beneficial. However, phytoplankton can become harmful under a few conditions. Rapid growth of one or multiple phytoplankton species in an area can cause the water to become **hypoxic**, or low in oxygen. This is because as the phytoplankton die, zooplankton eat them and consume more oxygen than the phytoplankton are producing (US Department of Commerce, 2015). Additionally, some phytoplankton produce chemicals that are toxic to other organisms. Some phytoplankton produce toxins that can make animals and humans sick in low cell numbers, and some toxic phytoplankton are only harmful when they grow rapidly in one place. This rapid growth, called a “bloom”, makes the water appear murky. In many **estuarine** and **marine** water bodies, this is often called “red tide” due to a bloom of **dinoflagellate** phytoplankton, which have reddish-brown colored pigments in their cells. Some dinoflagellates are bioluminescent at night when disturbed, so while these blooms appear red by day, they glow bright blue in the waves at night. **Bioluminescence** in dinoflagellates is assumed to be an **adaptation** that helps them avoid predators, because predators become illuminated when they try to eat the dinoflagellates, giving their location away to the predator’s predator (Abrahams & Townsend, 1993).

Each phytoplankton species has **biotic** and **abiotic** needs from the environment in order to grow. Environmental conditions such as water temperature, sunlight, and nutrient availability (think “vitamins” or plant fertilizer) impact phytoplankton growth (Rhee & Gotham, 1981). In **temperate regions**, different phytoplankton grow in different seasons just like how different flowers grow in different seasons on land. During a phytoplankton’s growing season, if there is enough sunlight and nutrients to support photosynthesis, they can grow rapidly. Temperate-region phytoplankton have adaptations that help them survive during the year when they cannot grow. For example, bloom-forming dinoflagellates will become **cysts**, or single cells with thick, protective outer walls, and lay in the sediment (Bravo & Figueroa, 2014). Cysts are alive, but dormant (a state like hibernation). This is unlike the **polar and tropical regions** of the world where temperatures are relatively stable year-round, and phytoplankton are rather limited by sunlight or nutrient availability.

Nutrients availability is crucial to phytoplankton growth. In the past few decades, **anthropogenic,** or human-derived contribution of nutrients to estuaries has increased, as well as the frequency and intensity of harmful algal blooms (HABs) in temperate estuaries (Anderson et al., 2002). Imagine what happens when you fertilize your garden: plants grow better, including the weeds. The weeds in your garden will quickly grow and sometimes out-compete, or absorb nutrients and grow faster, then the other plants. And if the weeds aren’t controlled, the plants you intended to grow will die. Just like weeds are harmful to your garden, HABs can be harmful to the aquatic environment as well as to animals and humans.

Polar region phytoplankton growth is not typically limited by nutrient availability, but rather by sunlight. Although, phytoplankton have special organelles called accessory pigments that help them absorb sunlight, an adaptation which helps them survive in polar regions (Neori et al., 1984). The opposite is true for tropical regions, where phytoplankton growth is typically limited by nutrient availability (Costa et al., 2009). Some phytoplankton have organelles that act as nutrient reserves (think about these like pockets where you can store snacks for when you're hungry later) (Pedersen & Borum, 1996). They can use nutrients from these reserves to survive when the environment does not have enough nutrients to support growth.

Phytoplankton toxins can **bioaccumulate**, or build up in the tissues of, in seafood organisms and make humans sick when they consume the seafood affected by HABs (Roué et al., 2016). Certain phytoplankton toxins can be detected in seafood organisms, but it is impossible to test every organism for toxins before consumption, therefore it is critical for scientists and water managers to be aware of HABs species in waters where seafood is grown. In Virginia, the HABs Task Force, which is made up of groups of scientists, water managers, and public health officials (i.e. scientists at the Virginia Institute of Marine Science and the Virginia Department of Health), meets regularly throughout the year to discuss the best monitoring and management of HABs in the Chesapeake Bay and its tributaries. Currently, scientists monitor aquatic systems for HABs by identifying and counting HAB species and reporting their presence to local health officials. HAB reports inform health officials and help them create advisories that keep the public safe from affected beaches and/or seafood.

In this lesson, students will be introduced to HABs, their significance, and the methodologies scientists use to monitor their presence. Students will integrate this new information while thinking like a scientist as they work through the worksheets.

Materials & Supplies:

Worksheet
Scissors
Calculators
Reusable cups, or paper dixie cups or plastic baggies
Coloring utensils (colored pencils or crayons)

Teacher Preparation: 1-2 hours

<u>Worksheets:</u>

Print off worksheets

- Activities 1, 2, 4 can be completed by each student or in small groups (2-3 students)
- Activity 3 should be handed out to each student

For the activities 1 & 2 worksheets:

- Cut out phytoplankton for each small group (phytoplankton pieces can be laminated for repeat use)
- Assemble “water samples” by putting cut-out phytoplankton pieces into their assigned dixie cups or plastic bags

For the activity 3 worksheet:

- Provide coloring utensils to each student

Activity 4 is a reflection worksheet. If needed, students may use other materials (completed worksheets, background information, the PowerPoint presentation) from this lesson to reflect on what they have learned.

Background Information:

Read through the background information ahead of time to decide how much time your students will need to read, digest, and understand the information. A pre-lesson breakdown of the information and vocabulary terms may be appropriate.

PowerPoint Presentation:

The presentation provides visual aids for the introduction of phytoplankton and harmful algal blooms. In the comment section of each slide is information for the teachers to relay to the students. The presentation should come before the breakdown of the background information so that students can see a visual representation of phytoplankton and harmful algal blooms (and get them excited about the lesson!).

Supplemental Graphics:

This PowerPoint presentation has 2 graphics for you to display while you read “an engaging introduction to phytoplankton” to the students.

Procedure:

1.Open and display the first slide of the “Supplemental graphics” PowerPoint.

Read “an engaging introduction to phytoplankton” aloud to the students.

An engaging introduction to phytoplankton

Breathe in… hold it. For one… two… three… now let it out, slowly. Keep your focus on your breath for a while longer. Imagine the tiny oxygen particles diffusing into your blood stream as you inhale, nourishing your body with the energy it requires to grow and heal. Allow yourself a moment of curiosity: where did this exceptional molecule, oxygen, a dire requirement for most of the cells in my body, come from?

Did your mind visualize atoms of oxygen being released into the atmosphere from a luscious, green forest? Well, as it turns out, the oxygen released by plants in a forest are consumed almost entirely by the animals living within and under its canopy. Less than 50% of the atmospheric oxygen we breathe comes from plants on land. The other 50-80% comes from single-celled plant-like creatures that live in aquatic ecosystems.

Visualize a body of water, it can be any kind: a lake, a pond, a vast, blue ocean. Now picture tiny, transparent orbs with speckles of green, yellow, brown, red. Some of these orbs are encapsulated by tiny, ordinate glass structures, others have "scales" of armor built of calcium carbonate, and some have whip-like tails that propel them through water. These microscopic wonders are known as phytoplankton. In the sunshine, phytoplankton get energized and make their own food. To do this, they absorb CO_2 from the water and perform a chemical reaction to turn the carbon molecules into food. The oxygen molecules are released back into the water after the reaction because they are not a necessary ingredient for their food. The oxygen molecules bubble up through water and burst into air, filling the atmosphere with our vital oxygen.

2. Present the "Who's that phytoplankton?" PowerPoint Presentation.

This presentation will prepare the class for the lesson by introducing them to harmful algal blooms; explaining what they are, how they impact the world, and the importance of monitoring their presence. The last slide of the presentation will be for the students to use for worksheet activity #1.

3. Read and breakdown the background information and vocabulary with students.

4. Worksheets

Worksheet Activity 1: Investigate the scene

Prep this activity by displaying the last slide of the presentation on the screen.

Students will read the "concerned citizen bloom report" scenario printed on the worksheet, and then they will become the phytoplankton scientists and investigate the bloom. They will start by assessing the scene on the screen and writing down observations they think might be important. Next, they will use the phytoplankton identification guide and their observations to formulate a hypothesis about which phytoplankton may be the cause of the algal bloom in the report.

Worksheet Activity 2: Phytoplankton Identification and Cell Counts

Prep this activity by color printing one phytoplankton sheet for each student, cutting out all the phytoplankton, laminating them for re-use (not mandatory), and putting them into sample bottles (reusable cups, paper dixie cups, or plastic baggies).

Students will “collect a bloom water sample” from “the sight of the report” and emptying the contents onto their “cell counting chamber”. They will generate cell count data by counting all of the cells of each species in their sample. Then, they will make inferences about their data in the post-activity assessment questions.

Worksheet Activity 3: Build-a-Bloomer

Prep this activity by passing out coloring utensils to the students.

Students will integrate their new knowledge about phytoplankton and their adaptations in this activity by inventing a “blooming” phytoplankton, or a phytoplankton that is so well adapted to their environment that they can grow like a harmful algal blooming species. Students will draw their phytoplankton with at least 3 visible adaptations. Then, they will have to consider these adaptations further by answering the post-activity assessment questions.

Worksheet Activity 4: Lesson reflection

This activity does not require any preparation.

This activity requires students to reflect on the information in the lesson. Students will list positive and negative impacts of phytoplankton, define “harmful algal bloom”, and consider how they may impact phytoplankton growth in their daily lives, and how they might help prevent increased intensity of harmful algal blooms.

Assessment:

Students will be assessed by their participation (asking/answering questions) during the PowerPoint presentation, and by the completion and quality of answers they provide in the after-activity assessment questions on the worksheet.

References:

Abrahams, M. V., & Townsend, L. D. (1993). Bioluminescence in Dinoflagellates: A Test of the Burgular Alarm Hypothesis. *Ecology*, *74*(1), 258–260. https://doi.org/10.2307/1939521

Anderson, D. M., Glibert, P. M., & Burkholder, J. M. (2002). Harmful algal blooms and eutrophication: Nutrient sources, composition, and consequences. *Estuaries*, *25*(4), 704–726. https://doi.org/10.1007/BF02804901

Bravo, I., & Figueroa, R. (2014). Towards an Ecological Understanding of Dinoflagellate Cyst Functions. *Microorganisms*, *2*(1), 11–32. https://doi.org/10.3390/microorganisms2010011

Costa, L. S., Huszar, V. L. M., & Ovalle, A. R. (2009). Phytoplankton functional groups in a tropical estuary: Hydrological control and nutrient limitation. *Estuaries and Coasts*, *32*(3), 508–521. https://doi.org/10.1007/S12237-009-9142-3/TABLES/4

Neori, A., Holm-Hansen, O., Mitchell, B. G., & Kiefer, D. A. (1984). Photoadaptation in Marine Phytoplankton Changes in Spectral Absorption and Excitation of Chlorophyll a Fluorescence. *Plant Physiology*, *76*(2), 518–524. https://doi.org/10.1104/PP.76.2.518

Pedersen, M. F., & Borum, J. (1996). Nutrient control of algal growth in estuarine waters. Nutrientlimitation and the importance of nitrogen requirements and nitrogen storageamong phytoplankton and species of macroalgae. *Marine Ecology Progress Series*, *142*(1–3), 261–272. https://doi.org/10.3354/MEPS142261

Rhee, G. -Y, & Gotham, I. J. (1981). The effect of environmental factors on phytoplankton growth: Temperature and the interactions of temperature with nutrient limitation1. *Limnology and Oceanography*, *26*(4), 635–648. https://doi.org/10.4319/LO.1981.26.4.0635

Roué, M., Darius, H. T., Picot, S., Ung, A., Viallon, J., Gaertner-Mazouni, N., Sibat, M., Amzil, Z., & Chinain, M. (2016). Evidence of the bioaccumulation of ciguatoxins in giant clams (Tridacna maxima) exposed to Gambierdiscus spp. cells. *Harmful Algae*, *57*, 78–87. https://doi.org/10.1016/J.HAL.2016.05.007

US Department of Commerce, N. O. and A. A. (2015). *Ocean Shorts: NOAA PORTS*. https://oceanservice.noaa.gov/podcast/june15/os10-hypoxia.html

Who's that Phytoplankton? Worksheet **Name:_______________________ Date:___________**

Scenario: A concerned citizen reported an algal bloom sighting in the York River, an estuarine river that feeds into the Chesapeake Bay, during a late-summer holiday weekend. They mentioned seeing an occasional group of dead fish in the water and recalled an unpleasant smell coming from the water. On the screen is a photograph of the reported algal bloom. In the photograph, the algal bloom is the dark reddish-brown colored streaks in the water, and the blue-green color is unaffected water. We need to find out what phytoplankton species is causing the bloom and determine any potential harm it may cause on the environment, wildlife, and/or humans. You will investigate the bloom by making observations about the environment and identifying and counting phytoplankton cells in a "water sample" from the bloom water.

Activity 1: Investigate the scene

Observe the photograph on the screen and write observations you think are important for determining the species that caused the bloom. Consider these questions: What color is the bloom water? Are dead fish present? What time of year was the bloom observed? Is the location of the bloom in a temperate, tropical, or polar region?

<u>From the photograph and scenario above write down some observations:</u>

Formulate a hypothesis:

Use the Phytoplankton Identification Guide to help you formulate a hypothesis about which phytoplankton may have been the cause of this harmful algal bloom.

Activity 2: Phytoplankton Identification and Cell Counts

A common method scientists use to monitor harmful algal blooms is by identifying and enumerating harmful phytoplankton cells in a water sample using a cell counting chamber and light microscopy. Typically, 1 mL of water is pipetted into a cell counting chamber and the chamber is placed under a light microscope. Scientists will identify and count each harmful phytoplankton cell in the chamber, determine if the number of cells present reaches the threshold to be considered a bloom (for many harmful species the threshold is ~1,000 cells/mL), then document and report their findings to relevant officials and those who may be impacted by the bloom.

You will try this method using the cell counting chamber below! Empty the contents of your bloom water sample into the cell count chamber. Use the Phytoplankton ID guide to help you determine what species are present in your sample. Write down the names of each phytoplankton you observe. Then, count and record the number of cells present for each species. Remember that some species make cell chains, so be sure to count each cell within a chain. Also keep in mind that the volume of your bloom water sample is 0.1 mL, and we need to report the number of phytoplankton cells in 1 mL, so multiply each cell count by 10 to get phytoplankton cells/mL.

Cell Counting Chamber 0.1 mL

Record your phytoplankton identification and cell counts:

Phytoplankton species #1:	Cell count:	x10 (cells/mL):
___________________________	_______________	_____________
Phytoplankton species #2:	Cell count:	x10 (cells/mL):
___________________________	_______________	_____________
Phytoplankton species #3:	Cell count:	x10 (cells/mL):
___________________________	_______________	_____________
Phytoplankton species #4:	Cell count:	x10 (cells/mL):
___________________________	_______________	_____________

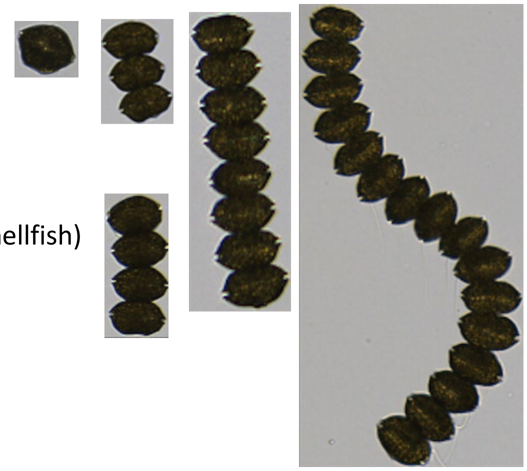
Activity 2 Assessment:

Question 1.
Which phytoplankton is responsible for the bloom in that was reported in the York River? Provide evidence (field observation notes, clues from the ID guide, cell counts) for your answer.

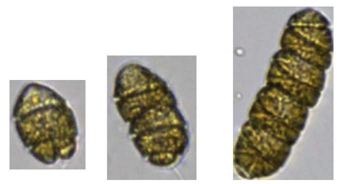
Question 2.
Do you think this bloom could be potentially harmful? If so, what might be some negative impacts of this bloom?

Phytoplankton ID Guide – Lower Chesapeake Bay Bloomers

Alexandrium monilatum (al-ex-an-dree-yum mon-eh-lay-tum)
Color: reddish-brown
Season: late-summer
Physical adaptations: chain-forming, flagella, bioluminescence
Chemical adaptations: produces an ichthyotoxin (toxic to fish/shellfish) called goniodomin-a (gone-ee-oh-doe-min aye)
Other notes: People often report a foul smell during blooms



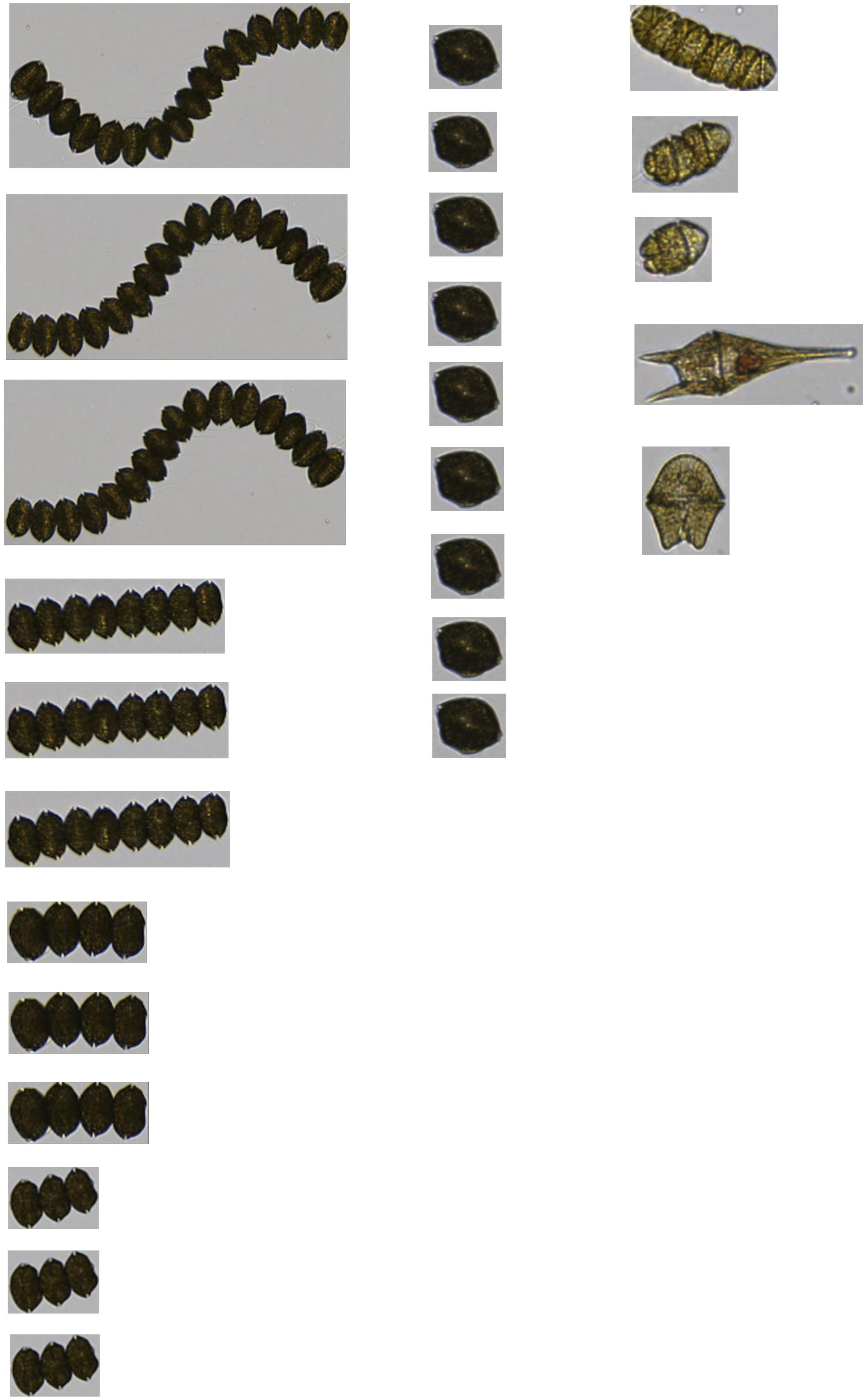
Margalefidinium polykrikoides
(m-argh-uh-leff-eh-din-ee-yum polly-kree-koy-dees)
Color: yellowish-brown
Season: mid-to-late-summer
Physical adaptations: chain-forming, flagella
Chemical adaptations: N/A
Other notes: People often report a foul smell during blooms



Akashiwo sanguinea
(ack-kash-ee-woe san-gwen-nee-yuh)
Color: yellowish-brown to reddish-brown
Season: mid-summer
Physical adaptations: flagella
Chemical adaptations: produces a surfactant (oil-like substance that sits on the surface of water)
Other notes: N/A

Tripos furca
(try-poes fur-cuh)
Color: yellowish-brown to reddish-brown
Season: mid-summer to late-fall
Physical adaptations: flagella, elongated body
Chemical adaptations: N/A
Other notes: The elongated spikes of this cell can clog fish gills. This can be harmful to fish during a bloom.

Phytoplankton cut-outs for the “bloom water sample”



Activity 3: Build-a-Bloomer

Introduction:
Phytoplankton have adaptations that help them grow and survive in their environment. Some adaptations help phytoplankton avoid being eaten by predators (i.e. spikey cell shape, toxin production, bioluminescence), while some help them grow and compete with other phytoplankton species for resources (i.e. nutrient storage organelles, accessory pigments). Furthermore, a phytoplankton group called dinoflagellates have flagella, or little propellers, that help them swim through the water. Dinoflagellates in temperate regions also have an adaptation that helps them survive when the environment cannot support their growth; they become cysts, or cells with thick, protective walls, and rest in the sediment. Another group, called diatoms, cannot swim to avoid predators, but they make houses out of glass to protect their cell. These glass houses are often wide and flat or have long spines, both of which help them float with the currents.

Directions:
You are going to invent a phytoplankton, specifically, a blooming species! You will need to consider what you have learned in this lesson to invent a phytoplankton that can grow very well in its environment.

Draw your phytoplankton on the back of this page. Choose or invent at least 3 adaptations that will help your phytoplankton survive and grow and include them in your drawing. Don’t forget to name it!

Tell me about your phytoplankton:
1. What adaptations does your phytoplankton have? Describe them.

   1.

   2.

   3.

2. Where (which region- temperate, tropical, or polar) will your phytoplankton grow best? And, why?

3. When your phytoplankton blooms, is it going to benefit the environment or harm it, or both? How so?

Activity 4: Lesson reflection

Question 1.
Are phytoplankton good or bad?
Create a list or Venn Diagram of the positive and negative impacts phytoplankton can have on humans and/or the environment. Provide at least 3 examples for each (3 positive impacts and 3 negative impacts).

Question 2.
Define harmful algal bloom.

Question 2.
What can you do in your life (today and in the future) to help prevent harmful algal blooms from increasing in frequency, duration, and intensity?

Who's that Phytoplankton? Worksheet **Name:________________________** **Date:____________**

Scenario: A concerned citizen reported an algal bloom sighting in the York River, an estuarine tributary of the Chesapeake Bay, during a late-summer holiday weekend. They mentioned seeing an occasional group of dead fish in the water and smelling something unpleasant. On the screen is an aerial photograph of the algal bloom that was reported. In the photograph, the algal bloom is the dark reddish-brown colored streaks in the water, the blue-green color is not. We need to find out what phytoplankton species is causing the bloom and determine any potential harm it may cause on the environment, wildlife, and/or humans. You will investigate the bloom by making observations about the environment and identifying and counting phytoplankton cells in a "water sample" from the bloom water.

Activity 1: Investigate the scene

Observe the photograph on the screen and write observations you think are important for determining the causative species. Consider these questions: What color is the bloom water? Are dead fish present? What time of year was the bloom observed? Is the location of the bloom in a temperate, tropical, or polar region?

Write down your field observations:

- The color of the bloom water is dark reddish-brown
- Dead fish were mentioned in the report
- Foul smell reported
- Time of bloom: late-summer
- Location: York River (lower Chesapeake Bay)
    - Temperate region

Formulate a hypothesis:

Use the Phytoplankton Identification Guide to help you formulate a hypothesis about which phytoplankton may be the cause of this harmful algal bloom.

Alexandrium monilatum is the phytoplankton species responsible for the reported bloom.

Activity 2: Phytoplankton Identification and Cell Counts

Empty the contents of your bloom water sample into the cell count chamber. You will identify and count all of the phytoplankton in the chamber. Use the Phytoplankton ID guide to help you determine what species are present in your sample. Write down the names of each phytoplankton you observe. Then, record the number of cells present for each species. Remember that some species make cell chains, so be sure to count each cell within a chain. Also keep in mind that the volume of your bloom water sample is 0.1 mL, and we need to report the number of phytoplankton cells in 1 mL, so multiply each cell count by 10 to get phytoplankton cells/mL.

Record your phytoplankton identification and cell counts:

Phytoplankton species #1:	Cell count:	x10 (cells/mL):
Alexandrium monilatum	102	1,020 cells/mL
Phytoplankton species #2:	Cell count:	x10 (cells/mL):
Margalefidinium polykrikoides	7	70 cells/mL
Phytoplankton species #3:	Cell count:	x10 (cells/mL):
Akashiwo sanguinea	1	10 cells/mL
Phytoplankton species #4:	Cell count:	x10 (cells/mL):
Tripos furca	1	10 cells/mL

Activity 2 Assessment:

Question 1.

Which phytoplankton is responsible for the bloom in that was reported in the York River? Provide evidence (field observation notes, clues from the ID guide, cell counts) for your answer.

I conclude that *Alexandrium monilatum* is the responsible phytoplankton for the bloom in the York River because:

- Cell count above the bloom threshold (1,000 cells/mL) at 1,020 cells/mL
  - According to the Phytoplankton ID guide:
    - *A. monilatum* is dark reddish brown like the color of the bloom seen in the report picture
    - *A. monilatum* grows best in the late-summer
    - *A. monilatum* is ichthyotoxic (produces a toxin that kills fish)
    - *A. monilatum* blooms smell bad

Question 2.
Do you think this bloom could be potentially harmful? If so, what might be some negative impacts of this bloom?

Potential negative impacts:

- Ecological
  - Fish kills
  - Hypoxia
- Economical
  - Loss of shellfish at shellfish farms
  - Decrease in fish/shellfish availability for seafood restaurants
  - Decrease in tourism in affected coastal towns (due to foul smell, murky water)

Activity 3: Build-a-Bloomer

Introduction:
Phytoplankton have adaptations that help them thrive in their environment. Some adaptations help phytoplankton deter predators (i.e. spikey cell shape, toxin production, bioluminescence), while some help them grow and outcompete other phytoplankton species (i.e. nutrient storage organelles, accessory pigments). Furthermore, a phytoplankton group called dinoflagellates have flagella, or little propellers, that help them swim through the water. Dinoflagellates in temperate regions also have an adaptation that helps them survive when the environment cannot support their growth; they become cysts, or cells with thick, protective walls, and rest in the sediment. Another group, called diatoms, cannot swim to avoid predators, but they make houses out of glass to protect their cell. These glass houses are often wide and flat which helps them to float with the currents.

Directions:
You are going to invent a phytoplankton, specifically, a blooming species! You will need to consider what you have learned in this lesson to invent a phytoplankton that can grow very well in its environment.

Draw your phytoplankton on the back of this page. Choose or invent at least 3 adaptations that will help your phytoplankton survive and grow and include them in your drawing. Don't forget to name it!

This is a creative assignment. If students can provide thoughtful explanations for their "invented" adaptations, they should get full credit. Students may also choose adaptations mentioned in this lesson, or others that they have learned about in previous lessons.

Activity 4: Lesson reflection

Question 1.
Are phytoplankton good or bad?
Create a list or Venn Diagram of the positive and negative impacts phytoplankton can have on humans and/or the environment. Provide at least 3 examples for each (3 positive impacts and 3 negative impacts).

Positives
Primary production/Base of aquatic food chain
Source of carbon/energy for other organisms
Source of oxygen
Take up CO^2
Bioluminescence
(Bonus points for answers below – not mentioned in lesson)
Terraforming of Earth
Oldest relatives of land plants
Significant source of “fossil” fuel/oil
Source of sand and calcareous rock/land formations (e.g. stromatolites, limestone)

Negatives
Hypoxia
Animal/fish/shellfish toxins
Human illness due to toxins
Act like “weeds”, outcompete other phytoplankton for nutrients/space

Question 2.
Define harmful algal bloom.

Rapid growth of one or multiple phytoplankton species in an area that makes the water murky and has a harmful effect on the environment, ecosystem, and/or human health.

Question 2.
What can you do in your life (today and in the future) to help prevent harmful algal blooms from increasing in frequency, duration, and intensity?

Reduce my carbon footprint! Dispose of my trash properly! Pick up after my pet! Do not litter! Do not use the (lake, river, pond, ocean) water or beach as a toilet! Teach others about harmful algal blooms! Write to my local/national government officials and ask them to help fund harmful algae research! Use less water!