K20 LEARN

Clear as Phytoplankton: A Tale of Four Lakes

Nutrients, Genetics, and Plant Growth

Heather Shaffery, Carrie Miller-DeBoer
Published by *K20 Center*

Grade Level	6th – 8th Grade	**Time Frame**	3-5 class period(s)
Subject	Science	**Duration**	200 minutes

Essential Question

How do genetic and environmental factors influence the growth of organisms? How does phytoplankton growth affect water clarity?

Summary

In this lesson, students use differences in water clarity among four Oklahoma lakes as a phenomenon. They investigate how local environmental conditions and the survival strategies and growth of phytoplankton (algae) affect water clarity. After designing and conducting experiments that relate water clarity variables to phytoplankton growth, students analyze patterns in phytoplankton community composition. Using the data, students model the cause-and-effect relationships among local conditions, genetic factors, and phytoplankton growth. Finally, students compare their data analysis with findings summarized in official water quality reports before using their models to develop a summative explanation for the relationship between phytoplankton growth and water clarity in a single lake.

Snapshot

Engage

Students examine photographs of lake water at macro and micro scales and then create an initial model to explain how phytoplankton growth affects water clarity.

Explore

In groups, students plan and carry out investigations that test how phytoplankton growth is affected by different water clarity variables. They also sort phytoplankton species into groups according to physical and functional characteristics.

Explain

Based on their data, student groups develop claims about phytoplankton growth. As a class, students create a concept map linking their claims and evidence to the lake water clarity phenomenon. Students refine their models to reflect the cause-and-effect relationships among water clarity variables, phytoplankton survival strategies, and water clarity.

Extend

Students use a Venn diagram to compare their previous data analysis with data from official water quality report summaries and then evaluate and revise their models.

Evaluate

Using their final models, students explain the relationship between phytoplankton growth and water clarity in a lake of their choice.

Standards

Next Generation Science Standards (Grades 6, 7, 8)

MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Oklahoma Academic Standards (8th Grade)

8.LS1.5 : Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
8.LS1.5.1: Genetic factors, as well as local conditions, affect the growth of the adult plant.

Attachments

- 73a32e07ab96b4bda5dcb0a9a9a9d9eb.docx
- 8a3ccf941a89faa0a6290bd0b2a5fb00.docx
- Clear-as-Phytoplankton-Lesson-Slides.pptx
- DIY-Secchi-Disk-Instructions-Clear-as-Phytoplankton - Spanish.docx
- DIY-Secchi-Disk-Instructions-Clear-as-Phytoplankton - Spanish.pdf
- DIY-Secchi-Disk-Instructions-Clear-as-Phytoplankton.docx
- DIY-Secchi-Disk-Instructions-Clear-as-Phytoplankton.pdf
- DIY-Secchi-Disk-Instructions-Clear-as-Phytoplankton.pdf
- DIY-Secchi-Disk.pdf
- Detailed-Facilitation-Guide-Clear-as-Phytoplankton.pdf
- Detailed-Facilitation-Guide-Clear-as-Phytoplankton.pdf
- Detailed-Teacher-Guide.pdf
- Example-Investigation-Procedure.docx
- Four-Lakes-Data-Reports-Clear-as-Phytoplankton - Spanish.docx
- Four-Lakes-Data-Reports-Clear-as-Phytoplankton - Spanish.pdf
- Four-Lakes-Data-Reports-Clear-as-Phytoplankton.docx
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- Four-Lakes-Phytoplankton-Communities-Clear-as-Phytoplankton.pdf
- Lake-Phytoplankton-Communities.pdf
- Lesson-Slides-Clear-as-Phytoplankton.pptx
- Lesson-Slides-Clear-as-Phytoplankton.pptx
- Phenomenon-Lake-Report-Data.pdf
- Phytoplankton-Cards-Clear-as-Phytoplankton - Spanish.docx
- Phytoplankton-Cards-Clear-as-Phytoplankton - Spanish.pdf
- Phytoplankton-Cards-Clear-as-Phytoplankton.docx
- Phytoplankton-Cards-Clear-as-Phytoplankton.pdf
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- Phytoplankton-Cards.pdf
- Procedure-Example-Clear-as-Phytoplankton.docx
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- Student-Notebook-Digital-Clear-as-Phytoplankton - Spanish.docx
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- cover-image.jpg
- fd2cf95561a7353753d3bb869f34e89a.docx

Materials

- Lesson Slides (attached)
- Detailed Facilitation Guide (attached; for teacher use)
- Print Student Notebook (attached)
- Digital Student Notebook (attached)
- Four Lakes' Phytoplankton Communities (attached)
- Procedure Example (attached)
- Phytoplankton Cards (attached)
- Four Lakes' Data Reports (attached)
- DIY Secchi Disk Instructions (attached; optional)
- Water bottles
- Pond water or fast-growing algae culture
- Nutrient variables
- Secchi disks (buy or DIY using attached instructions)
- Fluorescent lights

Engage

Teacher's Note: Guiding Attachments

See the attached **Detailed Facilitation Guide** for additional lesson guidance, possible student responses, recommendations for facilitating discussions, and formative assessment opportunities throughout the lesson.

Before beginning the lesson, consider whether you would like students to use a Student Notebook. If so, you may choose to have students work on paper or digitally. The attached **Print Student Notebook** and **Digital Student Notebook**, respectively, include space for students to record their reflections, data, and class discussion notes for all activities from the Engage through Extend sections of the lesson.

Introduce the lesson using the attached **Lesson Slides**. Display **slide 3** to share the lesson's essential questions and **slide 4** to go over the lesson objectives. Review these slides with students to the extent you feel necessary.

Display **slides 5–9** to engage students in the phenomenon—variation in lake water clarity and what affects it—by presenting them with images of water from four Oklahoma lakes. Have students make observations and ask questions about the images using the I Notice, I Wonder instructional strategy.

As students share, record their ideas and elicit additional details or clarification using tools like STEM Teaching Tools' Talk Science Resource Cards, which provide sentence and question stems.

Next, pass out the attached **Four Lakes' Phytoplankton Communities,** and display **slides 10–13** to show students the phytoplankton communities found in each lake, as seen under the microscope. Direct students to look for patterns in the phytoplankton communities, adding these ideas and questions to their previous "I Notice" and "I Wonder" lists.

Go to **slides 14–15**. Define phytoplankton (also called algae) and water clarity for students.

Teacher's Note: Vocabulary

While teaching vocabulary before students have done any exploration is generally discouraged, students cannot complete the lesson without knowing what phytoplankton are and what water clarity means. Since this vocabulary is necessary to complete the task, *not to understand the concepts*, it is appropriate to introduce those terms here.

Go to **slide 16**. Guide students in discussion to consider what might cause the amount of phytoplankton in the water to increase by asking them to list things that help plants grow. They should mention light, water, carbon dioxide, and nutrients.

Following the discussion, explain that students will focus on answering this question: "What factors explain how phytoplankton affect water clarity?" The question can be broken down into two sub-questions: "What factors cause phytoplankton to grow?" and "How do those factors indirectly affect water clarity?"

Go to **slide 17**. At this point, ask students to use the ideas from what they've observed and discussed so far to draw a model that explains the phenomenon.

Explore 1

Display **slide 18**. Ask students to look at the factors they included in their models that they think affect phytoplankton growth. Based on this information, ask them how they can test one of their factors to see if their idea is correct.

In pairs or small groups, students will plan and carry out an investigation, choosing a single variable that may affect phytoplankton growth. Make sure that *more than one* group is assigned to each variable (e.g., two groups test nitrogen, three groups test phosphorous, etc.) so they can later combine their data for analysis. Use **slide 19** to provide your class-specific instructions to students.

Make sure that some groups test increased nitrogen, some test increased phosphorus, and some test an addition of fertilizer that contains both nitrogen and phosphorus. If other students want to test light levels, pH, temperature, etc., consider adding these to the factors under investigation.

Students should record phytoplankton abundance data daily; the most efficient method for this is using a modified Secchi disk. For reference, the YouTube video "The Dirty Labcoat: The Secchi Stick" demonstrates how to use a Secchi stick.

Embedded video

https://youtube.com/watch?v=du1PA0pzdnQ

Secchi disks can be purchased online or you can make your own using the attached **DIY Secchi Disk Instructions**.

Teacher's Note: Investigation Setup

For this investigation, you will need to collect pond water with some algae in it already or order a fast-growing algae culture ahead of time. If using pond water, remove large grazers (like *Daphnia*) by pouring the water through a fine mesh of window screen (mesh size should be around 200 μm). Expect the experiment to last 5–10 days.

The performance expectation for this lesson focuses on constructing explanations from evidence, so it is up to your discretion how much focus to put on experimental design. However, for reliable comparisons among variables and groups, have all groups use a consistent setup (e.g., 500 mL of pond water in a plastic water bottle). This also allows the class to use a single set of controls instead of needing a control for each group of students. See the attached **Procedure Example** for an example of more detailed investigation instructions.

Go to **slide 20**. Once students have started their investigation, pass out a set of the attached **Phytoplankton Cards** to each investigation group. Have students compare the cards with the microscopic views of the four lakes' phytoplankton communities to identify the number of each type of phytoplankton found in each lake.

Go to **slide 21**. Students should use the genetic factors listed in the table on each card to sort the plankton into groups. Once the cards are sorted, students should record their sorting factor and list the phytoplankton in each group.

Next, students should choose a different factor, sort the phytoplankton again, and record their factor and list of phytoplankton. Have students sort phytoplankton according to a minimum of three factors.

Teacher's Note: Prerequisite Knowledge

It is assumed that students already understand the concept that genotype influences phenotype. Take a moment to activate this prior knowledge—review how genes in the phytoplankton's DNA determine not only what the phytoplankton looks like, but also the strategies it uses to survive (especially since phytoplankton do not have a brain).

Explain 1

Display **slide 22**. After students have finished sorting phytoplankton for a minimum of three factors, they should compare their sorted lists of phytoplankton with the groups of phytoplankton within each lake community, taking note of any patterns or relationships.

Teacher's Note: Categorizing Phytoplankton

Phytoplankton are extremely diverse, and algae scientists have struggled to find the best method for categorizing species in ways that explain their role in ecosystems. Therefore, they categorize phytoplankton into "*functional groups*," in which phytoplankton are sorted by physical characteristics or survival strategies. Use this opportunity to emphasize that students are sorting phytoplankton just as scientists do.

Once groups have had time to make their comparisons, bring them together to discuss as a whole class. Have students describe the ecological significance of the genetic factors listed on each card (e.g., being able to use more than one resource means they have more nutrients available than functional groups that cannot use more than one).

Ask students what they can conclude about the phytoplankton in each of the four lakes. If relevant, this is a good opportunity to help students take notes and make connections between the activity and other ecology concepts they may have learned previously.

Next, ask students: In what kind of environment would we find each phytoplankton group (functional group)? Be sure to focus specifically on nutrient conditions (high, low, both conditions) at some point during the discussion.

Go to **slide 23**. Once pairs and groups have made sense of their data, ask students to revise their initial models based on the evidence they have collected. If genetic factors were not included previously, students should add them at this point.

Explore 2

Display **slide 24**. Once the water clarity experiments are complete, create experiment focus groups or "factor expert panels" by combining groups that tested the same variable in their investigation. These groups should compile and compare data from their experiments. They should treat their individual experiments as replicates and use them to calculate averages that summarize their collective data.

Use **slide 25** to provide your class-specific instructions on grouping students, analyzing and graphing data, and making claims.

Based on the collective data, each group should develop a claim about their results (e.g., "[Our experimental factor] results in [some result]"). Note that water clarity is most likely to be influenced by nutrient resource levels. To prepare for the class discussion, groups should create a graph that displays their results summary and includes their claim in a caption.

Additionally, the "expert panels" should discuss their phytoplankton classifications to identify patterns among phenotypes (e.g., nitrogen fixers tend to be toxic) and comparisons with the phytoplankton community data for each lake. Students also should develop a few claims based on the patterns they observe during the group comparisons.

Teacher's Note: Scaffolding

To aid student analysis and discussion, consider using the Data Match instructional strategy, especially if students are novices at translating numbers and graphs into scientific ideas.

Explain 2

At this point, the class should work together and use the Concept Card Mapping strategy to synthesize what students have learned so far about the relationships among water clarity, environmental factors, and phytoplankton growth.

Before groups share their ideas for the concept map, post the images of lake water that were used to introduce the phenomenon. Add the nutrient and environmental variables from students' experiments as concepts to help anchor their ideas. Use **slide 26** to provide your class-specific instructions for creating the concept map.

Options for Creating a Concept Card Map

The concept map may be created physically on a whiteboard or poster, using markers or string to connect concepts and relationships, or it may be created in a digital program.

Ask all groups to share their claims and evidence from their experiment results and then add their graphs to the concept map. Next, have students share their claims about phytoplankton functional groups and communities.

As students share their ideas about the relationships among phytoplankton characteristics, environmental variables, and the phenomenon, ask students to use evidence to (1) add new concepts to the map, and (2) identify the relationship(s) among existing concepts.

Once all groups have shared, give them some time to identify any other relationships or concepts that they think should be added to the map to capture what they've learned so far.

Teacher's Note: Addressing Misconceptions

Make sure that all relationships indicated on the concept map are correct and supported by available evidence. If misconceptions persist, provide brief content lessons as needed.

Display **slide 27**. Once the class concept map is complete, students should use the compiled information and relationships discussed to revise their model again.

The revisions should explain the cause-and-effect relationships that influence phytoplankton growth and water clarity. Remind students that they should draw a model that shows how changes to the variables they tested in their investigations affect water clarity, even if the connections are indirect.

Go to **slide 28**. Before moving to the Extend section, ask students to make a prediction about the nutrient conditions for each of the four lakes. If students investigated other factors (e.g., light), they could also use these as part of their predictions.

Extend

Once students have a consistent and correct understanding of the environmental and genetic factors that affect phytoplankton growth, which influences water clarity, pass out the attached **Four Lakes' Data Reports**. It is recommended that you use one of these water quality reports to model how to interpret the information.

Students will use a Venn diagram to compare and contrast their predictions with the "Parameters" data in the reports. Creating the Venn diagram provides students with the opportunity to evaluate their models.

Teacher's Note: Tecumseh Lake

Based on nutrient levels, Tecumseh Lake is an outlier with nitrogen levels as high or higher than those of Lake Thunderbird. If groups tested light levels in the experiment, this may already be part of their model. If not, this is an opportunity for them to consider the red color of the water in Tecumseh Lake.

In this case, phytoplankton growth is limited by light availability instead of nutrient concentrations. This lake demonstrates the feedback loop created by water clarity. As water clarity decreases, less light is available for photosynthesis. While this is not necessarily the focus of this lesson, it does provide a segue into lessons on photosynthesis and respiration, human impacts through landscape use, and even the development of design solutions to maintain biodiversity and ecosystem services.

After students have evaluated their models, have a class discussion about their evaluations. Based on student responses, you may elect to discuss the purpose and limitations of models.

Encourage students to use their evaluation to further revise their model.

Optional Digital Modification

Consider using a polling method that allows students to share their model assessment anonymously with the class. Sites like Mentimeter have extra features to create outputs from direct student responses (e.g., word clouds) rather than forcing students to choose from preset multiple-choice options.

Evaluate

Display **slide 29**. Have students pick one of the lakes other than Tecumseh Lake and then use their model to explain their lake's water clarity. Emphasize that students *must* reference the evidence that supports their model.

Students may choose to deliver their explanation as a paragraph, a storyboard, a stop-motion animation, or a video. Have students present their explanations or curate them for other students to watch/read independently (e.g., Gallery Walk, Flip, Padlet, school LMS). After completing their own explanation, students should evaluate one or more peer explanations.

How you formally assess the final explanation (e.g., rubric, checklist, etc.) will depend on the format options students have to choose from, but the scoring should address connections among ideas and use of evidence rather than quality of presentation.

Additional Resources

To view more algae experiments, ideas, and lesson plans or to provide students with more resources for phytoplankton exploration, check out Algae Research and Supply and Phytopia.

Funding

This material is based on work supported by the National Science Foundation under Grant No. 1634630. Any opinions, findings, and conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Resources

- 2019 Oklahoma Lakes Report https://www.owrb.ok.gov/quality/monitoring/bump/pdf_bump/Reports/LakesReport.pdf
- A Compendium of Lake and Reservoir Data Collected by the National Eutrophication Survey in the Central United States. https://nepis.epa.gov/Exe/ZyPDF.cgi/91023FC6.PDF?Dockey=91023FC6.PDF
- Algae Bloom Experiment https://drive.google.com/file/d/0B2GUqEahXxAbeWRvd1dyRnBydTQ/view
- Central Watershed Planning Region Report http://www.owrb.ok.gov/supply/ocwp/pdf_ocwp/WaterPlanUpdate/regionalreports/OCWP_Central_Region_Report.pdf
- Easy Identification of the most common freshwater algae. https://www.researchgate.net/publication/284182579_Easy_identification_of_the_most_common_freshwater_algae_A_guide_for_the_identification_of_microscopic_algae_in_South_Af
- Estimating Biomass https://algaeresearchsupply.com/products/brainy-brinys-estimating-algae-biomass
- Growth and Reproductive Strategies of Freshwater Phytoplankton [book, edited by Craig Sandgren]
- Influence of Pulsed Inflows https://www.researchgate.net/publication/226165113
- Keeley Vol. 1
- Phytopia https://pace.oceansciences.org/phytopia.htm
- Pelagic Nutrient Cycles [book, Tom Anderson]
- Science Talk Resources Cards http://stemteachingtools.org/sp/talk-resource-cards
- K20 Center. (n.d.). Gallery Walk. Strategies. https://learn.k20center.ou.edu/strategy/118
- K20 Center. (n.d.). I Notice, I Wonder. Strategies. https://learn.k20center.ou.edu/strategy/180
- K20 Center. (n.d.). Data Match. Strategies. https://learn.k20center.ou.edu/strategy/1280
- K20 Center. (n.d.). Concept Card Mapping. Strategies. https://learn.k20center.ou.edu/strategy/123
- K20 Center. (n.d.). Mentimeter. Tech Tools. https://learn.k20center.ou.edu/tech-tool/645
- K20 Center. (n.d.). Flip. Tech Tools. https://learn.k20center.ou.edu/tech-tool/1075
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