Clear as Phytoplankton: A Tale of Four Lakes

Nutrients, Genetics, and Plant Growth

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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 phytoplankton? How does phytoplankton growth affect water clarity?

Summary

In this lesson, students investigate the phenomenon of differences in water clarity among four Oklahoma lakes. Students investigate how local environmental conditions and the survival strategies and growth of phytoplankton (algae) affect water clarity. Students then design and conduct experiments that investigate the relationship between water clarity variables and phytoplankton growth. They use this information to analyze patterns in phytoplankton community composition and to create models of the cause-and-effect relationships among local conditions, genetic factors, and phytoplankton growth. To conclude the lesson, students compare their data analyses with findings summarized in official water clarity reports. Students then use their models to develop summative explanations 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, 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

Student groups develop claims about phytoplankton growth based on data obtained during their investigations. Students then work together as a class to create a Concept Card Map that links 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 reports, then evaluate and revise their models.

Evaluate

Students use their final models to explain the relationship between phytoplankton growth and the water clarity of a lake of their choice.

Standards

ACT College and Career Readiness Standards - Science (6-12)

IOD403: Translate information into a table, graph, or diagram
SIN301: Understand the methods used in a simple experiment
SIN503: Determine the experimental conditions that would produce specified results
EMI402: Identify key assumptions in a model

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

- 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
- Facilitation Guide—Clear as Phytoplankton.docx
- Facilitation Guide—Clear as Phytoplankton.pdf
- 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
- Four Lakes Data Reports—Clear as Phytoplankton.pdf
- Four Lakes Phytoplankton Communities—Clear as Phytoplankton - Spanish.docx
- Four Lakes Phytoplankton Communities—Clear as Phytoplankton - Spanish.pdf
- Four Lakes Phytoplankton Communities—Clear as Phytoplankton.docx
- Four Lakes Phytoplankton Communities—Clear as Phytoplankton.pdf
- Lesson Slides—Clear as Phytoplankton.pptx
- 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
- Procedure Example—Clear as Phytoplankton.docx
- Procedure Example—Clear as Phytoplankton.pdf
- Student Notebook (Digital)—Clear as Phytoplankton - Spanish.docx
- Student Notebook (Digital)—Clear as Phytoplankton - Spanish.pdf
- Student Notebook (Digital)—Clear as Phytoplankton.docx
- Student Notebook (Digital)—Clear as Phytoplankton.pdf
- Student Notebook (Print)—Clear as Phytoplankton - Spanish.docx
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- Student Notebook (Print)—Clear as Phytoplankton.pdf

Materials

- Lesson Slides (attached)
- Facilitation Guide document (attached; for teacher use)
- Four Lakes Phytoplankton Communities handout (attached; one per group; print in color, one-sided)

- Phytoplankton Cards handout (attached; one per group; print in color, one-sided)
- Four Lakes Data Reports handout (attached; one set per group; print two-sided)
- DIY Secchi Disk Instructions handout (attached; optional)
- Procedure Example document (attached; one per teacher; optional)
- Student Notebook (Print) handout (attached; optional; one per student; print two-sided)
- Student Notebook (Digital) (attached; optional)
- Chart paper (three per class period)
- Water bottles
- Pond water or fast-growing algae culture
- Nutrient variables
- Secchi disks (buy or create using attached instructions)
    - Water resistant paint (black and white)
    - Hot glue gun
    - Metric ruler
    - Permanent marker
    - Metal washers (small enough to fit in the water bottles)
    - Plastic straw
- Poster board (optional, one per group)
- Markers (optional, one per group)
- Fluorescent lights

Preparation

Guiding Attachments

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

Prior to beginning the lesson, choose whether you would like students to use a student notebook. If so, decide whether you would prefer them to work on paper or digitally. The attached **Student Notebook (Print)** handout and **Student Notebook (Digital)** resource include space for students to record their reflections, data, and class discussion notes for all activities in the Engage through Extend sections of the lesson.

Lesson Prep

Prepare two chart papers for each class period. Label one chart paper “I Notice” and the other chart paper “I Wonder.”

Investigation Setup

Use **slide 19** to record your specific instructions for students to complete the following activity. For this investigation, you must collect pond water with algae in it or order a fast-growing algae culture ahead of time. If you choose to use pond water, remove large grazers, like *Daphnia* by pouring the water through a fine mesh of window screen, ideally around the size of of 200 μm. Expect the experiment to last around 5–10 days.

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

Expert Panel Instructions

Use **slide 26** to provide class-specific instructions on grouping students, analyzing and graphic data, and making claims.

Concept Mapping Instructions

Use **slide 27** to provide class-specific instructions for creating the Concept Card Map.

Engage

Introduce the lesson using the attached **Lesson Slides**. Display **slides 3–4** and share the essential questions and lesson objectives.

Display **slide 5** and engage students in the phenomenon—variation in lake water clarity and what affects it—by introducing them to images of water from four Oklahoma lakes. Have students make observations and ask questions about the image using the I Notice, I Wonder instructional strategy in their science notebooks. Have students share their thoughts with the class. As students share, record their ideas on the prepared chart paper. Repeat this process with **slides 6–9**.

Teacher's Note: Sentence Stems

You may consider using a tool like STEM Teaching Tools' Talk Science Resource Cards to provide sentence and question stems in order to elicit additional details or clarification.

Distribute one copy of the attached **Four Lakes Phytoplankton Communities** handout to each student. Display **slides 10–13** and show students the phytoplankton communities found in each lake, as seen under a microscope. Have students look for patterns in the communities and share out their observations and questions. Add their responses to the I Notice, I Wonder chart papers.

Display **slide 14** and define phytoplankton, also called algae. Display **slide 15** and define water clarity.

Teacher's Note: Vocabulary

While teaching vocabulary prior to exploration is generally discouraged, students must know the definitions of phytoplankton and water clarity to proceed in the lesson. Introduce this vocabulary so that students may complete the lesson tasks, but understand that students do not need to fully understand the concepts.

Display **slide 16** and guide students in a discussion about what might cause the amount of phytoplankton to increase in the water. Ask them to list things that help plants grow and record their responses on either a new sheet of chart paper or on the slide. Students might mention light, water, carbon dioxide, and nutrients.

Ask students to consider the question, “What factors explain how phytoplankton affect water clarity?” Further break down the question into two questions, “What factors cause phytoplankton to grow?” and “How do those factors indirectly affect water clarity?”

Display **slide 17**. Ask students to use the the ideas they've observed and discussed so far to draw a model that explains the phenomenon. Have students draw their models in their Student Notebooks.

Explore 1

Display **slide 18** and ask students to review the factors they believe affect phytoplankton growth. Ask them how they can test one of their factors to see if their idea is correct.

Organize students into pairs or small groups. Inform students that they should choose a single variable that may affect phytoplankton growth and use that variable to carry out an investigation.

Teacher's Note: Variables

Ensure that more than one group is assigned to each variable (e.g., two groups test nitrogen, three groups test phosphorous, etc.) so that groups can later combine their data for analysis. Display **slide 19** and review your class-specific instructions.

Communicate to students that some groups must test increased nitrogen, some must test increased phosphorus, and some must test an addition of fertilizer that contains both nitrogen and phosphorous. If students are interested in testing light levels, pH, temperature, etc., consider adding these factors to the investigation.

Have students record phytoplankton abundance data daily. The most efficient method for this is using a modified Secchi disk. Secchi disks can be purchased online or you can make your own using the attached **DIY Secchi Disk Instructions** document. For reference, the YouTube video *The Dirty Labcoat: The Secchi Stick* demonstrates how to use a Secchi stick. Unhide **slide 20** if students need further direction on how to use a Secchi stick.

Embedded video

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

Display **slide 21** and distribute one set of the attached **Phytoplankton Cards** to each investigation group. Have students compare the cards with the microscopic view of the four lakes' phytoplankton communities to identify the number of each type of phytoplankton found in each lake.

Display **slide 22** and have students use the genetic factors listed in the table on each card to sort the phytoplankton into groups. Have students record the factor they used to sort the cards and have them list their groups of phytoplankton in their science notebooks. Next, have students choose a different factor, sort the phytoplankton again, and record their factor and groups. Repeat the process, having students sort the phytoplankton according to at least three factors.

Teacher's Note: Prerequisite Knowledge

This lesson assumes that students already understand the concept that genotype influences phenotype. Take a moment to activate this prior knowledge. Review how genes in phytoplankton DNA determine not only what the phytoplankton look like, but also the strategies it uses to survive, especially because phytoplankton do not have a brain.

Explain 1

Display **slide 23**. Have students compare their sorted lists of phytoplankton with the groups of phytoplankton in each lake community. Have them take note of any patterns or relationships they notice.

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, algae scientists categorize phytoplankton into *functional groups*, in which phytoplankton are sorted by physical characteristics or survival strategies. Emphasize to students that they are sorting phytoplankton just as scientists do.

Lead a whole class discussion about students’ sorted groups of phytoplankton. Have students describe the ecological significance of the genetic factors listed on each card. For example, students may respond that functional groups that are able to use more than once resource 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, take the opportunity to guide students to take notes and make connections between the activity and other ecological concepts they have previously learned. Next, ask students in what kind of environment they would find each functional group of phytoplankton. Guide the discussion to focus specifically on nutrient conditions (high, low, and both).

Display **slide 24**. Ask students to revise their initial models based on the collected evidence and their conclusions about the data. If students did not previously include genetic factors, encourage them to add them at this point.

Explore 2

Teacher's Note: Factor Expert Panel Instructions

Prior to this phase of the lesson, add any class-specific instructions for your factor expert panels to **slide 26**.

Display **slide 25**. Organize students into experiment focus groups, or "factor expert panels," by combining groups that tested the same variable in their investigations. Have these new focus groups compile and compare data from their experiments. Have groups treat their individual experiments as replicates and use them to calculate averages that summarize their collective data.

Display **slide 26** and explain the investigation to the class. Tell groups that they must develop a claim about their results (e.g., "[Our experimental factor] results in [some result]") using the collective data. Note that water clarity is most likely to be influenced by nutrient resource levels. Have groups prepare for a whole class discussion by creating a graph that displays their results summary and includes their claim in a caption.

Have expert panels discuss their phytoplankton classifications to identify patterns among phenotypes (e.g., nitrogen fixers tend to be toxic) and make comparisons between the phytoplankton community data for each lake. Students 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

Teacher's Note: Lake Images

Prior to this phase of the lesson, post the images of lake water that were used to introduce the phenomenon at the beginning of the lesson. Add the nutrient and environmental variables from students' experiments to help anchor their ideas.

Inform the class that they must work together to create a Concept Card Map. Explain that their map must synthesize what they have learned about the relationships among water clarity, environmental factors, and phytoplankton growth.

Teacher's Note: Concept Card Map Instructions & Options

Prior to this portion of the activity, add any class-specific instructions for the concept card map to **slide 27**. You may choose to physically create the concept card map using a whiteboard or poster and markers and string to connect concepts or relationships. You may also choose to create a digital version of the map.

Display **slide 27** and introduce your class-specific instructions for creating the concept card map. Ask all groups to share out their claims and evidence from their experiment results and add these and 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, have them use evidence to add new concepts to the map and identify relationships among existing concepts. Once all groups have shared, allow them time to identify any other relationships or concepts they think should be added to the map.

Teacher's Note: Addressing Misconceptions

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

After the concept map is complete, display **slide 28**. Have students use the compiled information and relationships from the map to revise their models again.

As students work, ensure that their revisions explain the cause-and-effect relationships that influence phytoplankton growth and water clarity. Remind students that their models should show how changes to the different variables in the investigations affect water clarity, either directly or indirectly.

Display **slide 29**. Ask students to make a prediction about the nutrient conditions for each of the four lakes. If students investigated other factors (e.g., light), encourage them to use these as part of their predictions as well.

Extend

Distribute one copy of the attached **Four Lakes Data Reports** handout to each student. Use these water quality reports to model how to interpret the information.

Inform students that they must use a Venn Diagram to compare and contrast their predictions about nutrient conditions with the "Parameters" data in the reports. Have students draw a Venn Diagram or have them use the diagram provided in their Student Notebook handouts. Have them evaluate their models by comparing the factors in their models with the scientific data in the reports.

Teacher's Note: Tecumseh Lake

Based on the nutrient levels provided in the reports, 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 information may already be part of their models. If not, encourage them to consider the red color of the water in Tecumseh Lake.

In this case, phytoplankton growth is limited by light availability rather than 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 the primary focus of the lesson, this information provides 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.

Initiate a class discussion about students' Venn Diagrams and evaluations of their models. Consider discussing the purpose and limitations of models based on student responses. Encourage students to use their evaluations and information from the discussion to further revise their models.

Optional Digital Modification

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

Evaluate

Teacher's Note: Assessing Final Explanations

In this phase of the lesson, students create a final explanation that connects their models to one of the four lakes presented in the lesson. How you formally assess their final products is up to your discretion. Whether you choose a rubric, checklist, or other method, your scoring should address connections among ideas and use of evidence rather than the quality of the final presentation.

Display **slide 30**. Have each student choose one of the four lakes, other than Tecumseh Lake, and use their model to explain their chosen lake's water clarity. Emphasize that students must reference evidence that supports their model.

Have students deliver their explanations as a written paragraph, storyboard, stop-motion animation, or video. Have them present their explanations or curate them for other students to view using a tech tool like Padlet, your school LMS, or an activity like a Gallery Walk. After viewing their peers' explanations, students should evaluate their classmates' presentations.

Additional Resources

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

Teacher's Note: Funding

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Resources

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