

How Does Photosynthetic Activity Affect Shrubification?

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Teacher: Claire Gunder	Unit: Ecology
Grade/Course: 10/General Biology	Lesson Title: How Does Photosynthetic Activity Affect Shrubification?
NGSS Performance Expectation: HS-LS1-5 From Molecules to Organisms: Structures and Processes	
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	
Real World Phenomenon Addressed in the Lesson:	
The process of photosynthesis. Deciduous, evergreen, and graminoid plants: how they are different and how their structures lead to different photosynthetic strategies in the tundra.	
3 Dimensions of Science	
Science & Engineering Practice(s) Used:	
<ul style="list-style-type: none"> ● Asking questions and defining problems ● Develop and use models ● Analyzing and interpreting data ● Obtaining, evaluating, and communicating information 	
Crosscutting Concept(s) Used:	
<ul style="list-style-type: none"> ● Patterns ● Cause and effect ● Systems and system models ● Energy and matter ● Structure and function 	
Disciplinary Core Idea(s)	
LS1.C: Organization for Matter and Energy Flow in Organisms: The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.	
Background Information	
Prior Student Knowledge:	
Cellular respiration, cell structure and function, inter- and intraspecies competition, the definition of shrubification, and general ecology.	
Possible Preconceptions/Misconceptions:	
Students may refer to photosynthesis as the most important process that a plant undergoes. While photosynthesis is a critical component, and measuring photosynthetic activity can equate to a measurement of plant health, no one process is “the most important”. In the context of smaller plants, students may predict that	

leaves take up the most biomass of a plant, but may be able to visualize how larger plant species have more biomass in their stems, such as trees.

Some students may struggle with reading tables. They may think that every row is a different plant, instead of interpreting it as a different part of the plant. Instruction should be made explicitly clear, and plant species should be visually separated on the table.

Content Information for Teacher:

Shrubification: The following article is used to teach students the definition of shrubification in the lesson sequence before this one: <https://www.arctictoday.com/shrubification-mean-arctic/>. It is strongly recommended to read this article as a background on this phenomenon.

Graminoids: Some teachers may not be familiar with the term graminoids. The following article provides a general overview of graminoids:

<https://www.chicagobotanic.org/blog/plant-science-conservation/dont-avoid-graminoids>

5E	Evidence of Use/Student Activity
<p>Engagement</p> <ul style="list-style-type: none"> ● Capture attention ● Activate prior knowledge ● Connects to the real world phenomenon 	<ul style="list-style-type: none"> ● Hook activity: <ul style="list-style-type: none"> ○ Show a time-lapse video of a plant growing towards light. Ask students to discuss what they think is happening in the video. The link to the video can be found here. ● Discussion questions (small groups of 4): <ul style="list-style-type: none"> ○ What do you think plants need in order to grow? ○ How does light affect plant growth? ○ Have some groups share their discussions with the large group.
<p>Exploration</p> <ul style="list-style-type: none"> ● Test ideas and develop knowledge using explorations, investigations, experiments ● For NGSS, provide an initial activity/lab that allows for investigation of real world phenomenon (ABC: Activity Before Content) 	<ul style="list-style-type: none"> ● Small group activity: Students are divided into groups and each group is provided with different types of leaves (evergreen, deciduous, and graminoid). <ul style="list-style-type: none"> ○ Task: Observe the differences in structure, color, and texture of each leaf type. ○ Discussion questions: <ul style="list-style-type: none"> ■ What characteristics do you observe in each leaf type? ■ How do you think these characteristics relate to their environment and photosynthesis? ● Individual activity: Students are informed that they will investigate the different amounts of biomass that evergreen, deciduous, and graminoid plant species in the Alaskan tundra have. The teacher may have to define for students that biomass is the total quantity of an organism in a given area.

- **Task:** Using the hypothesis templates, make a prediction about which part of each 3 plant types has the most biomass.
 - In evergreen plants, I think that (new leaves / new stems / old leaves / old stems / flowering / below-ground stems) will have the most biomass because...
 - In deciduous plants, I think that (new leaves / new stems / old stems / flowering / below-ground stems) will have the most biomass because...
 - In graminoid plants, I think that (blades / sheaths / flowering / below-ground stems / standing dead) will have the most biomass because...
- **Small group activity:** Students are divided into groups and will observe the following data table. For a more challenging activity, the instructor may elect to have students calculate their own averages of the samples. In the version in the folder, the averages are filled in for students. The link to the metadata can be found [here](#).
 - Students will answer questions 6-8 of the student activity sheet in groups of 4.
- **Large group activity:**
 - **Discussion:**
 - Which plant part took up the most biomass in most of the samples?
 - How did your group determine which plant part had the most biomass amongst the 5 samples for each of the 3 species?
 - Students may state:
 - “We calculated the average.”
 - “We looked at trends in the highest numbers.”
 - Did your findings support your hypotheses? Did they surprise you? Why or why not?
- **Independent activity:** Students will record any new questions they have.
 - This is important because in the activity, they found that it is the root systems that have the most biomass in evergreen and deciduous plants and that the standing dead have the most biomass in graminoids. The leaves do not take up the most

	<p>biomass, in fact, it is the parts that don't conduct photosynthesis at all.</p>
<p>Explanation</p> <ul style="list-style-type: none"> Analyze data/information and construct explanations Communicate understandings orally and in writing Describe possible solutions 	<ul style="list-style-type: none"> Lecture: Present an explanation of photosynthesis, with these as the key ideas: <ul style="list-style-type: none"> The process of photosynthesis and the equation. <ul style="list-style-type: none"> Emphasizing how photosynthesis transforms light energy into stored chemical energy (glucose). The role of chlorophyll in light absorption. The differences between deciduous (seasonal leaf loss), evergreen (year-round foliage), and graminoid (grass-like) plants and how these differences affect how they conduct photosynthesis.
<p>Elaboration</p> <ul style="list-style-type: none"> Modify/refine procedures, prototypes, models, solutions, arguments, essays, etc. Apply or practice in a new setting 	<ul style="list-style-type: none"> POGIL activity: The link to the packet can be found here. <ul style="list-style-type: none"> Students are in groups of 4 with the following roles: <ul style="list-style-type: none"> Reader: reads questions and prompts out loud to the group. Recorder: writes responses to questions that the group discusses. Referee: watches the time and makes sure the group isn't stuck on questions for too long (makes calls to skip questions if needed). Reporter: reports responses to questions in large group discussions when the group is called on. Each model is timed, with the timer visible on the board. Students have until the timer goes off to respond to questions that correspond to the model. If they finish early, they may move ahead. Teacher will guide a discussion after the timer goes off, wherein students share responses to questions with the whole group. This gives students the opportunity to modify their responses.
<p>Evaluation</p> <ul style="list-style-type: none"> Self-assess understanding of concepts Demonstrate understanding of concepts through performance-based tasks Reflect and/or revise 	<ul style="list-style-type: none"> Model creation: Have students create a visual model (poster or digital presentation) that illustrates the photosynthesis process and incorporates: <ul style="list-style-type: none"> The inputs and outputs of photosynthesis. The types of plants discussed and how their structure supports their photosynthesis. <ul style="list-style-type: none"> Remind students of the pictures from the student activity sheet.

<p>answers or solutions to a complex question, issue, challenge, or real world problem</p>	<ul style="list-style-type: none"> ● Assessment: Model presentation assessment is based on creativity, accuracy, and understanding of the photosynthesis process.
<p>Lesson Closure</p> <ul style="list-style-type: none"> ● Summarize the lesson ● Check for understanding via exit slip or exit ticket ● Preview the next lesson 	<ul style="list-style-type: none"> ● In this lesson sequence, we learned what photosynthesis is, how it works, and what it does for plants. We also learned about the different types of plants found in the tundra (deciduous, evergreen, and graminoid) and how they've adapted for photosynthesis. ● We also learned that in the tundra, leaves do not make up the majority of any of our plants! In evergreens and deciduous plants, it is below ground stems (root systems) and in graminoids, it is standing dead. ● Ask students: Does photosynthesis contribute to shrubification? <ul style="list-style-type: none"> ○ Most students will answer no, but this isn't true. <ul style="list-style-type: none"> ■ This is a good segway into connecting student prior knowledge on resource competition. It is worth noting that the shrubs will rapidly outgrow the grasses, which shades them out and continues to harm them. ● The question then becomes, how do shrubs end up rapidly outgrowing the grasses? Point out to students that in their data, deciduous plants had the most biomass in their below ground stems. This becomes a segway into the next lesson, which can cover permafrost thaw and root systems.

Extension:

- **Research project:** Students can select one type of plant (deciduous, evergreen, or graminoid) and research its specific adaptations for photosynthesis.