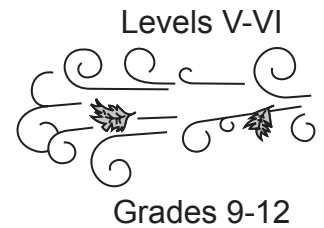


# Growing Plants in a Variety of Soil Conditions

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## Overview:

Permafrost thaw affects plant growth by changing the permeability and water content of the soil. In this lesson, students design and conduct an experiment to investigate the effect of permafrost thaw and soil water content on plant growth.

## Objectives:

The student will:

- write a hypothesis about the effect of soil moisture content on plant growth;
- design and conduct a controlled experiment to test a hypothesis;
- collect and analyze data;
- communicate experimental results; and
- explain the effect of various soil moisture contents on plant growth.

## GLEs Addressed:

### *Science*

- [9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.
- [10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.
- [9] SA1.2 The student demonstrates an understanding of the processes of science by hypothesizing, designing a controlled experiment, making qualitative and quantitative observations, interpreting data, and using this information to communicate conclusions.
- [10] SA1.2 The student demonstrates an understanding of the processes of science by reviewing pertinent literature, hypothesizing, making qualitative and quantitative observations, controlling experimental variables, analyzing data statistically (i.e., mean, median, mode) and using this information to draw conclusions, compare results to others, suggest further experiments, and apply student's conclusions to other problems.
- [9] SA2.1 The student demonstrates an understanding of the attitudes and approaches to scientific inquiry by formulating conclusions that are logical and supported by evidence.
- [11] SC3.2 The student demonstrates an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy by analyzing the potential impacts of changes (e.g., climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem.

### *Math*

- [9] S&P-1 The student demonstrates an ability to classify and organize data by designing, collecting, organizing, displaying, or explaining the classification of data in real-world problems (e.g., science or humanities, peers, community, or careers), using information from tables or graphs that display two sets of data or with technology.
- [10] S&P-1 The student demonstrates an ability to classify and organize data by designing, collecting, organizing, displaying, or explaining the classification of data in real-world problems (e.g., science or humanities, peers, community, or careers), using information from tables or graphs that display two or more sets of data or with technology.

## Materials:

- STUDENT INFORMATION SHEET: “Rubric”
- STUDENT WORKSHEET: “Permafrost and Growth”
- STUDENT WORKSHEET: “Lab Report”

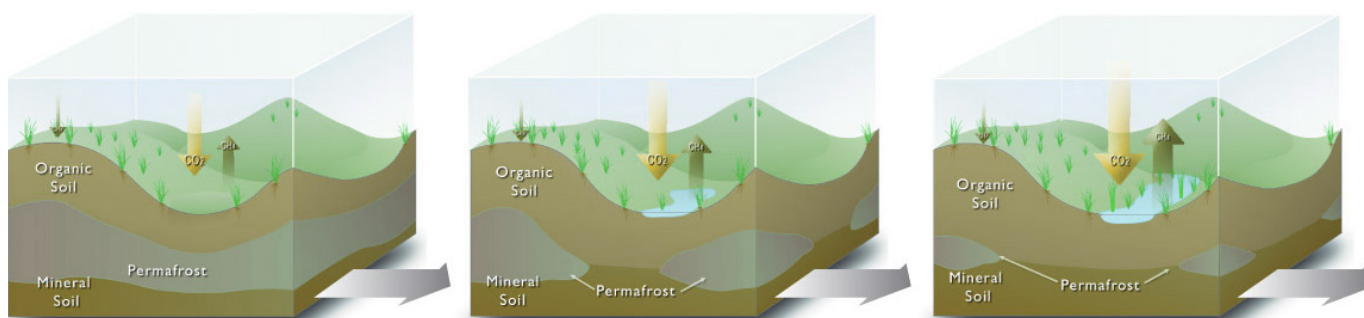
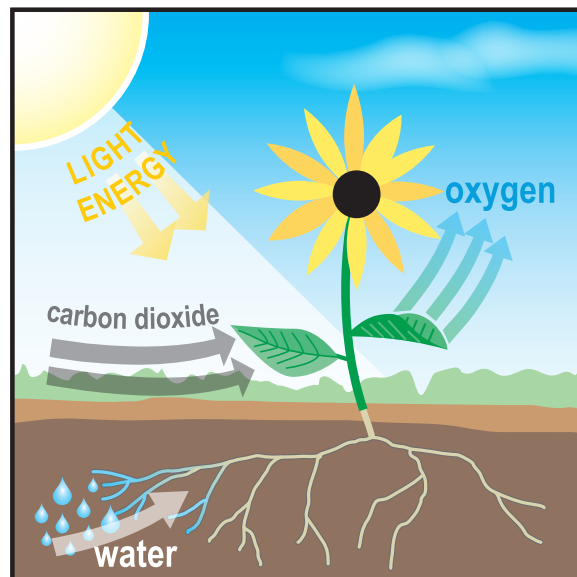
## Whole Picture:

Plants need water, sunlight, and carbon dioxide for survival. The leaves of plants absorb energy from sunlight and water. The roots of plants also take up water. Plants use sunlight and water to make sugar and oxygen. Sugar is used as food; oxygen is expelled into the air. This process is called photosynthesis.

Plants also need nutrients. Nutrients are present in the soil, but plants cannot ingest soil directly. Water (a solvent) dissolves nutrients in the soil, such as calcium (Ca), potassium (K), nitrogen (N), and phosphorus (P), and transports them to the plants. With too little water, plants do not get enough nutrients, which inhibits their growth.

Too much water can inhibit the aeration (introduction of air) of the plants, causing the plants to suffocate. This can result in the accumulation of toxic substances and low uptake of nutrients in the plants. Plants that have too much water may have lower leaves that are yellow, young leaves that are brown, may look wilted, have rotting or stunted roots, exhibit no new growth, or have soil that is green from algae.

The amount of water held in the soil depends on the soil’s permeability, which is determined by the size of the soil pores. More water can be held in soil with small pores, such as clay, than in soil with large pores, such as sand. Soil that is frozen (including permafrost) has a lower permeability.



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## Activity Procedure:

1. Divide students into groups and distribute the STUDENT WORKSHEET: “Permafrost and Plant Growth.” Ask students to answer the questions individually or in their groups, performing additional research as necessary. (NOTE: More information on this topic is located in the Whole Picture section of this lesson.) Share and discuss answers as a class.
2. Distribute the STUDENT INFORMATION SHEET: “Rubric,” and discuss the rubric as a class. If students are not familiar with rubrics, explain a rubric is a tool for assessment; show students how the rubric can be used to strive toward their desired grade.

3. Explain groups will design and perform an experiment related to permafrost thaw and plant growth. If necessary, explain a testable question is a question that can be tested by an investigation or experimentation. Ask groups to write a testable question for their experiment. Possible testable questions related to permafrost thaw and plant growth include: How does too much (or too little) water in the soil affect plant growth? How does permeability of the soil change plant growth? What is the relationship between soil permeability and the type of plants that grow in the soil?
4. Ask each group to share their testable question. Discuss as a class.
5. As a class, discuss how to develop a hypothesis to test each group's questions. Encourage students to write an "if, then, because" statement to develop their hypothesis. Instruct groups to write a hypothesis for their testable question and identify the independent variable.
6. Distribute the STUDENT WORKSHEET: "Lab Report," and instruct groups to record their testable question and hypothesis. Ask groups to write an experiment procedure. Remind groups that the experiment procedure should test the hypothesis, include multiple levels of the independent variable, and include multiple trials. Possible experiments include growing the same plant in three or four different pots and varying the amount of water added to each pot; or preparing four trays of soil with varying moisture content and adding a seed mix (such as bird seed) to each tray to determine which types of seeds sprout. Experiments will vary based on the testable question and hypothesis.
7. Remind students to record data prior to beginning their experiment as well as during the experiment. For example, students may wish to measure the moisture content of the soil they are using by weighing it, drying it, and then weighing it again. If students use multiple seeds, it is important to record each type of seed. Thorough observations should be recorded throughout.
8. Review each groups' experiment procedure before providing materials to the class. After approving each experiment procedure, allow students to proceed. Experiments may take several days or several weeks. Impose constraints as necessary.
9. As students complete their experiments, they should complete their worksheets, then prepare a presentation of experimental results. Groups should share all aspects of the lab report. Visual aides, such as drawings and enlarged versions of data tables and graphs, are encouraged.

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**Information Technology Extension:** Ask students to track and graph data in Excel and/or prepare their presentations using PowerPoint or similar presentation software.

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## Answers:

STUDENT WORKSHEET: "Permafrost and Plant Growth"

1. Plants need water for two reasons: A) water is part of photosynthesis that produces food for the plants, and B) water transports nutrients from the soil.
2. Too much water suffocates the plant.
3. Too little water prevents the plant from making food.
4. Permeability is determined by the size of the pores in the soil. Different types of soil have different pore sizes.

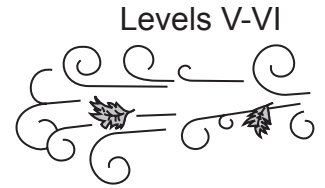
STUDENT WORKSHEET: "Lab Report"

Answers will vary. Use the STUDENT INFORMATION SHEET: "Rubric" to assess student performance.

Name: \_\_\_\_\_

# Permafrost and Plant Growth

## Student Worksheet



**Directions:**

Answer the following questions.

1. Explain two reasons water is necessary for plant survival.

A. \_\_\_\_\_

B. \_\_\_\_\_

2. Explain how too much water affects plant growth.

\_\_\_\_\_  
\_\_\_\_\_

3. Explain how too little water affects plant growth.

\_\_\_\_\_  
\_\_\_\_\_

4. Explain the relationship between type of soil (clay, silt, etc.) and permeability.

\_\_\_\_\_  
\_\_\_\_\_

5. How might permafrost thaw in the local area affect local vegetation?

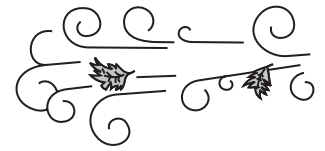
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\_\_\_\_\_

Name: \_\_\_\_\_

Levels V-VI

# Lab Report

## Student Worksheet (page 1 of 3)



### Testable Question:

Write a testable question about plant growth and permafrost thaw.

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### Hypothesis:

Write a hypothesis to answer the testable question.

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### Experiment:

#### Materials & Procedure:

On a separate sheet of paper, write a step-by-step procedure for your experiment. Remember to identify the independent and dependent variables, and include at least three different levels of the independent variable. Multiple trials are suggested. Include a list of all necessary materials.

#### Data:

On a separate sheet of paper (graph paper may be used), create one or more data charts to record data collected during the experiment. Be sure to record all observations.

#### Approval:

Ask your teacher to review and approve your experiment design before you begin.



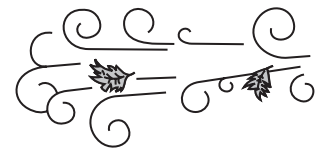


Student Information Sheet (page 1 of 2)



Objective	GLE	Below Proficient	Proficient	Above Proficient
The student writes a hypothesis about the effect of soil conditions on plant growth.	[9-10] SA1.2	The student does not write a hypothesis, or his or her hypothesis is incomplete (does not include a prediction and/or does not describe the expected relationship between the variables involved).	The student writes a hypothesis. The hypothesis includes a prediction and describes the expected relationship between the variables involved.	The student writes a hypothesis. The hypothesis includes a prediction, describes the relationship between the variables, and explains the rationale for the prediction.
The student designs and conducts a controlled experiment to test a hypothesis.	[9-10] SA1.2 [9] SA2.1	The student's experimental design is incomplete (procedure is missing or unclear, i.e. another student could not repeat the experiment), does not test the hypothesis, and/or is not controlled (tests more than one variable simultaneously).	The student's experimental design is written to test the hypothesis, identifies the independent and dependent variables, includes at least three different levels of the independent variable, and includes a clear and thorough description of the procedure to be followed.	The student's experimental design is written to test the hypothesis, identifies the independent and dependent variables, includes at least three different levels of the independent variable, includes a clear and thorough description of the procedure to be followed, and describes the use of multiple trials.
The student accurately collects and analyzes data.	[10] SA1.1 [10] SA1.2	A) The student does not chart data or is missing one or more of the following elements: tables properly labeled with the independent and dependent variables, and repeated trials recorded. B) The student does not graph data or is missing one or more of the following elements: graph title, both axes labeled, equal intervals used on both axes, and all data accounted for. C) Major errors in the data may exist.	A) The student charts data: tables are properly labeled with the independent and dependent variables, and repeated trials are recorded. B) The student graphs data: the graph is titled, both axes are labeled, equal intervals are used on both axes, and all data is accounted for. C) Small errors in the data may exist.	A) The student charts data: tables are properly labeled with the independent and dependent variables and all units; repeated trials are recorded; and mean, median, or mode are calculated. B) The student graphs data: the graph is titled, both axes are labeled, equal intervals are used on both axes, all data is accounted for, best-fit lines are included if appropriate. C) There are no errors in the data.

Student Information Sheet (page 2 of 2)



Objective	GLE	Below Proficient	Proficient	Above Proficient
<p>The student communicates experiment results by writing a lab report and making an oral presentation to the class.</p>	<p>[9-11] SA1.1</p>	<p>The student's lab report is missing one or more of the following sections: testable question or problem, background knowledge, hypothesis, experiment procedure, data, analysis (graph and written interpretation of data), or conclusion.</p> <p>The student's oral presentation is incomplete (does not include each of the sections in his or her written lab report) and/or is unclear and difficult to follow.</p>	<p>The student's lab report includes the following sections: testable question or problem, background knowledge, hypothesis, experiment procedure, data, analysis (graph and written interpretation of data), and conclusion.</p> <p>The student's oral presentation includes each of the sections in his or her written lab report. The student makes the presentation brief and precise and presents charts and graphs of data as relevant.</p>	<p>The student's lab report includes the following sections, which are properly labeled: testable question or problem, background knowledge, hypothesis, design, data, data analysis (graph and written interpretation of data), conclusion, <i>and recommendation for further study and/or improving the experiment.</i></p> <p>The student's oral presentation includes each of the sections in his or her written lab report. The student makes the presentation brief and precise and presents charts and graphs of data as relevant.</p>
<p>The student explains the effect of soil moisture content on plant growth.</p>	<p>[11] SC3.2</p>	<p>The student does not, or incorrectly, explain how soil moisture content affects the growth of plants in the background knowledge section of his or her report.</p>	<p>The student accurately explains how soil moisture content affects the growth of plants in the background knowledge section of his or her report.</p>	<p>The student accurately explains how soil moisture content affects the growth of plants in the background knowledge section of his or her report. The student provides examples.</p>