A First Look at Phenology

September 5, 2001

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Purpose

To increase students' awareness of qualitative changes in plant(s) during green-up and green-down or senescence from which they will be or are collecting quantitative leaf change data

To develop an understanding of the patterns, similarities, and differences among plants at the same location

Student Outcomes

Students will learn stated key concepts and be able to apply process skills in understanding patterns of green-up and green-down among plants.

Overview

Students will observe, compare, and classify plants during green-up or green-down and then make inferences based on the patterns they observe.

Time

Two to three class periods

Level

Beginning and Intermediate

Key Concepts

- Qualitative and quantitative data collection
- The time of green-up varies among plants at the same location
- The time and color of senescence or green-down varies among plants at the same location
- There are patterns that can be observed among different plants at the same location
- Features can be used to organize organisms into groups

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Skills

Observing
Measuring
Classifying
Collecting data
Analyzing data
Inferring
Predicting

Processes

Education: Inquiry/open
Scientific: Seasonal changes in plants

Materials

Hand lens
Survey tape
Pencils
GLOBE Science Notebook
Plants
Charts

Prerequisites

None

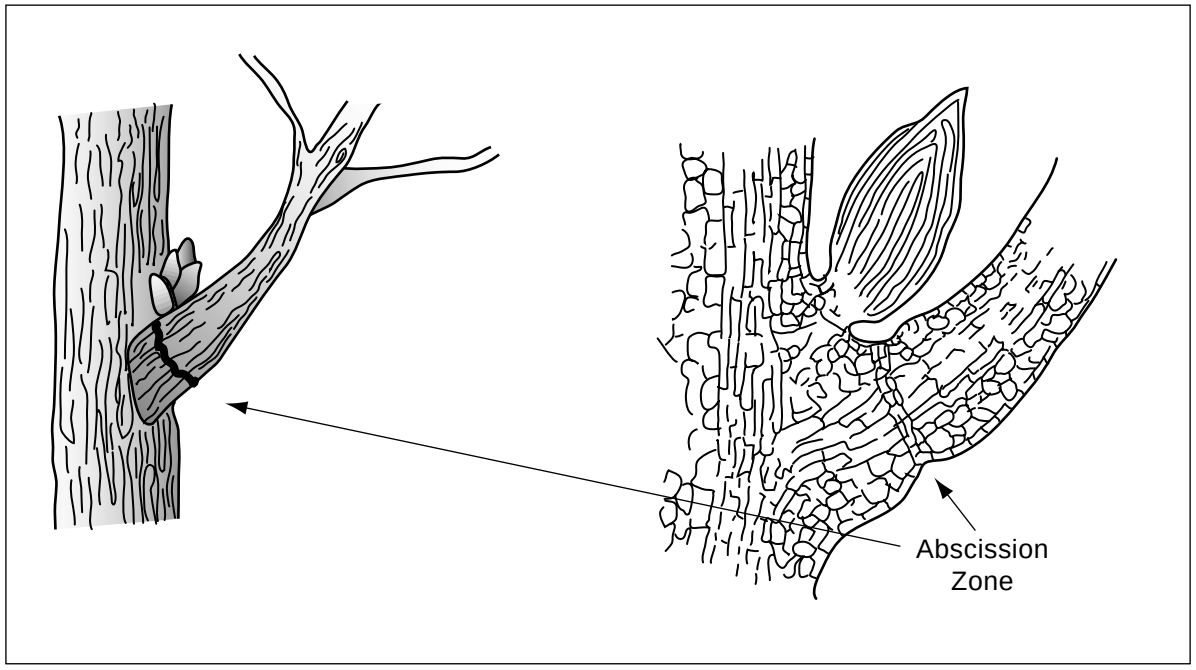
Background

Phenology is the study of organisms' response to seasonal and climatic changes in their environment. Seasonal changes include variations in day length or duration of sunlight, precipitation, temperature and other life-controlling factors. The focus of this activity is plant phenology during green-up and green-down/senescence. Green-up and green-down can be used to examine regional and global vegetation patterns, year to year variations, and vegetation responses to climate change.

For deciduous trees, bushes, and shrubs the growing season can be defined by the appearance of leaves in the spring and the dropping of leaves in the fall. Plant green-up is initiated when dormancy (a state of suspended growth and metabolism), ceases due to environmental conditions such as longer hours of sunlight, higher temperatures, and increased availability of water create favorable conditions for plant growth. This happens during spring for plants in temperate climates. Plant roots begin absorbing water and nutrients from the soil, and transport these along with other nutrients to other parts within the plant including buds or shoots. Growth-inhibiting substances are broken down and replaced by growth-promoting substances. Plant leaves start to come out, make chlorophyll to capture light energy and begin to photosynthesize or make food. With long hours of sunlight and a good supply of liquid water, plants continue to make food in the form of glucose, and store the excess.

In the desert, some plants lose all their leaves and enter into full dormancy during the hottest months when plant parts are most easily damaged by heat and shortage of water. Senescence or green-down for non-evergreen plants occurs in autumn. As daylight becomes shorter, temperatures cooler, and water harder to get, plants begin to shut down food production. Deciduous trees like maple, oaks, elms, aspen and birch, shed their leaves in preparation for winter. Many changes occur in deciduous tree leaves before they fall from the branch. At the base of each leaf is a special layer of cells called the *abscission* or separation layer. Through this layer, small tubes pass water into the leaf and food back to the tree all summer. In the fall the cells of the abscission layer begin to swell and form a cork-like material, reducing and finally cutting off flow

Figure EA-1: Leaf with Abscission Layer



between leaf and tree. Glucose and waste products are trapped in the leaf. Chlorophyll begins to break down without fresh water to renew it, and the green color of leaves disappears. As the bottom cells in the separation layer form a seal between leaf and tree, the cells in the top of the separation layer begin to disintegrate. They form a tear-line (making the leaf vulnerable to tearing off the branch) and eventually the leaf falls from the branch.

Loss of leaves in deciduous trees is an essential part of winter cold survival. Plants survive by reducing water loss during winter when water supply is greatly limited, and acclimation, a process by which plants become increasingly resistant to subfreezing temperatures without sustaining injury. Evergreens keep most of their leaves during winter and may continue to photosynthesize as long as they get enough water. However, reactions occur more slowly at colder temperatures.

The time of green-up and senescence will vary due to plant species and/or microclimate differences related to plant locations. Similarly, plant appearances (e.g. hue, shape, size, etc.) will also vary. It is important for students to practice careful observation of plants and the environment in order to make quantitative observations and in this activity, qualitative observations (using their sense of sight, touch, hearing and smell) on green-up or senescence, leading to generalizations about patterns related to seasonal changes.

Careful observation of characteristics is a prerequisite to classification. Classification is the grouping of things including objects and ideas, according to similar characteristics. Classification has been used by humans for thousands of years. By grouping living things according to observable characteristics, we better understand our environment, making life safer and more enjoyable. Many examples of the usefulness of classification in our everyday lives are evident in stores, offices, and homes. Classification is important to all fields of science as well. For scientists, classification helps them organize and understand the natural world. It is a means of learning more about life on earth and discovering the special relationships that exist between living things. Students can improve their observation and classification skills with awareness and practice of looking closely at objects for details. Careful observation is a foundation of all science and a useful tool for everyday life.

What To Do and How To Do It

Gear Up

1. After green up or green-down begins, ask students what they have observed happening to plants in the spring (or fall). Create a class list of observations. Ask probing questions to see if anyone understands that there is a variation in bud burst time in the spring and senescence/green-down time and color in the fall. Become familiar with the students' prior knowledge so that you can structure learning opportunities that will help them develop more viable conceptions about green-up and green-down, and extend their understandings. Example of questions: Have you noticed a difference in time of occurrence of budburst / changing of leaf color? Do you think plant type or species will affect this occurrence? Are there other factors that might affect timing and patterns of green-up or green-down? How do you think air temperature, available soil moisture, day length will affect green-up or green-down?
2. Ask students why they think observation is such an important skill for scientists. Discuss. Tell them that for the next activity they are going to have to observe carefully like a scientist would, observing much closer than normal. If there is time model this in the classroom by observing a leaf or branch with one sense at a time. This will help students expand their observations past just looking. Be sure that students understand that careful observation is a foundation of all science.

Exploration

1. Students should observe two different plants species one used for the phenology protocol and a new one at the same study site. It will facilitate comparison if they set up two columns in a page of their GLOBE Science Notebook, one for each plant. See example.
2. Demonstrate correct us of hand lens. Pass out hand lenses to students and take them outside to their protocol data collection site. This could be their Phenology study site, but it does not have to be. Ask the students to select a new plant (different species, same environmental conditions as other plant) or new plant (same species, different environmental conditions) and mark it with a piece of survey tape.
3. Next have them sit by their plants and observe carefully using their eyes alone first and then their hand lenses, then their other senses, one at a time. Have them record their observations in picture and words, including date and time. Start by observing just one leaf. The object of observation should be at or near the eye level of the student. Try to get the students to focus for at least five minutes. Don't prompt them about what to look for, so you can see how much and what they observe on their own. If students seem to need support in understanding possibilities for using four senses, you might brainstorm ways to collect data for each sense before going out to the field.
4. Have them share their observations back in the classroom, so that all students can benefit from those who looked more closely, in preparation for the next trip outside.
5. Take students out to the site at least two more times during the period of green up or green-down. At the site repeat steps two and three above.

Discussion questions

1. Ask students to share their observations/ comparisons of their plant(s) during green-up or green-down. Encourage all students to ask questions and discuss.
2. Ask them if they have observed any patterns with their plant. Patterns could be from observations of one plant over time or between plants. List on chart paper. Make one chart for "over time" patterns and another for "among plants" patterns. Discuss.
3. Ask students how their plants are alike and different?
4. Ask students if they can make any inferences (explanations of what they think might be happening based on their observations, etc.) based on their observations of the patterns. A sample response might be "I think that the willow leaves were dying faster because they were turning colors first."

Exploration—Classification

As green up is occurring, partner the students and take them back out to the site. Have them collect ten different leaves from the site representing a variety of sizes, shapes, and colors. Bring them back to the classroom.

For beginning classifiers:

- Have students draw one line down the center of the GLOBE Science Notebook page, so they can list their observations on one side and their questions on the other.
- Give students ten minutes to observe the ten leaves that they collected. Remind them to use four senses. Record.
- Have students group their leaves into two groups based on their observations. Tell them to be ready to share their labels or attributes with the class when they are called on. Share and discuss, then have them try grouping the leaves with completely different labels.

First Look at Phenology Learning Log

Date_____ Time_____

Species 1_____ Species 2_____

Observe with your four senses (sight, touch, hearing, smell) and a hand lens. Try to use one sense at a time. Describe your observations here in pictures and words.

Leaf 1	**Leaf 2**

For more experienced classifiers:

- You may want to start right away with using Venn Diagrams (see example below) or dichotomous keys (see guidelines and examples on *Land Cover/Biology Learning Activities* on Leaf Classification). Tell students that they must include at least one quantitative label (measurement). Have students draw their classification system, such as dichotomous keys or Venn Diagrams, on a large piece of chart paper or newsprint and attach leaves in appropriate places with tape or glue. Share and discuss.

Discussion questions

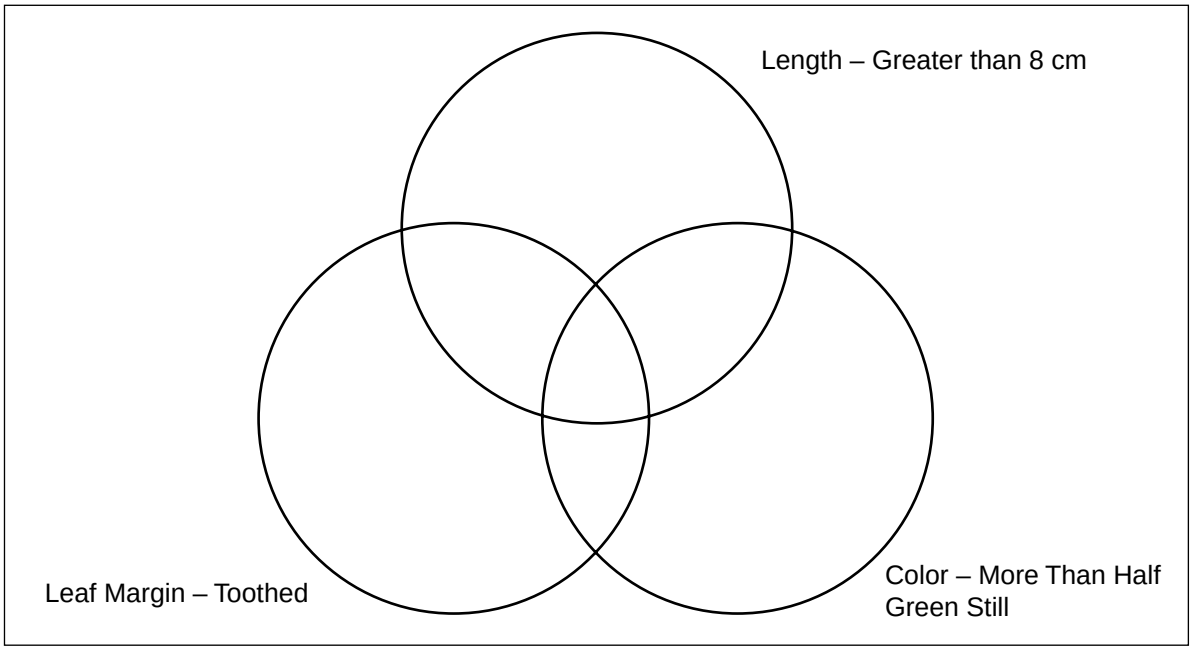
For beginning students:

- Have students share their classification strategies. Discuss.
- Ask students what patterns they can observe looking at all the charts. Discuss. Be sure they notice the timing of green up and senescence.
- Ask students to make inferences based on their observations about why there are variations in timing of green-up or green-down among plants at the same location. Be sure that students understand that timing of green-up and senescence, as well as the colors of senescence, vary among plants at the same location.
- Ask students what questions they have. Discuss.

For intermediate students:

- Ask the class if they can make any statements (generalizations) about leaves during green up/green-down based on their observation of all the leaves. List the statements made. Discuss. If there are any disagreements, have the group negotiate and reword until everyone can agree on the entire statement. Your goal here is to develop statements that are universal across observations. It may take looking again at the leaves or going back outside to settle debates. Stress that this is part of the scientific process. Compare their list of scientific statements to the list generated at the beginning of the lesson.
- Ask students if they have any ideas about why plants might change with the seasons. At this level it is enough for students to be able to say that they are getting ready for the new season.

Figure EA-2: Experienced Classifiers Venn Diagram Sample



- Ask students why they think scientists use classification. How does it help them? How can classification be useful to us in our everyday life? See *Background Materials*.

Further investigations

For beginning classifiers:

1. Have students try to classify (order) their leaves in a series (sequentially by length, width, surface area, or shades of color, etc.).
2. Next have the students check their classification by measuring their leaves with a ruler or a centimeter grid for length and width.

For more experienced classifiers:

1. Have students use a professional plant guide to key out their leaves and try to identify them. If possible invite a local plant specialist to confirm their plant identification. Use the *Error Matrix* from *Land Cover Biology Learning Activities*.
2. Give each group a branch from two local trees or shrubs. Have students come up with a list of attributes to compare how they are alike or different, such as:
   · surface area of leaves
   · firmness or toughness of either branch or leaf
   · number of leaves from a bud
   · smoothness of branch, suppleness of branch
   · color of leaves
   · number of veins
   · pattern of venation
   · number of leaves on a branch.
3. Discuss observations. Ask if there are any patterns.
4. Ask students if they have any ideas (inferences) about why the differences might exist. Ask students why it is important to recognize patterns and make inferences. Discuss. This might be a good opportunity to bring in a local plant specialist to answer questions and discuss possible causes for patterns students are observing. If none is available, there are many Web sites where they can connect with scientists.
5. Go to the GLOBE Web site and compare tree species they observed with those found in other latitudes. Are the same tree species found in other latitudes?
6. Ask students to list other possible variables (e.g. soil temperature, air temperature, day length, precipitation etc.) in the environment to monitor and make hypothesis as to why the observed changes have taken place. What variables affected the plants?

Assessment

GLOBE Science Notebook entry

Have students write and/or draw in their learning logs about:

1. Why observation and classification are important skills in science. (Have students explain the terms observation and classification and describe several good examples of why observation and classification are important in science or daily life)
2. What patterns they observed during green-up or green-down at their site including variations among the same plant species and different plant species
3. What they might infer based on their observations about how plants at their site change with the seasons and possible causes for the variations

Use the following rubric to score the writing. Students who have difficulty writing can be interviewed for understanding.

Performance Task

Have students gather ten items other than leaves from outside and classify them in two different developmentally appropriate ways (teacher's discretion). For example, young students can put items in two groups, while older students might be expected to develop a dichotomous key. This

has been presented in the Land Cover *Leaf Classification Learning Activity.*

Use the following rubric as you circulate throughout the class to score the performance task. Students who have difficulty writing can be interviewed for understanding.

Skills Checklist

Use the following checklist during the lesson to document students' skill abilities in the processes of science.

A First Look at Phenology
Skills of Science Assessment Checklist

Criteria	Student Names							
Observes carefully i.e.uses more than one sense (Exploration, Step 1)								
Correctly uses hand lens to gather information (Exploration Steps 2, 3 and 4)								
Identifies at least one pattern in plants (Discussion, Question 2)								
Records data (written or drawing of observations of plants in GLOBE Science Notebook)								
Infers reasonable causes for variations based on observations (Discussion question 4)								
Classifies in developmen-tally appropriate way (dichotomous key, Venn diagrams, or grouping)								

Assessment Rubric

A First Look at Phenology
Journal and Performance Rubric

	5	4	3	2	1
Discussion – Importance of observation and classification	Discussion shows thorough understanding of terms and several good examples of why they are important	Discussion shows thorough understanding of terms and their importance	Explanation in student's words show several ways of observation and classification and why they are important	Discussion shows understanding of the terms and some ability to discuss their importance	Discussion shows lack of understanding of terms, observation and/or classification
Discussion– Seasonal changes and possible causes	Includes thorough discussion of variations among and between plants related to seasonal change; Many inferences about causes	Includes thorough discussion of variations among and between plants related to seasonal change; Some inferences about cause	Includes thorough discussion of variations among and between plants related to seasonal change	Discussion shows some ability to apply variations observed to seasonal content	Little evidence of an understanding of how site observations are impacted by seasonal change
Discussion – Local patterns in senescence and green-up	Thorough discussion of variations among and between plants; Many inferences about causes for variations	Discussion of variations among and between plants; Inferences about causes for variations	Discussion of variation between and among at least 3 types of plants; Some inference	Missing discussion of either variation among or between plants; No inference	Some details provided but discussion shows lack of understanding of change over time
Performance Task – Constructs viable classification scheme(s) appropriate for	Constructs classification scheme correctly to classify 10 objects two different ways; No errors; Properties used show careful observation	Constructs classification scheme correctly to classify 10 objects two different ways; No more than one error; Properties used to show careful observation	Constructs classification scheme correctly to classify 10 objects two different ways; No more than one error; Properties used to show good observation	Some errors in construction of classification scheme to classify 10 objects; Properties used show lack of careful observation	Many errors in construction of classification scheme to classify 10 objects; Properties used show lack of careful observation
Performance Task – Classifies a set of teacher selected items, appropriate for developmental level.	Correctly uses dichotomous key (or grouping for younger students) with no errors	Correctly uses dichotomous key (or grouping for younger students) with no more than one error	Correctly uses dichotomous key (or grouping for younger students) with two errors	Correctly uses dichotomous key (or grouping for younger students) with 3-4 errors	Correctly uses dichotomous key (or grouping for younger students) with many errors