Lesson 13: What Is DBH?
How Do Scientists Measure Trees?

PURPOSE/QUESTION
Students will learn to measure trees which are the basis to understanding how trees sequester carbon.

GRADE LEVEL
9-12

TIME TO COMPLETE
60-90 minutes

STANDARDS
See appendix below-page 6

LEARNING OUTCOMES

- Students will develop an understanding of tree size and how scientists measure trees.
- Students will observe and measure tree cookies and explore the relationship between tree circumference and diameter.
- Students will compare the estimates of diameter made from circumference measurements (and vice versa).

STUDENT OBJECTIVES

- Observe the physical characteristics of and suggest ways to measure tree cookies.
- Measure the circumference and diameter of a tree cookie
- Based on the circle equation calculate circumference or diameter of a tree cookie
- Compare and contrast the calculated circumference and diameter values to the actual measurements.

TEACHER BACKGROUND

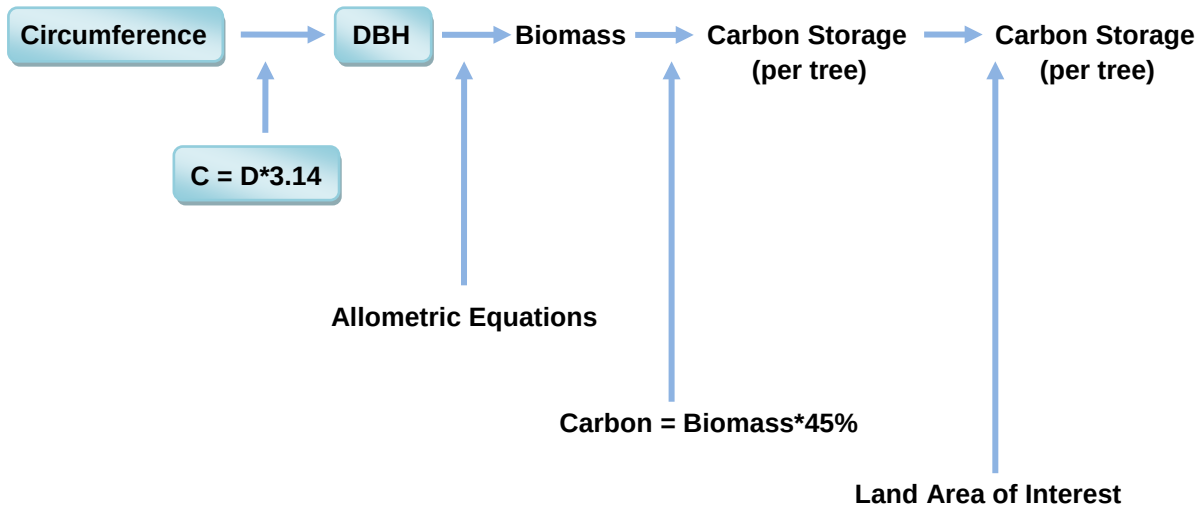
Scientists use a standard method to measure the size of trees, diameter-at-breast height (DBH), to ensure consistency over time, across plots and between data collectors. DBH means the diameter of each tree is measured at "breast height", defined as 1.35m up from the highest point of ground at the tree's base (See the *Tree Circumference Guide* for some pictorial examples). DBH measurements can be used to estimate the volume, biomass, and carbon storage of trees. Keep in mind that circumference and DBH are the first two steps in the process of understanding biomass and carbon storage in local ecosystems.

From geometry class, we know that diameter is a line that passes through the center of a circle, with the endpoints of the line located on the edge of the circle. How then can foresters and scientists measure tree diameter without cutting down the tree and measuring its cross section? Scientists measure the circumference of a tree and calculate the diameter using equation 1 shown below. Scientists sometimes use tape measures that are calibrated or adjusted for diameter based on this equation. These tapes are referred to as DBH tapes. During the GLOBE Carbon Cycle field data collection, however, students will measure tree circumference rather than diameter (due to tool restrictions); therefore it is important for them to know how circumference and diameter are related.

Teacher Background Continued

Circumference = π*diameter (where π = 3.14) or Diameter = Circumference/ π [equation 1]

Field Concepts Diagram



PREREQUISITE KNOWLEDGE & SKILLS

- Calculating average (mean) numbers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MATERIALS & TOOLS

- Several different sized tree cookies (1 per student pair)
- Flexible measuring tape (metric) (1 per student pair)
- Calculator (1 per student pair)
- Notebook and pencil (1 per student)
- Items for circumference height tool [Optional]
  - Sticks and permanent marker OR Strings and scissors (see part 2)

VOCABULARY

- Circumference
- Diameter
- DBH

ESSENTIAL QUESTIONS-PART 1

1. How do scientists measure trees?
2. What is the relationship between circumference and diameter?

PROCEDURE PART I – ENGAGE AND EXPLORE

1. Gather all materials before beginning, including student's worksheets.

2. In groups of two, select a tree cookie and complete Part 1, ***How Scientists Measure Trees. What is DBH?***

3. Class discussion of observations and suggestions for tree cookie measurement.

4. Answer essential question 1, complete equation 1, and prepare for the next step, ***Circumference vs. Diameter***.
   - Demonstrate to measure the circumference and diameter of a tree cookie.
   - Calculating averages is important to know for number 5.

5. Conduct measurements and calculations as directed on ***Circumference vs. Diameter***.

ESSENTIAL QUESTIONS-PART 2

1. What is diameter-at-breast-height? What is the importance of this measurement?

PROCEDURE PART 2 – EXPLAIN

1. Interpret the measurements and discuss answers to questions 4A-C.

2. Use question 4C to begin thinking about answering question 5, "**How might scientists (and you) use the circumference/diameter relationship to study live trees?"**

3. Discuss the standard height at which circumference (diameter) is measured, 1.35m, called diameter-at-breast-height (DBH).

4. Have a discussion about accuracy and precision. Brainstorm some ideas about what those terms mean, before going on to Part 3, ***Preparing to Measure Tree Circumference in the Field***.

ESSENTIAL QUESTIONS-PART 3

1. Explain the connection between this activity and the upcoming work to be done in the field.

PROCEDURE PART 3 – ELABORATE AND EVALUATE

1. Determine the height of 1.35m against their own body.

2. Students follow teacher directions to create a height measurement tool. [Optional]
   - Use a measuring tape or meter stick, measure out 1.35m:
     - on a stick and mark with a permanent marker

   OR

     - on a string and cut the string so it is exactly 1.35m tall

3. Perform activities to investigate accuracy and precision.

4. Create a chart or an Excel spreadsheet that is similar to you example in which to record your field work data.

**See activity example in *HowToMeasureTrees_example.xls*

TOOLS FOR ASSESSMENT

- Field Work Data Analysis – found in the Lesson 13 folder
- Concept Quiz – found on pg. 11
- Essay – found on pg. 14
- Foldables®
- Student Reading and Science Notebook Assessment Tools are found in the ***Rubrics*** folder

WEBSITES FOR FURTHER LEARNING

- Biltmore sticks
- Measuring standing trees and logs
- Forestry, Wildlife, and Trees - UNH
- Trees for Wildlife

STUDENT READING RESOURCES

- Northern Forest Affected by Global Warming
- Katrina Damage to Gulf Coast Forests
- Ground Observations Support Satellite View
- Best Climate Change Remedy? Plant Trees
- What the Ancient Redwoods Tell Us About Climate Change
- Climate Change Threatens Southwest's Iconic Joshua Trees

LESSON 13-APPENDIX

WEB ADDRESS FOR HYPERLINKS

VOCABULARY

- **Circumference**
  http://www.coolmath.com/reference/circles-geometry.html
- **Diameter**
  http://www.coolmath.com/reference/circles-geometry.html
- **DBH**
  http://forestry.about.com/cs/glossary/g/dbh.htm

WEBSITES FOR FURTHER LEARNING

- **Biltmore sticks**
  http://forestry.usu.edu/htm/rural-forests/forest-management/forest-timber-management/measuring-tree-volume-with-a-biltmore-stick/
- **Measuring standing trees and logs**
  http://pubs.ext.vt.edu/420/420-560/420-560.html
- **Forestry, Wildlife, and Trees – UNH**
  http://extension.unh.edu/FWT/trees.htm
- **Tree for Wildlife**
  http://www.nwf.org/Trees-for-Wildlife.aspx

STUDENT READING RESOURCES

- **Northern Forest Affected by Global Warming**
  http://earthobservatory.nasa.gov/IOTD/view.php?id=6487
- **Katrina Damage to Gulf Coast Forests**
  http://earthobservatory.nasa.gov/IOTD/view.php?id=8357
- **Ground Observations Support Satellite View**
  http://earthobservatory.nasa.gov/Features/BorealThreshold/boreal_threshold4.php
- **Best Climate Change Remedy? Plant Trees**
  http://www.ibtimes.com/best-climate-change-remedy-more-trees-study-says-299151
- **What the Ancient Redwoods Tell us about Climate Change**
  http://www.huffingtonpost.com/susanna-murley/ancient-redwoods-climate-change_b_900041.html
- **Climate Change Threatens Southwest Iconic Joshua Trees**
  http://insideclimatenews.org/news/20110630/joshua-tree-national-park-climate-change-science

LESSON 13-STANDARDS

National Science Education Standards

Unifying Concepts and Processes

- Systems, order, and organizations
- Evidence, models, explanation
- Change, constancy, and measurement

Standard A – Science as Inquiry

- Understandings of scientific inquiry

Standard G – History and Nature of Science

- Science as a human endeavor

National Education Technology Standards

Standard 1: Creativity and Innovation

- Use models and simulations to explore complex systems and issues
- Identify trends and forecast possibilities

Standard 3: Research and Information Fluency

- Process data and report results

Standard 4: Critical Thinking, Problem Solving, and Decision Making

- Collect and analyze data to identify solutions and/or make informed decisions.

Standard 6: Technology Operations and Concepts

- Understand and use technology concepts
- Select and use applications effectively and productively
- Troubleshoot systems and applications

National Council of Teachers of Mathematics Standards

Algebra

- Understand patterns, relations, and functions
- Use mathematical models to represent and understand quantitative relationships
- Analyze change in various contexts

Measurement

- Understand measurable attributes

Process

- Connections
  - Recognize and apply mathematics in contexts outside of mathematics

Climate Literacy Principles

Principle 1: The sun is the primary source of energy for earth's climate system.
Principle 3: Life on Earth depends on, is shaped by, and affects climate.

Energy Literacy Principles

Principle 3: Biological Earth processes depend on energy flow through the earth system.

LESSON 13-ESSENTIAL QUESTIONS ANSWER KEY

Part 1 – How Do Scientists Measure Trees? What is DBH?

1. Cylindrical like, top and bottom have rings of differing colors and widths, bark is the outer most layer, the bark has some bumps/ridges

2. Count the number of rings
   Measure circumference
   Measure diameter
   Measure height
   Weight the cookie
   Displace water to find density

Part 2 – Circumference vs. Diameter

1. Measure 1 tree cookie per group.
   a. Pull the measuring tape tightly around the tree cookie and record its circumference in the data table below. Sharing measurement responsibilities between group members, repeat the circumference measurement 2 more times on the same tree cookie.

   b. Measure the tree cookie's diameter and record in the data table. Repeat the diameter measurement 2 more times. Note: Measure the diameter in several directions across the surface of the tree cookie, as they will not be perfectly round and you want to make sure your measurements represent the overall shape of the tree cookie.

Example

	Circumference	Diameter
Trial 1	*25.2*	*7.6*
Trial 2	*25.4*	*8.0*
Trial 3	*25.4*	*7.8*
Average (1+2+3)/3	*25.3*	*7.8*

1. Calculate an average (mean) circumference and average (mean) diameter for the tree cookie.

Average (mean) = Sum all of the values ÷ by the # of values. [Equation 1]

2. Use equations 2 & 3 and the appropriate calculated averages (of circumference and diameter) to find a calculated circumference and diameter.

Calculated Circumference = π*average diameter (where π = 3.14) [Equation 2]

*C = 3.14*7.8*

Calculated Diameter = average circumference/ π [Equation 3]

D = 25.3/3.14

Example

	Circumference	Diameter
Calculated (using equation 2 & 3)	*24.5*	*8.0*

4.

a. Circumference values should be pretty close, as long as all students are practicing good measurement technique, which they may not be. Measurement accuracy and precision are discussed at greater depth in Part 3, so here just get students to examine the measurements they have made.

b. Diameter measurements will vary more widely especially if you have odd shaped tree cookies. Students will probably decide to measure diameter of the tree cookie on several different axes so the more odd shaped the cookie the more different the measurements could be.

c. Students will probably make note of the challenges they encountered when choosing how to measure diameter. Some may observe that in order to get a better average value of diameter you would want to measure the cookie on more than 3 axes, perhaps 10 or 20 measurements would get an average that would be closer to the calculated value. This would be the case because the calculated value basically assumes that the tree cookie surface is a perfect circle and does not account for bumps, ridges, growths, etc. that may exist on the tree cookie. Students may also suggest measurement error as a source of difference if you made a number of errors measuring either circumference or diameter your measured average will not be the same as the calculated value.

d. You should explain to students that when scientists/foresters want to know about the mass of trees, how much carbon they store, how many board feet they contain or how much wood product exists in a whole forest they must know at least one aspect, tree diameter at 1.35meters.

Why tree diameter? The primary reason is pretty simple; it is easier for people to conceptualize a tree with a diameter of 8cm than one that has a circumference of 24.5cm. Over the years there have been many methods developed to measure tree diameter, such as the Biltmore stick and tree calipers. The most commonly used method today, especially for highly accurate measurements that will be used in scientific studies, is the diameter tape. This is a calibrated tape where every 1inch marked on the tape is actually a distance of 3.14inches. This means that although you are measuring circumference you are reading the diameter.

Part 3 – Preparing to Measure Trees in the Field

3. b. i. *Example: Our measurements were relatively precise. All measurements were taken to the 10ths place and they were separated by only one tenth.*

ii. Example:
I think that our measurements were so similar because we pull the tape around the tree cookie using the same tightness all 3 times. We also all agreed ahead of time that we wanted to record the circumference to the nearest tenth of a centimeter.

I think there should be at least three trials completed for each measurement type. It is best to use more than two trials because if the results were different we would not know which one is more accurate.

c.

- *Follow the Tree Circumference Guide for marking 1.35m, circumference at breast height, on each tree.*
- *Re-mark any trees where the 1.35m line is fading to ensure the measurement is made at the exact same height each year.*
- *Make all circumference measurements to the nearest tenth of a centimeter.*
- *Work as a team to make sure the measuring tape is horizontal around the tree (not lower in the back where it is hard to see)*
- *Make sure there are no twists in the tape.*
- *Practice making a few measurements before beginning to record the data to make sure everyone agrees how tightly to pull the tape and knows how to read the measurement off of the measuring tape.*

- *Have the recorder repeat the measurement back to the measurer to ensure it is recorded correctly.*
- *If you have any doubt that a measurement you just made was not executed well, make the measurement again before reporting it to the recorder.*

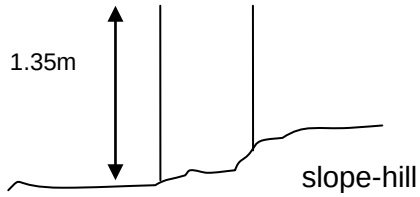
Name: _____ Date: _____

Science Concept Quiz

Lesson 13: What is DBH? Investigating How Scientist Measure Trees

When taking measurements it is important to be both **accurate**, the degree to which a measure or calculated value matches the true value and **precise**, the degree to which repeated measurements of the same object are in agreement. **Read the following scenario and decide whether or not the students used the correct procedure for measurement and were both accurate and precise when they calculated DBH.**

Rachel and Glenn chose a tree on their school grounds in which to calculate DBH. Their tree was located on a slope and had a circumference of 10cm. They made sure their tape measure was not twisted when they calculated the DBH. Rachel and Glenn performed their measurements and calculations 3 times to ensure they got the same calculation each time. They recorded their results in a chart and drew and labeled a diagram in their science notebook.



Rachel and Glenn were both accurate and precise in their measurements and calculations and used the correct methods for attaining their measurements.

A. Although Rachel and Glenn were both accurate and precise with their measurements they did not follow the correct procedure for attaining their measurements.
B. Yes Rachel and Glenn used correct methods for attaining their measurements and were both accurate and precise in their calculations.
C. No, Rachel and Glenn did not use correct methods for attaining their measurements and were not accurate and precise in their calculations.

_____ points out of 20

I. Answer

A.○ B.○ C.○

_____ points out of 15

II. What is the main concept behind the question?

1. Finding patterns in tree diameter
2. Calculating carbon storage
3. Analyzing results
4. Utilizing the scientific method correctly

_____ points out of 25

III. Provide the reasoning for choosing your answer in part II.

_____points out of 40

IV. Why are the other responses in part I not the best answer choice?

1.

2.

3.

4.

Use the rest of this page if more room is needed to fully communicate your thoughts.

Teacher Answer Key

1. A

2. 4

3. Answers will vary. Utilizing tools and following procedures are part of the scientific method and are critical to the success of an investigation.

4. Answers will vary.

   A) Rachel and Glenn were both accurate and precise because they repeated their measurements and their calculations; however the tree they chose was less than the 15cm circumference requirement and the measured DBH at the wrong location on the tree. They needed to calculate on the slope (right side of diagram).

   B) Rachel and Glenn did not follow the correct methods for measuring DBH and therefore their results are invalid.

   C) Rachel and Glenn did follow some of the correct methods just not all of the methods and so their results were not valid.

Student Name
Teacher/Class
Date

Lesson 13: What is DBH? How Scientist Measure Trees

Explain why you think scientist measure trees. What purpose does it serve? Make connections to the carbon cycle.

What Is the Expectation?

Use new lesson knowledge or student readings to support your position

Visual representations if applicable

Key vocabulary

Evidence of on grade level spelling and grammar usage