MIDDLE SCHOOL STUDENT GUIDE

THERE'S SUGAR IN GRASS?
BRIX REFRACTOMETER LAB

MATERIALS

- 1 refractometer
- 1 garlic press
- 1 soft cloth
- 1 bowl, paper bag, grocery sack (to mix grass)
- 1 collection bowl
- 1 transfer pipet
- 1 small screwdriver
- Plant material (either collected or provided by teacher)

PRECAUTIONS:

- If you are outside, make sure that you are in a safe area, and are aware of traffic or other hazards.
- Refractometers cannot be submerged in water. Water can be placed on the **prism** to clean them after use.

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LESSON OVERVIEW:

In this lesson, you will use a Brix refractometer to determine sugar concentrations in forages.

LESSON OBJECTIVES:

You will be able to:

1. Demonstrate proficiency in using a refractometer.
2. Determine the approximate amount of sugar in forages.
3. Evaluate the relationship between amount of sugar, photosynthesis and harvest time.

ESSENTIAL QUESTION:

How does photosynthesis in forages affect nutrient quality?

TOPICAL ESSENTIAL QUESTION:

Can we determine the optimal time to harvest forages to improve cattle performance?

ENGAGE:

In the space provided, draw the setup before you. Then write several sentences describing what you observe. Look at the beaker at eye level on the table, don't lift them up.

KEY VOCABULARY:

Refract
Refractometer
Quantitative
Qualitative
Glucose
Forage
Photosynthesis
Brix scale
Prism
Forages
Ruminant
Cattle Performance

ENGAGE:

In the space provided, draw the setup before you. Then write several sentences describing what you observe. Look at the beaker at eye level on the table, don't lift them up.

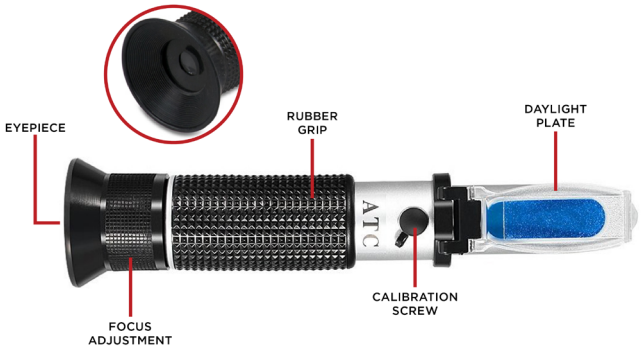
INTRODUCTION:

In this lab you will be investigating the sugar content of plant materials. Scientists and others (like you!) can use light to estimate the amount of sugars in a plant with tool called a **refractometer**. A refractometer measures how much light bends, or **refracts**, as it passes through a liquid. This angle is then used to estimate the sugar concentration in the plant, fruit or vegetable. Refractometers are used by agriculturalists, winemakers, fruit and vegetable buyers, food processers, beekeepers and many more. The refractometer uses a unit called a Brix value or score. This is one of the **quantitative** (numeric) values used to determine if a plant product (fruit, vegetable, grass) meets the standard for harvesting.

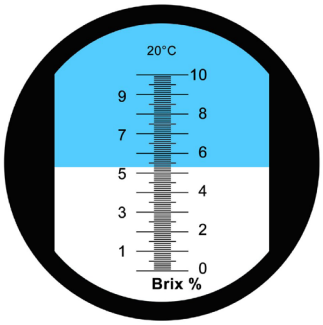
PROCEDURE:

Activity 1: Calibrate the Refractometer

1. Place two to three drops of distilled water on the prism surface.
2. Close the daylight plate so the water spreads across the whole surface without air bubbles or dry spots. Wait 30 seconds.
3. Look through the eyepiece toward a light source. You should see the graduations (the hashmarks with numbers) clearly. If you need to focus, turn the eyepiece to the left or right until it focuses. The upper portion of the field should be blue and the lower portion white.
4. Use the small screwdriver to turn the screw on the top of the refractometer until the blue field and white fields meet at zero (bottom of the scale).
5. Clean the plate with a soft, damp cloth before placing another sample on the prism.



Parts of a Refractometer



Reading a Brix Scale

https://www.kibeland.com/products/pd_31

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Activity 2: Practicing Reading the Brix Scale

1. Make sure that the refractometer has been cleaned with a soft, damp cloth if used before.
2. Place two to three drops of the sugar solution on the prism surface.
3. Close the daylight plate so the water spreads across the whole surface without air bubbles or dry spots. Wait 30 seconds.
4. Look through the eyepiece toward a light source, and read the scale to determine the Brix reading (where the blue field and white fields meet). Record your information in Table 1.
5. Clean the refractometer with a soft, damp cloth.
6. Repeat steps 2-5 for each sugar solution.

Table 1: Brix Reading of Sugar Concentration in a Solution

Sugar Solution	Brix Reading	Actual
1		
2		
3		
4		
5		

Activity 3: Taking the Brix Measurement of Forage

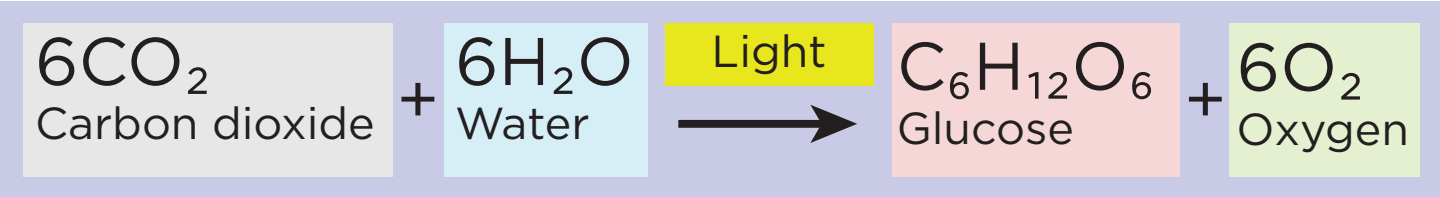
Record the sampling information (location, time of day, etc.) in Table 2

1. Select samples from plants that are healthy and are free of dirt and moisture. If necessary, dry with paper towel. Try to use only one variety or plant at a time (collect all alfalfa or all Bermuda grass).
2. Grasp a handful of the plant you have selected to sample from the approximate height that the animal would graze and tear them off the stem.
   a. If the plants are taller than 6 inches, take the top 4-6 inches of leafy materials.
   b. If the plants are shorter than 6 inches, remove the top 4-5 inches leaving 1-2 inches on the plant.
   c. Gather all the plant material together in a large container, then mix well.
3. Place a sample of mixed plant material just larger than the bowl of the garlic press. You will need to press the plant material down to fit inside the bowl. Hold the garlic press over the collection bowl and firmly press the handle down to squeeze the sap from the plant materials. Collect the sap.
4. Use a plastic pipet to transfer two to four drops of sap onto the daylight plate.
5. Close the sunlight cover and point the refractometer toward the light source. Focus the eyepiece by turning the ring to the right or left. Locate the point on the graduated scale where the blue and white fields meet. Record this reading in Table 2.

Table 2: Brix Readings in the Field

	Sample 1	Sample 2	Sample 3	Sample 4
Location				
Time of Day				
Temperature				
Weather Conditions (cloudy, humid, windy, etc.)				
Plant Sampled				
Brix Reading				

EXPLAIN:



Photosynthesis is one of the most important chemical reactions on our planet. Without it, life on Earth wouldn't be possible. Plants, algae and some bacteria are able to utilize this reaction to make their own food, **glucose**, while animals must eat food to obtain glucose. Glucose is a sugar that all living things use to fuel a process called cellular respiration. **Cellular respiration** is the process that provides cells with the energy they need to function. While it seems like a simple process, it's actually quite complex, with many factors playing into the successful creation of glucose, including the quality and quantity of light available, temperature, nutrient and water availability.

Plants photosynthesize during the daytime hours by taking in water and carbon dioxide to produce glucose. At the same time, the plant is undergoing cellular respiration to sustain life. The plants must create enough glucose during the daytime hours to both respire throughout the day and store enough glucose to provide energy throughout the nighttime hours.

One of the other factors that affects the photosynthesis process is the quality and quantity of light. Light is a type of energy that exists in waves. White light, like the sun, is actually made up of different colored wavelengths including red, yellow, orange, green, blue, indigo and violet (ROY G BIV). When white light strikes an object, it will absorb all the light except the colored wavelength that we see. That color wavelength is reflected off the surface, which is why we see specific colors. When plants photosynthesize, they are using all the wavelengths of light except green. This is why plants look green.

It is important to understand the photosynthetic process because it is critical for the growth and reproduction of plants. This is at the heart of the global agricultural system -- the one that provides food, clothing, shelter and fuel to everyone on the planet.

ELABORATE:

From an agricultural standpoint, it is important to realize that rates of photosynthesis will vary throughout the day. Levels of photosynthesis activity are lowest in the early morning and are highest in the late afternoon hours, around 6 p.m. This is an important piece of information for ranchers. Livestock like cattle eat forages, grasses, grains and **legumes** (plants like clover and alfalfa) to gain weight. Cattle are **ruminants**, meaning they have a divided stomach that contains microbes that break down food to release nutrients that are needed for growth. The more nutritious the forage, the better the cattle will perform. Research has shown that cattle that are fed a diet higher in plant sugars gain weight and produce milk in greater quantities (**cattle performance**). This means that if ranchers are growing grass to make hay, mowing in the late afternoon will produce a better forage. It should also be noted that sugar concentrations within the plant will vary from the bottom to the top of the plant. The top of the plant will have more sugar than the bottom.

While the Brix score is widely used in agriculture, it only provides an estimate of the amount of sugars in a plant. The estimates can range widely depending on environmental factors like barometric pressure, temperature, moisture, time of day, fertilization, crop species and maturity of the plant. Most professionals will use the Brix value in conjunction with other, more **qualitative** (visual, non-numeric data) methods to determine a plant product's readiness.

EVALUATE:

1. What might cause differences in Brix values between two plants of the same species in the same pasture?

2. What factors can affect the Brix value of a plant?

3. Why do you think sugar values vary between parts of the plant (leaf, upper stem, lower stem, roots)?

4. How do you think refractometers can be used in the agricultural industry?

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