the botany of desire

Based on the book by Michael Pollan

the taste of apples (sweetness)

What is sweetness, and how do we define it? In this lesson, students measure and compare the sweetness of different kinds of apples and some common artificial sweeteners. They also discuss the role that our desire for sweetness may have played in the apple's proliferation and popularity.

the taste of apples (sweetness)

overview

What is “sweetness?” How do you define it? A fruit’s sweetness varies not only with its age (ripe vs. unripe) but also with its type, or cultivar. A cultivar is a type of plant with desired characteristics that growers have created by breeding and then maintained by cultivation. So, cultivars of the same plant have different characteristics; using apples as an example, Red Delicious are sweeter than Granny Smiths or Lady Apples (Figure 1).

This lesson has your students create a scale that will allow them to measure and compare the sweetness of several types of apples, a non-sweet plant (potato) and a popular, sugar-sweetened soft drink.

Figure 1: Ten varieties of apples that vary in sweetness. Photo credit, Brian R Gantick/Monell Chemical Senses Center

We give ourselves altogether too much credit in our dealings with other species.

– Michael Pollan,
The Botany of Desire

objectives

Students will:

- Invent an "Apple Sweetness Scale" by tasting and rating ascending concentrations of sucrose (table sugar).
- Taste and rate at least four different varieties of apples, as well as a potato and a sugar-sweetened soft drink.
- Discuss:
    - why sugar tastes sweet.
    - the role that sweetness has played in the proliferation of the apple and its popularity.
    - the pros and cons of Michael Pollan's hypothesis that the evolutionary success of the apple is a result of its ability to satisfy the human desire for sweetness.

grade level: Grades 5-12

subject areas:

Physical Science, Life Science, Biology, and Chemistry

National Science Education Standards

Science National Content Standard 1: Science as Inquiry

As a result of activities in grades 9-12, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Science National Content Standard 2: Physical Science

As a result of their activities in grades 9-12, all students should develop an understanding of:

- Structure and properties of matter

Science National Content Standard 5: Science and Technology

As a result of activities in grades 9-12, all students should develop:

- Abilities of technological design
- Understandings about science and technology

Science National Content Standard 7: History and Nature of Science

As a result of activities in grades 5-8, all students should develop understanding of:

- Science as a human endeavor
- Nature of science
- History of science

materials needed

- Four to ten different types of apples (See Figure 2.)
- Potatoes (Russet is the preferred variety.)
- One 8-oz bottle of sugar-sweetened soda such as Coke or Pepsi
- Five concentrations of sucrose solution (1, 4, 6, 8, and 10%), made with table sugar and water (See instructions for preparation below.)
- Seven small (5-oz) cups per student, labeled as described below
- Data collection sheets (Reproducible 1)
- Bottled water
- Napkins
- Clips from the film The Botany of Desire (available online)

Figure 2: Students will rate sugar solutions, apples, a potato, and a sugar-sweetened soft drink. Photo credit, Brian R. Gantick/Monell Chemical Senses Center

before class starts:

Prepare five sucrose solutions (instructions below).

PROCEDURE:

1. With a clean 1000 mL graduated cylinder, measure out 900 mL of water and pour it into a clean beaker. Add 100 g of sugar. Stir to mix well and add additional water to bring the final total volume to 1000 mL. This will give you a 10% sucrose solution.
2. Repeat the steps above, making four additional solutions, adding:
   - 920 mls of water and 80 grams of sugar (8%),
   - 940 mls of water and 60 grams of sugar (6%),
   - 960 mls of water and 40 grams of sugar (4%), and
   - 990 mls of water and 10 grams of sugar (1%)
   - Remember to add additional water to bring the total volume to 1000 mL for each solution.
3. Pour solutions from each graduated cylinder into individual labeled cups (about 5 ml per cup). Each student should have seven cups total: one cup with plain water (cup 1), five cups containing the ascending sucrose concentrations (1, 4, 6, 8 and 10% sucrose; cups 2 through 6), and one cup of sugar sweetened soft drink (cup 7).

estimated time needed

60 minutes

background

The apple has long been a popular fruit around the world. A surprising fact about apples is that most taste bitter when picked from a tree grown from apple seeds rather than from grafts. Eighteenth and nineteenth century Americans grew bitter apples in abundance and used them to make one of the most popular beverages of the day: alcoholic or ("hard") cider. The fabled Johnny Appleseed helped to propagate the hard-cider apples by planting many apple seedlings. But, although they occur rarely in nature, sweet-tasting apples have become the ones most favored by humans, sometimes at the expense of varieties that aren't as sweet. Sweetness is a biological desire that's inborn in all human beings, so sweeter apples appeal more broadly than less sweet apples.

The perception of sweetness starts on our tongues. If you look on your tongue, you will see pink bumps called taste papillae. Inside the papillae are taste buds, which are onion-shaped structures that contain taste cells. The taste cells on our tongues help us gauge the saltiness, sourness, sweetness, acidity, and savoriness of foods and drinks. When sweet molecules from foods and beverages bind to receptors on the tongue, they fit together like a lock and key. Once the sweet receptor is stimulated, a series of biochemical steps take place in the taste cell that results in an electrical signal. Nerves convey this signal to the brain where it is interpreted as sweet. Sugars are not the only compounds to stimulate the sweet receptor. For instance, man-made compounds like saccharin also stimulate the sweet receptor. Babies are born liking sweet; this innate preference is thought to have evolved because sugars are a simple and safe source of calories. Sweetness is not an all-or-nothing experience; rather, it is a matter of degree. Apples or drinks can have a range of sweetness.

Note to Teachers: To view the movie clips referenced in these steps, please go to this lesson plan's page on The Botany of Desire website at **http://www.pbs.org/thebotanyofdesire/lesson-plan-sweetness.php** *and choose the clip from the video player.*

Sweetness Discussion:

As a class, view Clips 1 – 3 from *The Botany of Desire* and briefly discuss the concepts explored in the clips. What is the purpose of sweetness? How has the successful dissemination of apples throughout the world been related to sweetness? Is there such thing as too sweet?

Have your students try to express to each other how much sweeter soda is than an apple. Ask them if they think their taste preferences have changed as they have grown older, and if so, to speculate why that has occurred.

Before tasting begins, have your students first drink plain water to cleanse their palates.

Create a baseline for sweetness by having students taste the 10% sucrose solution (cup 6) and assign this level of sweetness a score of 100 on a sweetness scale. Have the students taste plain water (cup 1) and assign it a score of 0 on a sweetness scale.

Have students taste the 1, 4, 6, 8% sucrose solutions and using numbers from 0 to 100, rate the sweetness of each solution. They should record their ratings on their data collection sheet. Then provide students with slices or chunks from at least four different varieties of apples, a slice of potato, and 5 ml of a sugar-sweetened soft drink to taste (cup 7) and have students rate according to their sweetness. Your students should rate each item in relation to the sucrose solutions by assigning it a number. They may re-taste the sugar solutions to refresh their memories at any time. Some students may rate the sugar-sweetened soda as higher than 100.

See the example scale of sweetness ratings (Reproducible 2) obtained from a class of 10th-grade students below.

With students' individual assessments complete, prompt them to think about why we have so few cultivars of apples in our grocery stores, as well as how our choices of apples in the grocery store relate to their levels of sweetness.

Encourage students to share their observations on the experience. They are likely to point out differences in the sweetness of natural foods and the soda, and to talk about how sweetness is influenced by context, i.e., sweet seems different in an apple than in a sugar water solution. How does the color of the apple influence their perception of sweetness? Ask students to speculate on the growing expectation and tolerance for sweeter tastes such as sugar-sweetened soda.

Ask students to discuss the role that sweetness has played in the popularity and distribution of the apple across North America. Provide the following prompts:

- How is sweetness responsible for changing apple distribution from the mountains of Kazakhstan to all over North America?
- If the apple is so widely distributed, why are there so few varieties of apples on grocery store shelves in America?
- Has human desire for sweetness assured or endangered the survival of apples into the future?

Assessment

Discussion Questions:

Ask the following questions of your students and discuss their answers:

- What is the purpose of sweetness?
- Have our taste preferences as a species influenced our choices of what we eat?
- Have our choices of what we eat affected what is grown commercially?
- How has sweetness impacted distribution of apples and other fruits?

Extensions & Adaptations

- Explore more deeply the role that sweetness has played in the distribution of plants in the world. (*The Botany of Desire* by Michael Pollan is an excellent resource on this topic.)
- Explore the history of John Chapman (Johnny Appleseed) by viewing Clip 4 from *The Botany of Desire* and reading relevant excerpts from the book. What is the myth and what is the reality of Johnny Appleseed? Why was John Chapman so successful at distributing apple trees?

References

- Nelson G, Hoon MA, Chandrashekar J, Zhang Y, Ryba NJ, and Zuker CS. Mammalian sweet taste receptors. *Cell* 106: 381-390, 2001.
- Pollan, Michael. *The Botany of Desire: A Plant's-Eye View of the World.* New York: Random House, 2001.
- Reed DR, Tanaka T, and McDaniel AH. Diverse tastes: Genetics of sweet and bitter perception. *Physiol Behav* 88: 215-226, 2006. Available without charge on the Internet: http://www.ncbi.nlm.nih.gov/

Credits

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REPRODUCIBLE 1: Data Collection Sheet

Name_____

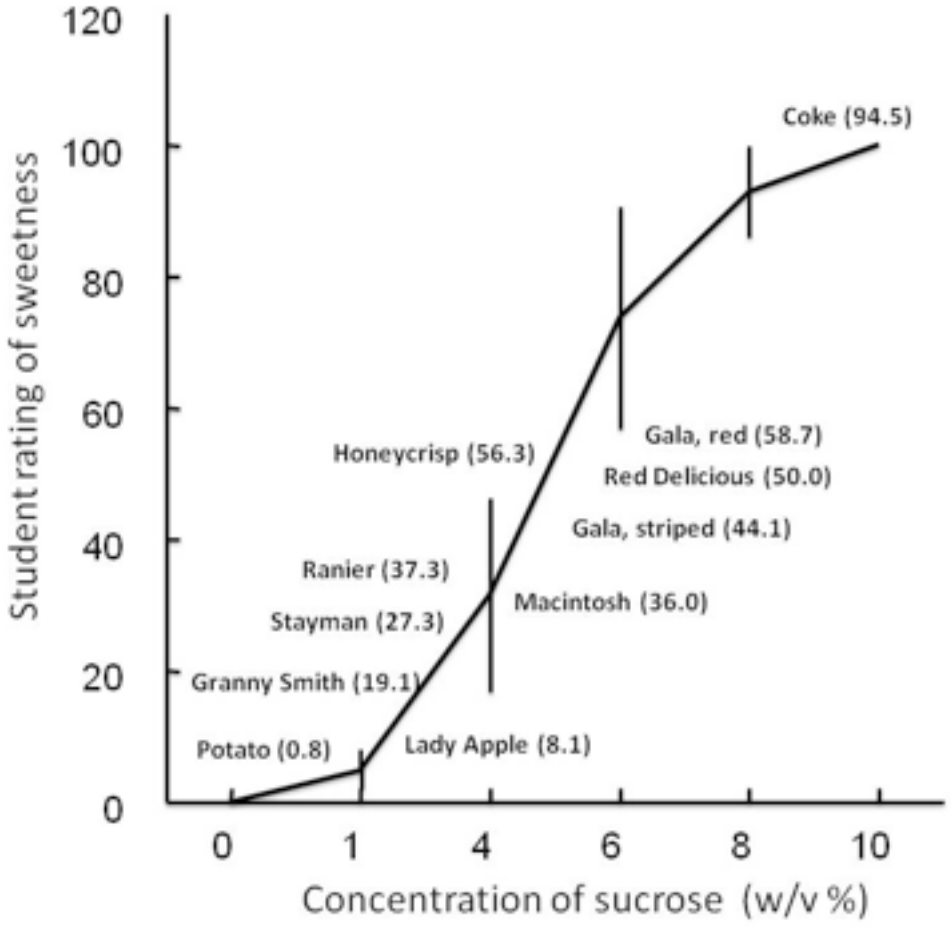
Date_____

Time_____

Cups	Rating
1 (plain water)	0
2 (1% sucrose)	
3 (4% sucrose)	
4 (6% sucrose)	
5 (8% sucrose)	
6 (10% sucrose)	100

Apple Rating
Red Delicious
Macintosh
Gala (striped)
Fuji
Gala (red)
Honeycrisp
Stayman
Granny Smith
Lady apple
Potato
Cup 7 (Coke or Pepsi)

REPRODUCIBLE 2: Sweetness Rating Scale



Sweetness scale data collected from 5 adults and 16 students. Line represents the average values (vertical bars are standard deviations) of the ratings by subjects sampling a range of sucrose concentrations. The scale was fixed at 0 for plain water and at 100 for 10% sucrose therefore no standard deviation bars are shown for those points. The ratings of each of the apple varieties as well as the potato and sugar-sweetened beverage are marked on the graph, with the average value in parentheses.