Acids, Bases, and Tooth Decay
Lan Huong Lai

Grade Level: 8th graders

Class size: 30-40 students in groups of 4-5

Class sessions: 2-3 (2 hours each)

Introduction:
Tooth decay, or dental cavity, is a common health problem and it is only second in prevalence to the common cold. About 90% of people in the US have at least one cavity and that 75% of people had their first cavity by the age of 5. Tooth decay is usually caused by plaque bacteria. These bacteria convert the sugars we eat into lactic acid. It is the buildup of lactic acid that dissolves the enamel, or outer surface of the tooth. The increase in acidity of the mouth will cause the pH to drop. Saliva helps protect our teeth by buffering our mouth with carbonate ions to neutralize the acid thus maintaining normal pH levels. We will model tooth decay in this lab using chicken bones, since bones have a very similar chemical make up to teeth, and acidic drinks. Students will also get a chance to test and measure what kinds of sugary foods cause the pH in their mouth to drop.

Objectives:
Upon completion of the activity students will able to:
1. Understand acids, bases, and how they relate to pH
2. Know how to use pH paper to get the pH of different liquids
3. Relate acidity to tooth decay

Summary:
Students will learn about how acidity causes tooth decay. The students will be introduced to acids and bases on the first day. There will be labs for students to test the pH of different liquids. Students will learn how to use pH strips to determine the pH of a solution. The students will learn how the saliva in our mouths has carbonate ions that neutralize the acids that we drink to protect our teeth from degradation. For the lab activity students will place chicken, which have a similar chemical composition to human teeth in liquids with different pH’s for about five days. Students will observe how acidic drinks can change the appearance and texture of the chicken bones. In addition, students will also evaluate the how different sugary foods change the pH in their mouth by recording pH levels of their mouth after they eat/drink a sugary food.

Sources:
www.faqs.org/health/topics/96/Tooth-decay.html
phpa.dhmh.maryland.gov/oralhealth/docs1/intermediate-activity-acidandyourmouth.pdf
Key words
Acid: a substance that can donate hydrogen ions
Base: a substance that can accept hydrogen ions
Indicator: a material that has the property of changing color in the presence of an acid or a base
Neutralization: the chemical reaction between an acid and a base that results in both substances losing their distinctive properties
pH: a scale that measures the concentration of hydrogen ions in solution
Enamel: hard mineralized surface of teeth
Tooth Decay: is the destruction of the enamel

California Eighth Grade Science Standards:
Chemical reactions are processes in which atoms are rearranged into different combinations of molecules. As a basis for understanding this concept:
• Students know reactant atoms and molecules interact to form products with different chemical properties.
• Students know how to determine whether a solution is acidic, basic, or neutral.

Materials:
Chicken bones
Plastic containers
pH strips
Sodas (Pepsi, Coke, sprite)
Orange Juice
Red bull
Gatorade
Monster
NOS
Lemonade
Sodium Bicarbonate
Vinegar
Solo cups
Dixie cups
Toothbrushes
Toothpaste
Gloves

Day 1:
Show PowerPoint presentation on acids and bases (Acids, Bases, and You worksheet)
  Demonstration: show how indicators and ph papers works
  Blowing into a basic solution with indicator
Show pH scale of different liquids
Talk about neutralization reaction
  Demonstration: vinegar and sodium bicarbonate
Introduce the anatomy of a tooth
Talk about how acids cause tooth decay
Go into detail about the protective role of saliva
Start Chicken Bone Lab activity
Pass out No Bones About It worksheet

Chicken Bone Lab
1. Split students into groups of four and have them pick their roles
   a. Weigh person: person that weighs the chicken bones
   b. pH person: person who takes the pH of liquids using pH paper
   c. Neutralizer person: person who will neutralize the reaction
   d. Data Recorder: person who records data and observations for the group
2. Let them choose what liquid they want to use for their experiment
3. Allow them to hypothesize what will happen to their chicken bone in their chosen liquid
4. Pass out two chicken bones to each group and have students wash and dry chicken bones
5. Have students weigh the chicken bones and then place the chicken bones in the liquid

Day 2:
Have a class discussion about food and how different types of food affect teeth. Make sure to discuss sugary foods. Ask students what happens to their teeth if they eat sugary foods.
1. Explain that the students will be doing an experiment today to see how sugary foods affect their teeth. Divide the class into groups of 4 students for the experiment.
2. Give each student water to drink before the experiment to neutralize the pH in their mouths. Have each student test their mouth with pH strips to find the starting pH level. Record on activity sheet.
3. Distribute one sugary snack to each group (check food allergies beforehand). Each group will only test one type of food. Let students predict which food will have the greatest effect on their teeth. Give each group a few minutes to eat their food.
4. Once the food is eaten, have the students test their mouths again using the litmus paper. Have the students record their pH levels every 5 minutes for the next 30 minutes. In groups, have the students discuss what the food is doing to their mouths.
5. After 30 minutes, distribute a cup of soda to each student and give them a few minutes to drink the beverage. Have the students record their pH levels every 5 minutes for the next 30 minutes. In groups, have the students discuss what the food is doing to their mouths.
6. Have the students drink a cup of water and record the pH levels. Then give the students time to brush their teeth and have them record the last pH level in their activity sheet.
7. Gather the class together for a group discussion to discuss how the food affected their mouth. Talk about acid attacks and how sugary foods mix with plaque in the
mouth to produce acid that can cause tooth decay. Discuss which foods produced the most acid.

**Day 3:**
Have the students finish up their chicken bones lab:
- The bones will be taken out of the liquid, washed, dried
- The weigh person will weigh the bones
- The pH person will take the final pH of the liquid
- The sealant/neutralizer person will neutralize the liquid to a neutral pH
- The Data recorder will make observations about the conditions of the bones after being in the liquid

Have a class discussion about the lab
Have each group talk about their conclusions
Take out egg from soda and discuss what happened to the egg
Wrap up the lab by talking about how to take care of teeth
Acids, Bases, and You

1. Properties of an Acid:
   a. pH _________ _________ 7
   b. Neutralizes __________
   c. Forms ___________ ions in solution
   d. ________________
   e. Tastes _____________

2. Properties of a Base:
   a. pH _________ _________ 7
   b. Dissolves __________ and ___________
   c. Neutralizes ______________
   d. Forms ___________ ions in solution
   e. ________________
   f. Tastes ________________

3. A ph scale measures how _____________ or _____________ a substance is.

4. A ________________ reaction is a reaction between an acid and a base to produce salt and water.

5. A ________________ is a _____________ substance produced from a reaction between an acid and a base.
6. Cavities or tooth decay are caused by:

7. The **enamel** is the __________ layer of the tooth.

8. The mineral that make up the enamel is called ________________.

9. ________________ is when hydroxyapatite **dissolves** and the ions separate and go into solution in the saliva

10. ________________ is when ions **come together** to form new hydroxyapatite.
No Bones About IT!!!

<table>
<thead>
<tr>
<th>Roles</th>
<th>Name of Group Member</th>
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<tbody>
<tr>
<td>Weigh Person</td>
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<tr>
<td>pH Person</td>
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<tr>
<td>Neutralizer Person</td>
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<td>Data Recorder</td>
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Name of liquid chosen: ______________________________________

Initial pH of Liquid: ______________________________________

Sugar Content of your liquid: __________________________

Initial Weight of Chicken Bones:

1.

2.

Describe the texture, color, feel of the chicken bones (hard, brittle, bendy, gray, soft...etc.):

What do you think your chosen liquid will do to your chicken bones?
Rotting Bones!!

Final pH of liquid: _______________________

<table>
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<tr>
<th></th>
<th>Dry chicken Bone (1)</th>
<th>Neutralized Chicken Bone (2)</th>
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<tr>
<td>Final weight</td>
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<tr>
<td>Initial weight</td>
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<tr>
<td>Difference in weight</td>
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1. Describe the texture, color, feel of the chicken bones (hard, brittle, bendy, gray, soft...etc.):

2. What happened to your chicken bones in the liquid? (Use words such as hydroxyapatite, enamel, sugar, acid, pH...etc.)

3. Did the neutralization help the bone from decaying or changing? Why? (Use words such as hydroxyapatite, enamel, sugar, acid, pH...etc.)
This experiment demonstrates how sugary foods and drinks mix with plaque in your mouth to create acids that can cause tooth decay.

Materials:
- Water bottles
- Dixie cups
- Sugar snacks
- pH paper strips
- Timer
- Activity Sheet
- Sugary drinks

Procedure:
1. Everyone in your group should drink a cup of water and then take the initial pH of their mouth. Note this pH in the activity sheet.
2. Get your sugary snacks from the teacher. Each student will have one sugary snack and start eating the snack.
3. Once each student has finished eating their snack. Make sure not to drink water. Start the timer.
4. Begin to take the pH of your mouth every 5 minutes for 30 minutes. Make sure to record this on the activity sheet.
   a. Graph your data on the graph paper while you wait
5. After 30 minutes, get your soda from the teacher. Everyone should have one cup of soda.
6. Make sure every finishes their drinks and begin the timer.
7. Begin to take the pH of your mouth every 5 minutes for 30 minutes. Make sure to record this on the activity sheet.
   a. Graph your data on the graph paper while you wait
8. After 30 minutes, everyone in your group should drink a cup of water and record the pH.
9. Everyone should brush their teeth and final pH reading. Remember to note all of your pH recordings in your activity sheets.
Name: ______________________________ Period: ___________ Date: ___________

Activity Sheet

Starting pH level: __________ Type of Sugary snack eaten: __________________

<table>
<thead>
<tr>
<th>Time</th>
<th>pH of your mouth</th>
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<tr>
<td>5 minutes</td>
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<td>10 minutes</td>
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<td>30 minutes</td>
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How do you think your sugary snack will affect the pH of your mouth?

What do you think the sugary snack is doing to your teeth right now?
Type of soda: ___________________ 😊

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<th>Time</th>
<th>pH of your mouth</th>
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How do you think the soda will change the pH of your mouth?

What do you think the soda is doing to your teeth?

<table>
<thead>
<tr>
<th>pH levels</th>
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<tr>
<td>After you drink water</td>
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<tr>
<td>After you brush your teeth</td>
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How do you think toothpaste protects your teeth?
Graph the change in pH of your mouth with the sugary snack:

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<th>Time 1</th>
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<th>Time 4</th>
<th>Time 5</th>
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Graph the change in pH of your mouth with the sugary snack and drink:

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<th>Time 4</th>
<th>Time 5</th>
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