Food for Thought...

The food you eat can affect your body in many ways. In this exercise, you will learn about how the food you eat can affect the acid/base balance of your body!

Acid vs. Base

An acid is a compound that **dissociates** (or breaks apart) in water to give hydrogen (H^+) **ions** (or charged molecules). Strong acids completely dissociate, whereas weak acids only partially dissociate. This means that not every molecule breaks apart.

Acid

A base is a compound that can ionize in water to give hydroxide ions (OH^-). You can test whether a solution is acidic or basic by measuring the concentration of H^+ ions in a solution. This will tell you the pH of the solution.

What is pH?

The pH scale tells you how acidic or basic something is. Substances with a pH < 7 are more acidic and those with a pH > 7 are more basic.

The pH scale is a log scale. This means that for every decrease in whole number, there is a ten-fold change in the acidity of the solution. For example, a solution that is pH 3 is ten times more acidic than a solution of pH 4 and 100 times more acidic than a solution of pH 5 (10 x 10 = 100).

Q: How many times more acidic is cola compared to milk if cola is pH 3 and milk is pH 7?_____

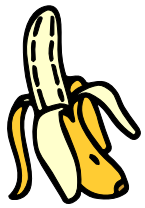
pH of Foods

Just as foods and drinks you eat come in all shapes and sizes, they also have very different pH values.

Lemons: pH 2

Corn: pH 7

Banana: pH 5



Foods also contain acid and base **precursors**. A **precursor** is something that comes before something else, or in science, it can be a substance that is eventually converted into another substance. Some examples of precursors are:

- A seed is a precursor to a plant
- Food is a precursor to energy it produces in your body

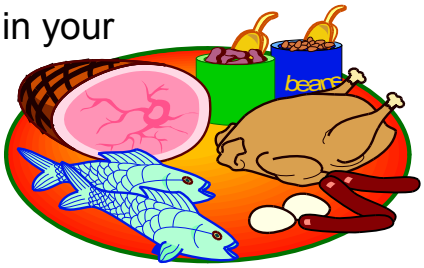
Can you name some other examples of precursors?

In the next few pages, we will learn what foods contain acid and base precursors. We will also learn why it is important to eat a balanced diet to maintain acid/base balance and how your body's pH can affect the health of your bones.

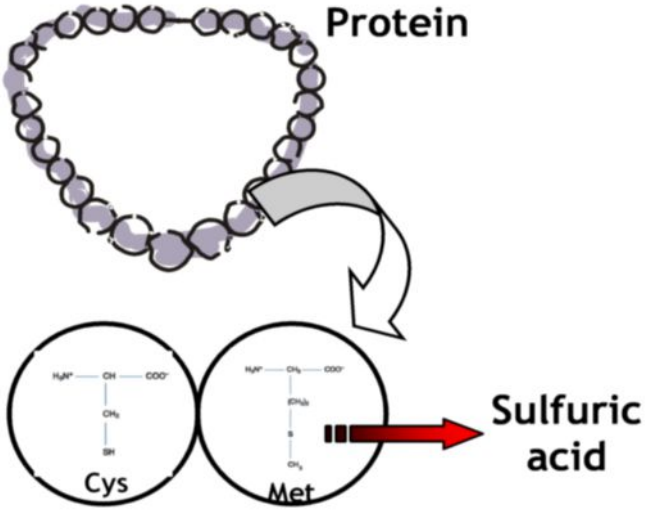
Precursors...

Acids

Acid and base precursors in foods we eat can change the pH of our body. Protein contains mostly acid precursors. Proteins are made up of building blocks (**amino acids**) and some of these building blocks contain sulfur. Sulfur is an acid precursor because it is converted to sulfuric acid in your body.



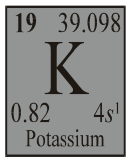
Protein from animal foods has more sulfur than protein from vegetable foods. So, if you eat a lot of animal protein (chicken, steaks, hamburgers, ham), then your body is producing more acid than someone who eats foods with vegetable protein.

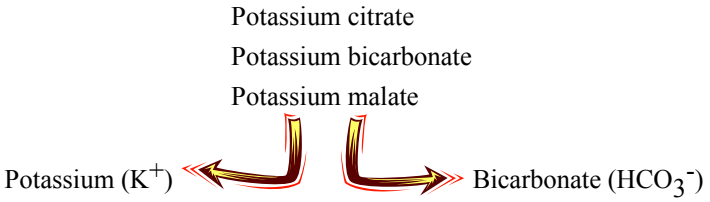


In the figure above, the necklace represents the amino acid building blocks of protein. Two of these amino acids are cysteine (Cys) and methionine (Met). These sulfur-containing molecules contribute to acid production in the body.

Bases

Certain foods, such as vegetables and fruits, contain base precursors. A good way to determine how many base precursors are in a food is to look at the potassium content of the food. Potassium has a positive charge and it is attracted to negatively charged molecules that are base precursors. Many of the negatively charged molecules associated with potassium are converted to bicarbonate, which is a base.





In the figure above, different forms of potassium compounds found in foods are shown. The body breaks these compounds down to potassium and bicarbonate, which is used to neutralize acid. The majority of excess bicarbonate is stored in bone. So, if you often eat meals with more acid precursors than base, your body can take HCO_3^- from the stores in bone. While this helps to neutralize acid, it also contributes to bone loss.

A Balanced Diet

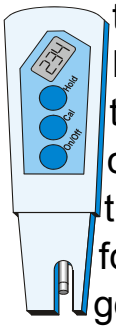
Eating a balanced diet is important so the body does not have to take HCO_3^- stores from bone. It is important for our body pH to stay within a certain range, or else many things can go wrong. In the next lesson, you will learn why lower pH in the body negatively affects your bones.

Experiments You Can Try...

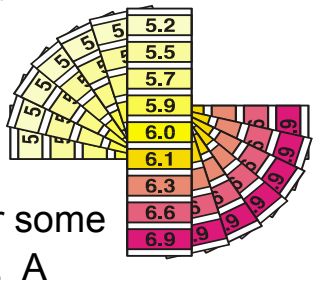
Experiment #1

Learning Objectives:

1) To learn about and compare 2 different methods of measuring pH.
2) To determine how much bicarbonate is necessary to neutralize cola.



Just because certain foods have a low pH doesn't necessarily mean that they will lower the body's pH if you eat them. Why? Because many of the acids in foods are broken down in the body to neutral compounds. Certain foods, however, contain either precursors to acids that are produced in the body (for example - proteins, as we learned earlier) or some foods contain acids that are not broken down by the body. A good example of this is the acid in colas (phosphoric acid).



There are many different ways to measure pH. Scientists often use a pH meter (pictured to the left) or pH paper (litmus paper - pictured to the right). pH paper is a special type of paper containing a chemical that will tell you the pH of a solution by the color it turns when it is dipped into the solution. Certain foods also contain chemicals that will change color when the pH of the food is changed. One example is red cabbage. The cabbage is red because of the chemical **anthocyanin**. This same compound is found in apple skin, grape skin, and plumbs. When anthocyanins are exposed to acidic conditions, they will appear pink. Neutral solutions will appear purplish, and basic solutions are yellowish-green.

Since we learned earlier that base precursors are broken down to bicarbonate in the body, we will use bicarbonate in this experiment to determine if we can neutralize the acid in cola.

Can you make a **hypothesis** (an educated guess) as to what you think will happen?

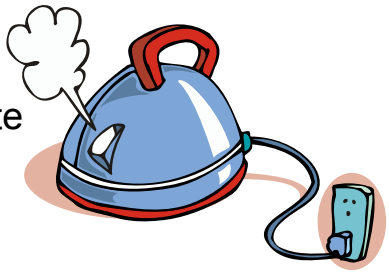
My hypothesis:_____

_____

Materials & Methods

You will need:

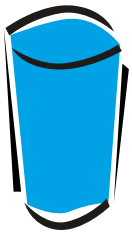
-1 can of cola (12 oz)
- pH paper (can be purchased at teaching supply stores, pharmacies, and some health food stores)
-Sodium bicarbonate (baking soda)
-3 glass (or plastic) cups
-Spoon for mixing
-1 red cabbage head
-Large pot for boiling
-Bowl
-Strainer
-1/4 teaspoon for measuring bicarbonate
-Boiling water
-Measuring cup



1. Break off the leaves of the red cabbage and place in enough boiling water to cover the leaves. Boil until leaves turn green and the water turns dark purple (about 10 min). Strain out the leaves and pour water into a bowl. Pour approximately 1/2 cup of cabbage water into 2 glasses (1/2 cup in each glass).

2. Put 1/4 cup cola into one of the cabbage water glasses.

3. Observe the color change of the juice in this glass compare to the glass of cabbage juice without cola.



Observations

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4. Now pour 1/2 cup cola into an empty cup and measure the pH by dipping one end of the pH paper into the cola. Quickly remove the paper and compare the color of the paper to the color on the pH paper container to determine the pH.

What is the pH of the cola?

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2. Place one 1/4 teaspoon of sodium bicarbonate in the cup with the cola and stir with a spoon. Measure the pH. Continue to add sodium bicarbonate (if necessary), one 1/4 teaspoon at a time, until the pH is neutral (pH 7).

How many teaspoons did it take to neutralize the cola?

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Food for Your Bones...

In this exercise, you will learn about how the food you eat can affect the health of your bones!

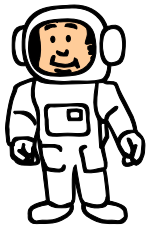
How does pH Affect Bone?

Let's use what you learned from the previous exercise to find out what happens to bone when the pH of the body decreases (becomes more acidic). Bone is a very large **reservoir** for bicarbonate in the body. A **reservoir** is a large or extra supply of something. *Can you name some other examples of reservoirs in the body?*

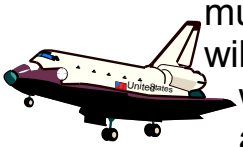
We learned earlier that bicarbonate is a base that can neutralize acids. Let's say that you ate a large meal with meat and no vegetables. Your body would produce sulfuric acid from the breakdown of the acid precursors in the food but there would be no base precursors from the diet to neutralize the acid. Your kidneys can handle some of the acid load, but when acid loads are too big for the body to handle, bicarbonate comes out of the bone to help neutralize the acid. As a result, there is increased bone **resorption** (or bone loss).

Scientists have found that a low pH can contribute to bone loss even in **devitalized** bone (bone that is no longer living - an example would be a dried chicken bone). Another way that low pH contributes to bone loss is that the cells responsible for bone resorption (called **osteoclasts**) are more active at low pH.

Astronauts are at Risk for Bone Loss



Astronauts lose bone while they are in space at a rate of about 1% per month. That doesn't seem like a lot until you think about how much you would lose over many years! Since astronauts will be heading toward Mars one day, scientists are working hard to try to figure out how bone loss among astronauts can be stopped.



Experiment You Can Try...

Experiment #2 (Note - this experiment will take 1 week for completion)

Learning Objectives:

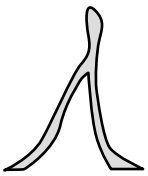
1) To determine the effect of acid on bone.
2) To compare effects of acidic cola and neutralized cola on bone

In the first experiment, you learned how much bicarbonate was needed to neutralize the cola. You will use that information in this experiment to determine whether neutralizing the cola can **inhibit** (or prevent) the effects of acid on devitalized bone.

Materials & Methods

You will need:

- 1 can of cola
- 2 glass (or plastic) cups
- Sodium bicarbonate (baking soda)
- 1 chicken wishbone (dried out)
- pH paper
- Spoon for mixing

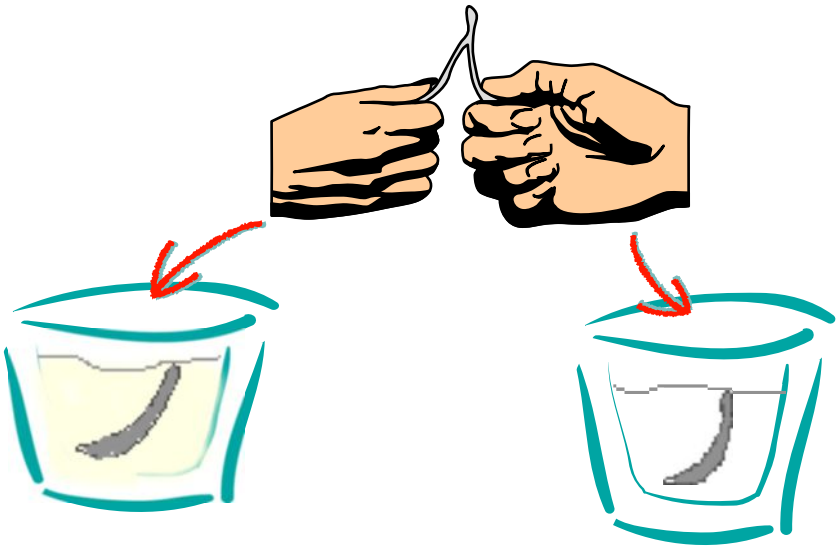


1. Pour half of the cola into the 2 cups.

2. Add the amount of bicarbonate you determined from the first experiment to neutralize the cola in one of the cups. Test with pH to make sure you have neutralized the cola in one of the cups.

3. Look at the chicken wishbone and record details such as how hard is the bone, what color is the bone, etc.

4. Break the bone in half and place one in each of the cola cups.



5. Look and touch the bones daily for 1 week. Record your observations. How did both bones change over time?

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Conclusions

What did you learn from these experiments?

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In your own words, why is it important to eat a balanced diet?

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