**VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE**

**http://studentorgs.vanderbilt.edu/vsvs**

**Science of Soda Pop**

**Fall 2012**

**Goal:**

**Materials**

1 clear bucket (fill with water)

2 Coke cans - 1 Diet, 1 Regular

1 2 oz cup of sugar

1 glass jar containing marbles

8 Ziploc bags containing:

1 Dropper bottles of Universal indicator

1 Universal indicator charts

1 1 oz bottle of sprite

1 1 oz bottle of diet sprite

1 1 oz bottle of vinegar

1 1 oz bottle of water

4 pipettes

2 9-well plates

1 6oz cup water

1 bottle seltzer water (sealed)

1 bottle seltzer water (previously opened)

1 styrofoam cup of Dry ice

16 Ziploc bags containing

5 Glucose test strips

1 dropper bottle of sucrose water

1 dropper bottle of glucose water

1 dropper bottle of fructose water

1 1 oz bottle of regular coke

1 1 oz bottle of diet coke

1 bag containing 16 tweezers

Models of sucrose, glucose, fructose

16 Handouts of sucrose, frustose and glucose pictures, graphs of soda consumption

16 Handouts of ingredient labels

32 worksheets

**Preparation notes: Pour some club soda into a 16 oz cup and stir it with a spoon. This is the “de-gassed” seltzer water. Screw (tightly) the cap back on the bottle.**

1. **Introduction**

About 52 gallons of soda pop is drunk per person per year in America.

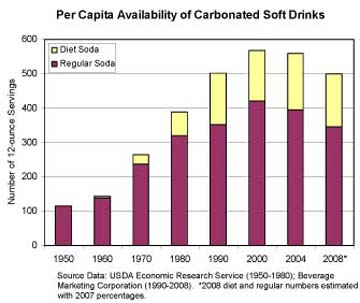
That is over 550 12 oz cans EACH.

Look at the graphs on the Handout.

1. The consumption of soda drinks has increased since your parents or grandparents were kids.

In 1950, just over 100 12 oz cans of soda was drunk per person in the US.

In 2008, 5 times that amount (500 12 oz cans) was consumed.



1. People in the United States drinks ten times more soda drinks than Japanese people.



Consumption of [carbonated](http://www.nationmaster.com/encyclopedia/carbonation) soft drinks. Litres per person per year, 2002.

**SOURCE:** [Global Market Information Database](http://www.euromonitor.com/), published by Euromonitor

**Note: 1 liter = 34 US oz., almost 3 12 oz. cans**

**II. What is in a Soda Drink?**

Tell students to look at the ingredient labels and circle the materials in the sodas. This can be done as a classroom activity.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Regular Coke** | **Diet Coke** | **Regular Sprite** | **Diet Sprite** |  |
| Fat | Fat | Fat | Fat |  |
| Protein | Protein | Protein | Protein |  |
| Fiber | Fiber | Fiber | Fiber |  |
| Sodium | Sodium | Sodium | Sodium |  |
| Carbohydrates | Carbohydrates | Carbohydrates | Carbohydrates |  |
| Sugars | Sugars | Sugars | Sugars |  |
| Vitamins | Vitamins | Vitamins | Vitamins |  |
| Calcium | Calcium | Calcium | Calcium |  |
| Carbonated Water | Carbonated Water | Carbonated Water | Carbonated Water |  |
| HFCS | HFCS | HFCS | HFCS |  |
| Phosphoric Acid | Phosphoric Acid | Phosphoric Acid | Phosphoric Acid |  |
| Citric Acid | Citric Acid | Citric Acid | Citric Acid |  |

1. **Coke/Diet Coke Density: Demonstration**

1. Fill the bucket with water. Place the 2 soda cans next to the bucket.
2. Ask the students what they think will happen when you place the can of Coke in the water. Accept answers and then place the can of Coke in the water. It should sink.
3. Next, ask the students what they think will happen when you place the can of Diet Coke in the water. In this case, the can of Diet Coke floats.
4. Ask the students about what reasons they can give for why the Coke sinks, but the Diet Coke floats? (Note: the cans have not been altered in any way). *After a few guesses, tell them that the difference between the two cans are their densities.*

**Defining Density**

1. Ask the students if they know what density is. Tell them that they can think of density as how much mass there is in a given volume.
2. In math terms, D (density) is equal to mass (m) divided by volume (v): D = m/v. Write this equation on the board, along with the definitions of the symbols (D, m, v).
3. Defining Density Demonstration

Materials:

1. Show students the glass jar with marbles in it. Tell students that the marbles represent water molecules.
2. Pour the container of sugar into the jar.
3. Explain to students that the sugar packs around water molecules in a similar way in sugar water and Regular Coke.
4. Ask students why they think regular coke is denser than diet coke. *Regular Coke has a higher mass because of the added sugar, and hence is denser.*

**II. Density Activities**

**A. Calculation**

Look at the copies of the ingredient labels on the Handout.

Put the following chart on the board:

**Regular Coke** **Diet Coke**

Volume: 382 mL. Volume: 382 mL.

Mass: 387 g Mass: 367 g

* Point out that the volume (or amount of coke in each can) of each can is the same, but the mass (weight) of each can is different.
* Then ask the students if they can think of a reason for the difference in mass.
* Share the following explanation with students.

**Explanation**

The masses of the diet and regular soda are different because regular soda contains 39 g of sugar (**14 sugar packets**) while diet soda contains none (but does contain artificial sweetener). Hold up 14 packets of sugar to emphasize how much sugar is in a regular can of soda.

Using the equation on the board, go through the density calculation with students.

**Regular Coke** **Diet Coke**

D = 387 g/382 mL D = 367/382 mL

D = 1.01 g/ml D = 0.96 g/mL

**Note**: Share the following information with students: The density for regular coke is only slightly greater than the density of water (1.00 g/mL). As a result, some regular cokes float; especially older ones which show a slightly expanded lid. Tests in the lab show that the lid on old cans of regular coke expand so the volume of the can is slightly larger (387 mL) which gives a density less than 1.00 g/ml.)

**III. Are Soda Pop Drinks Acidic or Basic?**

**Groups of 4** **students** will share soda drink and other liquids and Universal indicator and charts.

However, **pairs of students** will do the experiment.

Ask: *What do you know about acids?* (Ask students to name some acids.)

Responses may include references to battery acid, acid indigestion, stomach acid, acid rain, citrus

acid, and chemicals in a lab.

Tell students that natural acids in food give foods a sour, sharp flavor.

Ask: *What do you know about bases?* (Ask students to name some bases.)

Most students know less about bases than acids. Responses may include lye, detergents.

Ask the students: *Has anyone heard of the pH scale?*

Tell students that the pH scale was designed to measure the acidity or basicity of solutions.

**On the pH scale, lower numbers are more acidic solution and higher numbers are more basic.**

Most household chemicals have pH’s between pH 0 and 14, but more concentrated solutions of acids and bases exist that go beyond either end of this scale.

**For VSVS information only:** In 1909, the Danish biochemist S.P.L. Sorenson devised a scale that would be useful in his work of testing the acidity of Danish beer. This scale became known as the pH scale from the French *pouvoir hydrogene*, which means hydrogen power.

Tell students to:

1. Place the well plate on the Observation sheet.
2. Use a different pipette for each liquid.
3. Follow the chart and use a pipette to half fill each well **in row 1** with the correct liquid (or a VSVS member will do this for you). The soda pop solutions will be used for different tests.
4. **Testing the pH of soda pops**: add a squirt of Universal Indicator to the liquids **in row 1** and determine the pH of the different liquids (compare colors on chart).
5. **Ask questions**:
   1. Is there any difference between regular and diet sodas? (*not much*)
   2. Is the pH of sodas closer to vinegar or water? (*vinegar*)

**Why are soda pops acidic?**

Is it the gas? Is it the phosphoric or citric acid?

1. **Is it the carbon dioxide gas?**
2. **Demonstration**

Show students the cup of water, and add universal indicator to it to get a good color.

Hold the cup so all students can see it, and add a piece of dry ice to it. Have students note the color change (getting more acidic).

CO2 + H2O → H2CO3

Carbon dioxide water carbonic acid

**Explanation:** When dry ice is added to water, carbon dioxide gas bubbles are produced. As some of the carbon dioxide dissolves in the water it forms carbonic acid, a weak acid that acidifies the solution. Students should observe a color change as the carbon dioxide dissolves in water - from green to red. The end result pH is between 3-4.

1. **Experiment**

Tell students to look at the ingredients listed for the soda pops, and the club soda (on reverse side of 4 soda pop labels handout).

Make sure students understand that club soda has no additives other than carbon dioxide.

1. Follow the chart and use a pipette to half fill each well with the correct liquid in **Row 2**.
2. Add a squirt of Universal Indicator to the liquids **in row 2** and determine the pH of the different liquids. Ask questions:
   1. Did “degassing” the club soda change the ph? (yes)
   2. What causes the acidic pH of club soda? (carbon dioxide)

**IV. Testing for Sugars**

Background

Ask students: What do you use as a sweetener on or in foods?

Answers may vary – sugar , maple syrup, honey, artificial sweeteners such as aspartame.

Tell students: in the 1970’s, almost all the sweetener we consumed came from cane or sugar beets – the same white stuff that you have in a bowl on your table at home. It is called sucrose. Regular soda drinks also used to have sucrose added as the sweetener.

Since the 1970’s, when the price of sugar increased and the cost of growing corn decreased (sugar import tariffs increased and subsidies for growing corn increased), sucrose has been replaced with cheaper high fructose corn syrup. By 1985, HFCS had replaced sugar in many processed foods and most soda drinks. Now Americans get half their sugar calories from sucrose, and half from HFCS. That trend is shown on the graph on the Handout.

What is the difference between sucrose and high fructose corn syrup?

Show students the 3 sugar models.

Tell students to look at the Handout and point out the 3 sugars – glucose, fructose and sucrose. Point out the differences between the models.

Regular table sugar (**sucrose**) is called a disaccharide. It has 2 molecules - 1 each of **glucose** and **fructose**, bonded together. It comes from cane or sugar beet juice. It occurs naturally in fruit and vegetables.

**Fructose** is a monosaccharide and is found naturally in fruits, honey. It is sweeter than glucose and sucrose, so producers can use less of it.

**Glucose** is also a monosaccharide found in fruits, vegetables and honey and is called the energy sugar.

**High fructose corn syrup** is made from cornstarch to form glucose which is then converted to fructose. The final HFCS is then made by mixing glucose and fructose in the ratio wanted. The ratio varies depending on the food it is going to be put in – processed foods usually use a 42:53 ratio of fructose to glucose. Sodas usually use a 55:42 mixture.

Do our bodies use these different sugars in different ways?

All sugars have the same number of calories in them – 4 calories per gram, and our bodies do not care where the calories came from.

However, the body stores and uses the sugars in different ways.

**Sucrose** is converted to fructose and glucose in the small intestine.

**HFCS** contains free **fructose** and **glucose** and does not have to be digested before the intestine can absorb the sugars. Also, our bodies absorb fructose and glucose by different mechanisms.

Most **glucose** is used as an immediate source of energy for cells. It is regulated by insulin. Excess glucose is excreted.

**Fructose** is insulin-independent and travels to the liver. All of the fructose taken in by our bodies is taken up by the liver. It causes increased fat deposition in the abdominal cavity.

A Princeton University study showed that “all sweeteners are not equal” when it comes to weight gain. Rats were fed HFCS and sugar, so that the calorie count was the same. The HFCS rats gained significantly more weight and gained more fat in the abdomen.

**So what kind of sugars are in the soda drinks being tested today.**

Ask students if they know about testing for glucose with glucose strips.

* + Diabetics use these strips to monitor their glucose levels.

Tell the student pairs to:

1. Place the glucose, fructose, sucrose and water bottles on the appropriate circles on the

Observation Sheet.

1. Take the caps off of the 1-oz bottles.
2. Use the tweezers to hold one end of the strip **(do not touch the glucose test strip with fingers – fingers may have glucose on them**) anddip a test strip into each of the bottles.
3. Place the test strip in the rectangle on the paper below the 1 each bottle.
4. Follow the chart and use a pipette to half fill each well with the correct soda pop (or a VSVS member will do this for you) in **Row 3**
5. Following the same procedure as in 1-4, dip a test strip into each of the wells containing the soda pops. Place the test strip below the well diagram.
6. Wait a few minutes before checking the results.
7. Compare the color on the test strip with the Glucose Results Color Chart, and record the value from the Glucose Results Color Chart on their observation sheets. *Test strip will be dark green if glucose is present.*
   * **Yellow** indicates **no glucose** and shades of **green** indicate the presence of **glucose**. The darker the shade of green, the more glucose is present.
8. Put the caps back on the bottles.

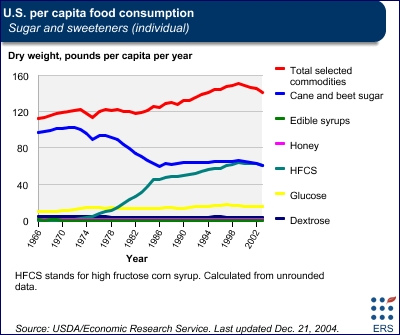
**Note:** The test strip for the diet sodas should be yellow, indicating the absence of glucose. If anyone’s strip did turn green, try to determine why. This could happen due to contamination if glucose was spilled in the water or if a student touched the strip after handling the glucose set-up.

What conclusion can you come to?

Glucose is found in the Regular coke, but not Diet Coke.

Glucose is not present in sucrose (sugar) water or the fructose water.

Lead students to understand that if glucose is present in soda pops, then it came from HFCS, which contains fructose as well.



**Starch test**

**Starch test**

**TESTS**

Place glucose strips in the rectangles and determine if the soda pop contains glucose.

Sucrose water

Glucose bottle

Fructose Water

Water bottle

**\**

Is Glucose present?

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**Starch test**

**GLUCOSE TESTS**

Sucrose water

Glucose bottle

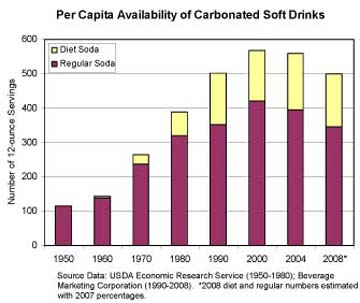
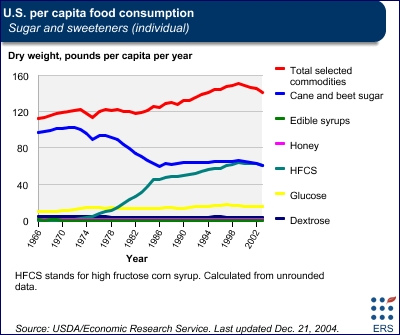
Fructose water

Water bottle

**\**

Is Glucose present?

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Consumption of [carbonated](http://www.nationmaster.com/encyclopedia/carbonation) soft drinks. Litres per person per year, 2002.

**SOURCE:** [Global Market Information Database](http://www.euromonitor.com/), published by Euromonitor



|  |  |  |
| --- | --- | --- |
| **Product** | **pH (acidity)** | **Sugar per 12 oz** |
| Pure Water | 7.00 (neutral) | 0.0 |
| Club soda |  | 0.0 |
| Diet Coke | 3.39 | 0.0 |
| Coke Classic | 2.63 | 9.3 tsp. |
| Pepsi | 2.49 | 9.8 tsp. |
| Mountain Dew | 3.22 | 11.0 tsp. |
| Sprite | 3.42 | 9.0 tsp. |
| Diet 7-Up | 3.67 | 0.0 |
| Dr. Pepper | 2.92 | 9.5 |
| Diet Dr. Pepper | 3.41 | 0.0 |
| Gatorade | 2.95 | 3.3 tsp. |
| Hawaiian Fruit Punch | 2.82 | 10.2 tsp. |
| BATTERY ACID | 1.00 | 0.0 |
| Source: Minnesota Dental Association |  |  |

**Starch test**