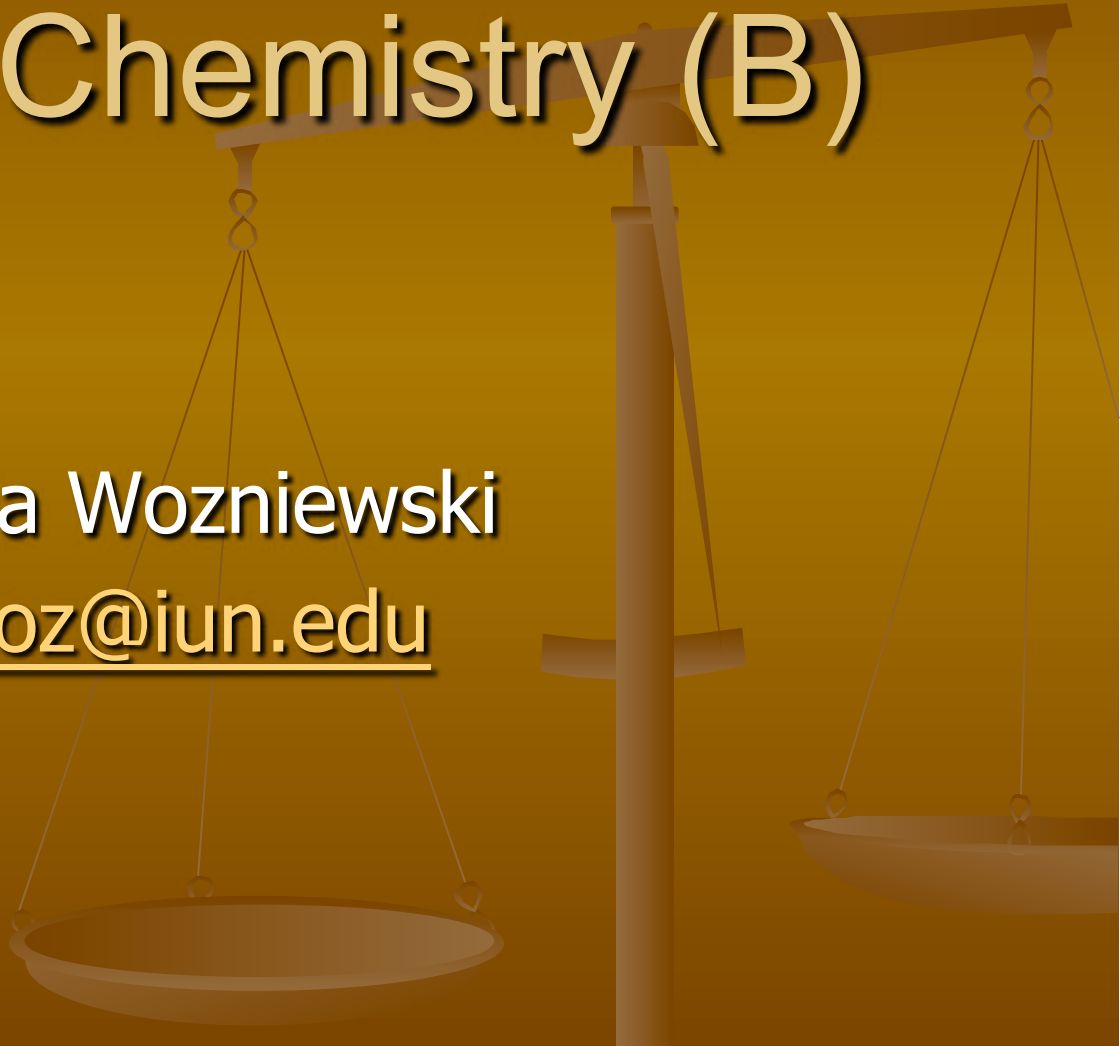


Food Chemistry (B)

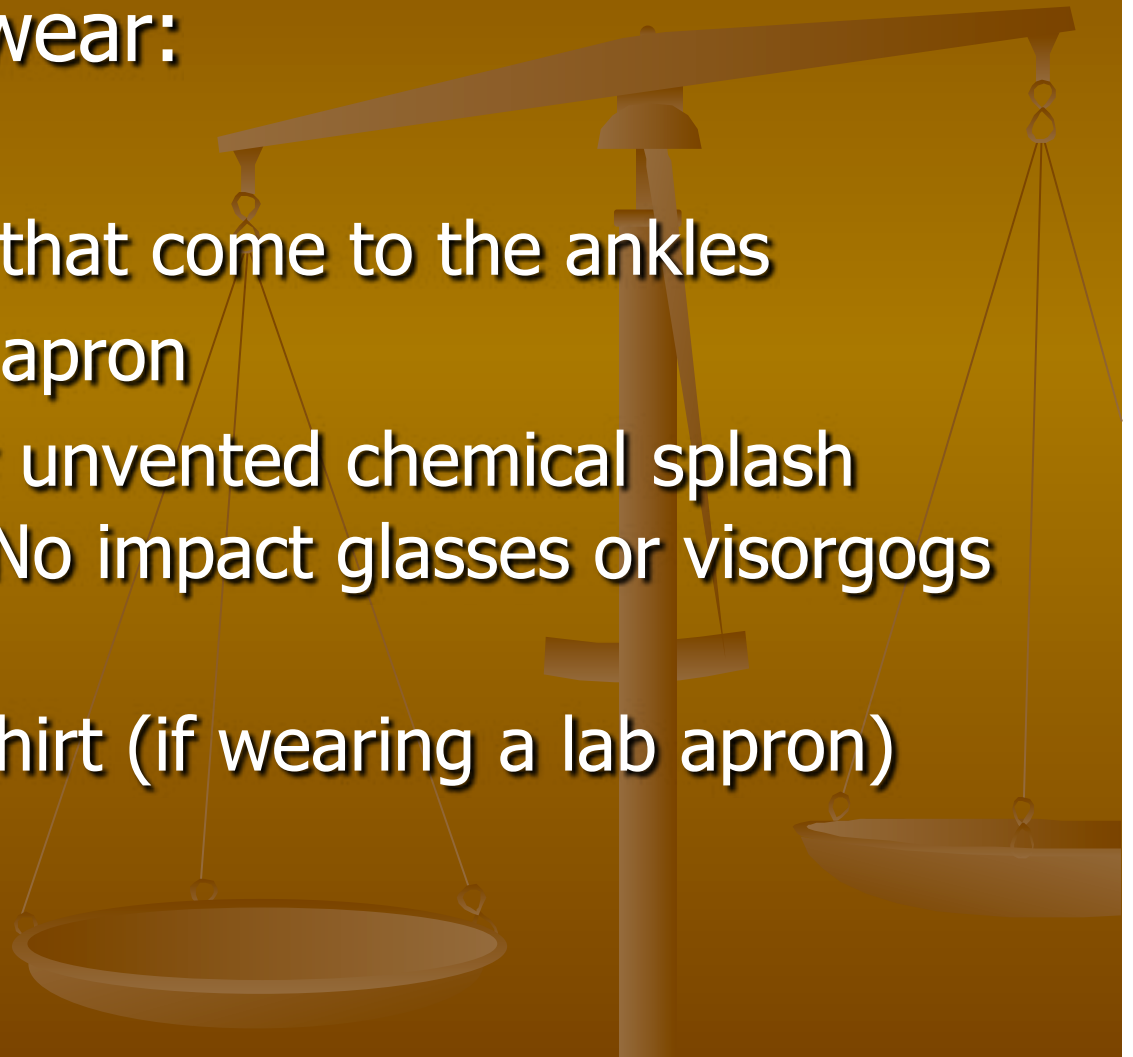


Linda Wozniowski

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Safety

- Students must wear:
 - Closed shoes
 - Slacks or skirts that come to the ankles
 - Lab coat or lab apron
 - Indirect vent or unvented chemical splash proof goggles. No impact glasses or visorgogs are permitted
 - Long-Sleeved Shirt (if wearing a lab apron)



What Students MUST Bring

- Homemade Calorimeter w/non-mercury thermometer

- Safety Gear & writing instrument



What Students May Bring

- Non-image Calculator
- Up to 5 pages of notes (both sides) including any calibration data for calorimeter. May be in plastic sheet protectors
- “Can’t Judge a Powder” Kit consisting of:

Beakers	Test Tubes	Spot plates
Stirring rods	pH paper	Beral Pipettes
Conductivity Tester (Non-AC)	Hand lens	Paper Towels
Test tube rack	Test tube holder	Test tube brush

What Supervisors Will Supply

- Everything the student will need
 - This may include:
 - Glassware
 - Reagents
 - Balances
 - Hot plates
 - Thermometers
 - Probes
 - Magnets
 - Stirrers



Main Focus

- Chemistry of Food
- How to prepare students
- Experiment ideas
- Resources

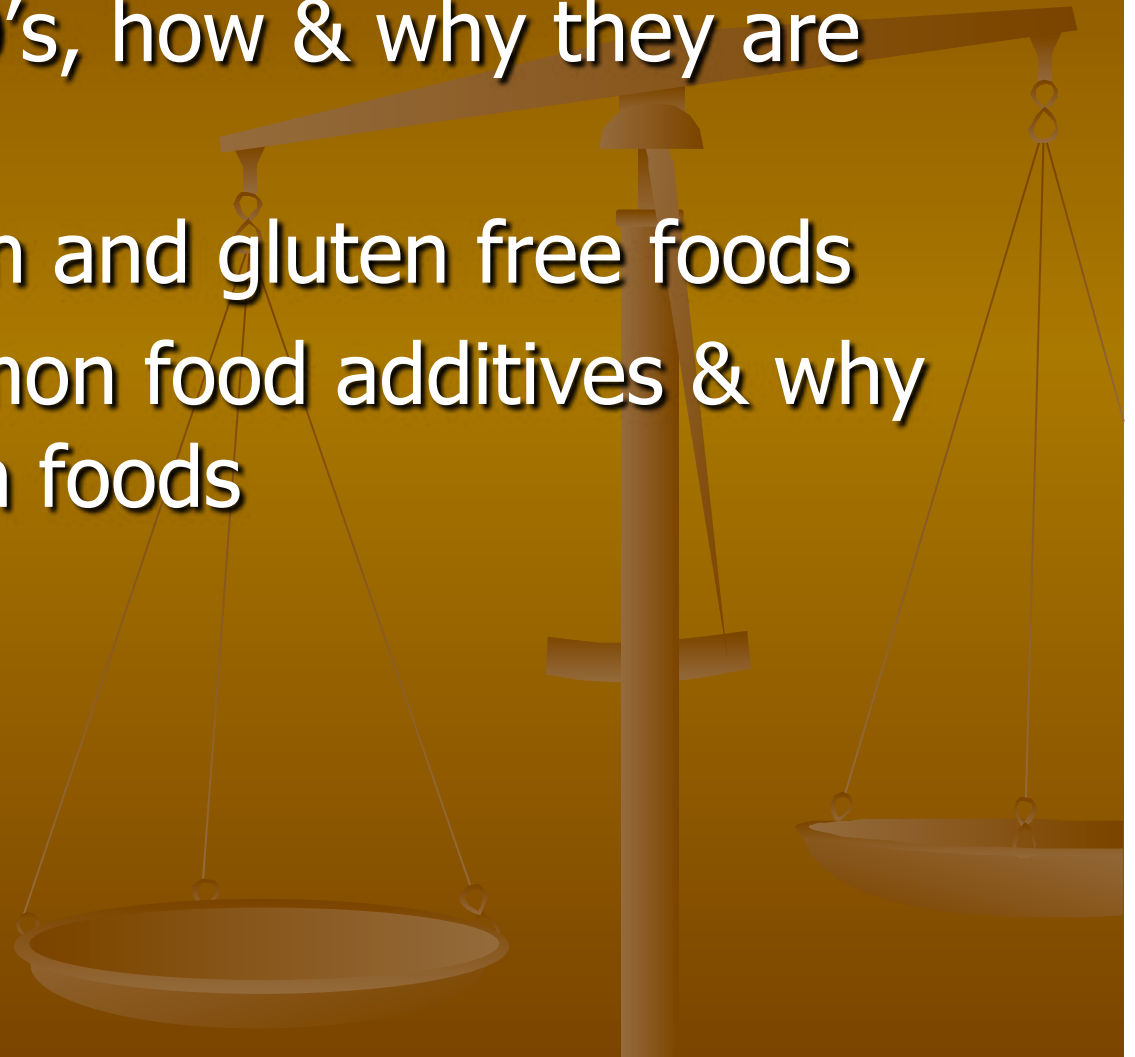


Chemistry of Food-Overview

- a. Identify the sources of and understand the role of lipids, carbohydrates and proteins typically found in baked goods, and use tests to identify these compounds, including the Benedict's, Iodine, Biurets, and Brown Bag tests.
- b. When given samples of sweeteners, use the Benedict's test to identify reducing sugars.
- c. When given samples of baked goods ingredients, use the Biuret test to identify and rank the ingredients by protein content.
- d. Identify common allergens in foods
- e. Determine Calories in foods from a common commercial food label.
- f. Determine the moisture loss and density of baked goods.
- g. Identify leavening agents using chemical tests, and understand the role of the leavening agents in baked goods.

Chemistry of Food-Overview, con't

- h. Identify GMO's, how & why they are used in foods
- i. Identify gluten and gluten free foods
- j. Identify common food additives & why they are used in foods



Before your event

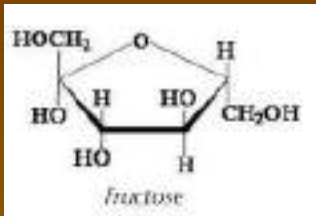
- Research! Understand the science first
- Experiments
 - Make a calorimeter
- Calibrate the calorimeter – multiple trials
- Experiment with the calorimeter with different foods (do this under a hood or outside)



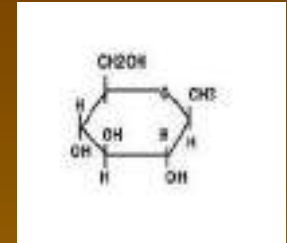
Grain Foods

- Contain
 - Liquids....
 - Lipids
 - Leavening agents
 - Flours
 - Sweeteners
 - Additives
- Must understand WHY you are using the ingredient...what function does it provide?





Carbohydrates-Sugars

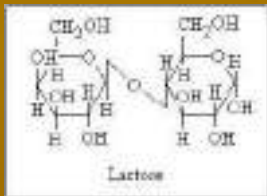


■ Sugars

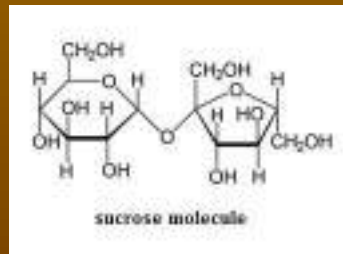
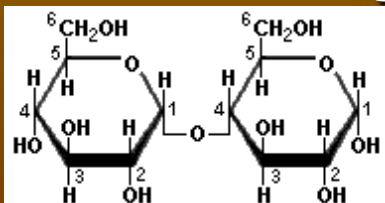
■ Monosaccharides

- Glucose
- Fructose

■ Disaccharides



- Lactose (glucose and galactose) - milk
- Maltose (glucose and glucose) -
- Sucrose (glucose and fructose –table sugar



■ Reducing sugars

- Examples: glucose, lactose, fructose

■ Non-reducing sugar

- Example: sucrose

■ Used as:

- "liquid"-lubricant
- Flavor
- Fast energy
- Retain moisture
- Delay egg protein coagulation
- Inhibitor of gluten formation
- Regulator of gel formation
- Inhibitor of food spoilage

■ When heated above its melting point, sugar caramelizes



Carbohydrates-Complex

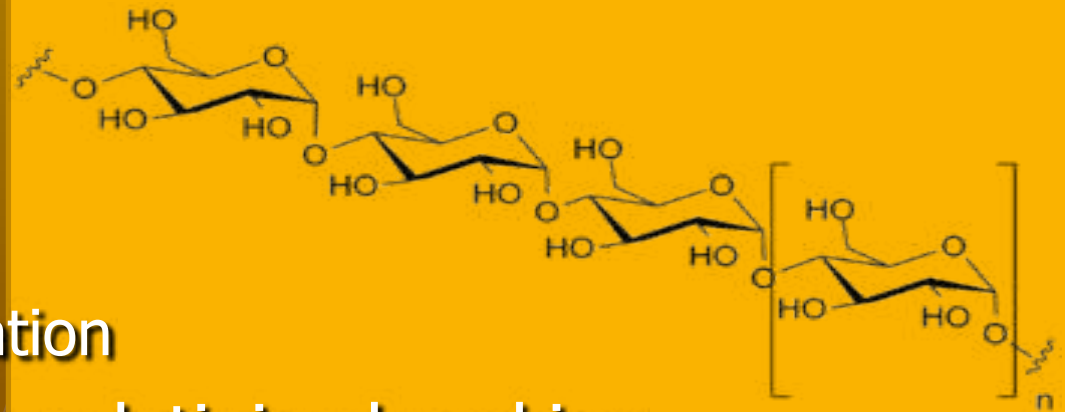
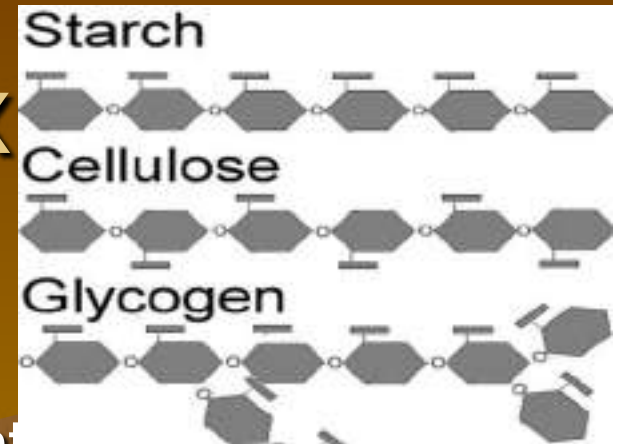
Polysaccharides

■ Examples:

- starch - glucose polymers, found in plants
- cellulose –found in plant fibers, insoluble
- Pectin-units are sugar acids rather than simple sugars, found in vegetables and fruits

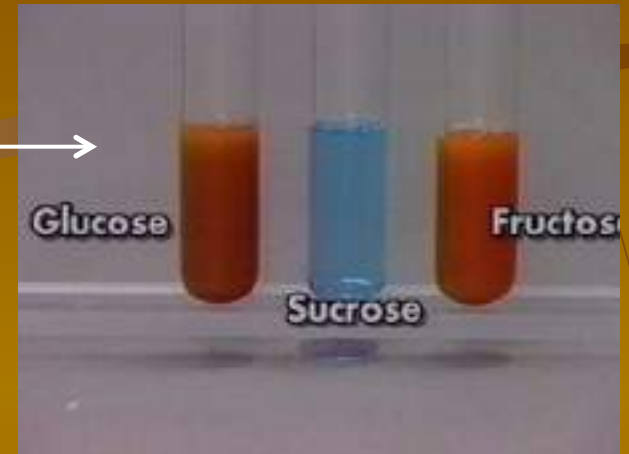
■ Used to:

- Provide nutrition
 - Give body to food
 - Help with waste elimination
- ### ■ When heated, starches gelatinize-breaking molecular bonds



Tests for carbohydrates

- Benedicts test for sugars
- Iodine test for starch



Positive
Reaction

Benedict's Test

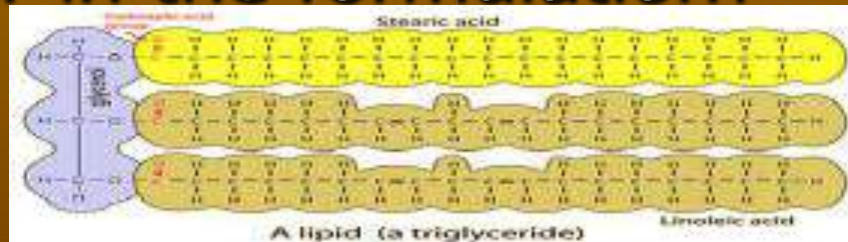
- The Benedict's test allows us to detect the presence of reducing sugars (sugars with a free aldehyde or ketone group). All monosaccharides are reducing sugars. Some disaccharides are also reducing sugars. Other disaccharides such as sucrose are non-reducing sugars and will not react with Benedict's solution. Starches are also non-reducing sugars.
- The copper sulfate (CuSO_4) present in Benedict's solution reacts with electrons from the reducing sugar to form cuprous oxide (Cu_2O), a red-brown precipitate.
- The final color of the solution depends on how much of this precipitate was formed, and therefore the color gives an indication of how much reducing sugar was present if a quantitative reagent was used.
- With increasing amounts of reducing sugar the result will be:
green yellow orange red

Iodine Test

- The **Iodine test** is used to test for the presence of starch.
- Iodine solution – Iodine is dissolved in an aqueous solution of potassium iodide - reacts with starch producing a deep blue-black color.
- Although the exact chemistry of the color change is not known, it is believed that the iodine changes the shape of the starch to change the color

Lipids

- Present as fats extracted from plants or animals (butter, vegetable oil) or as constituents of food (chocolate)
- Contributions to foods: texture and flavor
- Contain only Carbon, hydrogen and oxygen
- Most common form for lipid in foods is as a triglyceride
- What difference in texture would you see substituting vegetable shortening or vegetable oil for butter in the formulation?



Lipids

- <http://www.wellsphere.com/healthy-cooking-article/butter-vs-shortening-in-baking/156136>

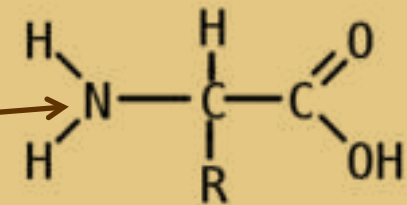


- Conversion between solid structure to a liquid state is called the melting point
- How would changing the melting point of the lipid used change the cookie texture?
- Brown Bag Test
- Saturated fats have no double bonds in any of the fatty acid chains in the triglyceride hence it is saturated with hydrogen.
- Saturated fats are usually from animals
- Unsaturated fats are usually from plants
- Saturated fats considered not heart healthy

Proteins

- Proteins are made up of amino acids

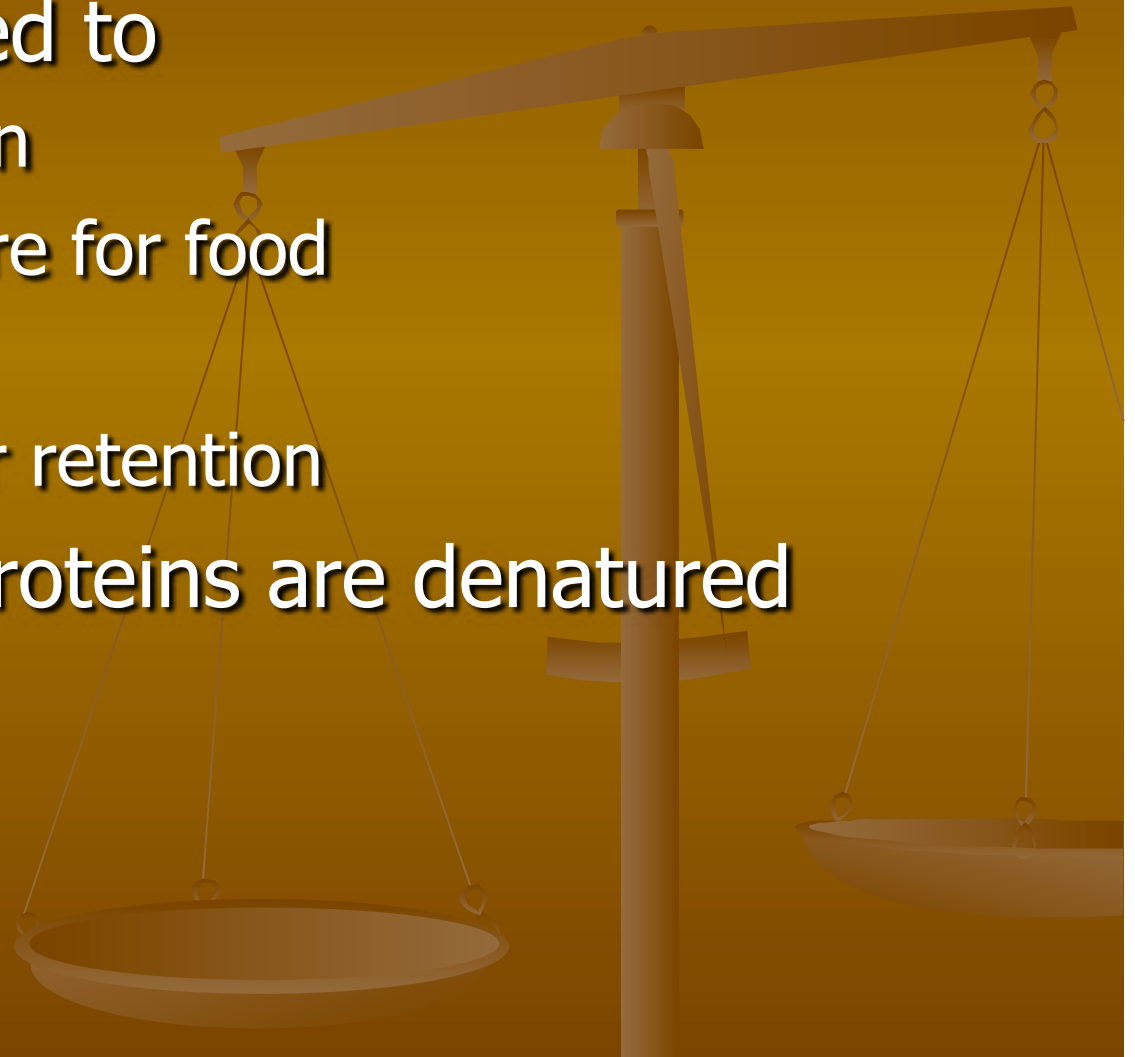
- essential and nonessential aa's
- Contains Nitrogen



- Protein can be found in the flour, egg and milk as well as other ingredients.
- A mixture of proteins forms Gluten.
- Gluten proteins are limited to the seeds of the grass family
- They are prized for giving elasticity to doughs which allow breads, etc. to trap air & rise.

Proteins

- Proteins are used to
 - Provide nutrition
 - Provide structure for food
 - Provide texture
 - Help with water retention
- When cooked proteins are denatured



Proteins

- **Biuret Test**
- The Biuret Reagent is made of sodium hydroxide and copper sulfate. The blue reagent turns violet in the presence of proteins, and the darker the purple color, the more protein is present.
- Biuret's Reagent is unstable, but can be mixed on the spot using NaOH & Benedicts



Leavening agents

- Used to produce a gas that 'lightens' dough or batter.
- used to raise baked goods.
- water a leavening agent (pie crusts, some crackers)
- air incorporated into batter (angel and sponge cakes)
- expand when heated and cause the raising of the dough or batter when gas is trapped in matrix of gluten and starch from flour



Leavening agents

- Baking soda
 - -NaHCO_3
 - **Needs moisture plus an acid source** such as vinegar, citrus juice, sour cream, yogurt, buttermilk, chocolate, cocoa (not Dutch-processed), honey, molasses (also brown sugar), fruits or maple syrup **to react**
 - used to neutralize acids in foods
 - around 4 times as strong as baking powder
 - can cause soapy flavor in high amounts

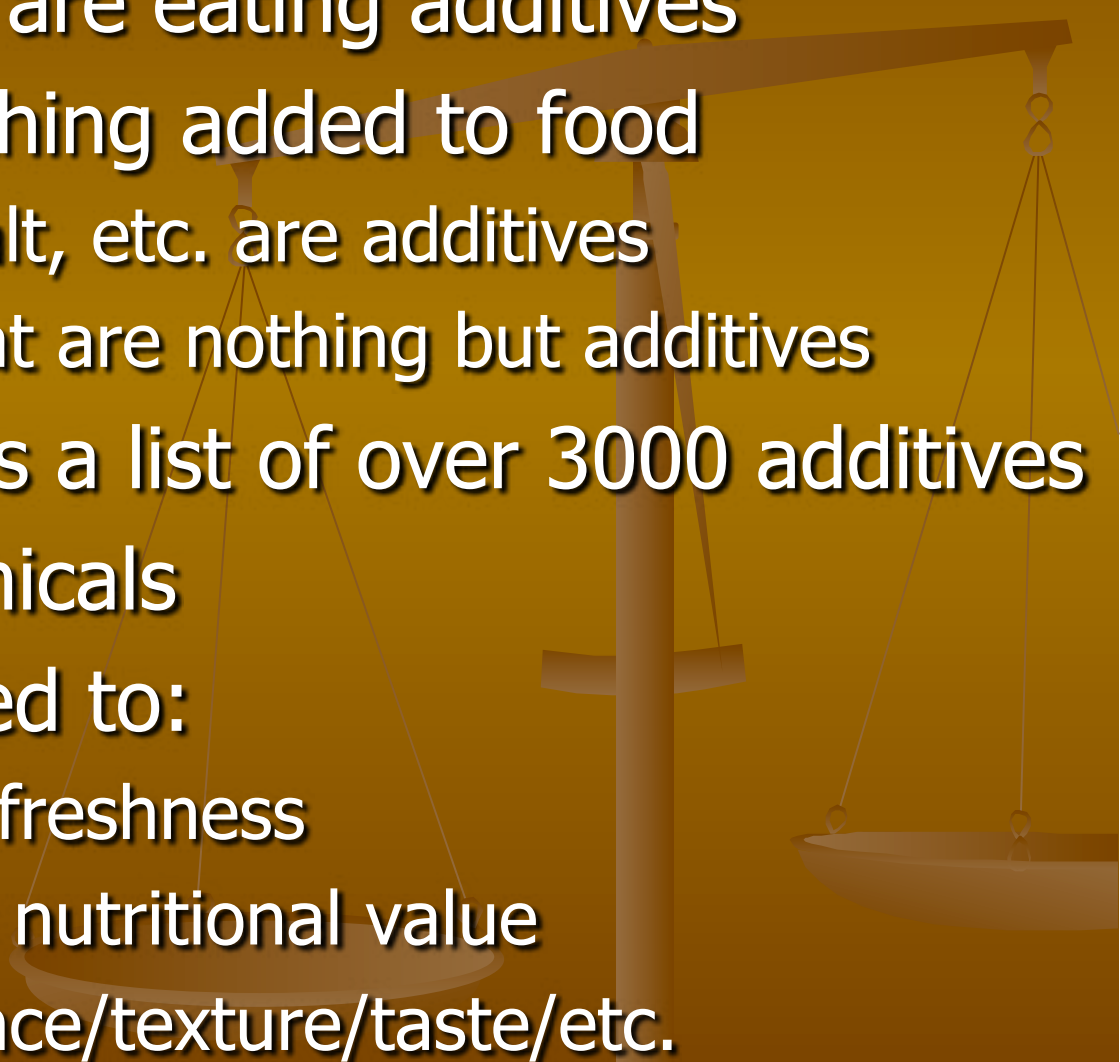


Leavening agents

- Baking powder
 - NaHCO_3 plus acidifier(s) and drying agent (usually an acid salt and cornstarch)
 - can cause acidity and/or bitter off-flavor
 - two acidifiers used in double acting to produce CO_2 in two steps
 - Reacts when moistened and also reacts when heated
 - double-acting is the only commercial baking powder available today.



Additives

- Unless you are picking a pea right off the vine and eating it, you are eating additives
 - Additives are anything added to food
 - So sugar, flour, salt, etc. are additives
 - Some foods we eat are nothing but additives
 - The FDA maintains a list of over 3000 additives
 - All foods are chemicals
 - Additives are added to:
 - Improve safety & freshness
 - Improve/maintain nutritional value
 - Improve appearance/texture/taste/etc.
- 

Allergens

- Top 8 food allergens must be labeled (FDA)

Peanut	Tree Nut	Milk	Egg
Wheat	Soy	Fish	Crustacean Shellfish

- > 50 million Americans have a food allergy
- Common symptoms include

Vomiting	Hives	Short of breath	Wheezing
Repetitive Cough	Trouble Swallowing	Weak Pulse	Pale or blue skin
Dizzy or Faint	Anaphylaxis	Hoarse throat	Stomach cramps

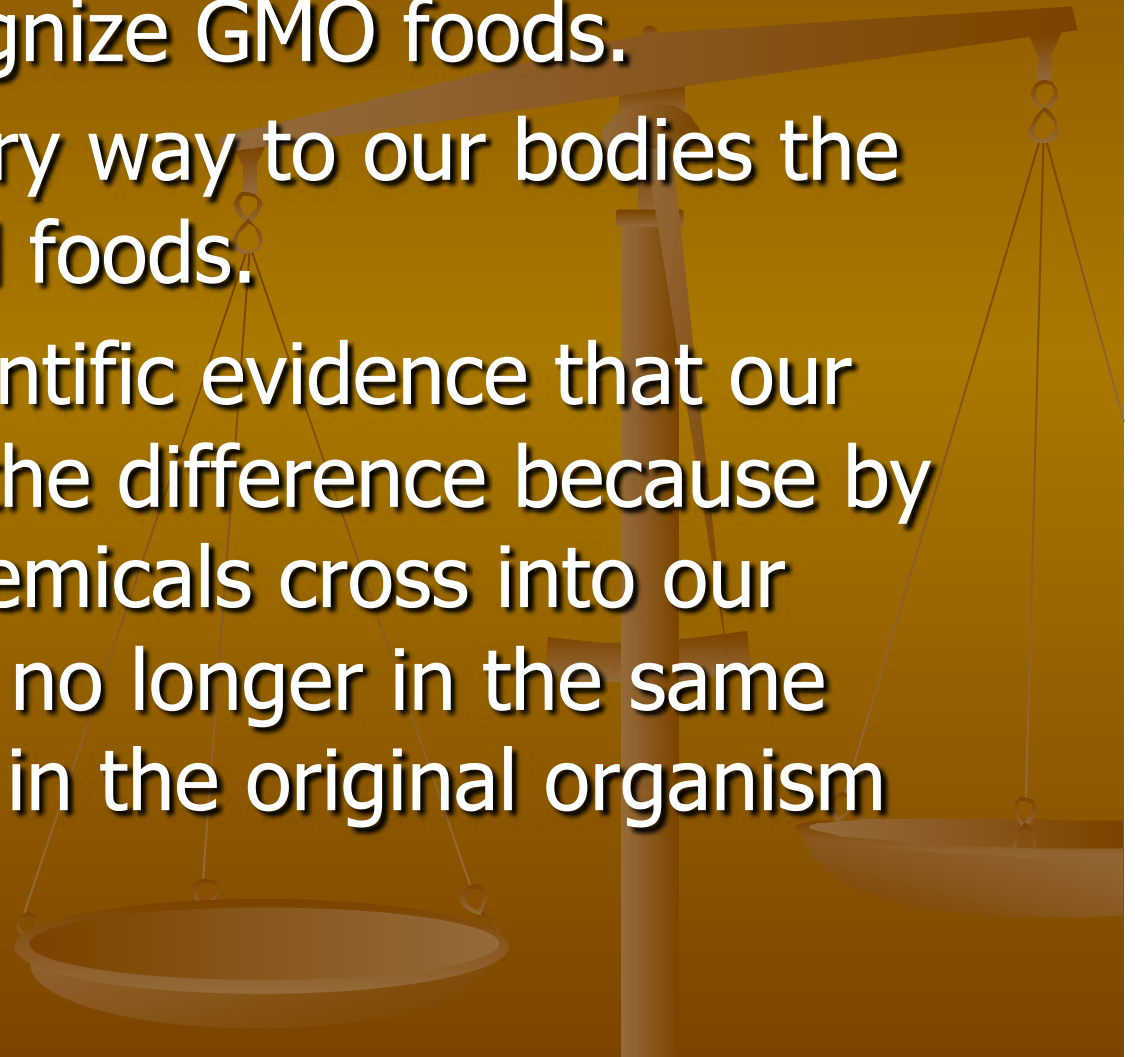
- Allergies can be grown out of or into
- There is lots of cross reactivity

GMO-Genetically Modified Organism

- Makes organisms able to withstand adverse conditions/regulate fertility/resistant to disease.
- For the purposes of this event, limited to crops.
- When foods are eaten, the chemicals that make up the food are both physically (teeth) and chemically (saliva and stomach HCl) broken up into small molecules (amino acids, sugar, fats), which are absorbed by the body.
- The DNA of the plants does not cross into the body-just the broken up molecules.
- Altering the DNA, does not change anything except the order of the nucleic acid chemicals.

GMO-con't.

- No way to recognize GMO foods.
- They are in every way to our bodies the same as natural foods.
- There is no scientific evidence that our bodies can tell the difference because by the time the chemicals cross into our bodies they are no longer in the same form they were in the original organism we ate.



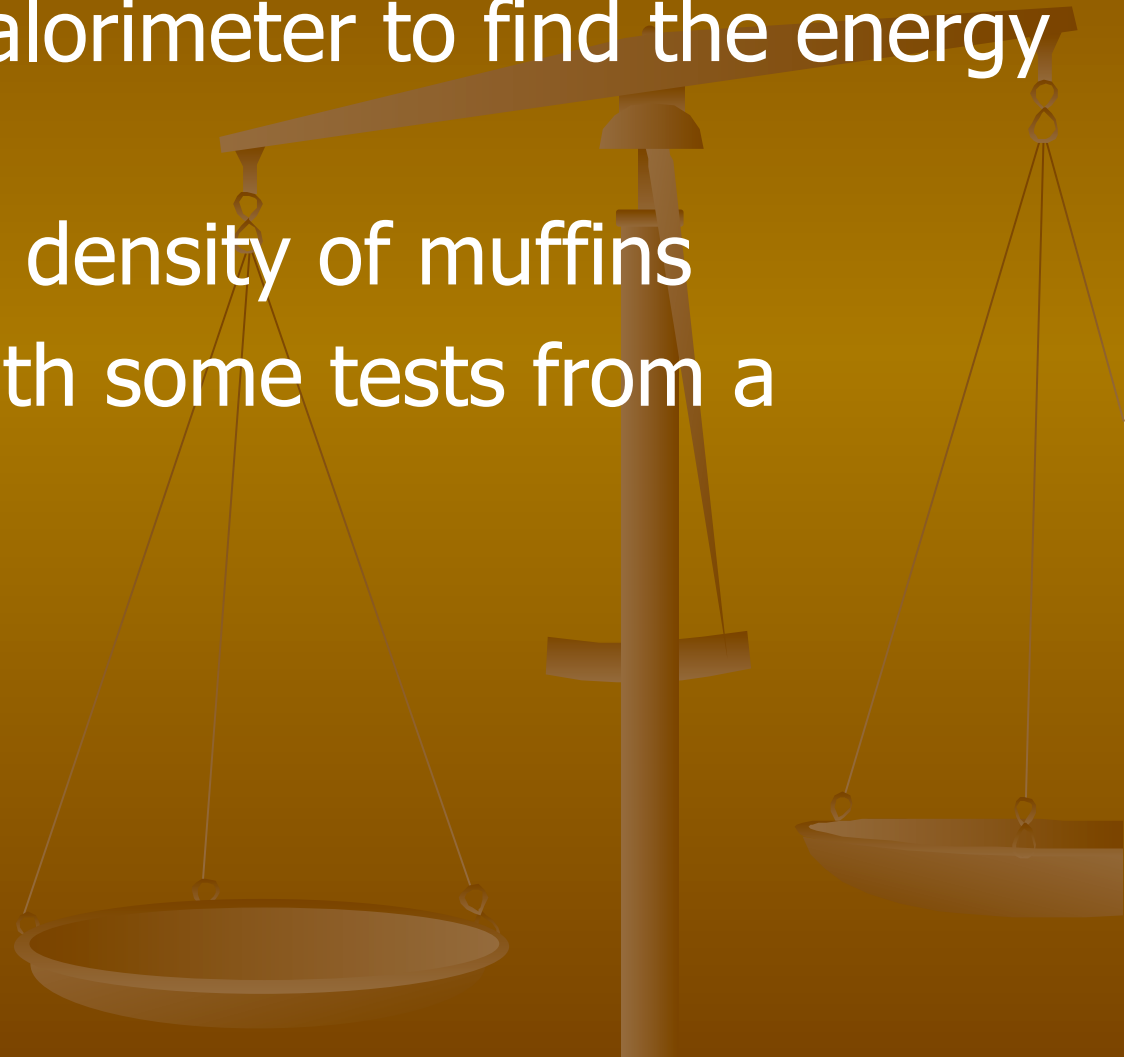
Notebook

- Notebook keeping
 - All experimental data and documentation should be recorded in notebook
 - Must securely hold all items
 - Don't erase in lab notebook!
 - Document all references
 - Use pen



Time to Play

- We can use a calorimeter to find the energy in Cheetos
- We can find the density of muffins
- We can work with some tests from a simulated test.
- It is your option



Making Calorimeter

- Cut top off empty pop can
- Cut “door” in the side of pop can
- Wash out second empty pop can
- Fit second can into first



- Make a food holder by bending up a paperclip

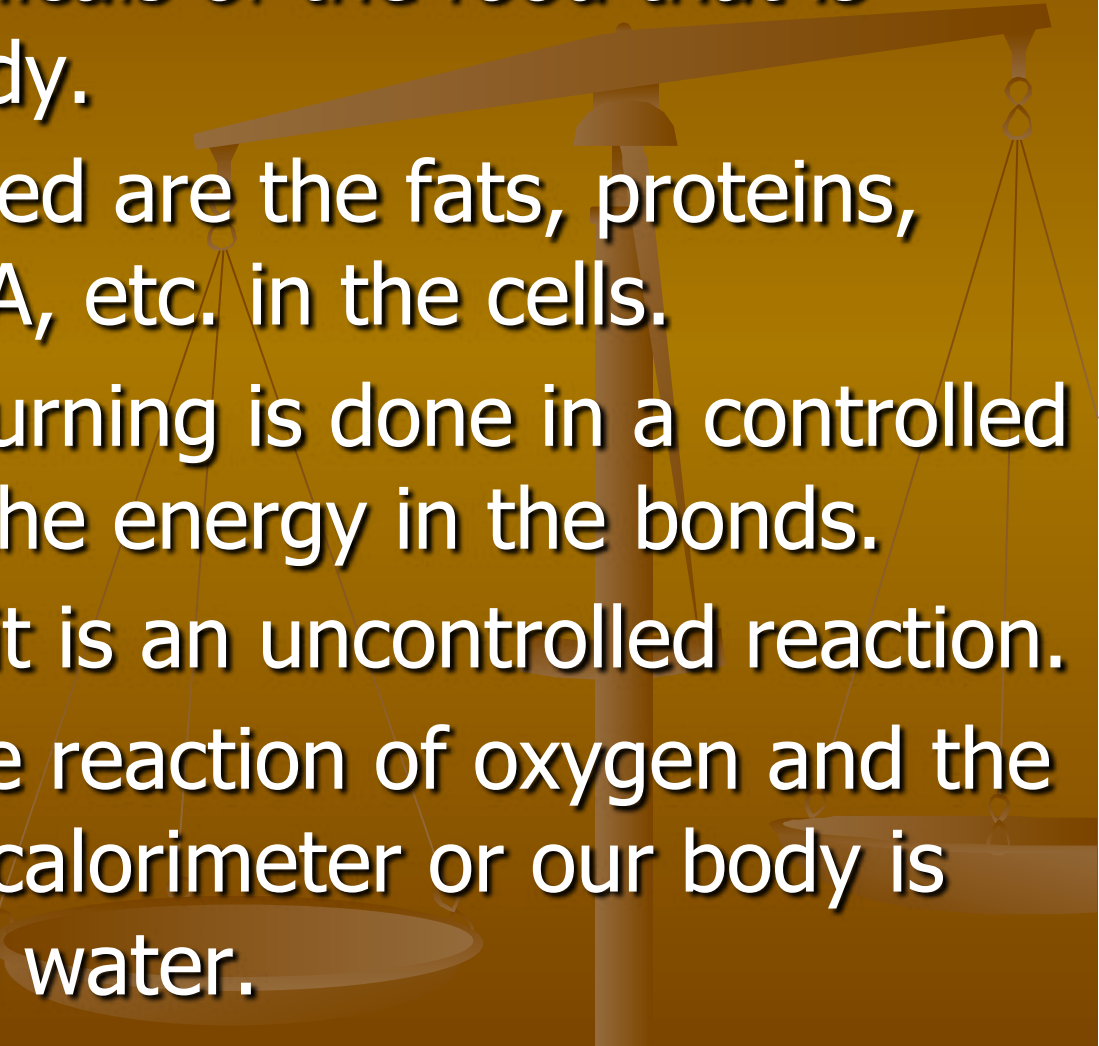
Calorimeter

- Has two components
 - A cup or something similar to hold water
 - Something to hold the cup



- Must fit in a 30 cm^3 box or be penalized 10% of calorimeter score.
- Does not have to be anything fancy
- Must be calibrated to work

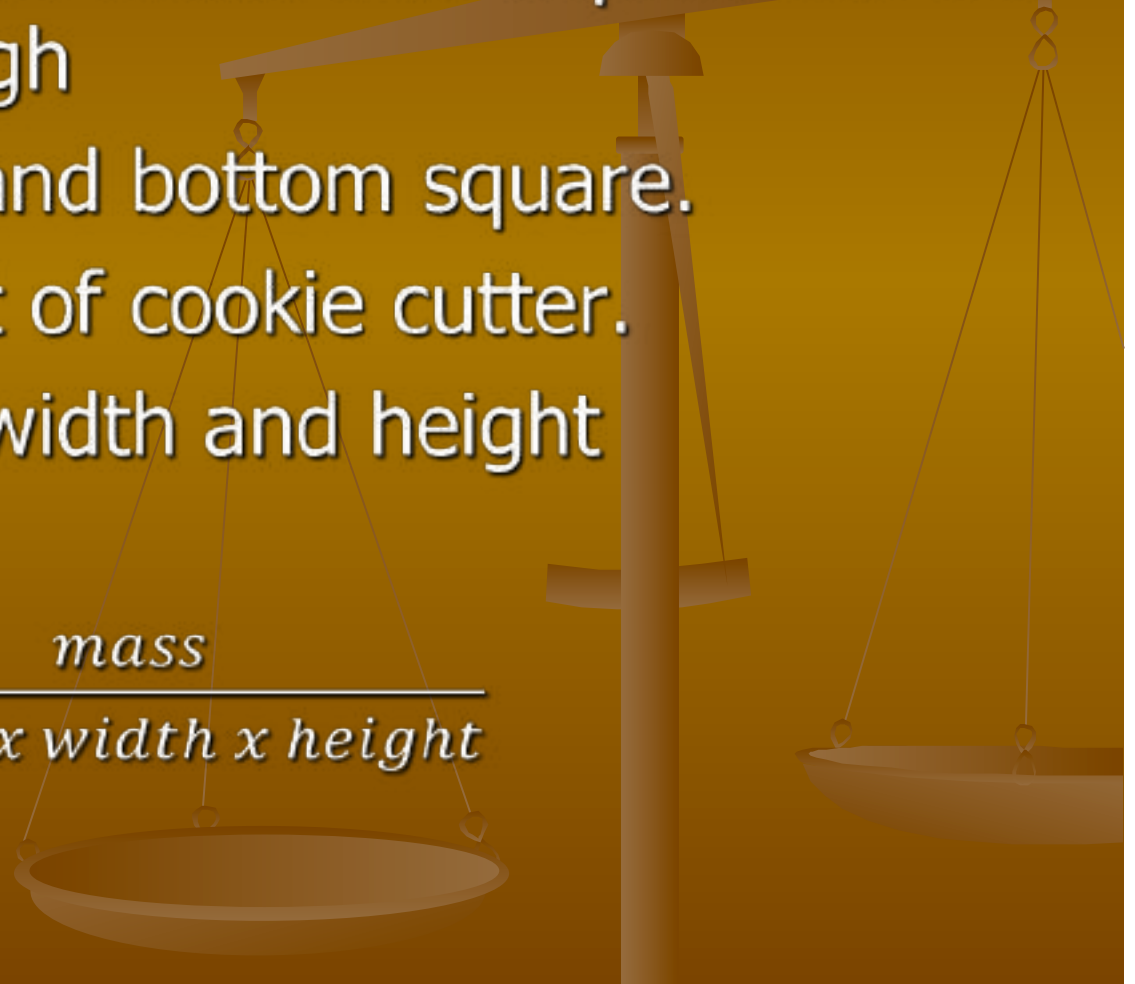
Calorimeter-con't

- Designed to measure the amount of heat energy in the chemicals of the food that is available to the body.
 - What is being burned are the fats, proteins, carbohydrates, DNA, etc. in the cells.
 - In our body, this burning is done in a controlled fashion to extract the energy in the bonds.
 - In the calorimeter it is an uncontrolled reaction.
 - The products of the reaction of oxygen and the food, in either the calorimeter or our body is carbon dioxide and water.
- 

Measuring Density

- Push square cookie cutter into cupcake to cut all the way through
- Trim off the top and bottom square.
- Push cupcake out of cookie cutter.
- Measure length, width and height
- Measure mass

- $Density = \frac{mass}{length \times width \times height}$

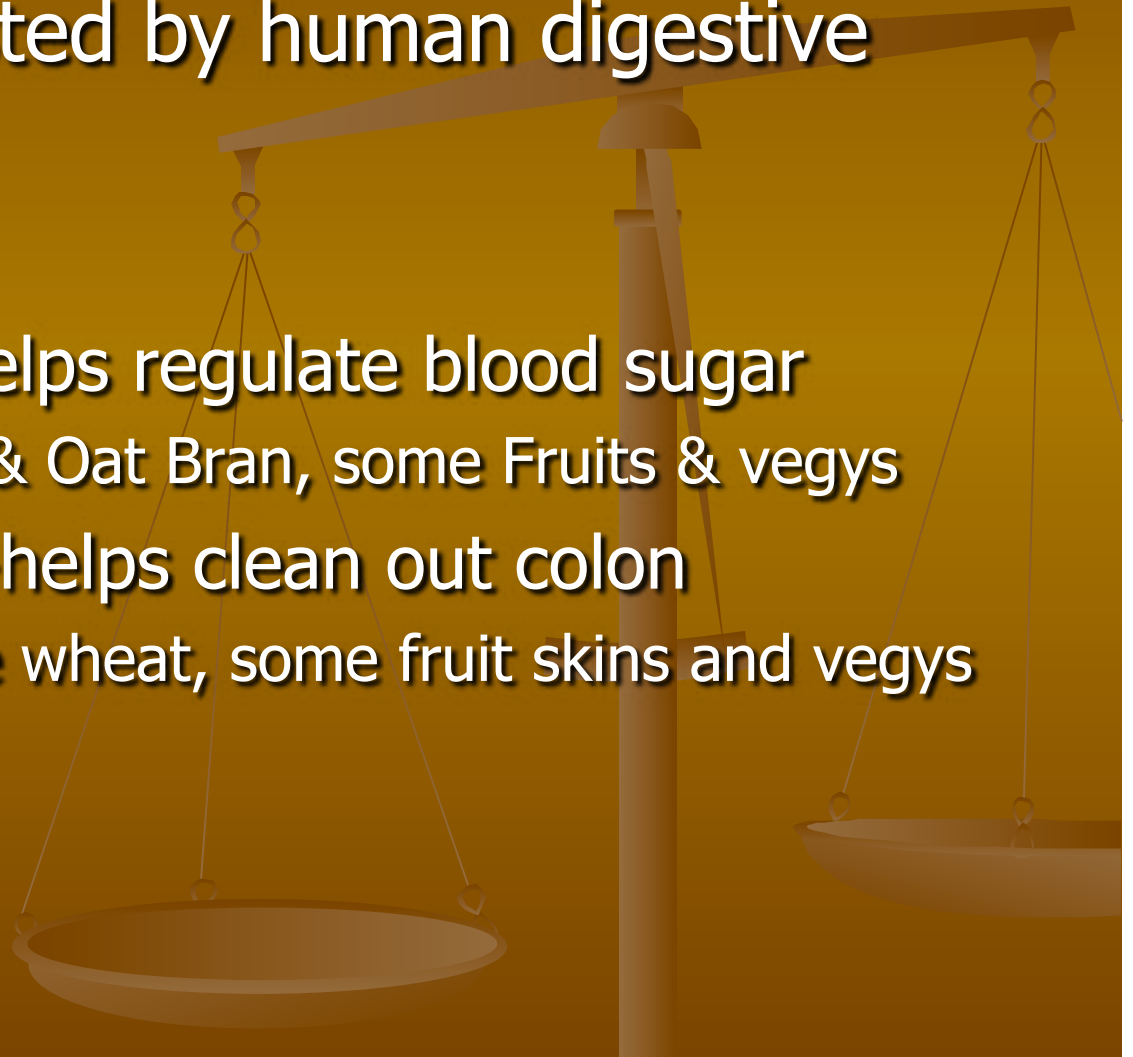


Nutrition

- Calorie - amount of heat required to raise the temperature of 1 gram of water 1 degree Celsius.
- Kilocalorie (1000 calories) is the unit commonly used to represent energy values of foods -or Calorie with a C instead of a c
- Not all carbohydrates (or fats, or proteins) yield the exact same amount of energy when burned in a calorimeter, so common averages from studies (in kcal/g) are used
- Carbohydrates average 4.1 kcal/gram in a bomb calorimeter, are about 98% digestible and yield 4 kcal/g when consumed
- Proteins average 5.7 kcal/g in a bomb calorimeter, are not as easily digested and yield an average of 4 kcal/g when consumed
- Lipids average 9.5 kcal/g in a bomb calorimeter, are 95% digested and yield an average of 9 kcal/g when consumed
- Fats (lipids) are the most concentrated source of food calories
- Carbohydrates are the cheapest source of calories, proteins the most expensive

Fiber

- Foods not digested by human digestive system
- Two types
 - Soluble Fiber-helps regulate blood sugar
 - Found in Oats & Oat Bran, some Fruits & vegys
 - Insoluble Fiber-helps clean out colon
 - Found in whole wheat, some fruit skins and vegys



Nutritional labeling

- 1) Fill in the following blanks.
 - a) There are ____ Calories/gram of fat.
 - b) There are ____ Calories/gram of carbohydrate
 - c) There are ____ Calories/gram of protein
 - d) There are ____ Calories/gram of water
- 2) Use the nutritional label given for information to answer the following questions:
 - a) Calculate the Calories in one serving of this product.
 - (1) Calories from Fat
 - (2) Calories from Protein
 - (3) Total Calories in one serving
 - b) What percent of the carbohydrate Calories come from fiber?
 - c) If the daily value of iron is 18 mg per day, calculate the amount (in mg) of iron in one bar of this product.

Nutrition Facts	
Serving Size 1 bar (48g)	
Servings Per Container 12	
Amount Per Serving	
Calories	Calories from Fat
% Daily Value*	
Total Fat 8g	13%
Saturated Fat 2.5g	14%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 70mg	3%
Potassium 165mg	5%
Total Carbohydrate 26g	9%
Dietary Fiber 5g	18%
Sugars 11g	
Protein 8g	16%
Vitamin A 0%	Vitamin C 0%
Calcium 2%	Iron 10%

Resources

- For Event Supervisors

- <http://mypage.iu.edu/~lwoz/socrime/index.htm>

- For Lesson Plans for classroom use

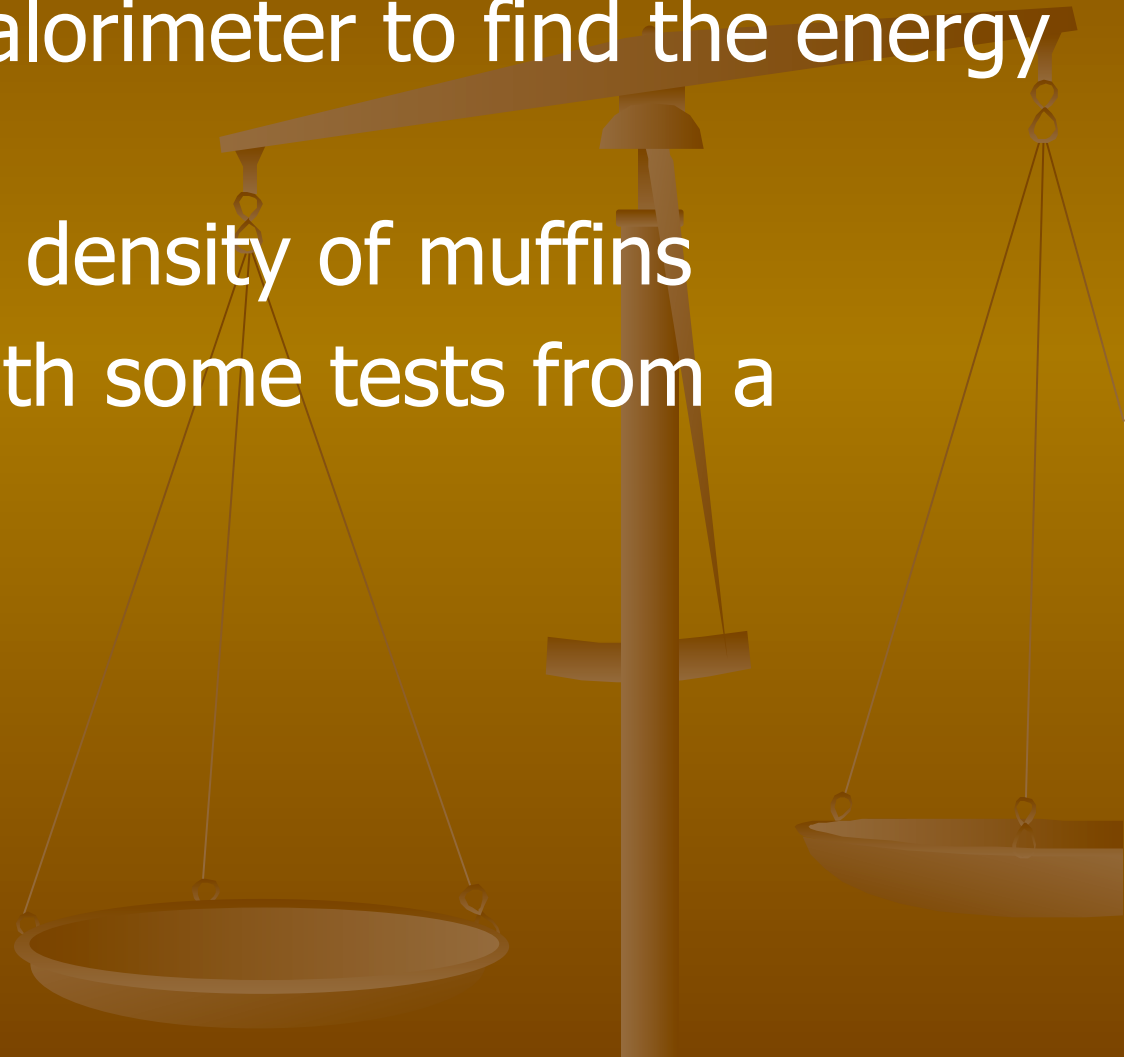
- <http://mypage.iu.edu/~lwoz/socrime/index.htm>

- <https://gmoanswers.com>

- <http://www.fda.gov/Food/IngredientsPackagingLabeling/FoodAdditivesIngredients/ucm094211.htm>

Time to Play

- We can use a calorimeter to find the energy in Cheetos
- We can find the density of muffins
- We can work with some tests from a simulated test.
- It is your option



Making Calorimeter

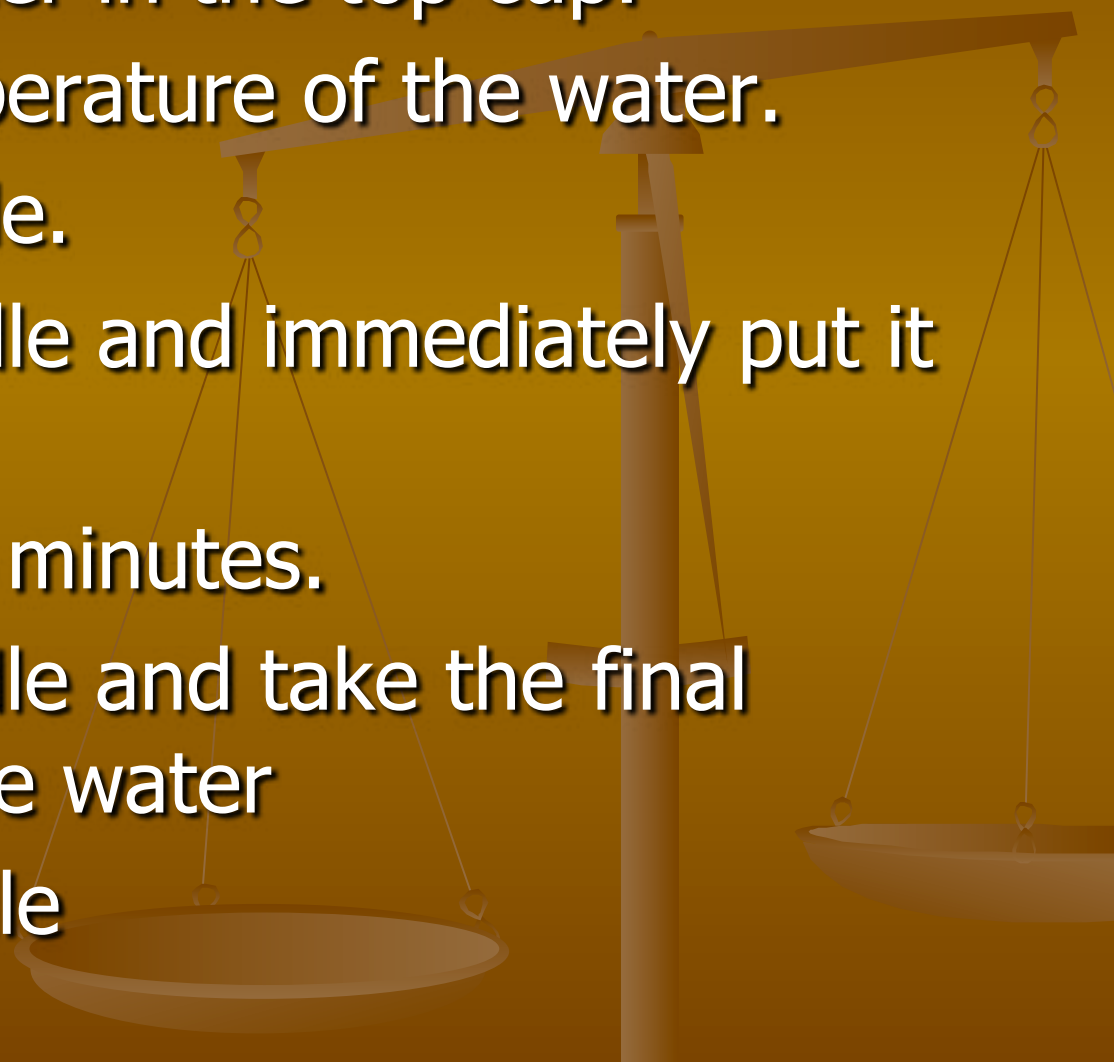
- Cut top off empty pop can
- Cut “door” in the side of pop can
- Wash out second empty pop can
- Fit second can into first



- Make a food holder by bending up a paperclip

Calibrate the Calorimeter

- Put 100 ml of water in the top cup.
- Measure the temperature of the water.
- Weigh a tea candle.
- Light the tea candle and immediately put it under the water.
- Let it burn for ~ 4 minutes.
- Blow out the candle and take the final temperature of the water
- Reweigh the candle

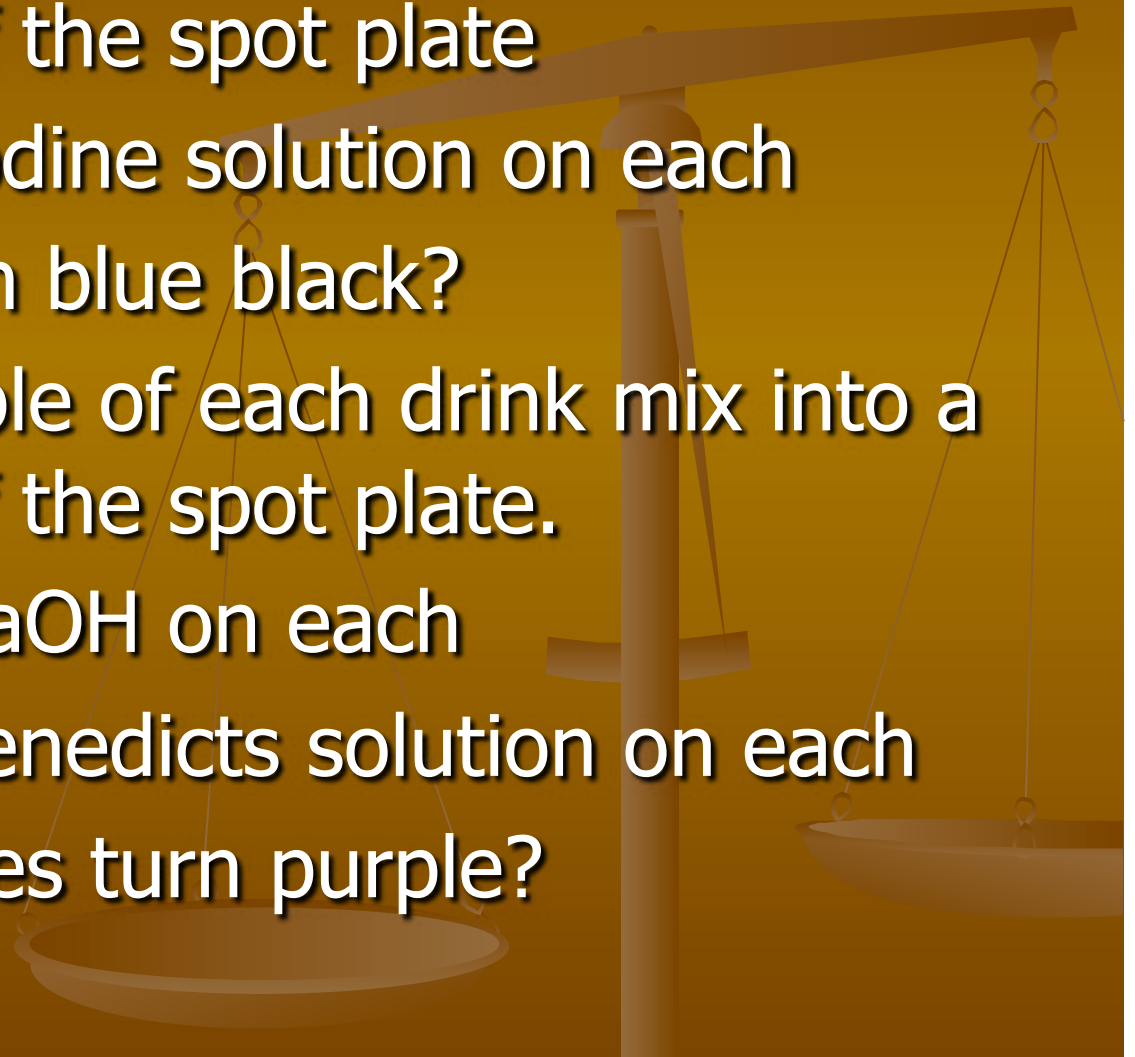


Calibration Calculations

- The accepted low heat value of paraffin wax is 41.5 kJ/g.
- $\Delta H = mC\Delta T/n$
- $M = 100 \text{ g}$ – the water was 100 ml=100g
- $C = 4.18 \text{ J/(g} \cdot \text{K)} = 1.0 \text{ cal/(g} \cdot \text{C)}$ for water
- ΔT = difference in temperature of water
- n = difference in mass of candle
- Efficiency = $\Delta H / 41.5 / 1000$ (to change J to kJ)

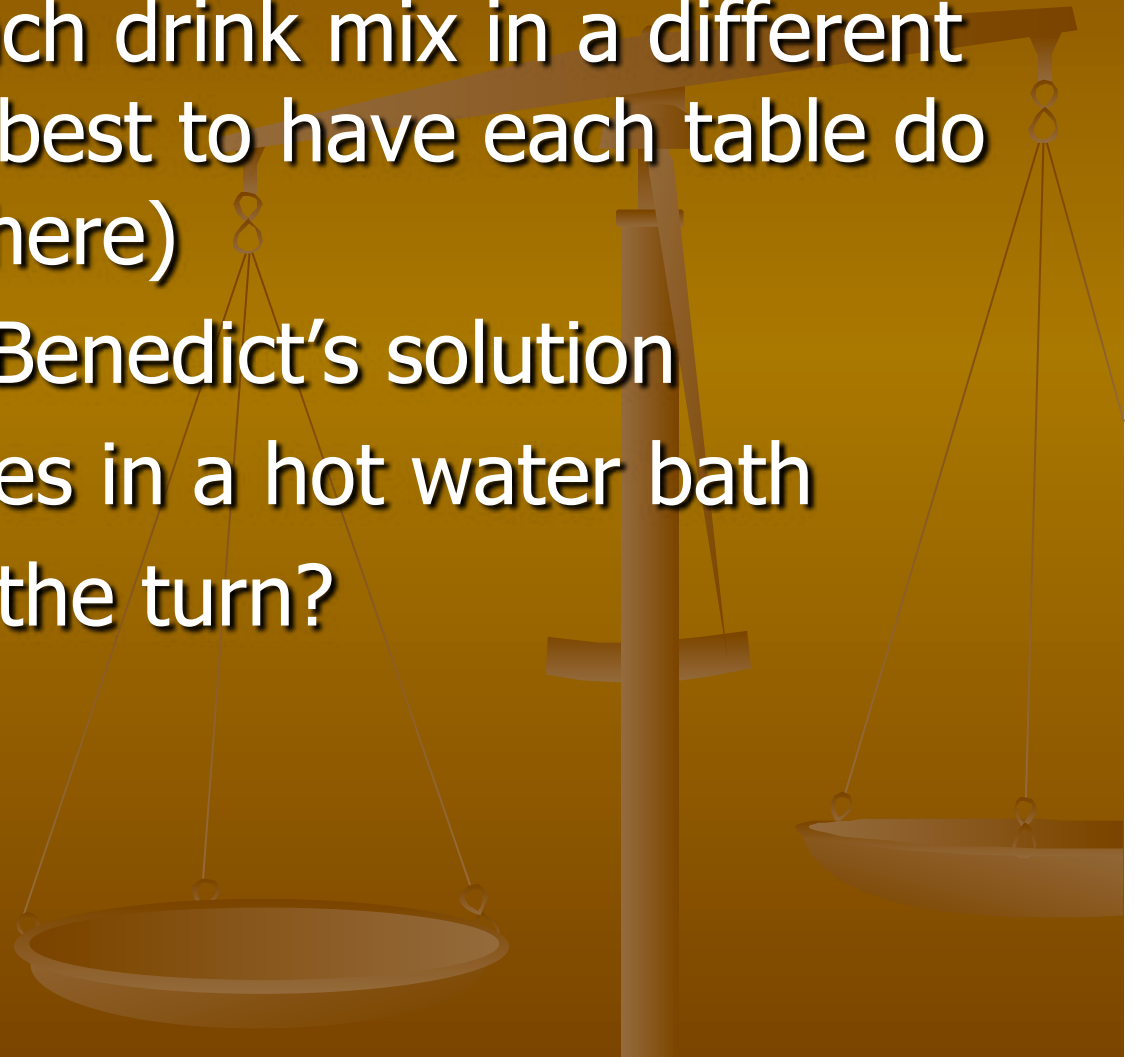
Sample Test

- Put a little of each of the drink mixes in a different well of the spot plate
- Put a drop of Iodine solution on each
- Which ones turn blue black?
- Put a new sample of each drink mix into a different well of the spot plate.
- Put a drop of NaOH on each
- Put a drop of Benedicts solution on each
- Stir – Which ones turn purple?



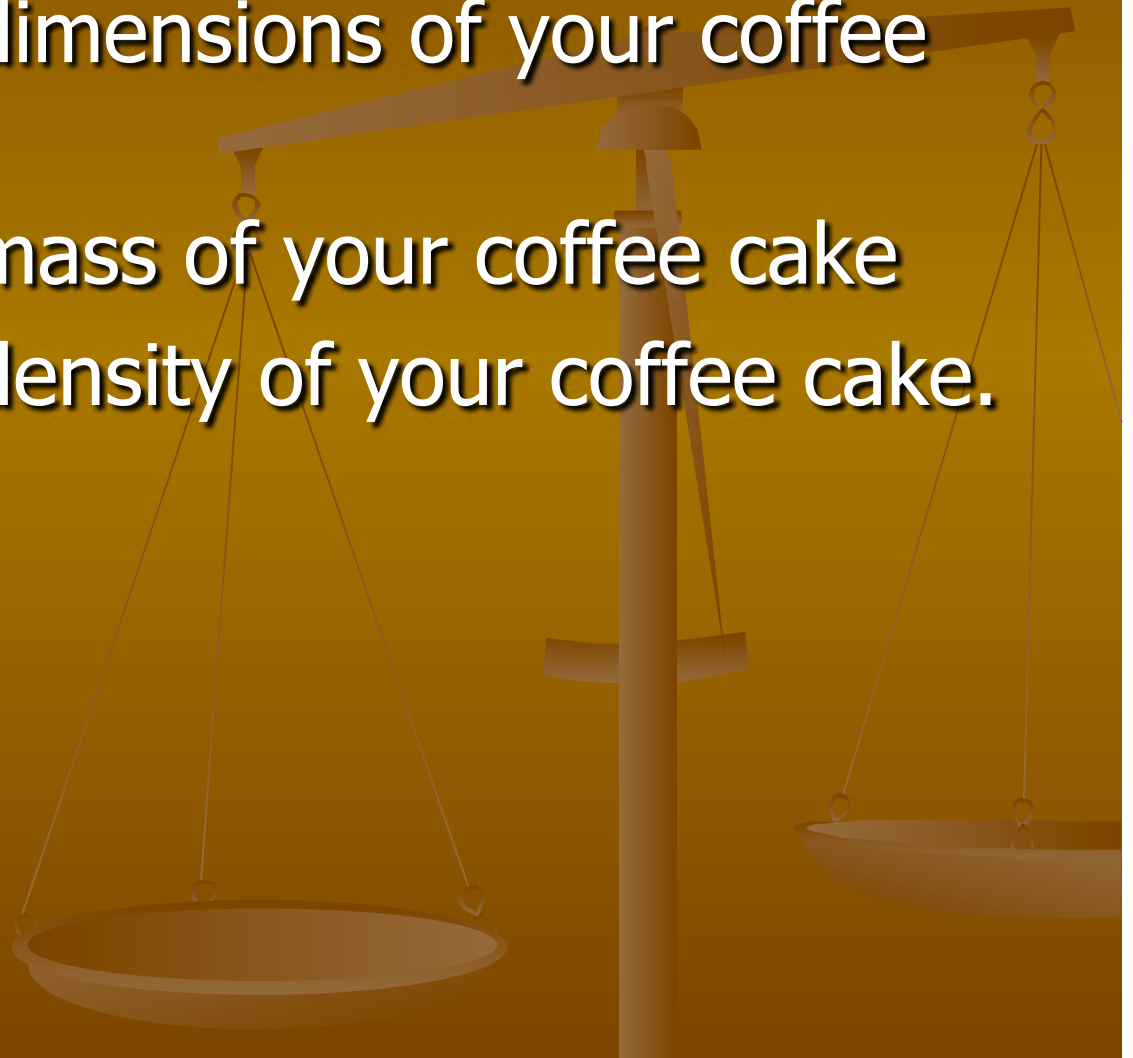
Sample Test continued

- Put a little of each drink mix in a different test tube. (It is best to have each table do a different mix here)
- Add 5 drops of Benedict's solution
- Put the test tubes in a hot water bath
- What colors do the turn?



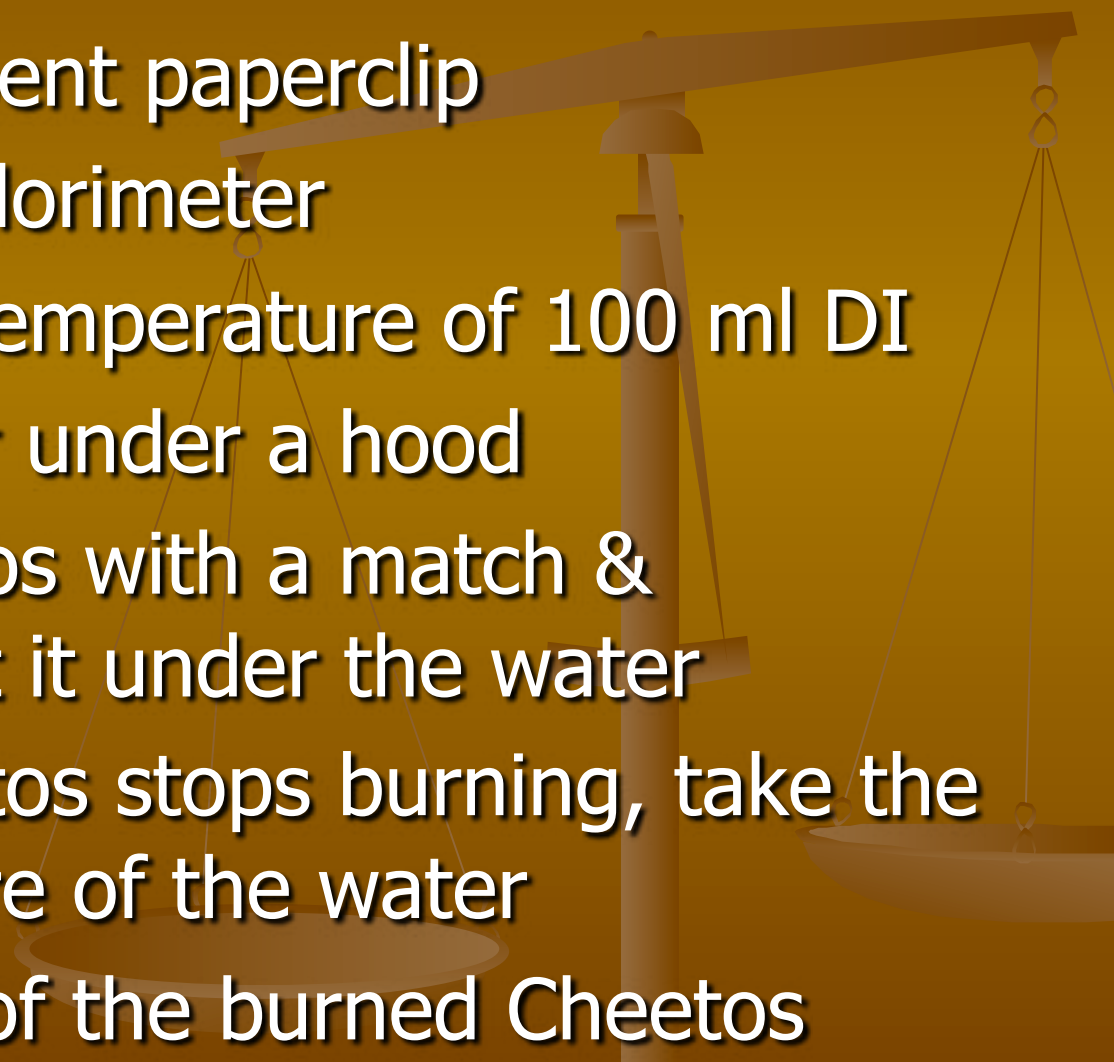
Density

- Determine the dimensions of your coffee cake
- Determine the mass of your coffee cake
- Determine the density of your coffee cake.



Using the Calorimeter

- Mass a Cheetos
- Impale it on a bent paperclip
- Prepare your calorimeter
- Find the initial temperature of 100 ml DI
- Move outside or under a hood
- Light the Cheetos with a match & immediately put it under the water
- When the Cheetos stops burning, take the final temperature of the water
- Take the mass of the burned Cheetos



Calculations

- Determine $\Delta H = mC\Delta t/n = 100(4.18)\Delta t/n$
- Divide by 1000 to turn to kJ/g
- Divide by the efficiency of your system
- Divide by 4.186 to change to Calories
- Compare to accepted value of Cheetos Crunchy of 5.17 Calories/g

