Thinking outside…and inside…the box!

Science Olympiad
Food Science Event 2007-2008

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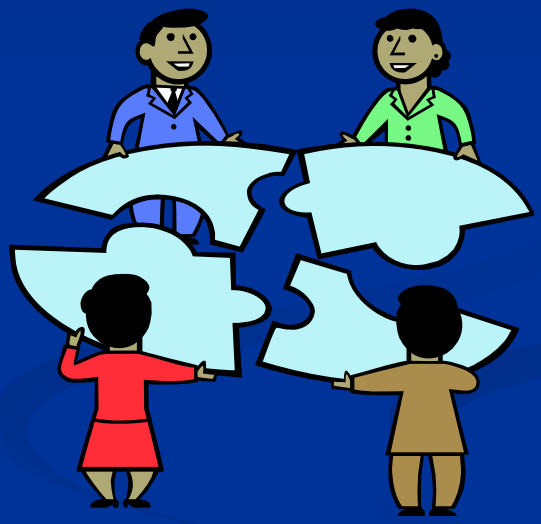
www.ncstatefoodscience/info

What will your team gain from Food Science?

- Critical thinking and problem solving skills
- Teamwork
- Basic lab skills
- Basic knowledge of Food components and how they function
- Nutritional labeling



Where to start?

- http://www.ncstatefoodscience.info
  - Former state and regional events…even a previous coaches clinic lab exercise!
  - Sources for reagents and supplies
  - Information and instructions specific to the sample tasks and competition

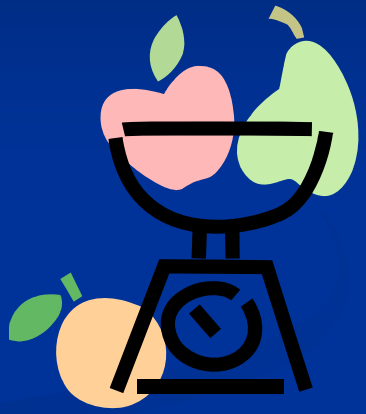
Skills to Learn

- Critical thinking, problem solving and teamwork
  - Use of time- can partners work independently?
  - Have team members excel in different tasks
  - What is the question really asking ?
  - Read questions and THINK about possible answers before performing tests

Think OUTSIDE the box!

Skills to Learn

- Basic lab skills
  - Pipeting
    - What is a drop?
  - Measuring and weighing
    - To Tare or not to Tare?
    - Accuracy counts!
  - Calculations and results
    - Significant figures
- Most procedures will be given...will not need to memorize them step by step



Components to Learn

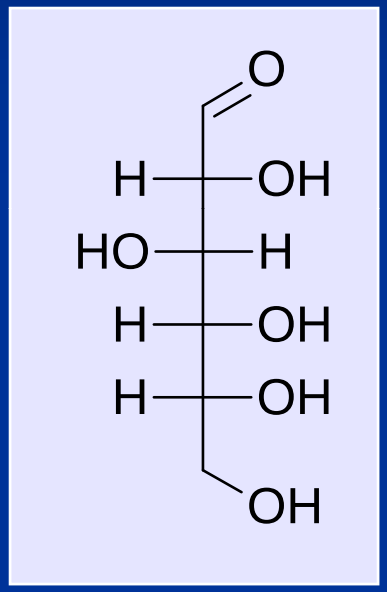
- Basic knowledge of Food components and how they function
  - Carbohydrates
    - Sugars, Starches and plant gums
    - Benedict's test, Lugol's Iodine
  - Lipids
    - Basic Structures
    - Sudan IV
  - Proteins
    - Amino acids
    - Biuret test
  - Caloric values
  - Moisture/Density
  - Iron
  - Vitamin C
  - Leavening agents

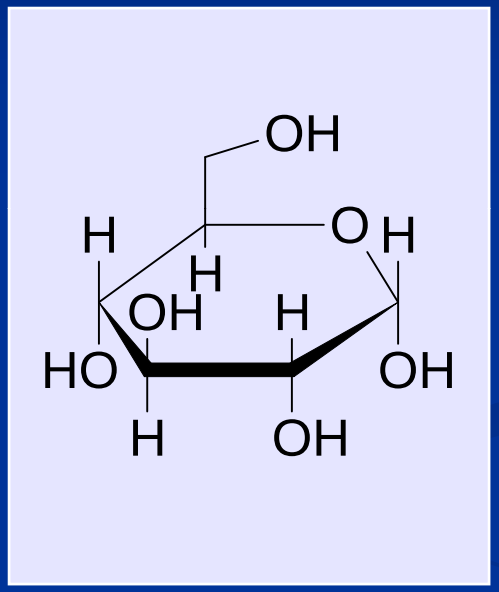
Carbohydrates

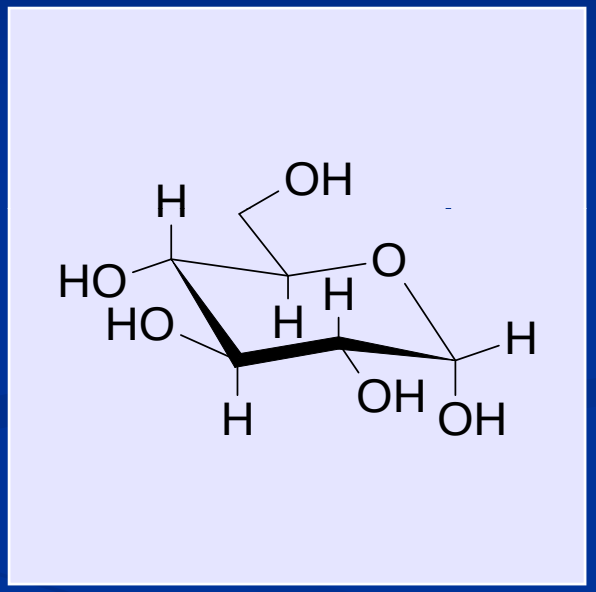
- Carbohydrates
  - $C_x(H_2O)_y$ carbon along with hydrogen and oxygen in the same ratio as water
- Basic unit – monosaccharide
- Multiple units –
  - disaccharide (2)
  - trisaccharide (3)
  - oligosaccharide (2-10)
  - polysaccharide (>10)

Carbohydrates

- Carbohydrate Structures (C only)







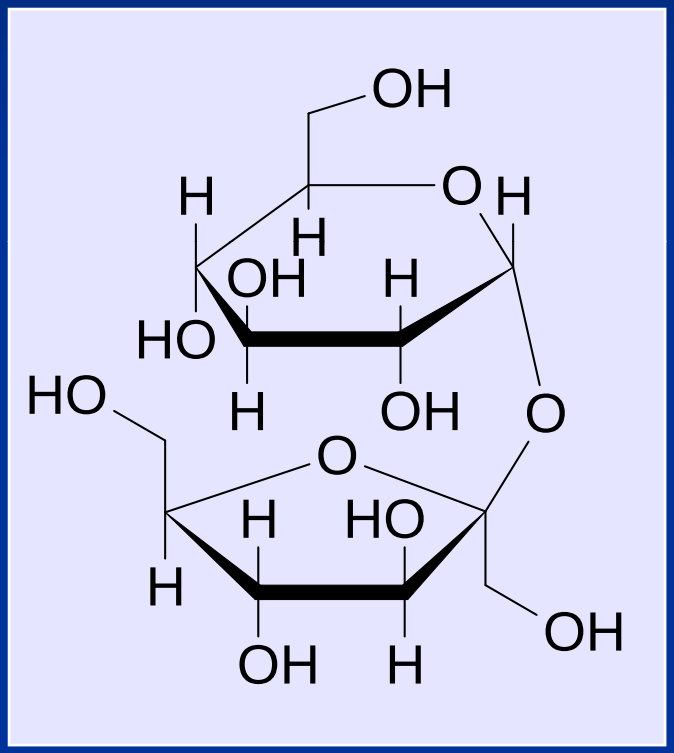
Glucose: D (+) glucose
Fisher

a-D(+) glucopyranose
Haworth

a-D(+) glucopyranose
$^4C_1$ chair

Glucose, Fructose and Glactose are monosaccharides

Carbohydrates



- Disaccharides
- Examples:
  - Lactose (glucose and galactose) -milk
  - Maltose (glucose and glucose) -
- Sucrose
  - Carbon 1 of glucose linked to carbon 2 of fructose –table sugar

Carbohydrates

Polysaccharides

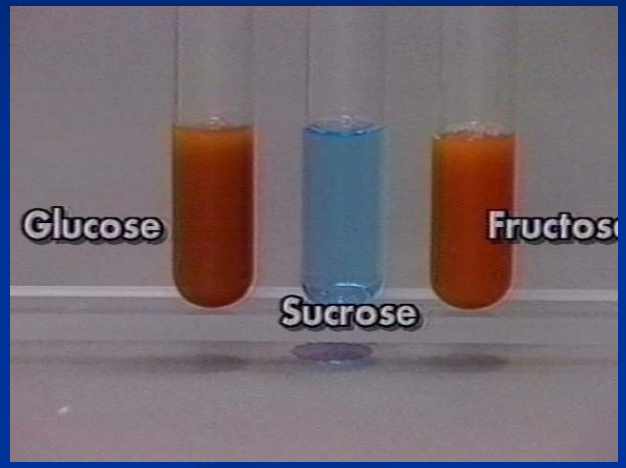
- Examples:
  - starch - glucose polymers, found in plants
  - cellulose –found in plant fibers, insoluble
  - Pectin-units are sugar acids rather than simple sugars, found in vegetables and fruits
- Branched vs. linear
  - Starches are a mixture of branched (amylopectin) and linear (amylose) polysaccharides

Carbohydrates

- Reducing vs. non-reducing sugars
  - Reducing sugar contains an aldehyde group
  - Examples: glucose, lactose
  - Non-reducing sugar contains a ketone group
  - Example: sucrose

Tests for carbohydrates

- Fehlings test or 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 aldehyde or ketone group of the reducing sugar to form cuprous oxide (Cu2O), a red-brown precipitate.
- $CuSO_4 \Rightarrow Cu^{++} + SO_4^{--}$
- $2\ Cu^{++}$ + Reducing Sugar $\Rightarrow Cu^{+}$
  (electron donor)
- $Cu^{+} \Rightarrow$ Cu2O (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

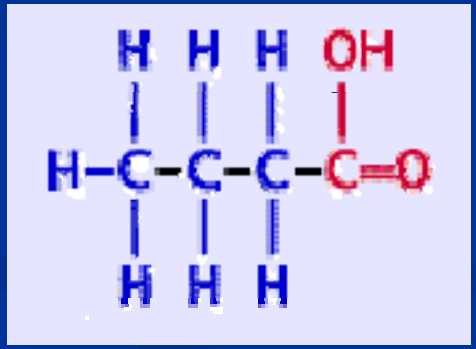
- The **Iodine test** is used to test for the presence of starch.
- Iodine solution – Iodine is dissolved in an aqueous solution of potassium iodide - reacts with starch producing a deep blue-black color.
- This reaction is the result of the formation of polyiodide chains from the reaction of starch and iodine. The amylose, or straight chain portion of starch, forms helices where iodine molecules assemble, forming a dark blue/black color. The amylopectin, or branched portion of starch, forms much shorter helices and iodine molecules are unable to assemble, leading the color to be of an orange/yellow hue. As starch is broken down or hydrolyzed into smaller carbohydrate units, the blue-black color is not produced. Therefore, this test can determine completion of hydrolysis when a color change does not occur.
- Iodine solution will also react with glycogen and cellulose, although the color produced is browner and much less intense.
- Retrieved from "http://en.wikipedia.org/wiki/Iodine_test"

Lipids

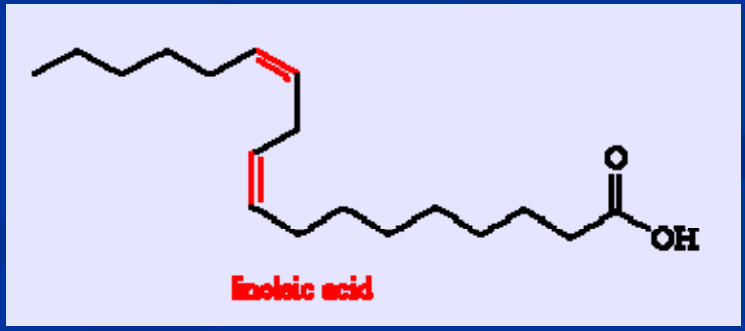
- Present as fats extracted from plants or animals (butter, vegetable oil) or as constituents of food (cheese, meats)
- Contributions to foods: texture and flavor
- Unique characteristics:
  - Crystalline structure
  - Melting and solidifying
  - Association with water or other molecules

Lipids

- Lipids are composed of multiple fatty acids
  - Aliphatic monocarboxylic acids
  - Have 1+ carboxyl groups
- Saturated
  - No double bonds
    - saturated with hydrogen
- Unsaturated
  - Double bonds



Butyric acid (4:0)



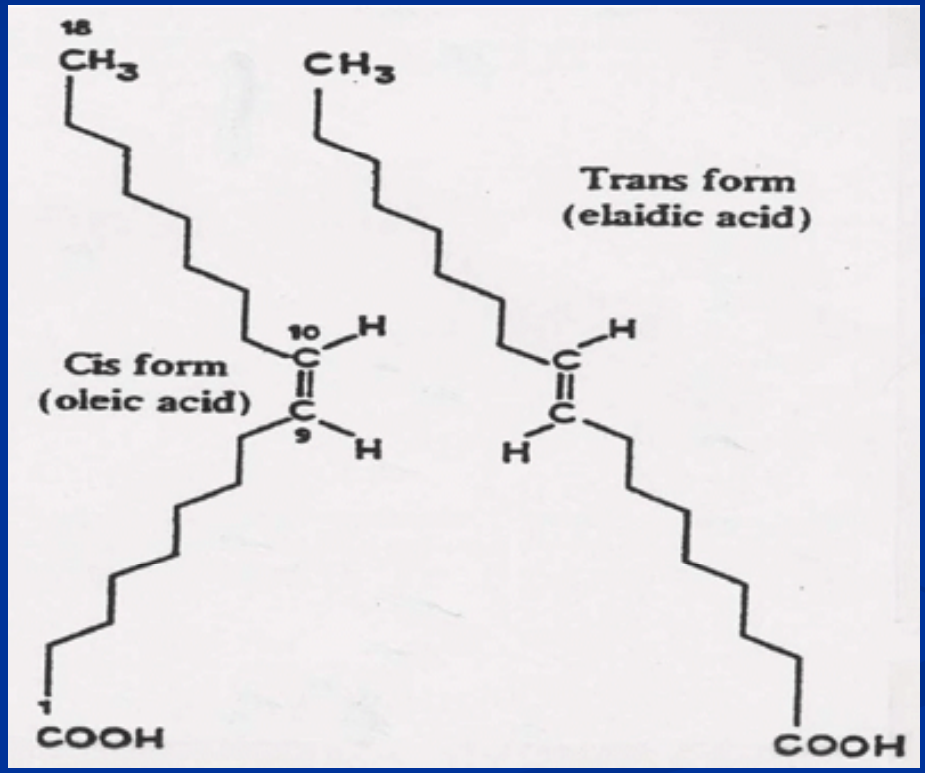
Linoleic acid (18:1)

Lipids

- Cis vs. trans
  - Fatty acids with the same number of carbons and double bonds are not necessarily identical molecules
  - Geometric conformation can vary
    - Cis –*on this side*
    - Predominate in nature
    - Trans –*across*
    - Exist in small quantities naturally
    - Consumed in lrg amounts as hydrogenated fats

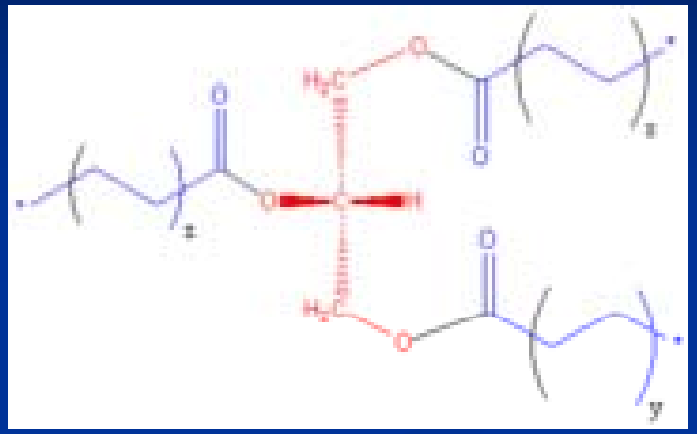
Lipids

- Cis vs. Trans



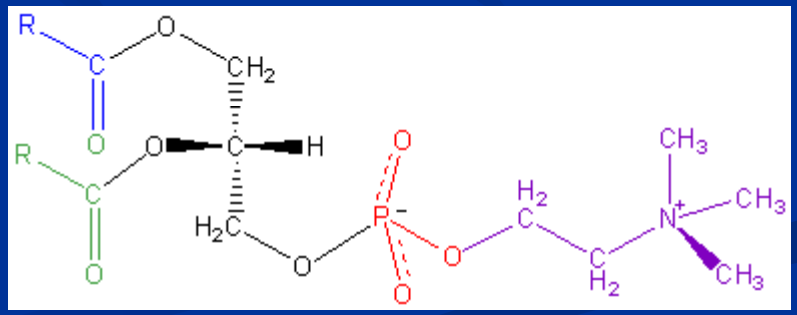
Lipids

- Fatty acids are arranged in groups of 3 on a 3 carbon glycerol backbone - triacylglycerol



Triacylglycerol

- Phospholipids contain at least one phosphate and nitrogen group in one of the fatty acids



Lecithin

Lipids

- Brown Bag Test (B)

or Sudan IV (C)

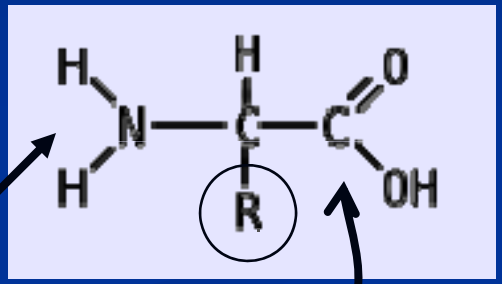
Lipids

- Conversion between crystalline (solid) structure to a liquid state is called the melting point
  - Affected by
    - Saturation
    - Number of carbons in fatty acids

Saturated	**MP**	**Unsaturated**	**MP**
Butyric (4:0)	*-5.3oC*	Palmitoleic (16:1)	*0oC*
Palmitic (16:0)	*62.9oC*	Oleic (18:1)	*16.3oC*
Steric (18:0)	*70.1oC*	Linoleic (18:2)	*-5oC*
		Linolenic (18:3)	*-11oC*

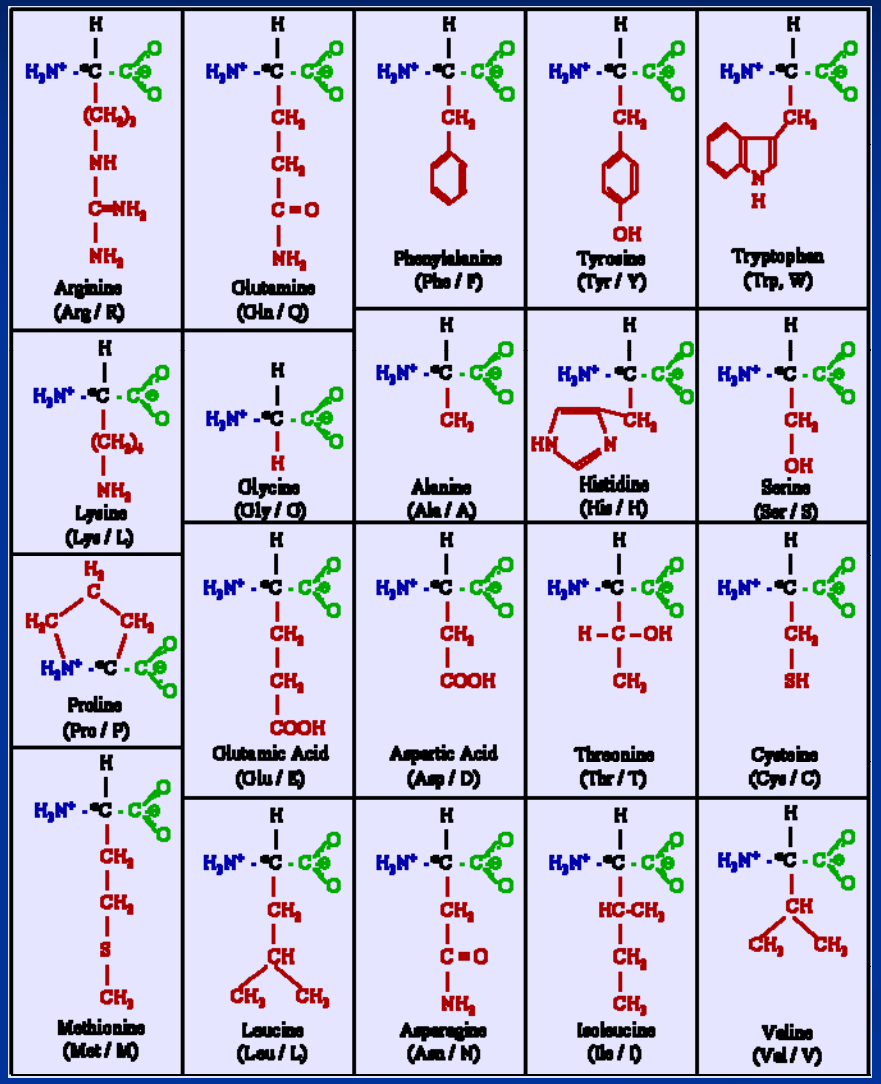
Proteins

- Proteins are made up of amino acids
  - 20 kinds
  - 8 essential and 12 nonessential
  - Each contains 1 primary amino and 1 carboxyl group



  - Each amino acid has 2 isomerizations: D & L
  - At physiological pH the amino group has a (+) charge and the carboxyl group is (-) charged

Proteins (C only)

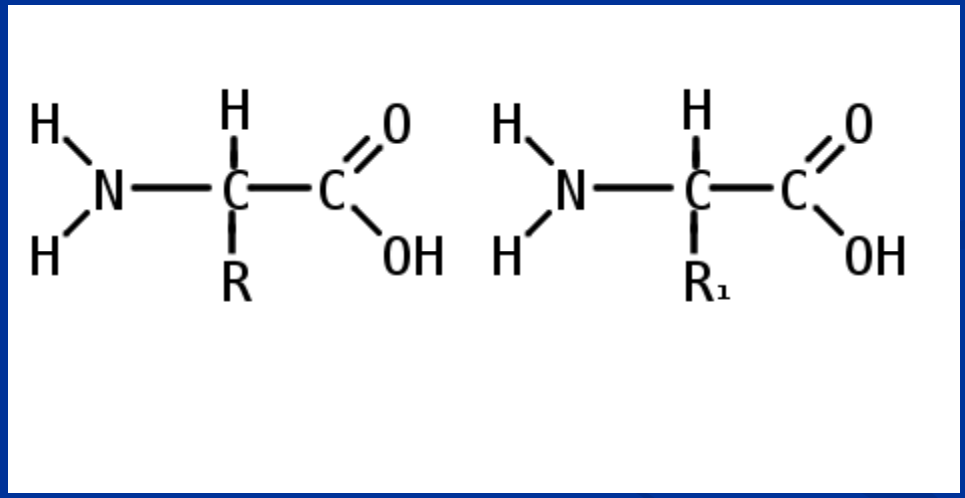


Structures of amino acids (C only)

Hydrophobic

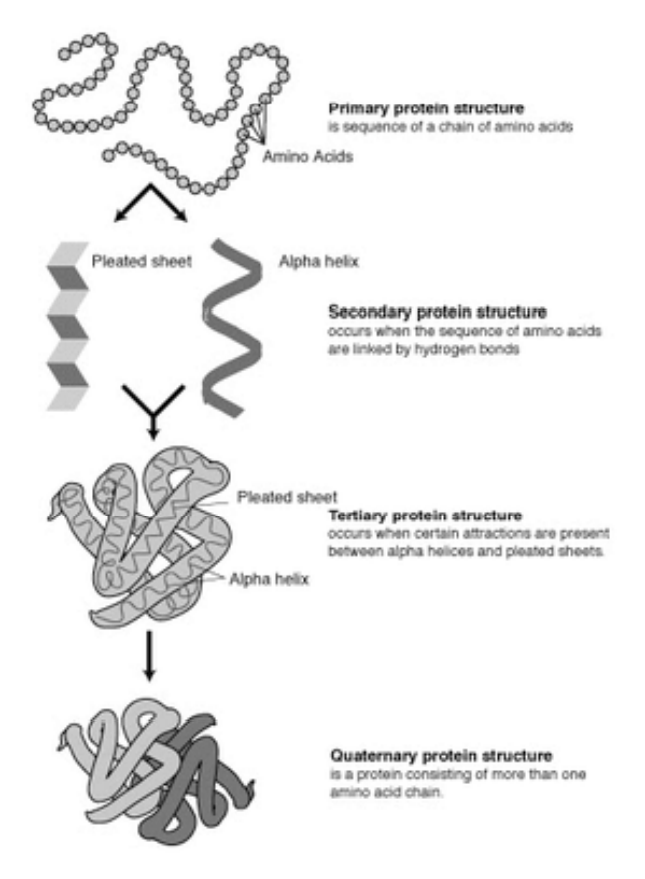
Proteins (C only)

- Amino acids are connected by peptide bonds to make proteins
- Condensation
- reaction to create
- a peptide bond
- Different levels
- of structure:
  - Primary, secondary, tertiary, quaternary



Proteins (C only)

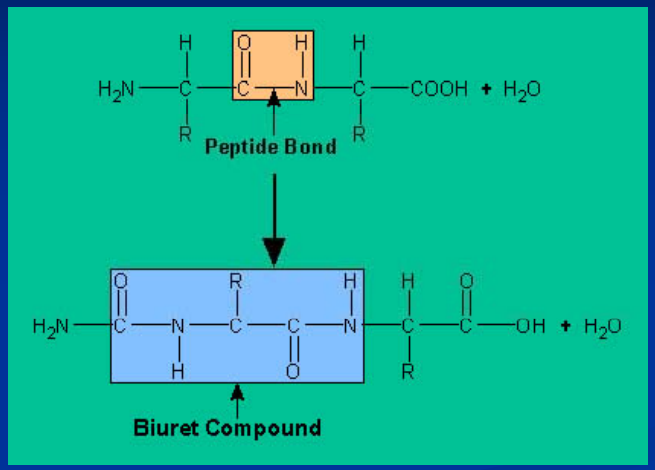
Amino acids are connected by peptide bonds to make proteins



Yellow stripes are representative of beta-sheets.
Pink coil is representative of alpha helices.

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 changes to pink when combined with short-chain polypeptides.

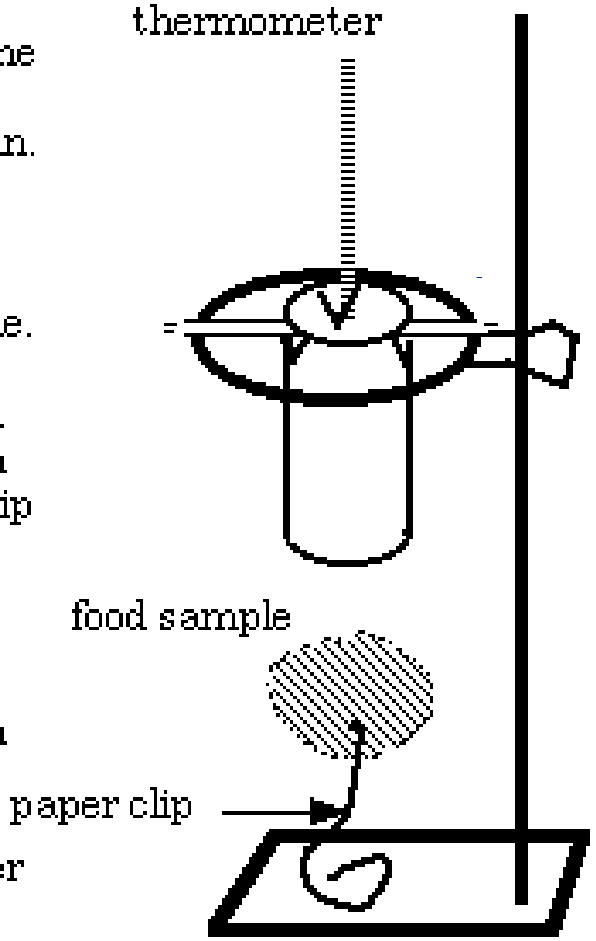


Quantitative carb/protein test

- To determine quantitative amounts of carbohydrates or proteins in skim milk, must first separate before drying.
- To a known weight of milk, acidify with lemon juice to coagulate proteins. Collect coagulate and dry (protein).
- Take remainder and dry in oven. Weigh remainder (carbohydrate and trace minerals).

Calorimeter

1. With a bottle opener, punch out two triangular holes at the top of the soda can so that a stirring rod can be slid through the holes. Mass out 100 g of water in the soda can.
2. Measure the initial temperature of the water.
3. Mass out approximately 2-3 grams of the nut/food sample.
4. Construct a nut/food burner by piercing the nut/food with one end of the paper clip and forming a support base with the other end. Place a piece of aluminum foil under the clip to catch any ash or burning food.
5. Place the soda can on the ring clamp over the nut/food burner, using the stirring rod to support the can. A wire mesh is not needed and would only lower results. Position the can approximately 3-4 cm above the nut/food.
6. Ignite the nut with a match, and allow it to heat the water inside the can, while stirring continuously.



http://www.woodrow.org/teachers/chemistry/institutes/1988/calorimeter.gif

Calorimeter calculations

Wt. of sample (g)
Wt. of water used (g)
Initial Temp. of water (° C)
Final Temp. of water (° C)

1000 calories= 1 Food Calorie
1 calorie= 4.184 Joules (J), 1 Food Calorie= 4.184 kilojoules (kJ)
Heat capacity of water= 4.184 joules/(g x °C)
Heat absorbed by water (J)=
mass of water x (temp final – temp init.) x heat capacity of water
Calories= heat absorbed by water (J)/4.184

Nutritional labels (B only)

- Carbohydrates and proteins yield 4 kcal/g when consumed
- lipids average yield 9 kcal/g when consumed
- fats are the most concentrated source of food calories
- carbohydrates are the cheapest source of calories
- proteins the most expensive
- Labels will have values deleted. Must figure out missing values by using the values above. These are mostly **math problems**.

Nutritional labeling

1)Fill in the following blanks on the result sheet.

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

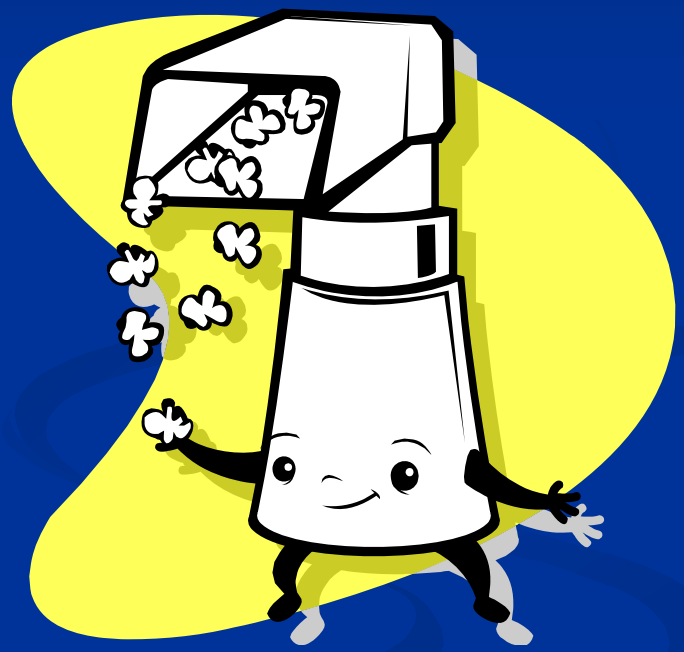
Amount Per Serving
Calories [redacted] Calories from Fa[redacted]

	% 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%

Moisture of popcorn

- www.popcorn.org
- Heating the kernels of corn changes the water to steam...making it pop. This test measures the free water in the kernel, not the absolute moisture. Some “bound” water may still be present.
- Need to weigh popcorn kernels both before and after cooking.
- Subtract weight of popped kernels from weight of same kernels initially to find amount of water lost
- Divide water lost by initial weight of kernels and multiply result by 100
- $\frac{\text{(Weight initial-weight final)}}{\text{weight initial}} \times 100$
- How much water would be in a single kernel????

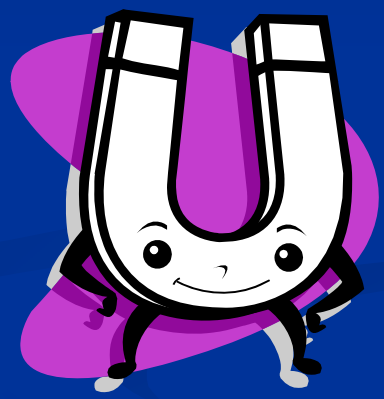


Density

- measure of mass per unit volume
  - **Expressed in kilograms per cubic meter (kg/m3), grams per cubic centimeter (g/cm3) kilograms per litre (kg/L), pounds per cubic foot (lb/ft³), pounds per cubic yard (lb/yd³), pounds per cubic inch (lb/in³), ounces per cubic inch (oz/in³), pounds per gallon (for U.S. or imperial gallons) (lb/gal), pounds per U.S. bushel (lb/bu),**
  - **dependent on temperature and pressure (PV=nRT)**
  - **common device for measuring fluid density is a pycnometer**
  - **Liquids- Place a known volume of liquid on a balance (measure in graduated cylinder, pipet, etc.**
  - Solids
    - traditional shapes
      - may use geometry to figure out area of sample, then weight (marshmallows, hotdogs with ends cut off, etc).
    - Non-conforming shapes
      - Submerge weighted sample into container filled to the brim with water. Allow water to spill into container on balance. (apples, eggs, etc.)
      - Fill known volume with sample, then weigh (flours, etc.)

Iron in breakfast cereals

- **Iron** is often added to fortified cereals in the form of powdered **iron** (often listed as reduced **iron** in the ingredients. Powdered **iron** is easy to measure, has no stability problems, and does not affect the taste or color of the **cereal** in this form.
- Weigh approx. 2 cups of breakfast cereal containing iron or reduced iron into a plastic baggie and crush the cereal with a rolling pin or meat tenderizer (don't tear the bag!)
- Weigh a magnetic stir bar.
- Place stir bar in a 2L beaker. Add about 1.5 L water to beaker as well as cereal. Stir on stir plate for 15 minutes (add more water if it gets too thick)
- Retrieve stir bar (either with another magnet or by carefully pouring off cereal mixture)
- Weigh stir bar. ((Weight after-weight before) is amount of iron in cereal.



Vitamin C Determination

- Vitamin C is ascorbic acid.
- Ascorbic acid is used in many food items for varied reasons, including nutritional improvement or replacement for losses during processing, chelating metals and as an antioxidant, which can prevent rancidity in oils, prevent color depletion in meats and improve bread dough texture.
- It is depleted by light and heat.

Vitamin C determination

- Iodine reacts with vitamin C.
- If a sample contains vitamin C, iodine added to the sample will react with it and no longer be iodine. At the same time, the vitamin C that reacts with the iodine also is no longer vitamin C. When the amount of iodine added to the sample is greater than the amount of vitamin C that was there, all the vitamin C will be destroyed and there will be some iodine left over.
- So to find out how much vitamin C is in a sample, you can add small amounts of iodine, until the iodine you add no longer disappears as soon as it is added.
- Starch and iodine can pair up to make a dark blue material. In this combination, the iodine can still react with vitamin C. When that happens, the starch-iodine pair does not exist any more (because the iodine is gone), so the dark blue color disappears as well. So if you add the starch-iodine solution to the sample with vitamin C, the blue color of the sample will disappear until you have added enough iodine to react with all of the vitamin C. When that happens, the blue color will persist.
- It is much easier to see the blue color of the starch-iodine solution than to see the faint yellow color of a weak iodine solution. So the starch acts as an "indicator" for iodine. It makes it easy to see if any iodine is in the sample.

Leavening agents

- Produce fermentation in dough (yeast) or a liquid or a material (baking soda or powder) 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
  - -NaHCO3
  - **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
  - NaHCO3 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 CO2 in two steps
  - Reacts when moistened and also reacts when heated
  - double-acting is the only commercial baking powder available today.

Questions?

- Website for coaches and teams:
  - www.ncstatefoodscience.info
- E-mail specific questions
  - Sharon Ramsey: sharon_ramsey@ncsu.edu

Time to play!

- Leavening agents
- Unknown samples
  - Vitamin C
  - Protein
  - Starch
  - Sugars