Unit 4: Kitchen Chemistry
Unit Objectives:

1. Explain the difference between an acid and a base and state several examples of each.
2. Describe how acids and bases are characterized using the pH scale.
3. Using the pH scale identify substances as acids and bases.
4. Describe the characteristics of acids and bases in terms of reactivity and taste.
5. Use litmus paper and cabbage juice to test various everyday kitchen substances for acidity and basicity.
6. Categorize food nutrients into three groups including carbohydrates, proteins and fats.
7. Describe the major properties of carbohydrates in terms of their role in nutrition.
8. Explain the differences between simple sugars and starches and describe how each provides nutrition.
9. Describe what a protein is and give several examples of foods that are rich in proteins.
10. Describe what fats are and give several examples of foods that are rich in fats.
11. Compare and contrast saturated fats and unsaturated fats in terms of their chemical composition.
12. Describe how the difference in the composition of saturated and unsaturated fats results in differences in nutritional value for humans.
13. Explain the general goal of food preservation and state several means by which that goal is accomplished.
14. Describe the process of salting and drying to achieve food preservation and explain how they are similar and different.
15. Compare and contrast the processes of canning, freezing and pickling to achieve food preservation in terms of their effectiveness and limitations.
16. Explain what is meant by leavening and state 3 common processes where leavening is achieved in food preparation.
17. Describe the process of crystallization and explain how it is achieved.
18. Describe the parts of a water solution using the terms solvent and solute.
19. Explain what is meant by a solution concentration and how solutions can be saturated and super-saturated.
20. Compare and contrast 5 types of colloidal dispersions.
Lesson 1: Acids and Bases

- One property of substances that is important in cooking is pH.
- pH stands for the power of hydronium ions.
- Hydronium ions are naturally present in almost anything used in the kitchen.
- pH is referred to as an inverse scale so substances with high power of hydronium ions have a low pH.
- The pH scale runs from zero to 14.
  - Substances with high power of hydronium have a low pH between zero and 7 and are referred to as acidic.
  - Substances with a low power of hydronium have a high pH between 7 and 14 and are referred to as basic or alkaline.
  - Substances with pH exactly at 7 are referred to as neutral.

- Testing pH
- There are many ways of testing pH. The simplest method is by using an indicator.
- Indicators are made from natural pigments or dyes that change color when exposed to different pH ranges.
- Examples of some common indicators are litmus paper (red and blue) and cabbage juice.
- The following table summarizes characteristics of acids and bases.

<table>
<thead>
<tr>
<th></th>
<th>Acid</th>
<th>Base</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH range</strong></td>
<td>Zero to 7</td>
<td>Between 7 and 14</td>
<td>Exactly 7</td>
</tr>
<tr>
<td><strong>Characteristics</strong></td>
<td>- Sour taste</td>
<td>- Bitter taste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Reactive w/ metals</td>
<td>- Slippery</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- React w/ fats</td>
<td>Yummy and refreshing</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Acidic</td>
<td>Basic or alkaline</td>
<td></td>
</tr>
<tr>
<td><strong>Reaction w/ Red Litmus paper</strong></td>
<td>No change</td>
<td>Turns blud</td>
<td>No change</td>
</tr>
<tr>
<td><strong>Reaction w/ Blue litmus paper</strong></td>
<td>Turns red</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td><strong>Reaction to purple cabbage juice</strong></td>
<td>Turns pink</td>
<td>Turns green</td>
<td>No change</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td>Lemon juice</td>
<td>Ammonia</td>
<td>Water milk</td>
</tr>
<tr>
<td></td>
<td>Soda</td>
<td>Baking soda</td>
<td>Milk</td>
</tr>
</tbody>
</table>
Lesson 2: Comparing Food Nutrients

- Foods and beverages that humans consume have varying degrees of nutritional value.
- Most of what is consumed will fit into one of 3 categories.

1. Carbohydrates have approximately 4 calories per gram.
   - Simple sugars are examples of carbohydrates that have relatively small molecules.
     - Foods that contain sugar, corn syrup, fruit juice, fructose or honey have simple sugars.
     - The small molecules of simple sugars break down easily and therefore provide quick energy.
     - Quick spikes in blood sugar from simple carbohydrates send messages to the body to store energy as body fat.
   - Complex carbohydrates are larger molecules that are more difficult for your body to break down.
     - Foods that come from grains and fruits and vegetables are composed primarily of complex carbohydrates
     - Because they break down slower they provide the body with more evenly paced energy.
     - They are less likely to be stored in the body as fat.
     - Examples are starch rich foods like potatoes and rice, grain products like pasta, bread, oatmeal and vegetables.
2. Proteins have approximately 4 calories per gram.
   - Proteins are naturally occurring molecules in all plant and animal life forms.
   - Typically foods coming from animal products are higher in protein
     - Examples: Fish, eggs, milk, cheese, beef
   - Some plant based foods are also high in protein
     - Examples: soy products like tofu, many types of beans, and nuts.
   - Proteins are an essential part of a healthy diet as they support the human body’s work to produce healthy cells and tissue of all kinds.

3. Fats have approximately 9 calories per gram
   - Fats of the right type and in the right proportion are an essential component of a healthy human diet.
   - Fats are categorized into two types based on the benefit they provide to diet.
     - Saturated fats are generally less healthy.
       - The word saturated means full. Something that is saturated is full of something.
       - A saturated sponge is unable to soak up any additional water until you wring it out.
       - Saturated fats are full with the maximum number of hydrogen atoms in their molecular structure.
     - Fats that are saturated are more likely to remain as fat in the body where they can be deposited as fat tissue or clog up blood vessels.
- Saturated fats usually come from high fat animal products like bacon, hamburgers, egg yolks, butter.
  - Most deep fried foods are fried in saturated fats which they soak up.
    - E.g. wings, fries, most fast food.
- Unsaturated fats are generally healthier.
  - The molecular structure of unsaturated fats have “spaces” where hydrogen atoms could exist.
    - There is at least one location where two carbon atoms are connected by two pairs of electrons
    - This is referred to as a double bond.
  - Unsaturated fats are more likely to be “burned” as energy in the body and therefore less likely to clog up blood vessels.
    - Unsaturated fats can even reverse clogged blood vessels by dissolving and carrying away the saturated fats in the blood flow.
  - Unsaturated fats are common in plant based fats like avocados, olives and peanuts.
- The following table summarizes the differences between saturated and unsaturated fats.

<table>
<thead>
<tr>
<th>Saturated Fats</th>
<th>Unsaturated Fats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon atoms are connected by single bonds</td>
<td>Some carbon atoms are connected by double bonds</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Solids at room temperature</td>
<td>Liquid at room temperature</td>
</tr>
</tbody>
</table>

**Examples:**
- Butter
- Crisco
- Deep fried foods

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**Saturated**

![Saturated Diagram]

**Unsaturated**

Double bond

**Examples:**
- Olive oil
- Canola oil
- Avocados
- Fish
- Walnuts
Lesson 3: Food Preservation and Preparation

Food Preservation:

- All foods are susceptible to spoiling which can be caused by a variety of processes.
  - Most food spoilage is due to growth of microorganisms like bacteria and mold.
- Food preservation methods usually focus on preventing growth of microorganisms.
  - Salting –
    - Creates a low moisture environment which is hostile to microorganism growth
    - Examples – Salted fish, bacon, ham
  - Drying – dehydrating
    - Microorganisms require water to flourish.
    - Removing water from food prevents spoiling
    - Examples: Jerky, raisins,
  - Canning – multiple steps to storing food in a sterilized container
    - All microorganisms are killed by heating the food product and the canning container to a high temperature.
    - The container is filled with the food while both are hot and a lid is tightly sealed while still hot.
    - Examples: soup, vegetables, spaghetti sauce, etc, etc, etc.
  - Freezing –
    - The food is stored at a very low temperature where microorganism growth is near zero.
    - Meat, vegetables, fruits.
  - Refrigeration –
- Food is stored in a cool refrigerator which dramatically slows the growth of microorganisms.
  - Pickling
    - Mixing the food with salt, sugar, and/or acid.
    - Microorganisms don’t grow in acidic solutions or solutions of high concentration salt or sugar.
    - Examples: Pickles (cucumbers), beans, cabbage (sauerkraut), eggs.

**Leavening**

- Many foods require a proper texture as well as flavor to be enjoyable.
- Bread for example is more enjoyable when it is light and moist as opposed to dense and dry.
- This texture is achieved through a process called leavening which means creating air pockets in the food.
- These pockets are created during the food preparation process through a chemical reaction that produces carbon dioxide (CO$_2$).
- Following are some common examples of how leavening is achieved in food preparation.
  - Yeast raised dough –
    - Yeast is a living microorganism that is added to dough recipes like bread, pizza dough and rolls.
    - Yeast catalyzes a chemical reaction that produces CO$_2$ prior to baking the dough.
    - After giving the dough time to “rise” as a result of this process it is baked with the gas bubbles in the dough.
• Acid / base reactions
  ▪ When acids and bases react they produce CO₂
  ▪ Many dough and batter recipes include both an acid and a base that causes CO₂ to be produced and trapped in the batter.
  ▪ Commonly used acids include lemon juice, milk and vinegar
  ▪ Commonly used bases include baking powder and baking soda.
  ▪ Used with pancakes, muffins, quick breads and cakes.

**Crystallization**

• Crystallizations is a very common food preparation method that requires understanding of solutions

• The process starts by dissolving sugar in water at an elevated temperature.
  ▪ The water is referred to by chemists as the solvent.
  ▪ The sugar is referred to by chemists as the solute.
  ▪ The mixture of sugar and water is called a solution.

• The solution is prepared to be saturated which means that it has the maximum amount of sugar dissolved in the water.
• As the solution cools the dissolved sugar turns back to a solid forming small crystals
• This process is used to produce rock candy and fudge.
Colloidal Dispersions in Cooking

- A colloidal dispersion is a type of heterogeneous mixture that is common in food products.
- It has two separate phases and are continuously dispersed.
- They are categorized based on the states of matter of the two components.

<table>
<thead>
<tr>
<th>Type</th>
<th>Phases</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gel</td>
<td>Liquid suspended in a solid</td>
<td>Jello, Jelly</td>
</tr>
<tr>
<td>Sol</td>
<td>Solid suspended in a liquid</td>
<td>Milk of Magnesia</td>
</tr>
<tr>
<td>Sponge</td>
<td>Gas suspended in a solid</td>
<td>Cake, Bread</td>
</tr>
<tr>
<td>Foam</td>
<td>Gas suspended in a liquid</td>
<td>Whipped cream, Lemon Meringue</td>
</tr>
<tr>
<td>Emulsion</td>
<td>Liquid suspended in an immiscible liquid – 2 liquids that don’t mix (oil and water)</td>
<td>Mayonnaise, gravy, salad dressing.</td>
</tr>
</tbody>
</table>

In the News: Gluten
Gluten is a type of protein. It is naturally occurring in wheat, rye and barley grains. Rice and corn grains do not contain gluten. It affects the texture of foods like bread as it makes leavening possible. Some people have an allergy to gluten which is a condition known as Celiac disease. The only effective treatment for Celiac disease is eliminating gluten from one’s diet.

The number of Americans adopting gluten-free diets has grown dramatically over the past several years. Some avoid eating wheat, barley, and rye because they have an autoimmune disorder called celiac disease, some are sensitive to gluten which can cause stomach upset, and others simply avoid gluten in an effort to lose weight. While many feel the diet has improved their overall health, are there potential downsides to abstaining from gluten?

UConn Today recently discussed going gluten-free with Dr. Haleh Vaziri, gastroenterologist at UConn Health in the Division of Gastroenterology and Hepatology. Vaziri is board-certified in internal medicine and gastroenterology and diagnoses and treats a wide range of gastrointestinal issues, including celiac disease and problems related to food sensitivities.

**What is gluten?**

Gluten is the portion of the protein component of wheat that forms the structure of dough. It gives dough its sticky and pliable consistency.

**What is celiac disease?**

Celiac disease is an autoimmune digestive disease with permanent intolerance to gluten in wheat, rye, and barley. In celiac disease, gluten causes damage to the small intestine, and this affects its ability to absorb nutrients.

**What are some symptoms of celiac disease?**

Abdominal pain, bloating, diarrhea, anemia, irritability, mouth ulcers, an itchy skin rash.

**The number of people suffering from celiac disease or gluten sensitivity seems to be increasing – why is that?**

There are different hypotheses: 1) The disease may have been under-diagnosed in the past. 2) Our environment today is much too clean and the human immune system has few things to battle and therefore starts attacking itself. 3) The wheat today may be different than wheat years ago because of hybridization, and therefore elicits an immune response when consumed.

**Is there any downside to following a gluten-free diet if you don’t have celiac disease or a gluten-sensitivity?**

By law, wheat flour must be enriched and fortified whereas other non-wheat flour products are not required to do so. There is no harm in eating gluten-free; however, a gluten-free diet
may lack certain nutrients that are found in fortified wheat products, including vitamin B1, B2, B3, and (Iron) Fe.

There is also the possibility of weight gain, if gluten-containing food is replaced with fatty food.

**Do you think going gluten-free is just another food fad?**

Gluten is only harmful if you have a gluten allergy and/or celiac disease. There are some people who report feeling better on a gluten-free diet without having celiac disease.

Possible reasons for this include 1) a placebo effect; 2) elimination of another food component along with gluten; or 3) a real intolerance of gluten, other than celiac disease.

Another factor to keep in mind is that the gluten-free diet is more expensive.

What is Celiac disease?

Should a person that does not have celiac disease go on a gluten-free diet? Why or why not?