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Food, Cooking and Nutrition-Engaging a Wide Audience to Explore Inter-Disciplinary Science Topics

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Food, Cooking and Nutrition – Engaging a Wide Audience to Explore Inter-disciplinary Science Topics

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Kitchen Chemistry Classes Take Off!

http://cen.acs.org/articles/90/i36/Kitchen-Chemistry-Classes-Take-Off.html

- Harold McGee
  - 1984 book “On Food and Cooking”
  - NY Times column “The Curious Cook”

- “Science and Cooking: From Haute Cuisine to Soft Matter Science” at Harvard University
  - One famous chef along with Physics professor David Weitz “lectures” each week

- “Kitchen Chemistry” at MIT
  - Patricia Christie’s posts available on OpenCourseWare (http://bit.ly/9ohQaT)

- “Chemistry of Cooking” @ American University (DC)
- “Sweet and Savory Science” @ DePauw University (IN)
- “Food, Glorious Food” @ University of Wisconsin, Eau Claire (WI)
- “Science of Cooking” @ Minnesota State University (MN)
Food and Cooking and Science

- Eating is consuming biological material — plant or animal — that has been manipulated through molecular alteration (acted upon by other ingredients and cooked). But preparing food can be a powerful way to understand the effect of mechanical and chemical environments on cellular behavior.

- The more the students understand the scientific basis of food and cooking, the more control they have over the final product and a greater comfort level in the kitchen.

- If students can be trained to approach cooking using the scientific method, they can be better society members by understanding science in a practical way, rather than as magic.
Food, Cooking and Nutrition @UWG

- 2 credit hour course in the general education core curriculum
- Mix of non-science majors and science majors, mainly freshman and sophomore level
- Meets once a week for 1 hour 50 minutes.
- Team taught by two Chemistry professors
  - Organic/biochemist
  - Chemical engineer/physical chemist
- Class structure
  - 15 minute lecture on molecular components of food and the reactions those ingredients undergo during cooking.
  - 15 minute video/simulation/animation
  - 60 minutes hands-on activities
  - 20 minutes data analysis and post-activity discussions
Thematic Approach to Food

- Experiencing food
  - Using five senses; genetic basis

- Breakfast theme
  - Eggs and pancakes

- Lunch theme
  - Hamburgers (meat, bread, condiments, pickles)

- Snack theme
  - Popcorn, ice cream, milk shake and chocolate lava cake

- Dinner theme
  - Mexican cuisine: salsa, guacamole, tortilla chips
  - French cuisine: sweet and savory patisserie
  - Indian cuisine: acid/base reactions with curry
  - Japanese cuisine: adhesion/cohesion with sushi
“Chemicals” – all edible
Equipment – familiar and non-threatening
Measuring and other devices – reliable, accurate and precise
Our tongues detect five flavors: sweet, salty, sour, bitter, and umami. Umami is described as “savoriness,” and has been known to the Japanese for centuries. Scientists have only recently found a receptor for it.

Experiencing Food

- **Taste**
- **Odor**
- **Texture**
- **Appearance**

Contrary to popular belief, you sense all tastes, to varying degrees, on all parts of your tongue. Taste cells can perceive more than one flavor.

We can detect around 10,000 odors, but how we tell one from the other is still unknown. Scientists think we have many different receptors that “light up” in various combinations in response to different scents.

The tongue is covered with bumps called **papillae**.

Each papilla contains multiple **taste buds**.

Taste buds are filled with **gustatory cells** - the cells that do the tasting. The tip of each gustatory cell protrudes through a pore on the surface of the tongue.

**Nerves** carry signals from the gustatory cells to the brain.

The tip of each gustatory cell is covered with an assortment of **bitter taste receptors**, which can detect a wide variety of compounds. Stimulation of any of these receptors sends a signal to the brain: bitter!
Eggs

- Commercial production of eggs
- Anatomy of an egg
- Nutritional value of eggs
- Freshness of eggs
- Role of eggs in various dishes
- Cooking the perfect soft boiled egg – denaturing proteins due to temperature changes
Pancakes

- Science of leaveners and leavening agents
- Maillard “browning” reaction
Burgers

- Composition of meat
- Color of meat
- Chemical reactions in cooking meat
- Record internal temperature of meat, weight and diameter of patty – use thermometer, scale and ruler
- Compare changes in weight and diameter using different cooking methods via bar graphs.

Flow Chart for Reduced Myoglobin to Oxymyoglobin to Metmyoglobin Formation

- Reduced Myoglobin (FBS = H₂O) Purple
  - Reduction (electron gain)
  - Oxygenation
  - Oxymyoglobin (FBS = O₂) Bright red
  - Deoxygenation
  - Oxidation (electron loss)
- Metmyoglobin (FBS = OH) Brown
Cheese and Butter

- Composition and nutrition of milk
- Cheese - denaturing milk proteins with pH change
- Butter - emulsion explosion

Milk treatment:
- Coagulation
- Whey draining
- Salting/Pressing
- Ripening
Mayonnaise

- Insolubility of oil and water
- Emulsification with egg yolks to produce stable mayo mix
Fat free Milkshake

- Counting calories using 4-4-9 rule
- Types of fats
- Thickening agents to increase viscosity
Chemistry of Chocolate

Fermented and Dried Cocoa Beans
  Cleaning and Roasting
  Breaking and Winnowing
    Shells
    Nib
    Germ separation
  Milling

Cocoa manufacture
  Alkalization
  Fat pressing
  Presscake
  Cocoa Butter
  Breaking, Grinding, and Sifting
  Cocoa Powder

Chocolate Liquor

Chocolate Manufacture
  Addition of Sugar, Flavour, Milk, Cocoa Butter, etc.
  Mixing and Refining
  Conching
  Tempering

Molding
  Plain or Milk Chocolate
  Chocolate-casted Products

Enrobing

How To Taste Chocolate

Tasting chocolate means learning to listen to all of your senses in turn, and put sensations into words.

Sight
The sense of sight provides your first contact with the chocolate: its colour and shine will influence the tasting, which uses all the senses.

Smell
The volatile molecules responsible for aromas reach us in two different ways:
- Via the nostrils.
- Via retronasal olfaction: via the back of the oral cavity when food is in the mouth. (see diagram)

Orthonasal
To smell the aroma of a piece of chocolate, break it in two. The main aromas in chocolate are: cocoa, milk, caramel and vanilla. You may also detect notes of nuts (almonds, walnuts, hazelnuts, peanuts) and fruit (most commonly dates, strawberries, raisins). Sometimes you may detect aromas of smoke and malt. This is known as orthonasal olfaction.

Retronasal
Our perception of the flavour of chocolate depends on our perception of the smell. As you will be aware, if you hold your nose or have a cold, you cannot taste the flavour of foods as effectively. The aromas released when you first put the chocolate in your mouth include: cocoa, milk, caramel, vanilla and nutty notes (almonds, walnuts, hazelnuts, peanuts).

By allowing the chocolate to melt in the mouth you can detect notes of fruit (dates, strawberries, raisins, etc.) or malt. Depending on the type of chocolate, you may also detect specific aromas such as honey, coffee, or floral, spiced or smoky notes.
Heat Transfer – Popcorn, Ice Cream & Lava Cake

- Phase change in popcorn
- Water content and popping efficiency of popcorn
- Effects of heat transfer on making ice cream and lava cake

<table>
<thead>
<tr>
<th>Method</th>
<th>Conduction</th>
<th>Convection</th>
<th>Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steaming</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Boiling</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Deep frying</td>
<td>High</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Sautéing</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Broiling</td>
<td>Moderate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Baking</td>
<td>High</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Grilling</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>Microwaving</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Tortilla Chips, Salsa and Guacamole

- Fruit or vegetable
- Genetically modified organisms
- Hotness scale for pepper
- Ripening of fruits and vegetables
- Browning of fruits and vegetables

### Scoville Heat Units

<table>
<thead>
<tr>
<th>Scoville Rating</th>
<th>Pepper Type</th>
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</thead>
<tbody>
<tr>
<td>15,000,000-16,000,000</td>
<td>Pure capsaicin</td>
</tr>
<tr>
<td>9,100,000</td>
<td>Nordihydrocapsaicin</td>
</tr>
<tr>
<td>2,000,000-5,300,000</td>
<td>Standard US Grade Pepper Spray</td>
</tr>
<tr>
<td>855,000-1,041,427</td>
<td>Naga Jolokia</td>
</tr>
<tr>
<td>876,000-970,000</td>
<td>Dorset Naga</td>
</tr>
<tr>
<td>350,000-577,000</td>
<td>Red Savina Habanero</td>
</tr>
<tr>
<td>100,000-350,000</td>
<td>Habanero Chile</td>
</tr>
<tr>
<td>100,000-350,000</td>
<td>Scotch Bonnet</td>
</tr>
<tr>
<td>100,000-200,000</td>
<td>Jamaican Hot Pepper</td>
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<tr>
<td>50,000-100,000</td>
<td>Thai Pepper, Malagueta Pepper, Chiltepín Pepper</td>
</tr>
<tr>
<td>30,000-50,000</td>
<td>Cayenne Pepper, Ají pepper, Tabasco pepper</td>
</tr>
<tr>
<td>10,000-23,000</td>
<td>Serrano Pepper</td>
</tr>
<tr>
<td>7,000-8,000</td>
<td>Tabasco Sauce Habanero</td>
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<tr>
<td>5,000-10,000</td>
<td>Wax Pepper</td>
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<tr>
<td>2,500-8,000</td>
<td>Jalapeno Pepper</td>
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<tr>
<td>2,500-5,000</td>
<td>Tabasco Sauce (Tabasco pepper)</td>
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<td>1,500-2,500</td>
<td>Rocotillo Pepper</td>
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<td>1,000-1,500</td>
<td>Poblano Pepper</td>
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<td>500-800</td>
<td>Tabasco Sauce (Green Pepper)</td>
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<tr>
<td>500-1,000</td>
<td>Anaheim pepper</td>
</tr>
<tr>
<td>100-500</td>
<td>Pimento, Pepperoncini</td>
</tr>
<tr>
<td>0</td>
<td>No Heat, Bell Pepper</td>
</tr>
</tbody>
</table>
Multi-cultural Cuisine

Manipulate color of Indian curry using natural spices, especially turmeric

Create specialty crust for French bakery using variety of flour, butter and humidity

The art of Teppanyaki and sushi in Japanese cuisine
UWG and K-12 Collaboration

- Selected activities used for professional development workshops for K-12 teachers
  - Phase change using popcorn and ice cream
  - Engineering using popcorn storage container
  - Specialty cookies and muffins
- Health
  - Fat-free milk-shake recipes using thickeners
  - Vegan mayonnaise using egg substitute emulsifiers
  - Gluten free bread
Acknowledgements

University System of Georgia Board of Regents STEM II Initiative “University of West Georgia Institutional STEM Excellence (UWISE)” grant