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
Experiencing Food

- Taste
- Odor
- Texture
- Appearance

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

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.

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.

Experiencing Food

- Taste
- Odor
- Texture
- Appearance

The tongue is covered with bumps called papillae.

Experiencing Food

- Taste
- Odor
- Texture
- Appearance

Each papilla contains multiple taste buds.

Experiencing Food

- Taste
- Odor
- Texture
- Appearance

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.

Experiencing Food

- Taste
- Odor
- Texture
- Appearance

Nerves carry signals from the gustatory cells to the brain.

Experiencing Food

- Taste
- Odor
- Texture
- Appearance

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

What's in a Buttermilk Pancake?

Flour (cups) | Sugar (tbsp) | Baking Powder (tsp) | Baking Soda (tsp) | Salt (tsp) | Buttermilk (cups) | Milk (cups) | Eggs | Butter (tbsp)
---|---|---|---|---|---|---|---|---

http://allrecipes.com/recipe/buttermilk-pancakes-i/
http://allrecipes.com/recipe/moms-buttermilk-pancakes/
http://www.marthastewart.com/318689/best-buttermilk-pancakes
http://www.joyofbaking.com/breakfast/ButtermilkPancakes.html
http://www.epicurious.com/recipes/food/views/Buttermilk-Pancakes-109480
http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/1999/05/05/FDS3601.DTL
http://www.tastebook.com/recipes/2297906-Best-Buttermilk-Pancakes-from-Scratch
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.
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

[Diagram showing milk composition and nutrition]

[Images of curds and whey, buttermilk, and butter]

- Fill the mason jar halfway with whipping cream
- Tighten the lid!
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
- Addition of sugar, flavour, milk, cocoa butter, etc.
- Mixing and refining
- Conching
- Tempering

Chocolate manufacture
- Molding
- Enrobing
- Plain or milk chocolate
- Chocolate-coated products

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)

Texture (mouthfeel)
In the second mouthful of chocolate, you assess the hardness of the chocolate and its graininess. By tasting the sample, you can assess the stickiness of the chocolate and how quickly it melts.  

Retronasal olfaction
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).

Sensory hearing
Sweetness is not used to any great extent in chocolate tasting. However, it can play a significant role when ingredients such as pieces of nut or puffed rice are added to chocolate. These are described as crunchy and crisp.

Taste
The tongue only detects the four basic tastes: sweet, salty, sour and bitter.
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>
</tr>
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<tbody>
<tr>
<td>15,000,000-16,000,000</td>
<td>Pure capsaicin</td>
</tr>
<tr>
<td>9,100,000</td>
<td>Norldihydrocapsaicin</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, Malaguetta Pepper, Chiltepin Pepper</td>
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<tr>
<td>30,000-50,000</td>
<td>Cayenne Pepper, Aji pepper, Tabasco pepper</td>
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<td>10,000-23,000</td>
<td>Serrano Pepper</td>
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<td>7,000-8,000</td>
<td>Tabasco Sauce Habanero</td>
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<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>Poblanio Pepper</td>
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<tr>
<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, Peperoncini</td>
</tr>
<tr>
<td>0</td>
<td>No Heat, Bell Pepper</td>
</tr>
</tbody>
</table>

Fruit Development
- dormant
- nutrients
- AbA

Fruit Ripening
- acid
- starch
- chlorophyll
- pectin (hard)
- large organics
- ETHYLENE
- kinase
- amylose
- hydrolase
- pectinase
- hydrolases
- neutral sugar
- anthocyanin
- no pectin (soft)
- aromatic

Fruit Abscission
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