

Chem 130L: Science of Cooking (NS)

Syllabus, Summer Session 2, 2021

(Soft) Prerequisite: CHEM99D or equivalent.

Days and time: MW: 5:00-6:15pm; TTh: 7:00-8:15pm

Location:

- Monday & Wednesday: synchronous (or asynchronous) lecture.
- Tuesday & Thursday: synchronous (or independent) lab.

Instructor: Patrick Charbonneau

Office hour: M 4:00-5:00pm (or by appointment), via Zoom.

Chef: Todd Ohle

Office/lab hours: TTh 30 mins before and after lab (or by appointment), via Zoom.

Teaching assistant: TBA

Course Description:

Gastronomy is increasingly popular, and its main practitioners are stars. But Ferran Adrià, Joan Roca, and Grant Achatz share more than fame. They use science to create gastronomic art that challenges our culinary experience. Traditional techniques used to be followed blindly; they are now deconstructed to bring them to new heights. In this course we explore the science that lies behind the new frontier in taste.

Main course objectives:

- Understand some of the science involved in cooking.
- Discover the tools and technologies used by world-leading chefs for their creation.

Secondary objectives :

- Develop an interest in culinary creation.
- Educate one's sense of taste.

Students will handle (and taste) food, in order to consolidate the scientific learning. ANY FOOD ALLERGY MUST BE DECLARED ON THE FIRST DAY OF CLASS. Specialized cooking supplies and material will be mailed before the start of the semester. Standard cooking supplies (cream, flour, sugar, etc) and material (see list below) should be obtained on one's own.

Standard supplies and material should be available on time for the lab session, or earlier, when specified in the lab description.

Text

-H. McGee, *On Food and Cooking*, Scribner, 2004 (required). A classic text that gives a general overview of the science that underlies cooking. Available online to Duke affiliates from the library website: <https://find.library.duke.edu/catalog/DUKE009409146>

Standard Material List

Various supplies and pieces of equipment will be mailed to you before the start of the class. You are additionally expected to have access to the (non-exhaustive) list of pieces of equipment:

- wooden spoon;
- small pot;
- whisk;
- (high heat) spatula;
- pie tin or heat proof dish;
- strainer;
- slotted spoon;
- small cups (any small vessel that can hold about 12 oz of liquid);
- immersion blender;
- baking ramekin/dish;
- baking sheet;
- non-stick pan;
- Ziploc-type bags.

If getting a hold of all or some of these is a hurdle to class participation, please contact the instructors ahead of the first lecture.

Grading Scheme

Online reading quizzes: 10% (Due before Monday class).

Lab worksheets: 15% (Due at the end of lab, most Tuesdays and Thursdays).

Assignments: 15% (Due by the end of TA office hour, roughly every Wednesday).

Midterm paper about a science-based culinary creation: 30% (Due date: June 8, 2020).

Final group presentation (Exam Period): 30%.

Absence Policy

No late assignment or quiz will be accepted for credit regardless of the nature of the absence.

Community Standard

This course expects participants to follow the Duke Community Standard

<https://studentaffairs.duke.edu/conduct/about-us/duke-community-standard>

Course Outline

Topic 1:

Lecture: Monday, June 28, 2021

Overview of the course. Introduction, math review, and historical and scientific context.

Topic 2:

Lecture: Tuesday, June 29, 2021

Phases of matter and phase transitions. Molecular structure, molecular interactions, and phase behavior. Fluid and solid states. Microscopic interpretation of pressure and temperature. Phase diagrams of “simple materials”: water and ethanol. Crystallization and vaporization in cooking.

Kitchen: Thursday, July 1, 2021

Introduction to cooking: basic hygiene, security, utensils. Crystallization of sugar, candies.

Reading: *On Food and Cooking*: Appendix: “A Chemistry Primer” p. 811-818 (print)/p. 1043-ss (online); Chapter 15: “The Four Basic Food Molecules” p. 792-809 (print)/p. 1021-ss (online); Chapter 12, Section “Sugar Candies and Confectionery” p. 680-687/880-897 (online) (optional: Kinds of Candies 687-693 (print)/p.897-913 (online)); Chapter 14: “Boiling and Simmering” p. 784-786 (print).

Topic 3:

Lecture: Wednesday, June 30, 2021

Components of food: mixtures and intermolecular forces. Types of mixtures and basics of aromas explained in the context of intermolecular forces including notions of saturation and equilibrium.

Kitchen: Tuesday, July 6, 2021

Fresh Cheese.

Reading: *On Food and Cooking*: Chapter 1: “Milk Biology and Chemistry” p. 16-21 (print) & “Cheese” (only first 6 subsections) p. 51-66 (print); Chapter 8: “Cooking with Herbs and Spices” p. 397-401 (print).

Topic 4:

Lecture: Wednesday, July 7, 2021

Viscosity and elasticity: texture and mouthfeel.

Demystifying texture by explaining how the chewy, soft, runny, and thick sensations we experience result from the elasticity and viscosity of foods and sauces.

Kitchen: Thursday, July 8, 2021

Thickeners and gels.

Reading: *On Food and Cooking*: Chapter 5: “The Composition and Qualities of Fruits and Vegetables” (only first 2 subsections) p. 261-266 (print) & “Cooking Fresh Fruits and

Vegetables” (only the “Texture” subsection of the first subsection) 282-284 (print); Chapter 11: “Solid Sauces: Gelatin Jellies and Carbohydrate Jellies” & “Sauces Thickened with Flour and Starch” p. 605-620 (print).

Topic 5:

Lecture: Monday, July 12, 2021

Gelation and polymers. Physical process of gelation, chemistry and physics. Chemical gels, e.g. using transglutaminase; physical gels, e.g. alginate, gelatin, eggs; how gelation can be tuned. Spherification. Pectin. Advanced gelation agents.

Kitchen: Tuesday, July 13, 2021

Gels and gummies.

Reading: *On Food and Cooking*: Chapter 3: “Cooking Fresh Meat: The Principles” (only last 3 subsections) p. 149-154 (print); Chapter 4: “The Anatomy and Qualities of Fish” (only middle 2 subsections) p.191-193 (print); Chapter 5: “Preserving Fruits and Vegetables” (only “Sugar Preserves” subsection) p. 296-299 (print).

Topic 6:

Lecture: Wednesday, July 14, 2021

Dispersions in the Kitchen. Microscopic analysis of special mixtures that form when droplets of air, liquid, or water are infused in a liquid of choice.

Kitchen: Thursday, July 15, 2021

Mousses, mayo, meringue

Reading: *On Food and Cooking*: Chapter 5: “Cooking Fresh Fruits and Vegetables” (only subsection “Foams and Emulsions” in the “Pulverizing and Extracting” subsection) p. 289 (print); Chapter 11: “Sauces Thickened with Droplets of Oil or Water: Emulsions” p. 625-639 (print); Chapter 1: “Unfermented Dairy Products” (only “Cream” subsection) p. 27-32 (print); Chapter 2 “Egg Foams: Cooking with the Wrist” (only first 6 subsections) p. 100-109 (print).

Topic 7:

Lecture: Monday, July 19, 2021

Diffusion. Basic concepts of random diffusion applied to the diffusion of heat (cooking), diffusion of water, and diffusion of particles.

Kitchen: Tuesday, July 20, 2021

Spherification and cake.

Reading: *On Food and Cooking*: Chapter 10: “Thick Batter Foods: Batter Breads and Cakes” p. 554-560 (print); Chapter 14: “Forms of Heat Transfer” p. 780-787 (print).

Topic 8:

Lecture: Wednesday, July 21, 2021

Proteins and enzymes. Introduction to proteins and their building blocks amino acids. Modification of cooking conditions can alter the proteins in food to provide new textures and flavors.

Kitchen: Thursday, July 22, 2021

Custards and soufflés.

Reading: *On Food and Cooking*: Chapter 2: "Egg Biology and Chemistry", "Egg Quality Handling, and Safety", "The Chemistry of Egg Cooking", "Basic Egg Dishes", "Egg-Liquid Mixtures" p. 73-100 (print) & "Egg Foams" (only "Soufflés" subsection) p. 109-113 (print); Chapter 3: "Cooking Fresh Meat" (only first subsection) p. 154-156 (print); Chapter 4: "Unheated Preparations of Fish and Shellfish" and "Cooking Fish and Shellfish" p. 206-218 (print).

Topic 9:

Lecture: Monday, July 26, 2021

Flavors and flavor modification. Sense of taste, tricking the sense of taste, and altering flavors using browning reactions and texture manipulation.

Kitchen: Tuesday, July 27, 2021

Hamburgers -- caramelized onions and browned meat.

Readings: *On Food and Cooking*: Chapter 14: "Browning Reactions and Flavor" p. 777-780 (print); Chapter 12 "The Nature of Sugar" (only the "Sugar Substitutes" subsection) p. 659-663 (print); Chapter 3: "Cooking Fresh Meat: The Principles" (only first 2 subsections) p. 147-149 (print); Flavor p. 270-275; Chapter 6 "Seaweed" (only the "Seaweed and the Original MSG" box) p. 342 (print); Chapter 8: "The Nature of Flavor and Flavorings" and "The Chemistry and Qualities of Herbs and Spices" (except last subsection) p. 387-395 (print) & "A Survey of Temperate-Climates Spices" (only the "Chilis" subsection) p. 418-420 (print).

Topic 10:

Lectures: Wednesday, July 28, 2021

Bacteria and yeasts. Bacterial multiplication, limit population, resource depletion, chemotaxis. Bacteria and their role in transforming food, for better or for worse.

Kitchen: Thursday, July 29, 2021

Kimchi and/or Sourdough (<http://robdunnlab.com/projects/science-of-sourdough/>)

Readings: *On Food and Cooking*: Chapter 10: "Dough and Batter Ingredients" and "Breads" p. 531-550 (print) & "Pastries", "Cookies" and "Pasta, Noodle and Dumplings" p. 560-579 (print); Chapter 9: "Legumes" (only the "Fermented Soybean Products" subsubsection of the "Soybeans and Their Transformations" subsection) p. 496-500 (print); Chapter 13: "The Nature of Alcohol" (only the first subsection) p. 715-716 (print); Chapter 1: "Yogurt" p. 47-51 (print).

Topic 11:

Lecture: Monday, August 2, 2021

Heating, cooling and tempering. Critical temperatures for phase transitions (egg, meat, chocolate). Manipulating temperatures for optimal ice cream physical properties.

Readings: *On Food and Cooking*: Chapter 1: "Unfermented Dairy Products" (only the "Ice Cream" subsection) p. 39-44 (print); Chapter 12: "Chocolate" p. 694-712 (print).

Kitchen: Tuesday, August 3, 2021

Chocolate tempering.

Topic 12:

Lecture: Wednesday, August 4, 2021

Flavor Preferences. Biological explanation for preferences of particular flavors, and a discussion of the interaction between humans, animals, and the plants that produce food for humans.

Kitchen: Friday, August 5, 2021

Chef office hour to discuss and work on final project.

Final Exam:

Group presentations scheduled August 6-8.

Instructor Bios

Professor Patrick Charbonneau

Professor Charbonneau received a PhD in chemical physics from Harvard, and joined the chemistry faculty at Duke in 2008, where he studies the theory of soft materials (see <https://chem.duke.edu/faculty/patrick-charbonneau>). A native of Montreal, he is told to have loved beets and raspberries from an early age. His interest in food has since broadened somewhat.

Chef Todd Ohle

Todd Ohle began his culinary career at The Culinary Institute of America, and subsequently worked in various restaurants and as a private chef in Miami Beach. In 1999, Todd and his wife moved to North Carolina, where in 2001, he became executive chef at Rocky Top Hospitality. He rose to become Director of Culinary Operations and executive chef of 1705Prime, but was left wanting to spend more time with his two young daughters. In 2008, Todd thus switched course to become the Food and Beverage Director at The Cypress of Raleigh retirement community. In 2016, his daughters now teenagers, Todd realized his dream of opening his own restaurant(s). In 2018, he became VP of Dining Services at the Carolina Meadows retirement community in Chapel Hill.