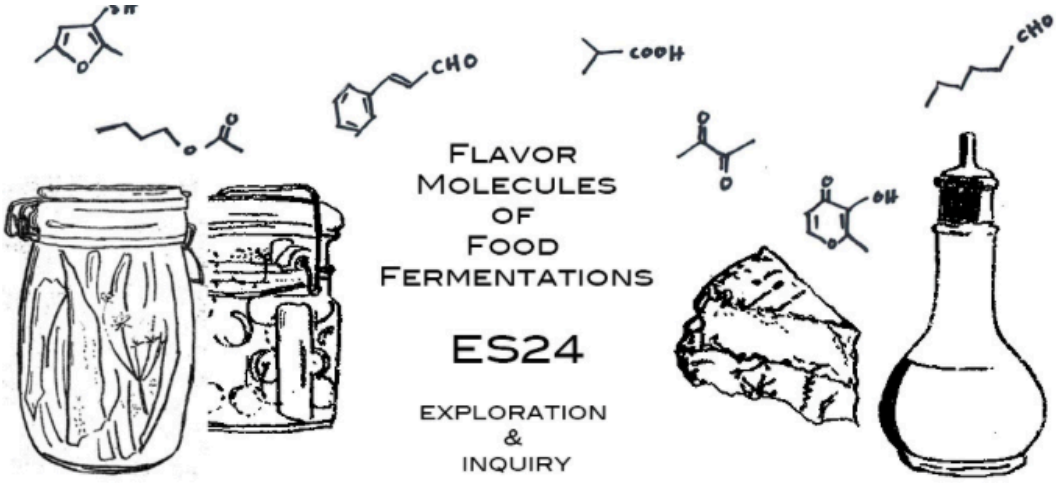

ES 24

Flavor Molecules of Food Fermentations: Exploration and Inquiry

Spring 2016

Website: https://canvas.harvard.edu/courses/11284

Microorganisms produce a diverse array of specialized small molecules as part of their metabolic processes. In this course we will study the production, properties, and characterization of these molecules through the lens of food fermentation. In particular, we will focus on the small molecules that contribute taste and aroma in fermented foods. Students will experience the scientific inquiry process in a creative way by designing and implementing their own research project based on a fermented food of their choosing. Still a field with much potential for discovery, interested students are invited to continue their research project in the summer.

Instructor Pia Sörensen
sorensen@seas.harvard.edu
Pierce Hall 206A
Office Hours: T 4.30-5, Th 1.30-2.30, by appointment, or find me on skype (pia.m.sorensen)

TF Mai Nguyen (mainguyen01@g.harvard.edu)

Prerequisites

Ls1a, LPSA or equivalent; one semester Organic Chemistry is recommended but not required

Goal

The ultimate goal of this class is to guide you in conducting a successful research project, successful meaning a project that is substantive, original, and addressing a question whose answer would make a genuine contribution to knowledge about flavor molecules and fermentation.

Our approach will be to start the semester with a deep-dive into the field: we will try our hands at various fermentation processes, explore the literature, engage with visiting speakers, and make a small number of local field trips. Throughout we will engage with the material by asking questions and exploring potential research projects. We will then spend the second half of the semester working on the projects, while sharing and collectively discussing our findings. Thus, this course is in many ways a mini-version of the scientific process: from a cursory interest in a field, to tangible data and communication and publication of results.

Course Aims and Objectives

At the end of this course you will have gained knowledge and/or experience in the following areas:

- Chemistry of flavor molecules, physiology of flavor, microbial reactions communities, and metabolites, the role of fermentation in foods
- Scientific principles and application of instruments used for chemical and microbial characterization
- Experimental design process, analysis and interpretation of data
- Team work, communication, peer review

Expectations

You are expected to attend class weekly, participate in class activities, as well as design, conduct, write, and present a research project.

Class-meetings

Class meetings take place twice weekly **Tu/Thu 2.30-4.30 pm in NW B145 (the cooking lab)**; meetings alternate between short lectures, discussions of assigned readings, hands-on laboratory exercises, or excursions to nearby labs or facilities. Lectures are multidisciplinary, covering small molecules, flavor compounds, physiology of taste and aroma, microbial communities and metabolic processes, the role of fermentation reactions in foods, chemical characterization, and experimental design. In addition, students spend a significant amount of time outside of class on their project.

Project

You will work individually or in groups of two to define a scientific question of interest and develop a research plan to address the question. To assist with this process, you will submit 4 sets of 5 open-ended possible research questions based on the material covered in the first 4 weeks of the semester. You will then choose two of these questions to explore deeper ("project explorations"), ultimately resulting in one topic to explore for the project proposal. The course staff will assist in design and implementation, but each project will be unique, original, and open-ended. You will give short updates to the class and a final presentation of your findings to the class, and submit a final report. You will also contribute to the development of your classmates' projects via peer review. This field still has much potential for discovery and there is every reason to be ambitious in your choice of research topic. You are invited to continue your research project in the summer.

Field Trips

Two small "field trips" have been scheduled. One is to the Small Molecule Mass Spec Facility in the basement of Northwest, and the other is to a local fermentation facility (details to TBA).

Grading

The final course grade will take into account the following components:

Participation	20%	Attendance, contribution to discussions, collaboration with team- and classmates, responses to readings
Assignments	20%	4x5 Project proposal questions based on the topic of the week 2 Project explorations Short fermentation presentation
Project	60%	Collaboration and participation 1 proposal Peer-review of 2 proposals Presentation Report

Texts

Readings will be drawn from scientific articles and the following books (most are on reserve in Cabot library). For a full list, see the course website.

The Art of Fermentation, Sandor Katz
Wild Fermentation, Sandor Katz
Mastering Fermentation, Mary Karlin
Brock Biology of Microorganisms, Madigan et al
Flavor Chemistry and Technology, Gary Reineccius
On Food and Cooking, Harold McGee (2nd edition)
Neurogastronomy, Gordon M. Shepherd

Academic Integrity

Discussion and the exchange of ideas are essential to doing academic work. For assignments in this course, you are encouraged to consult with your classmates as you work on problem sets and labs. However, after discussions with peers, make sure that you can work through the problem yourself and ensure that any answers you submit for evaluation are the result of your own efforts. In addition, you must cite any books, articles, websites, lectures, etc that have helped you with your work using appropriate citation practices.

Accommodations for Students with Disabilities

Students needing academic adjustments or accommodations because of a documented disability must present their Faculty Letter from the Accessible Education Office (AEO) and speak with the instructor by the end of the second week of the term. Failure to do so may result in the Course Head's inability to respond in a timely manner. All discussions will remain confidential, although the instructor can contact the AEO to discuss appropriate implementation.

Schedule at a Glance

Date	Topic	To-Do
01.26	Introduction to the class, fermentation, flavor + Hands on exploration	
01.28	Fermentation and food I + Hands on exploration	5 project questions
02.02	Fermentation and food II + Hands on exploration	
02.04	Flavor compounds, structures of small molecules + Hands on exploration	5 project questions
02.09	Short fermentation presentations	
02.11	Short fermentation presentations	5 project questions
02.16	Physiology of taste and aroma	
02.18	Physiology of taste and aroma	5 project questions
02.23	Chemical characterization Visit: small molecule mass spec facility	
02.25	Chemical characterization	2 project explorations
03.01	Microbial characterization	
03.03	Microbial characterization	
03.08	Microbial communities and metabolic processes	
03.10	Microbial communities and metabolic processes Guest speaker: Ben Wolfe, Tufts University	Proposals due
03.15	SPRING BREAK	
03.17	SPRING BREAK	
03.22	Sensory Analysis Guest speaker: Bill Nesto, Boston University	
03.24	Projects	Peer review of proposals
03.29	Projects	
03.31	Projects	
04.05	Projects	
04.07	Projects	5-min in class project update
04.12	Projects	
04.14	Projects + Fermentation field trip	
04.19	Projects	
04.21	Projects	
04.26	Student presentations	Presentations
04.28	Student presentations	
04.28-05.04	Reading period	Report due 5/5

HAPPY SUMMER!

Detailed Schedule and Readings

(see the course website for assignment guidelines and other course materials)

Date **Topic and Readings**

01.26 Introduction to the class, fermentation, flavor + Hands on exploration

01.28 Fermentation and food I + Hands on exploration

- Recipes: Pickles, Sauerkraut, Ginger beer

02.02 Fermentation and food II + Hands on exploration

- Recipes: Dairy ferments: Yogurt, Kefir, Viili, Piimä, Filmjölk, Matsoni, Buttermilk
- Assigned Readings:
  - *Karlin, Mastering Fermentation, p. 10-11 (The hows of fermentation)*
  - *Katz, Wild Fermentation, p.28-36 (Philosophy of fermentation)*

02.04 Flavor compounds, structures of small molecules + Hands on exploration

- Assigned Readings:
  - *Brenner, Sörensen, Weitz, Science and Cooking: A Companion to the Harvard Course, Chapter 10 (Introduction to fermentation)*
  - *McGee, On Food and Cooking, p.291-6 (Fermented vegetables and fruits*)
  - *Katz, The Art of Fermentation, 2013, p. 95-100 (Fermented vegetables and fruits*)
  - *McGee, On Food and Cooking, p.44-51 (Fermented dairy products*)

02.09 Short fermentation presentations

02.11 Short fermentation presentations

02.16 Physiology of taste and aroma

02.18 Physiology of taste and aroma

- Recipes: Fruit vinegars, Pickled eggs, Kombucha, Jun, Fermented fish
- Assigned readings
  - *Interview article with Marcus Meister (Caltech) on the current state of the question "how many smells can humans distinguish between":* https://www.caltech.edu/news/sniffing-out-answers-conversation-markus-meister-47229
  - *Charles Spence, Multisensory flavor perception, Cell, 2015*
  - *How to make a wine with 35 molecules:* http://cen.acs.org/articles/92/i38/Taste-Wine-Science.html?h=1292515390
  - FOR INTEREST (not required) *Gordon Shepherd, Neurogastronomy, 2012*
  - FOR INTEREST (not required) *Molecular basis of flavor pairings:* http://www.scientificamerican.com/article/flavor-connection-taste-map-interactive/

02.23 Visit: small molecule mass spec facility (Harvard, with Sunia Trauger)

02.25 Chemical characterization

- Recipes: Grain fermentations: Tempeh, Amazake, Sourdough (wild), Sourdough (various starters)
- Assigned readings:
  - *Reineccus, Flavor Chemistry and Technology, p 123-31 (Flavors formed via fermentation)*
  - FOR INTEREST (not required): Netflix just released a 4 part documentary based on Michael Pollan's book "Cooked". The last part is on fermentation. Available on Netflix, or here: https://www.youtube.com/watch?v=mqAIjSPX2Jw

03.01 Microbial characterization

- Assigned readings
  - *McGee, On Food and Cooking, p.531-2 (Yeast and bread baking)*
  - *McGee, On Food and Cooking, p.715-16 (Yeast and alcoholic fermentation)*
  - *McGee, On Food and Cooking, p.544 (Sourdough)*

03.03 Microbial characterization

- Guest speaker: Kevin Bonham, Harvard University
- Assigned readings:
  - The following readings offer an introduction to the current state of the field of gene sequencing:
  - *Part I:* http://blogs.scientificamerican.com/food-matters/how-to-study-a-complex-microbial-world-part-1-dna-sequencing/ (Links to an external site.)
  - *Part 2:* http://blogs.scientificamerican.com/food-matters/how-to-study-a-complex-microbial-world-8211-part-2-next-generation-sequencing-technology/ (Links to an external site.)
  - *Part 3:* http://blogs.scientificamerican.com/food-matters/how-to-study-a-complex-microbial-world-8211-part-3-genes-to-genomes/ (Links to an external site.)

03.08 Microbial communities and metabolic processes

03.10 Microbial communities and metabolic processes

- Guest speaker: Ben Wolfe, Tufts University
- Assigned readings
  - *Wolfe and Dutton, Fermented foods as experimentally tractable microbial ecosystems, Cell, 2015*
  - *Wolfe et. al., Cheese rind communities provide tractable systems for in situ and in vitro studies of microbial diversity, Cell 2014*

03.15 **SPRING BREAK**

03.17 **SPRING BREAK**

03.22 Sensory analysis

- Guest speaker: Bill Nesto, Master of Wine, Boston University

03.24 Projects

03.29 Projects

03.31 Projects

04.05 Projects

04.07 Projects

04.12 Projects

04.14 Projects

04.19 Projects

04.21 Student presentations

04.26 Student presentations

04.28-05.04 Reading period

HAPPY SUMMER!