BME 0173/NUTR 0253: Cellular Agriculture & Biofabricated Foods Fall 2024

Welcome to BME 0173/NUTR 0253!

This course will give students an in-depth understanding of **cellular agriculture**: the science of producing conventionally animal-based food products with cell cultures instead of animals. Our names are Dr. Matt McNulty, James Dolgin, and Ellie Contreras, and we will be your instructors. We enjoy teaching this course because it provides a holistic overview of the concepts of cellular agriculture, food science, and the use of biotechnology in food production.

The School of Engineering values diversity and inclusion; we are committed to a climate of mutual respect and full participation. Our goal is to create learning environments that are usable, equitable, inclusive, and welcoming. If there are aspects of the instruction or design of this course that result in barriers to your inclusion or accurate assessment of achievement, please notify us as soon as possible.

As a student, there may be times when personal stressors or emotional difficulties interfere with your academic performance or well-being. The Counseling and Mental Health Service (CMHS) provides confidential consultation, brief counseling, and urgent care at no cost for all Tufts undergraduates as well as for graduate students who have paid the student health fee. To make an appointment, call 617-627-3360. Please visit the CMHS website: http://go.tufts.edu/Counseling to learn more about their services and resources.

The StAAR Center (formerly the Academic Resource Center and Student Accessibility Services) offers a variety of resources to all students (both undergraduate and graduate) in the Schools of Arts and Science, Engineering, the SMFA and Fletcher; services are free to all enrolled students. Students may make an appointment to work on any writing-related project or assignment, attend subject tutoring in a variety of disciplines, or meet with an academic coach to hone fundamental academic skills like time management or overcoming procrastination. Students can make an appointment for any of these services by visiting go.tufts.edu/TutorFinder, or by visiting our website (https://students.tufts.edu/staar-center).

Important Information:

Class Meetings:
Mondays, 6:00-9:00PM EST
Science and Technology Center (SciTech), Room 136 (Medford/Somerville)

Instructor(s):
James Dolgin (james.dolgin@tufts.edu)
Ellie Contreras (elizabeth.contreras@tufts.edu)
Matt McNulty, PhD (matthew.mcnulty@tufts.edu)

Grader
Mason Villegas (mason.villegas@tufts.edu)

Semester Hour Units:
3 SHU

Prerequisites:
Background in cell biology or biomedical engineering, or instructor permission.

Course Communications:

We appreciate hearing questions from students. You are welcome to email questions to us (CC all instructors and the grader) or set up a time for office hours with us.

Office Hours:

Instructors: In-person or over Zoom, by appointment only
Grader: In-person or over Zoom, by appointment only

If you have any questions about course material, assignments, or your progress in the course, please attend office hours to discuss. Office hours are offered by appointment only, please email the instructors and TA to schedule. If your question needs to be addressed in private, please email the instructors to discuss.

Course Summary:

This course will take students through the various scientific processes, product development challenges, and regulatory, environmental, and consumer considerations involved in producing alternative proteins from cell culture (termed "cellular agriculture"). Students will read journal articles on relevant and recent research, hear from researchers and thought leaders, discuss, and explore the impacts of agricultural biotechnology and novel food production systems, and view food biotechnology through both scientific and entrepreneurial lenses.

Course Goals:

By the end of the semester, students will understand how engineering food can and must differ from engineering for medicine and critically assess key areas of research that are needed to advance the field of cellular agriculture.

Texts or Materials:

Recommended Textbook: *Cellular Agriculture: Technology, Society, Sustainability and Science*

The full textbook is available online for Tufts students through the Tisch library. To access the book, click on the first option (Elsevier ScienceDirect eBooks), which will take you to a ScienceDirect's page where the book is available. Students are able to access it through the JumboSearch portal and logging in with their Tufts username and password.

Mandatory and suggested readings in preparation for each class will be announced and linked on the Canvas site (https://login.canvas.tufts.edu/). Students will be required to perform their own review of literature for specified assignments.

How to be Successful in this Course:

Your grade in this course will be determined by various assignments designed to culminate in a final project pitch. Points will be awarded for each assignment, and an overall course score will be calculated from the weights given below:

- 25% -- Misc. Assignments (discussion posts, graphical abstract, etc.)
- 10% -- Class Engagement (attendance, participation, etc.)
- 10% -- Project Proposal (initial research and 1-page summary of midterm report)
- 25% -- Midterm Project
- 30% -- Final Project

Assignments and Grading:

Below you will find descriptions of the graded assignments. Rubrics for the notebook and report submissions can be found in Canvas modules (https://login.canvas.tufts.edu/).

Task	Weight	Description
Misc. Assignments	25%	Weekly Discussion Posts (4 points per post, 84 total) Students will read articles relevant to class each week and post to the discussion board (via Canvas discussion threads). This is an open-ended assignment meant to get you thinking critically about the content. You may include something you found interesting, follow-up questions you have, ideas the readings have given you, impressions, etc. Discussion should include information synthesized from the readings and be constructive in pursuit of additional knowledge. **Note: We are looking for context and completeness, not one-sentence remarks.** Responses should be **100 words minimum per reading.** Please refer to the "Weekly Discussion Post Rubric" on Canvas for more information. Graphical Abstract (16 points) After the first two weeks of lecture, you'll have learned a variety of topics in cellular agriculture – during this activity, we're asking you to pretend that your research group is working towards a product with improved qualities compared to its animal-based counterpart (i.e. better taste, ethics, etc.). You're publishing a paper on your new product, process, and results. Create a graphical abstract for this paper using BioRender.
Class Engagement	10%	Students are expected to attend all classes on time as well as actively participate in weekly journal club discussions/guest speaker activities. During the semester, students must attend a total of **10** times to receive full credit for this assignment.

		Students should participate in some capacity every week. This could be to ask a question in class, presenting for your group in journal club, interacting with lecturers during class time, attending office hours, or speaking with instructors about course material before or after class.
Project Proposal	10%	Initial Research (20 points) To keep teams on track for the midterm project, please post a list of 7-10 references your teams has found for state of the art / current solutions to the proposed challenge in cellular agriculture. In a word document, please provide a proper citation (any acceptable scientific format is fine) – please do not just provide links to the papers. 1-page Summary of Midterm Approach (80 points) Prepare a 1-page (single space) summary of the technical research that your group plans to flesh out for your midterm project. You should support your proposed approach with literature references, and should provide enough detail so that the instructors can understand, evaluate, and offer feedback and guidance for your midterm project. Please include a references list / bibliography.

Midterm Project	25%	Paper (50 points)
		Groups of 3 - 4 students will generate a written research summary (max 5 pages, single spacing, 12 pt font) that explains:
		    1) Background information on the technological hurdle facing cultivated meat.
		    2) Current state of the art research / proposed solutions to that hurdle including:
		        A) Literature evidence of feasibility
		        B) Steps to develop amdimplement proposed research / solutions
		        C) Potential challenges facing the development of the current state of the art / proposed solutions
		        D) Alternate approaches to address these challenges
		
		Presentation (35 points)
		Students will prepare a 10-minute presentation (+5-10 minutes for questions) to explain their research summary to the class.
		
		Reviewer Feedback (15 points)
		Prepare a 2-page (single space) response to questions that were raised during your midterm presentations, or were brought up in your comments from the instructors. For each question you choose to answer (you may pick up to 5), you should discuss whether you think the question / comment impacts your understanding of the state of the art around your problem, and if / how you plan to incorporate changes into your final project writeup and presentation. You

		should also mention any changes that you plan to make to your project as a result of the other presentations.

Final Project	30%	Paper (50 points)
		Student groups will generate startup company ideas based on their technical hurdle and solution. They will expand their midterm into a written proposal (max 10 pages, single spacing, 12 pt font) that explains:
		  1) Mission statement and company focus
		  2) Background info on the need facing the industry (can use / build on midterm paper)
		  3) A detailed explanation of the technical solution (can use / build on midterm paper)
		  4) Market information and competitive landscape for the company
		  5) Regulatory and consumer context and strategy
		  6) Timeline and milestones
		
		Presentation (25 points)
		Students will prepare a compelling pitch that they will present to class as well as invited external "investors". Pitches will be 20 minutes followed by 10 minutes for questions. Presentations should:
		  1) Grab our attention and offer a convincing case for your proposal.
		  2) Be clear and informative (e.g. background information, market context, etc.)
		  3) Explain why our investment would be money well spent
		  4) Be engaging and compelling (e.g., visually pleasing, well-structured, etc.)
		  5) Include information on timeline and steps (e.g., milestones)

Grading Range:

A **passing grade for graduate students in the course is B- or better.** Course grades will be based on the metrics below (subject to revision during the course):

A $> 93\%$

A- $90 - < 93\%$

B+ $87 - < 90\%$

B $84 - < 87\%$

B- $80 - < 84\%$

C+ $77 - < 79\%$

C $74 \ - < 76\%$

C- $70 - \ < 73\%$

D+ $67 - \ < 69\%$

D $64 - \ < 66\%$

D- $60 - \ < 63\%$

F $< 59\%$

Instructions for Submission of Assignments and Exams:

Assignments **will be due before class begins (e.g., by 5:59 pm) on the due date**. *No late assignments will be accepted,* and a zero grade will be recorded for missing work. If you think you may have difficulty completing an assignment on time, please ask the instructors and TA for an extension as early as possible. No extensions will be granted fewer than 24 hours before an assignment is due other than in the case of an emergency; in such cases, please notify the instructors and TA as soon as possible.

Academic Conduct:

You are responsible for upholding the highest standards of academic integrity, as specified in the Biomedical Engineering Biomedical Engineering Handbook located here: https://engineering.tufts.edu/graduate/graduate-student-handbook or the Friedman School's Policies and Procedures Handbook located here: https://nutrition.tufts.edu/about/policies-and-procedures, as well as Tufts University's policies (https://students.tufts.edu/community-standards/support-resources/academic-integrity-resources). This includes understanding and avoiding plagiarism, which is defined as the unacknowledged use of someone else's published or unpublished work. It is the responsibility of each student to understand and comply with academic integrity standards, as violations will be sanctioned by penalties ranging from failure on an assignment and the course to dismissal from the school.

Generative AI Policy:

While generative AI is a helpful tool for kickstarting the brainstorming process, and may help in leading you towards an answer to a question, **we will not tolerate generative AI as a substitute for your own writing or reading**. Treat AI as you would any other individual when it comes to determinations of plagiarism. Using AI to "chat" about project ideas/get your creative juices flowing is fine. **Using AI to write your papers, craft responses, or summarize readings for you is unacceptable and will be considered plagiarism**. Plus, it hinders your learning process and prevents you from reaping the benefits of the course.

Due to AI's incipient stage of technological development and validation, we neither encourage nor condemn the use of generative AI as a tool in your learning process. Use generative AI at your own risk, as it is still prone to errors and misinformation, and **always fact-check AI responses using peer-reviewed information.**

For the Tufts University-wide guidelines on AI, please see: https://it.tufts.edu/guidelines-use-generative-ai-tools

Accommodation of Disabilities:

We will do our best to ensure each of you has the resources you need to succeed. Tufts University is committed to providing equal access and support to all students through the provision of reasonable accommodations so that each student may access their curricula and achieve their personal and academic potential. If you have a disability that requires reasonable accommodations, please contact the Arts and Sciences & Engineering Dean of Student Affairs at 617-627-3158 or the Friedman School Assistant Dean of Student Affairs at 617-636-6719 to make arrangements for determination of appropriate accommodations. Please be aware that accommodations cannot be enacted retroactively, making timeliness a critical aspect for their provision.

Attendance Policy:

This course will be delivered in-person. In the event Medford/Somerville and Boston campuses are closed due to pandemic, weather, or a temporary cancellation issue, students should expect to be notified by email by the instructors if class is cancelled.

- Attendance to all class sessions is expected for students and will be reflected in your engagement grade (except in the case of extenuating circumstances, addressed on a case-by-case basis). If you are unable to attend a class session, please email the instructors and TA at least 24 hours in advance, and we will try to provide a video recording of the zoom session.
- If you are ill, please do **NOT** come to campus. Contact the instructors or TA to let them know. A makeup assignment will be assigned for excused absences.

Course Overview:

Below you will find the course's Canvas site (https://login.canvas.tufts.edu/) as organized by weekly modules, with all readings and assignments posted the week they are assigned and clear instructions for each assignment submission. This schedule is subject to modification at the instructors' discretions.

WEEK	DATE	COURSE TOPIC	LECTURER(S)	ASSIGNMENTS
1	Monday 09/09	Introduction and Logistics **Lecture:** History of Food Technology **Activity:** Alt Protein Taste Test	James Dolgin	**Read:** *Scientific, sustainability and regulatory challenges of cultured meat* and post to discussion board [due 09/16] **Read:** *Spontaneous immortalization of chicken fibroblasts generates stable, high-yield cell lines for serum-free production of cultured meat* and post to discussion board [due 09/16]
2	Monday 09/16	**Lecture:** Cellular Agriculture 101 **Activity:** Graphical Abstract	Ellie Contreras	**Read:** *A Beefy-R culture medium: Replacing albumin with rapeseed protein isolates* and post to discussion board [due 09/23] **Read:** *Aggregating in vitro-grown adipocytes to produce macroscale cell-cultured fat tissue with tunable lipid compositions for food applications* and post to discussion board [due 09/23] **Submit:** Midterm / final project groups and select "problem" of choice [due 09/23] **Submit:** Graphical Abstract [due 09/23]

3	Monday 09/23	**Lecture:** Muscle & Fat Biology **Activity:** Journal Club	John Yuen, PhD (CTO – DECO Labs) Andrew Stout, PhD (CSO – DECO Labs)	**Read:** *[Deep dive: Cultivated meat bioprocess design](#)* and post to discussion board [due 09/30] **Read:** *[The microbial food revolution](#)* and post to discussion board [due 09/30] **Submit:** A bioprocess / bioreactor patent from an alternative protein company and post to discussion board [due 09/30] **Submit:** Initial research after reviewing literature for midterm problem [due 09/30]
4	Monday 09/30	**Lecture:** Cell Expansion & Scale-Up **Lecture:** Functional Food Ingredients via Precision Fermentation	Matt McNulty, PhD Dilek Uzunalioglu, PhD (Senior Director, Food Discovery and Design – Motif FoodWorks)	**Read:** *[An Edible, Decellularized Plant Derived Cell Carrier for Lab Grown Meat](#)* and post to discussion board [due 10/07] **Read:** *[Repurposing Agricultural Waste as Low-cost Cultured Meat Scaffolds](#)* and post to discussion board [due 10/07] **Submit:** 1-page summary of midterm approach (include bibliography) [due 10/07]
5	Monday 10/07	**Lecture:** 3D Tissue Engineering **Activity:** Journal Club	Glenn Gaudette, PhD (Chair of the Dept. of Engineering – Boston College)	**Read:** *[Biomolecular Interactions Governing Fresh Meat Color in Post-mortem Skeletal Muscle: A Review](#)* and post to discussion board [due 10/21] **Read:** *[Meat Omics: Trends and Applications of Omics Strategies in Meat Research](#)* and post to discussion board [due 10/21] **Read:** *[Cultured meat with enriched organoleptic properties by regulating cell differentiation](#)* and post to discussion board [due 10/21] **Read:** *[Application of texture analysis methods for the characterization of cultured meat](#)* and post to discussion board [due 10/21] **Continue:** Midterm presentation and paper [due 11/04]

6	Monday 10/14	NO CLASS – INDIGENOUS PEOPLES' DAY		**Review:** Feedback from instructors regarding 1-page summary of midterm approach
7	Monday 10/21	**Lecture:** Meat Science **Activity:** Journal Club	Ranjith Ramanathan, PhD (Assoc. Prof., Dept. of Animal and Food Sciences – Oklahoma State University)	**Read:** *Lab-grown meat is supposed to be inevitable. The science tells a different story.* and post to discussion board [due 10/28] **Read:** *Empirical economic analysis shows cost-effective continuous manufacturing of cultivated chicken using animal-free medium* and post to discussion board [due 10/28] **Read:** *Insiders Reveal Major Problems at Lab-Grown-Meat Startup Upside Foods* and post to discussion board [due 10/28] **Continue:** Midterm presentation and paper [due 11/04]
8	Monday 10/28	**Lecture:** Broader Context and Considerations in Cell Ag **Activity:** Q & A with Industry Leaders	Eric Schulze, PhD (CSO – Nexture Bio) Matthew Leung, PhD (VP of Research & Development – Nexture Bio)	**Submit:** Midterm presentation and paper [due 11/04]
9	Monday 11/04	Midterm Presentations	Matt McNulty, PhD Ellie Contreras James Dolgin Mason Villegas	**Read:** *Consumers' perception of cultured meat relative to other meat alternatives and meat itself: A segmentation study* and post to discussion board [due 11/12] **Read:** *Life cycle assessment of Beefy-9 and Beefy-R serum-free culture media for cell-cultivated beef production* and post to discussion board [due 11/12] **Continue:** 2-page response to questions received during midterm presentation [due 11/18]
10	Tuesday 11/12	**Lecture:** Environmental Impact	Nicole Tichenor-Blackstone, PhD (Asst. Prof.,	**Read:** *Chemical and sensory analyses of cultivated pork fat tissue as a flavor enhancer for meat*

		Assessment Consumer Acceptance of Cultivated Meat **Activity:** Journal Club	Division of Agriculture, Food, and Environment – Tufts University Friedman School of Nutrition Science and Policy) Sean Cash, PhD (Bergstrom Foundation Prof. in Global Nutrition – Tufts University Friedman School of Nutrition Science and Policy)	*alternatives* and post to discussion board [due 11/25] **Read:** *FDA's Scientific Memo for GOOD Meat, Inc.* and post to discussion board [due 11/25] **Read:** *FDA's Scientific Memo for UPSIDE Foods, Inc.* and post to discussion board [due 11/25] **Submit:** 2-page response to questions received during midterm presentation [due 11/18] **Continue:** Final presentation and paper [due 12/02]
11	Monday 11/18	Final Paper and Presentation Working Session	Matt McNulty, PhD Ellie Contreras James Dolgin Mason Villegas	**Continue:** Final presentation and paper [due 12/02]
12	Monday 11/25	**Lecture:** Safety and Risk Assessment of Novel Foods and Ingredients **Lecture:** Sensory Evaluation	Stiffy Hice, PhD (Program Lead – FDA) Scott Frost, PhD (Post-Doctoral Scholar, Dept. of Biology – Tufts University)	**Submit:** Final presentation and paper [due 12/02]
13	Monday 12/02	Final Project Presentations #1	Matt McNulty, PhD Ellie Contreras James Dolgin Mason Villegas	
14	Monday 12/09	Final Project Presentations #2	Matt McNulty, PhD Ellie Contreras	

			James Dolgin Mason Villegas	

Topics, Assignments, and Learning Objectives for Each Class Session:

This section includes a detailed, week-by-week description of Class Topics, Learning Objectives, required readings, and Assignments due.

Week 1 (09/09): *History of Food Technology*
Learning Objective(s):
- Discuss course expectations, class structure, and university guidelines
- Discuss the history of food technology and the context of sustainability in food innovation

Class Structure and Assignment(s):
- **Part 1** – *Lecture:* Introduction and Logistics, History of Food Technology
- **Part 2** – *Activity:* Alt Protein Taste Test
- **Assignments:**
    - Read cultivated meat review paper and post to discussion board [due 09/16]

Scientific, sustainability and regulatory challenges of cultured meat
Spontaneous immortalization of chicken fibroblasts generates stable, high-yield cell lines for serum-free production of cultured meat

Week 2 (09/16): *Cellular Agriculture 101 & Graphical Abstract Activity*
Learning Objective(s):
- Define and explain cellular agriculture, precision fermentation, and cultivated meat concepts
- Identify the motivations behind the cellular agriculture field
- Recognize the role of cellular agriculture in science, technology, and consumer spaces

Class Structure and Assignment(s):
- **Part 1**– *Lecture:* Cellular Agriculture 101
- **Part 2 –** *Activity:* In-class Graphical Abstract
- **Assignments**:
    - Read journal articles and post to discussion board for each [due 09/23]

A Beefy-R culture medium: Replacing albumin with rapeseed protein isolates
Aggregating in vitro-grown adipocytes to produce macroscale cell-cultured fat tissue with tunable lipid compositions for food applications
    - Form midterm & final project groups and select your "problem" of choice [09/23]
    - Finish and submit Graphical Abstract assignment [09/23]

Week 3 (09/23): *Muscle & Fat Biology*
Learning Objective(s):

- Explain the science of muscle and fat tissue generation *in vitro* and *in vivo*
- Distinguish between muscle and fat and their differential contributions to cultivated meat development

Class Structure and Assignment(s):
- **Part 1** – *Lecture:* Muscle & Fat Biology (Dr. John Yuen, PhD and Dr. Andrew Stout, PhD)
  - o Dr. Yuen is a recent graduate of the Kaplan Lab with expertise in fat biology. Dr. Stout is a recent graduate of the Kaplan Lab with expertise in muscle biology.
  - o Both are currently working at [DECO Labs](#), a cell ag start-up. Dr. Yuen serves as their CTO while Dr. Stout serves as their CSO.
- **Part 2** – *Activity:* Journal Club
- **Assignments:**
  - Read journal articles and post to discussion board for each [due 09/30]

Deep dive: Cultivated meat bioprocess design
The microbial food revolution
- Find a patent from an alternative protein company that details a novel bioprocess or bioreactor and post an advantage and disadvantage of their technology to the discussion board [due 09/30]
- Initial research after reviewing literature for midterm problem [due 09/30]
- Optional readings:

Edible mycelium bioengineered for enhanced nutritional value and sensory appeal using a modular synthetic biology toolkit
Innovation in precision fermentation for food ingredients
Precision fermentation for improving the quality, flavor, safety, and sustainability of foods
Precision fermentation for food proteins: ingredient innovations, bioprocess considerations, and outlook — a mini-review
Computer-aided chemical engineering research advances in precision fermentation
Fed-Batch Bioreactor Cultivation of Bacillus subtilis Using Vegetable Juice as an Alternative Carbon Source for Lipopeptides Production: A Shift towards a Circular Bioeconomy

Week 4 (09/30): *Cell Expansion & Scale-up*
Learning Objective(s):
- Define cell proliferation
- Discuss different scale-up strategies and requirements
- Understand differences between pharmaceutical and food large-scale cellular expansion
- Articulate challenges and considerations pertaining to cultivated meat scale-up
- Discuss the production and marketing of acellular/fermentation-derived products

Class Structure and Assignment(s):
- **Part 1** – *Lecture:* Cell Expansion and Scale-up
  - o Dr. Matt McNulty currently serves as the Associate Director for the Tufts University Center for Cellular Agriculture (TUCCA). Before TUCCA, Dr. McNulty earned his PhD in Chemical Engineering from UC Davis and was a research fellow at the Good Food Institute.
- **Part 2** – *Lecture:* Functional Food Ingredients via Precision Fermentation

- o Dr. Dilek Uzunalioglu currently is a the Senior Director of Food Discovery and Design at Motif FoodWorks. Dr. Uzunalioglu received her PhD in Food Science from Rutgers University.
- **Assignments:**
  - Read journal articles and post to discussion board for each [due 10/07]

An Edible, Decellularized Plant Derived Cell Carrier for Lab Grown Meat
Repurposing Agricultural Waste as Low-cost Cultured Meat Scaffolds

  - Prepare one-page summary of planned midterm approach (include bibliography) [due 10/07]

Week 5 (10/07): *3D Tissue Engineering*
Learning Objective(s):
- Discuss strategies to form non-planar constructs of meat
- Evaluate the importance of 3D tissue engineering from cellular agriculture and food perspectives

Class Structure and Assignment(s):
- **Part 1** – *Lecture:* 3D Tissue Engineering, led by guest Dr. Glenn Gaudette, PhD
  - o Dr. Gaudette is a Boston College Department of Engineering Professor and Inaugural Chair specializing in scaffolds made from plant materials for 3D tissue engineering applications.
- **Part 2** – *Activity:* Journal Club
- **Assignments:**
  - Read journal articles and post to discussion board for each [due 10/21]

Biomolecular Interactions Governing Fresh Meat Color in Post-mortem Skeletal Muscle: A Review
Meat Omics: Trends and applications of Omics strategies in meat research
Cultured meat with enriched organoleptic properties by regulating cell differentiation
Application of texture analysis methods for the characterization of cultured mea

  - Continue work on midterm presentation and paper [due 11/04]

Week 6 (10/14): NO CLASS – INDIGENOUS PEOPLES' DAY
Class Structure and Assignment(s):
- **Part 1 & 2** – N/A
- **Assignments:**
  - o Review feedback from instructors regarding 1-page summary of midterm approach

Week 7 (10/21): *Meat Science*
Learning Objective(s):
- Explain the science behind postmortem meat biochemistry
- Identify benefits associated with improvements in muscle food appearance, particularly beef color

Class Structure and Assignment(s):
- **Part 1** – *Lecture:* meat science, led by guest Dr. Ranjith Ramanathan, PhD
  - o Dr. Ramanathan is an Associate Professor in the Department of Animal and Food Sciences at Oklahoma State University. He has expertise in postmortem meat biochemistry to increase both the body of knowledge and economic benefits associated with improvements in muscle food appearance, particularly beef color.

- **Part 2** – *Activity:* Journal Club
- **Assignments:**
    - Read journal articles and post to discussion board for each [due 10/28]

Lab-grown meat is supposed to be inevitable. The science tells a different story.

Empirical economic analysis shows cost-effective continuous manufacturing of cultivated chicken using animal-free medium

Insiders Reveal Major Problems at Lab-Grown-Meat Startup Upside Foods

- Continue work on midterm presentation and paper [due 11/04]
- Optional reading for further perspectives on the cultivated meat discourse
    - *The revolution that died on its way to dinner*
    - *Cradle to production gate life cycle assessment of cultured meat growth media: A comparison of Essential 8 and Beefy-9*

This paper was met with some very well-researched criticism from members of the cultivated meat community. See here for a rebuke by Elliot Swartz

Week 8 (10/28): *Cell Ag: Broader Context and Considerations*

Learning Objective(s):
- Recognize broader context of the field of cellular agriculture from the perspective of industry experts
- Discuss the importance of cellular agriculture investment and its considerations

Class Structure and Assignment(s):
- **Part 1** – *Lecture:* Perspectives from industry, led by Dr. Eric Schulze and Dr. Matthew Leung
    - o Dr. Schulze is the CSO at Nexture Bio. Previously, he served as a USDA regulator as well as VP of Global Regulatory and Public Policy for cultivated meat start-up, UPSIDE Foods.
    - o Dr. Leung is the VP of R&D at Nexture Bio. Previously, he served as Associate Director of Manufacturing Sciences / Technology Development for cultivated meat start-up, UPSIDE Foods.
- **Part 2** – *Activity*: Q & A with industry leaders
- **Assignments:**
    - Prepare write-up and presentation of technical solution and midterm project [due 11/04]

Week 9 (11/04): *Midterm presentations*

Learning Objective(s):
- Illustrate understanding of one technical issue within the field through the presentation of a literature-based, novel solution to the issue
- Apply feedback regarding proposed technical solutions for the final project

Class Structure and Assignment(s):
- **Part 1** – Presentations
- **Part 2** – Presentations
- **Assignments:**
    - Read journal articles and post to discussion board for each [due 11/12]

Consumers' perception of cultured meat relative to other meat alternatives and meat itself: A segmentation study

[Life cycle assessment of Beefy-9 and Beefy-R serum-free culture media for cell-cultivated beef production](#)
- Generate a two-page response to questions received during presentations [due 11/18].

Week 10 (11/12): *Environmental Impact / Consumer Acceptance / Acellular Production*

Learning Objective(s):
- Evaluate the considerations and consumer interests of cellular agriculture from environmental, socioeconomic, and sensory perspectives

Class Structure and Assignment(s):
- **Part 1** – *Lecture:* from Friedman Nutrition School guests [Dr. Nicole Tichenor Blackstone](#), PhD & [Dr. Sean Cash](#), PhD
  - o Dr. Nicole Tichenor-Blackstone is an Assistant Professor in the Division of Agriculture, Food, and Environment at the Friedman School of Nutrition Science and Policy at Tufts University. Nicole's research focuses on developing and evaluating strategies to improve food system sustainability.
  - o Dr. Sean B. Cash is an economist and Associate Professor at Friedman School of Nutrition Science and Policy at Tufts University. His research focuses on how food, nutrition, and environmental interventions and policies affect both producers and consumers.
- **Part 2** – *Activity:* Journal Club
- **Assignments:**
  - Read journal articles and post to discussion board for each [due 11/25]

[Chemical and sensory analyses of cultivated pork fat tissue as a flavor enhancer for meat alternatives](#)
[FDA's Scientific Memo for GOOD Meat, Inc.](#)
[FDA's Scientific Memo for UPSIDE Foods, Inc.](#)
- Generate a two-page response to questions received during presentations [due 11/18]
- Work on Final Project presentation and writeup [due 12/02]

Week 11 (11/18): Final Project Working Session

Learning Objective(s):
- Critically analyze final project proposals with instructors and peers.

Class Structure and Assignment(s):
- **Part 1** – Final project group working sessions with instructor guidance and feedback.
- **Part 2** – Enjoy Thanksgiving!
- **Assignment**s:
  - Work on Final Project presentation and writeup [due 12/02]

Week 12 (11/25): Sensory Evaluation and Safety Compliance

Learning Objective(s):
- Evaluate strategies researchers/companies in the cell-cultivated meat/alternative protein fields can use to demonstrate safety for government approval and consumer acceptance.
- Analyze sensory evaluation assessments, their importance, and considerations.

Class Structure and Assignment(s):
- **Part 1** – Lecture: Safety and regulation of novel food products led by Dr. Stiffy Hice, PhD
  - o Dr. Stiffy Hice received their PhD from Iowa State University in Food Microbiology and currently serves as the Program Lead for FDA's Human Foods Made from Cultured Animal Cells Premarket Consultation Program.
- **Part 2** – Lecture: Sensory evaluation led by [Dr. Scott Frost](), PhD
  - o Dr. Scott Frost is a cellular agriculture post-doctoral fellow at Tufts University. His current work focuses on sensory and chemical analysis to characterize taste active properties of food and beverages.
- **Assignments**
  - Work on Final Project presentation and writeup [due 12/02]

Week 13 (12/02): Final project presentations part 1
Learning Objective(s):
- Illustrate understanding of one technical issue within the field through the presentation of a literature-based, novel solution to the issue (building upon midterm presentation)

Class Structure and Assignment(s):
- **Parts 1 & 2** – Class Presentations / questions

Week 14 (12/09): Final project presentations part 2
Learning Objective(s):
- Illustrate understanding of one technical issue within the field through the presentation of a literature-based, novel solution to the issue (building upon midterm presentation)

Class Structure and Assignment(s):
- **Parts 1 & 2** – Class Presentations / questions

Please note this schedule is subject to modification at the instructors' discretions.