MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Civil and Environmental Engineering

1.S979 Materials Innovation in Agriculture, Food Security and Food Safety

Spring Term 2018
Lectures: T 1-2.30 (1-273)
R 1-2.30 (1-273)
Laboratory: R 2.30 (1-354)

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Course Description

The class offers a unique perspective on the interplay between advanced materials, agriculture and food.

The main focus of the course is to illustrate the impact that advanced materials-based innovation is imparting to four key areas of agriculture; a) Management of plant diseases y, b) Mitigation of saline soil, c) Enhancement of crops yield and productivity, and d) Food safety and food security. The course will cover an introduction on advanced materials – with a key focus on biopolymers – that work at the biotic/abiotic interface to impact agriculture and food. Materials-based innovation in the aforementioned key areas will then be presented throughout the course.

In the first part of the class, students will be exposed to engineering design concepts that are germane to biopolymer processing, functionalization and characterization, which will be coupled with hands-on activity in a lab setting. During these activities, students will regenerate, process and functionalize biopolymers (e.g. silk and keratin) from raw to advanced materials (e.g. nanostructured coatings and nanoparticles). This will pave the way for the second part of the class, which will be centered around a proposed research project that aims at bringing materials-based innovation in agriculture. The design project will be based on four main challenges in AgTech; a) Management of plant disease, b) Mitigation of saline soil; c) Enhancement of crops yield and production and d) Food safety. Students will work in group of 2-4 to propose an innovative research topic to address these challenges, execute some key experiments in the lab to gather preliminary data and write a grant-like application (NSF style).

The course will be divided in the following three modules:

- ·Module A – Advanced-biopolymers technologies. Biopolymers regeneration, assembly, processing and functionalization. Focus will be on silk, keratin, collagen, chitin, cellulose hyaluronic acid and DNA. Methodology to regenerate silk fibroin and keratin will be explored in a lab setting.
- Module B – Project design to use materials based innovation to solve challenges in one of the following topics:
  - *Management of plant diseases*. Use of innovative, material-based techniques to manage root-, xylem- and phloem-restricted plant infections by sustained release of antimicrobial agents and thermal therapies. The cases of Citrus Greening and Soy Rust

will be discussed.
  - *Mitigation of saline soil*. The fundamental mechanism of soil salinification will be presented. A key focus on the use of rhizobacteria to alleviate soil salinity will be discussed. Encapsulation, preservation and delivery of rhizobacteria in the seed environment will be discussed. A laboratory experience showing the effects of rhizobacteria on soil salinity will be performed.
  - *Enhancement of crops yield and production*. A wide and deep overview on the major strategies used to control and enhance crop yield and productivity will be covered. GMO vs non-GMO strategies will be discussed, with a focus on biodiversity and disease resistance.
  - *Food Safety*. The use of advanced materials to address food safety and food security will be discussed. In particular, topics on food coatings to control post-harvest physiology, smart sensing of food spoilage through RFID, metamaterial and bioinks technologies, and biotechnology tools to reduce water usage will be covered.
- Module C – Final Report. Students will be required to develop a research proposal, conduct some experiments in the lab to gather preliminary data and then write a grant proposal.

Lectures

Lectures will be on TR in the 1.00-2.30 pm interval in 1-273. Lectures will actually start at *five minutes past* to allow you to be there on time and end *fine minutes before*. Lecture notes complementary to the topics class covered in will be posted on Stellar for each lecture. The subject content is defined by the material presented in lectures, recitations and reading assignments, so **regular attendance at lecture is strongly advisable**.

Laboratory and Design Project

THE FOLLOWING MANDATORY TRAININGS ARE REQUIRED FOR EACH STUDENT TO HAVE ACCESS TO the BL1 LAB FACILITY used in this class:

- Lab Specific Chemical Hygiene Training
- Managing Hazardous Waste
- General Chemical Hygiene

To complete these trainings, visit this webpage and follow the instructions:
https://ehs.mit.edu/site/about-training

Laboratory: During the laboratory experiences we will regenerate biopolymers (*e.g.* silk fibroin) from their raw state to water suspensions. We will then explore several fabrication techniques that allow to impart new form and functions to biopolymers to solve problems in agriculture, food security and food security.

Design Project: Group of students (2-4 people) will be formed and will discuss a design project with the instructor. The design project needs to address an unsolved problem that is germane to agriculture, food security and food safety, using some of the tools developed in class or during the laboratory experience. Students are encouraged to find unment

technical challenges within the following themes: a) Management of plant disease, b) Mitigation of saline soil; c) Enhancement of crops yield and production and d) Food safety.

Final Report

The research project will culminate

Grade

1.S979 final grade will be based on the quality of the final report (45%), the design project presentation (45%) and participation in class (10%).

Stellar Site

Lecture Schedule 1.S979

Date	Topic	Type of class
Feb 6	Structural Biopolymers (silk, cellulose, chitosan, agarose,…)	Lecture with slide support
Feb 8	Structural Biopolymers	Journal club
Feb 13	Membranes and Transport in Food and Packaging Applications	Lecture with slide support
Feb 15	Smart Food Packaging	Journal club
Feb 20	No class	
Feb 22	Structural Biopolymers Regeneration and Fabrication	Laboratory
Feb 27	Agrochemicals in soil and plants	Lecture with slide support
Mar 1	Delivery of agrochemicals in soil and plants	Journal club
Mar 6	Compendium of Seeds and Plants Anatomy and Physiology	Lecture with slide support
Mar 8	Compendium of Crops Anatomy, Physiology and Spoilage	Lecture with slide support
Mar 13	Nanomaterials in Agriculture	Lecture with slide support
Mar 15	Nanomaterials in Agriculture, title TBD	Invited Lecture
Mar 20	Food preservation	Lecture with slide support
March 22	Food coating	Journal club
April 3	Food coating	Laboratory
April 5	Food coating	Laboratory
April 10	Supply chain authentication	Lecture with slide support
April 12	Supply chain authentication	Journal club
April 17	No class this week	

April 24	Phloem- and Xylem-Restricted Plant Disease	Lecture with slide support
April 26	Citrus Greening and Zebra Chip Mitigation	Journal club
May 1	Soil and soil degradation	Lecture with slide support
May 3	Mitigation of soil salinity	Journal club
May 22	PROJECT FINAL REPORT	
May 25	PROJECT PRESENTATION	