General Education Course Enhancement Grant Competition

Principle Investigators: **William Mustain**, Assistant Professor**, Anson Ma**, Assistant Professor, **Daniel Burkey**, Assistant Professor-in-Residence

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Title of Course/Project: *CHEG 1200: Introduction to Food Science and Engineering*; (Chemical Engineering). First offering – Spring 2013.

Course Objectives:
We propose to develop an accessible science and engineering elective course based upon the application of chemical and engineering science to the production and processing of various foodstuffs that students have regular interaction with in their daily lives. This course will be suitable for a student who has taken an introductory chemistry course (prerequisite: CHEM 1127Q or CHEM1124Q/1125Q), and is designed to fulfill the CA 3 (Science and Technology) content area. We believe that this course fulfills the criteria for a CA 3 course in the following ways:

- **Explores a specific area of science and technology in a broadly accessible way:** All students are familiar with the preparation of food and beverages, either directly or indirectly, and this course will introduce them to the inherent scientific and engineering processes and challenges.
- **Promotes an understanding of modern scientific inquiry:** Students will be exposed to the field of modern food science, which borrows heavily from chemistry and chemical engineering, and is an active area of research for several of the faculty involved.
- **Introduces students to unresolved questions in science or technology:** The application of rigorous scientific inquiry to the field of food science is relatively new in the human experience. For most of human history, food preparation has been considered more of an art than a science, so there are still many unanswered questions about the chemistry of food, and how processing can affect the quality of the final product.
- **Promotes interest, competence, and commitment to continued learning:** By applying modern scientific and engineering principles to an area where students have ready access (the kitchen), we hope to spark in them an interest to learn more about the subject by making it accessible and with a low barrier to entry – most of the things they need to experiment on their own, they already have access to.

We anticipate that this offering will complement some of the courses offered in the Nutritional Sciences (NUSC) department, most specifically NUSC 1645 (The Science of Food) and NUSC 3233 (Food Composition and Preparation)[*n.b.* NUSC 3233 has significant prerequisites, including NUSC 1165 – Intro to Nutrition as well as CHEM 2241/2243 - Organic Chemistry]. We believe that the basic level, the application of engineering principles to food, as well as the module on beverages and fermentation are unique differentiators for our proposed course.

To accomplish the objectives, we propose the following four core areas to comprise the technical content for the course:

1. **Meats**

   Meats typically undergo complex chemical and physical transformations upon cooking that have a significant impact on their texture and palatability. Meats that contain significant moisture content or are insufficiently dried before cooking can steam rather than brown, as a layer of steam forms between the hot surface and the meat. Browning, indicative of the Maillard reaction, gives cooked meats the distinct exterior texture and flavor that is characteristic. Caramelization, while similar to the Maillard reaction, involves a complimentary series of chemical reactions that can impart their own distinct flavors. Flavor profiles in meats can also often be accentuated via marinating or brining, which are examples of chemical engineering mass transfer principles, as flavor compounds are drawn into the meat and water is expelled via diffusion and osmosis. In this first pillar we will discuss:

- Steaming vs. caramelization (involving sugars) vs. the Maillard reaction (involving amino acids); chemical and physical changes in cooked meat, and the differences between searing and finishing.
- Marinating and brining: chemical reactions, diffusion, and osmotic phenomena
- Thermal conduction vs. thermal convection; how heat transfer principles affect texture and cooking time.

2. **Dairy Products**

Milk can be processed into a wide variety of dairy products such as cheese, butter, cream, yogurt, and ice cream. Understanding the science behind dairy products is important not only for processing the materials, but also for prolonging the shelf life of the end products (e.g., the use of pasteurization to suppress microbial activity). In this pillar, we will:

- Highlight the fundamental differences in processing methods for different types of dairy products
- Introduce how basic chemical engineering principles (such as thermodynamics, heat and mass transfer, and fluid mechanics) can be applied to design, control, and scale up the production process. For instance, the production of ice cream essentially involves high shear mixing (related to fluid mechanics) and freezing (heat transfer and phase change).
- Focus on how the composition and processing conditions affect the morphology and sensory properties of the dairy products

All in all, the processing and production of various dairy products will offer an excellent example and unique opportunity to illustrate how simple engineering principles can be applied to convert a natural product into various forms. As part of the haptic learning experiences, we will also coordinate with the UConn dairy bar to tour their on-campus ice cream manufacturing facilities. We believe this course will appeal to students with different backgrounds.

3. Baking

The third pillar will focus on applications of chemistry and chemical engineering to the field of baking. Baking encompasses a wide range of chemical and physical processes that affect the taste, flavor, and texture of the final product. Baking also has wide application to a diversity of foodstuffs, from breads and rolls to cookies and cakes, all using the same core set of ingredients, but combined and processed in different ways. Key concepts that will be covered in this section are:

- Biological Leavening: The introduction of carbon dioxide into a dough or batter via a microorganism, most often yeast. The amount and release rate of the carbon dioxide has a distinct impact on the texture of the finished product, which in the case of breads can range from hard and dense to light and airy.
- Chemical Leavening: The introduction of carbon dioxide via a chemical agent when exposed to water and/or heat. These are often used in quick recipes, like cakes and cookies, where a long reaction time is undesirable.
- The role of the protein gluten in the structure and texture of baked goods
- The role of basic chemical engineering principles, such as thermodynamics, kinetics, and heat transfer to understand how various recipes' baking times are influenced by chemical and physical phenomena

4. Beverages

The final focus pillar for the class outlined in this proposal revolves around the preparation and packaging of consumable liquids. Beverages provide a unique opportunity for the instructor to accomplish two important goals that we try to satisfy in every chemical engineering class. First, after a very focused, real-world (at-home) approach to the first three pillars of the class, this pillar will allow the team to introduce the university population to industrial processes and open discussions into manufacturing-scale problems. Continuous forced carbonation is one such difficulty.

Second, fermented beverages (in this course, beer will be considered initially) are an ideal capstone topic, combining several scientific principles from the previous three units. Beer is also an interesting way to present scientific information to the broader university community through an area where they have tangible experience. The key concepts from brewing that will be tackled include:

- Equilibrium considerations for forced vs. natural carbonation
- Maillard reactions during barley kilning, which balances sweet and bitter flavors. This would also reinforce concepts from the Meat course pillar
- Mashing, which involves starch extraction and enzymatic decomposition. Here, raw materials and processing conditions (i.e. temperature, pH, water chemistry) yield tangible differences in product quality/design
- Fermentation, which will provide a simple introduction into the biology and chemical kinetics surrounding aerobic vs. anaerobic processes, as well as the ATP/ADP (glycolysis) and citric acid energy cycles.

Faculty Expertise:
Several of the participating faculty have existing research areas that overlap with the course content. Mustain teaches a chemical engineering elective on fermentation processes, and advises a graduate student on the construction of a continuous fermentation project. Ma's research focuses on ice crystal formation in ice cream and the effect on texture and other properties.

Assessment:
Learning Outcomes:

1. At the end of the course, students will possess a basic understanding of the chemical and physical processes involved in the production or preparation of various foods and beverages.
2. At the end of the course, students will be able to discuss the effect of various processing parameters on the expected quality of a finished food or beverage.
3. At the end of the course, students will have a basic mathematical competency in food science and engineering. Based on the techniques discussed, students should be able to mathematically describe, at a basic level, certain processes to predict the result of an experiment ('recipe').
4. At the end of the course, students should have a greater appreciation for the science and engineering processes that impact their nutrition and food production.

Assessment Methodology:
The course is scalable – depending on the level of enrollment and interest. For large classes, regular homework, quizzes, and exams will be able to assess outcomes 1-3. Outcome 4 can be assessed via pre- and post-course surveys, which are qualitative. Given the fact that access to many of the required tools and ingredients for experimentation is readily available, **group projects** will be assigned. Students will be asked to qualitatively describe differences in their created products based upon the techniques used. The products will also be shared in class for group comparison and discussion. In all cases, hands-on demonstration of the principles discussed will be performed by the faculty, to draw a physical connection between the course material and the real world. Most of the budget requested goes to the purchase of the basic materials needed for demonstration purposes.

In terms of student learning (i.e. Bloom's Taxonomy), we believe that the accessible nature of the course topic (food and beverages) together with the low barrier to entry for experimentation will encourage students to actively transfer the **knowledge** gained from the classroom to the **application** of that knowledge in the creation of their own products (i.e. cooking, brewing, baking). The sharing of the student creations in the classroom setting will also promote **analysis** and **evaluation** based on the comparison of different groups' techniques, successes, and failures. General applicability of the knowledge will hopefully foster creativity in the students, allowing them to take the base knowledge and apply it in creative ways (**synthesis).**

2012 GENERAL EDUCATION COURSE ENHANCEMENT GRANT COMPETITION

Name: Mustain/Ma/Burkey **Title:** CHEG 1200: Introduction to Food Science & Engineering

The maximum amount available for each proposal is $10,000, payable in two installments at the beginning of fiscal years 2013 (July 1, 2012- June 30, 2013) and 2014 (July 1, 2013-June 30, 2014). A maximum of $5,000 will be distributed per year for each proposal. Funds can be used at any time during the fiscal year for purposes that support the activities of the proposal and conform to University of Connecticut guidelines.

Fiscal 2013	**Amount budgeted**	**Fringe ***	**Total**
Summer salary	$0	$0	$0
Supplies	$5000	None	$5000
Travel	$0	None	$0
Research (Faculty Account) Ledg 2	$0	$0	$0
Other	$0	$0	$0
Total	$5000	$0	**$5000**

Fiscal 2014	**Amount budgeted**	**Fringe ***	**Total**
Summer salary	$0	$0	$0
Supplies	$1000	None	$1000
Research (Faculty Account) Ledg 2	$0	$0	$0
Travel	$4000	None	$4000
Other	$0	$0	$0
Total	$5000	$0	**$5000**

* Please check the Accounting Office website for summer fringe rates. www.accountingoffice.uconn.edu. As following year fringe rates are not posted until July, estimate 20% fringe for regular faculty.

Justification:

As indicated in the proposal, a significant goal of the proposal is to provide students with a tangible representation of food science and engineering. To that end, most of the funding for this project is requested for supplies that directly support the four pillars. Hotplates, utensils, sample containers, mixers, ice cream makers, food processors, breadmakers, soda carbonators are all hardware that will be used in the class. General costs for these items (in some cases, multiple units) have been estimated from Amazon.com. Additionally, $1000 per year will be budgeted for consumables (milk, eggs, meat, spices, flour, barley, etc.). In year 2, $4000 is requested to offset travel costs to the national AIChE (American Institute of Chemical Engineers) meeting (2013 – San Francisco), where the development of this class will be presented in the Engineering Education section.

DEPARTMENT RESOURCES STATEMENT

To the Evaluation Committee,

Please find attached the proposal for CHEG 1200: Introduction to Food Science and Engineering, in response to the 2012 Gen Ed Grant competition. This proposal is being submitted by Profs. Mustain, Ma, and Burkey from Chemical Engineering.

Please note that Prof. Carter (department head) has indicated his support for this proposal under separate email.

Best regards,

Dan

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CHEG 1200 dept head statement of support

From: CB Carter Engr [mailto:cbcarter@engr.uconn.edu]
Sent: Wednesday, February 29, 2012 8:49 AM
To: Provost's Office - Geoc
Cc: daniel@engr.uconn.edu; mustain@engr.uconn.edu; Ma, Anson
Subject: CHEG 1200

Provost Gen Ed Development Grant

Letter confirming support for a new course:

This CHEG course is to be submitted to the Provost's office for the $10K Gen Ed development award

I support the enhancement/development of this course (CHEG 1200: Introduction to Food Science and Engineering). Upon completion of the project, I confirm that the Department Head will make every effort for the course to be offered every, or every other, year at the typical class size for the duration of at least five years.

C. Barry Carter

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Editor-in-Chief, Journal of Materials Science
President (2011-2014), International Federation of Societies for Microscopy
IFSM is an ICSU Scientific Associate (www.IFSM.UConn.edu)
Chair, MRS Awards Committee (2012-2014)
Fellow, AAAS, MRS, MSA, ACerS and RMS
Member, Connecticut Academy of Science & Engineering
Member, AIChE and MAS

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CERAMIC MATERIALS: Science & Engineering Carter & Norton (Springer 2007)
TRANSMISSION ELECTRON MICROSCOPY: A Textbook for Materials Science Williams & Carter (Springer 2009)
JOURNAL of MATERIALS SCIENCE: www.springer.com/JMaterialsScience 2010 Impact Factor is 1.859
REALTIME: http://realtime.springer.com/journal/1573-4803 Now averaging >60,000 downloads every week

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