

# Fundamentals of Cellular Engineering

*Syllabus for Chem Eng 690F (Fall 2010)*

## Course Description

Cellular engineering involves the characterization and manipulation of cellular function with applications in healthcare, energy and the environment. This course will address the fundamental and applied aspects of cellular engineering in relevant thematic segments co-taught by engineering and science faculty. Topics covered include metabolic engineering, protein engineering, membranes and drug delivery, stem cells and cancer, and plant biotechnology.

## Course Objectives

This is the gateway course for the Institute for Cellular Engineering (ICE) Interdisciplinary Graduate Education and Research Traineeship (IGERT) program. The ICE IGERT program cross-trains students at the critical interface of engineering and the life sciences, creating tomorrow's interdisciplinary leaders in the field of cellular engineering. Course objectives:

- Broadly educate students about the field of cellular engineering
- Involve 15+ ICE training faculty to illustrate the depth of cellular engineering research on campus, as well as provide an interdisciplinary networking opportunity for students to meet faculty outside of their home discipline
- Organize lectures into themed segments (each with a faculty coordinator) to insure course cohesion
- Assign segment-based homework assignments, and incorporate interdisciplinary, team-based assignments to reinforce the interdisciplinary theme and encourage cross-discipline peer networking
- Train students in the art of communicating across disciplines through interactive class discussion

## Logistics

Class will meet on **Tuesday and Thursday evenings from 6:00 – 7:30 pm in LGRT 201**, unless otherwise indicated. Attendance is mandatory for all sessions and role will be taken. If you are unable to attend, please email the course TA and the session instructor *prior* to the class. The course is organized into themed blocks relevant to cellular engineering. There will be one coordinating faculty member for each block and instructors will communicate with each other to lay out a comprehensive strategy that includes both pedagogical material and more detailed research descriptions. Sessions may vary from instructor to instructor, and may include lectures only, lectures plus journal discussion, and journal discussion only. There are no textbook requirements for this course. Occasionally, instructors may request prior review of articles or publications. In this event, the TA will either email the files or upload them to the course website.

## Grading Policy

Upon course completion, you will be assigned a letter grade that is based on attendance/participation and your cumulative performance on homework assignments. The instructors in each themed segment will develop a single homework assignment and have been encouraged to involve group work to enhance the interdisciplinary learning experience of the course. Each assignment will be graded on a scale from 1 to 10. ***Assignments must be completed and returned to the TA during class on the due dates specified below.*** Late or missing assignments will be figured as zeros for calculation of your final homework grade. There will be no exams. The final course grade will be determined as 80% of the final homework average and 20% attendance and course participation. Therefore, it is critical that you attend each class and actively engage in discussions.

Dates	Themed Segments	Assignment Due
9/7, 9/9	<b>Introduction to Course and Cellular Engineering</b> ( <u>Ross</u> )	9/16/10
9/14, 9/16, 9/21, 9/23	<b>Protein Folding and Engineering</b> ( <u>Hardy</u> with Garman, Chambers and Chien)	9/30/10
9/28, 9/30, 10/5, 10/7	<b>Cytoskeleton</b> ( <u>Ross</u> with Debold and Lee)	10/14/10
10/14, 10/19, 10/21	<b>Membranes and Delivery</b> ( <u>Santore</u> with Bermudez and Schnell) (note: Tuesday, 10/12 follows a Monday class schedule)	10/28/10
10/26, 10/28, 11/2, 11/4	<b>Stem Cells and Cancer</b> ( <u>Telfer</u> with Mager, Tremblay, and Tew)	11/10/10
11/9, 11/10, 11/16, 11/18	<b>Plant Biotechnology</b> ( <u>Normanly</u> with Parkash) (note: Wednesday, 11/10 follows a Thursday class schedule – so don't miss class!)	11/30/10
11/23, 11/25	No Class: Thanksgiving Week	
11/30, 12/2, 12/7, 12/9	Final Oral Presentations ( <u>Ross</u> )	

## Detailed Syllabus Schedule:

Dates	Topic
Week 1 9/7, 9/9	<p><b>Introduction to Course and Cellular Engineering (Ross)</b>  <u>Lecture topics:</u> overview of cellular engineering  <u>Experimental methods described:</u> Northern blots, Reverse transcriptase PCR, Coulter Counter, Agrobacterium transformation.  <u>Assignment:</u> In reference to your own thesis project: How does it relate to cellular engineering? What interdisciplinary technique(s) do you use in your research? How might your project translate into an industrial application?</p>
Weeks 2 and 3 9/14, 9/16, 9/21, 9/23	<p><b>Protein Folding and Engineering (Hardy with Garman, Chambers and Chien)</b>  <u>Lecture topics:</u> Directed evolution; computational design of biologically active molecules; protein folding and kinetics; <i>in vitro</i> and <i>in vivo</i> protein folding; molecular chaperones, and chaperone based therapies.  <u>Assignment:</u> Problem set based on protein folding, rational design, computational design and directed evolution approaches to protein engineering.</p>
Weeks 4 and 5 9/28, 9/30, 10/5, 10/7	<p><b>Cytoskeleton (Ross with Debold and Lee)</b>  <u>Lecture topics:</u> intracellular transport; axonal transport; intraflagellar transport; ciliary beating; cellular motility; muscle motion and regulation; mitosis.  <u>Experimental methods described:</u> Total internal reflection fluorescence imaging, single molecule imaging and tracking, photoactivation localization microscopy, muscle fiber assays, filament gliding assays, optical tweezers, three bead assay and force feedback assays, spinning disk confocal, photobleaching and photoactivation, single molecule counting.  <u>Assignment:</u> Working in interdisciplinary groups, design an “experiment” to test a mechanistic model describing a function of a specified cytoskeleton/motor system.</p>
Weeks 6 and 7 10/14, 10/19, 10/21	<p><b>Membranes and Delivery (Santore with Bermudez and Schnell)</b>  <u>Lecture topics:</u> Understanding membrane properties; gene/drug delivery; membranes as drug delivery systems; understanding the mechanism of protein targeting and assembly in the plastids (chloroplasts) of plants.  <u>Assignment:</u> Two-part assignment:  <ul style="list-style-type: none"> <li>- Provide a summary on current new models for membrane structure</li> <li>- Problem set: calculate protrusion energies, decay lengths, force-distance profiles and undulation force-distance profile</li> </ul> </p>
Weeks 8 and 9 10/26, 10/28, 11/2, 11/4	<p><b>Stem Cells (Telfer with Mager, Tremblay, and Tew)</b>  <u>Lecture topics:</u> Embryonic stem cells, induction of pluripotent stem cells from somatic cells, adult stem cells, development of differentiated cells from stem cells, methods of protein or gene delivery  <u>Experimental methods described:</u>            Culturing of stem cells, cloning of animals, induction of pluripotent cells from somatic cells, induction of differentiated cells from stem cells, methods of protein or gene delivery.  <u>Assignment:</u>  <ul style="list-style-type: none"> <li>- Problem set based on stem cells, their differentiation into targeted cell types, delivery of protein, DNA, or RNA to cells.</li> </ul> </p>
Weeks 10 and 11 11/9, 11/10, 11/16, 11/18	<p><b>Plant Biotechnology (Normanly with Parkash)</b>  <u>Lecture topics:</u> Human uses for plant and microbial secondary metabolites, classical and “omics” approaches to characterizing metabolite synthesis pathways. Specific examples of secondary metabolite engineering and the establishment of gene-to-metabolite networks. Engineering plants for reduced arsenic uptake for human health and increased uptake for phytoremediation  <u>Experimental methods described:</u> Separation methods, internal standards, mass spectrometry.  <u>Assignment:</u> Students can choose between two assignments: (1) Chose a plant or microbial secondary metabolite of value (either for human health or industrial purposes) but for which a biosynthetic pathway is unknown. Discuss how to engineer the cost effective production of this compound. Make sure to include the obstacles that need to be overcome and a strategy for doing so. Include citations to any published material that is used (provide full citations with authors names, the publication, volume, year and page numbers). (2) 2-3 page summary of the overview of the topic and what are their own views about the GM plants developed for environmental clean-up or human consumption.</p>
Week 12	No Class: Thanksgiving Week
Weeks 13 and 14 11/30, 12/2, 12/7, 12/9	<b>Final Oral Presentations (Ross)</b>

Coordinating faculty member is listed first and underlined.

**Accommodation Policy:**

The University of Massachusetts Amherst is committed to providing an equal educational opportunity for all students. If you have a documented physical, psychological, or learning disability on file with Disability Services (DS), Learning Disabilities Support Services (LDSS), or Psychological Disabilities Services (PDS), you may be eligible for reasonable academic accommodations to help you succeed in this course. If you have a documented disability that requires an accommodation, please notify me within the first two weeks of the semester so that we may make appropriate arrangements.

**Academic Honesty Policy:**

Since the integrity of the academic enterprise of any institution of higher education requires honesty in scholarship and research, academic honesty is required of all students at the University of Massachusetts Amherst. Academic dishonesty is prohibited in all programs of the University. Academic dishonesty includes but is not limited to: cheating, fabrication, plagiarism, and facilitating dishonesty. Appropriate sanctions may be imposed on any student who has committed an act of academic dishonesty. Since students are expected to be familiar with this policy and the commonly accepted standards of academic integrity, ignorance of such standards is not normally sufficient evidence of lack of intent.