BME653 Micro-/Nanotechnologies for Interfacing Live Cells

3 hours/week (Tuesdays 6-9pm) (Fenster 698) (3 credits) Spring 2013

Instructor: Raquel Perez-Castillejos (office: Fenster613)(e-mail: raquelpc@njit.edu)

Course Description: Biological cells are sophisticated physicochemical systems that are part of tissues and organs within multicellular organisms. Humans have always been interested in understanding how single cells operate and how cells integrate themselves in massive complex systems (tissues, organs) to perform a common function. However, the dimensions of cells (around 10 microns) always precluded an easy interaction with those cells. Recent success in the miniaturization of microfluidic devices for cell culture makes it possible to build sensors and actuators with the same (or similar) dimensions to those of cells. In this course we will study technologies and tools available for interfacing live cells from a sub-cellular, single-cell, and multi-cellular (tissue models) approach.

Office hours: Mondays 4:00 – 5:00 pm in Fenster 613 and by appointment.

Prerequisites: graduate students or instructor's permission.

Week	Topics
1 (Jan22)	· **COURSE INTRODUCTION**
2 (Jan29)	· **DESIGN CONSTRAINTS FOR CELL-INTERFACING DEVICES** · **SUBCELLULAR PROBES**
3 (Feb5)	· **Presentation 3.1**: S.E. Cross et al., *Nanomechanical analysis of cells from cancer patients,* Nature Nanotechnology **2007**, 2:780. · **MICROFLUIDICS**
4 (Feb12)	· **Presentation 4.1**: S.L. Stott *et al.*, *Isolation of circulating tumor cells using a microvortex-generating herringbone-chip*, PNAS **2010**, 107(43):18392. · **Presentation 4.2**: P. Abbyad et al., *Sickling of red blood cells through rapid oxygen exchange in microfluidic drops,* Lab Chip **2010**, 10:2505. · **FLUID FLOW AND LIVING CELLS, MECHANOTRANSDUCTION**
5 (Feb19)	· **Presentation 5.1**: D. Huh et al., *Reconstituting organ-level lung functions on a chip*, Science **2010**, 328:1662-1668. · **Presentation 5.2**: M.A. Asnaghi et al., *A double-chamber rotating bioreactor for the development of tissue-engineered hollow organs: from concept to trial,* Biomaterials **2009**, 30:5260. · **FABRICATION TECHNOLOGIES**
6 (Feb26)	· **Presentation 6.1**: E.E. Hui and S.N. Bhatia, *Micromechanical control of cell-cell interactions*, PNAS **2007**, 104:14. · **Presentation 6.2**: T.G. Leong et al., *Tetherless thermobiochemically actuated microgrippers*, PNAS **2009**, 106:703. · **BIODETECTION: LAB ON A CHIP, CD LAB, LAB IN A DROPLET**

7 (Mar5)	· **Presentation 7.1**: A.A. Chen et al., *Multiplexed high-throughput analysis of 3D microtissue suspensions*, Int. Bio. **2010**, 2:517. · **Presentation 7.2**: N. Misawa et al., *Highly sensitive and selective odorant sensor using living cells (…)*, PNAS **2010**, 107(35):15340. · **MULTI-CUE MULTICELL SYSTEMS ON 2D SUBSTRATES**
8 (Mar12)	· **LABORATORY 1: FABRICATION**
9 (Mar26)	· **LABORATORY 2: CHARACTERIZATION**
10 (Apr2)	· **Presentation 10.1**: J. Fu et al., *Mechanical regulation of cell function with geometrically modulated elastomeric substrates*, Nat. Methods **2010**, 7:733. · **Presentation 10.2**: M. Håkanson et al., *Engineered 3D environments to elucidate the effect of environmental parameters on drug response in cancer*, Integrative Biology **2011**, 3:31. · **MULTI-CUE MULTICELL SYSTEMS ON 3D MATRICES**
11 (Apr9)	· **Presentation 11.1**: C.M. Nelson et al., *Tissue geometry determines sites of mammary branching/morphogenesis (…)*, Science **2006**, 314:298. · **Presentation 11.2**: S. Chung et al., *Cell migration into scaffolds under co-culture conditions in a microfluidic platform*, Lab Chip **2009**, 9:269. · **MULTI-CUE MULTICELL SYSTEMS IN 3D MATRICES**
12 (Apr16)	· **Presentation 12.1**: K. Pataky et al., *Microdrop printing of hydrogel bioinks into 3D tissue-like geometries*, Adv. Mat. **2012**, 24:391. · **Presentation 12.2**: A. Nishiguchi et al., *Rapid construction of three-dimensional multilayered tissues with endothelial tube networks by the cell-accumulation technique*, Adv. Mat. **2011**, 23:3506. · **DELIVERY OF SOLUBLE/BOUND CUES, CHEMOTAXIS**
13 (Apr23)	· **Presentation 13.1**: C. Moraes et al., *A microfabricated platform for high-throughput unconfined compression of micropatterned biomaterial arrays*, Biomaterials **2010**, 31:577. · **Presentation 13.2**: K.E. Sung et al., *Transition to invasion in breast cancer: a microfluidic in vitro model enables examination of spatial and temporal effects*, Int. Biology **2011**, 3:439. · **NANOTOPOGRAPHY, NANOPARTICLES, NANOTOOLS**
14 (Apr30)	· **Presentation 14.1**: J.J. VanDersarl et al., *Nanostraws for direct fluidic intracellular access*, Nano Letters **2012** (available online). · **Presentation 14.2**: B. Tian et al., *Three-dimensional, flexible nanoscale field-effect transistors as localized bioprobes*, Science **2010**, 329:830. · **REVIEW AND EVALUATION OF THE COURSE**

Textbook: The course does not require any textbook. The basic resource of course material will be the lecture notes and peer-reviewed publications provided by the instructor plus the library of references that students will build while preparing the weekly assignments (paper analyses, presentations). Course materials are provided through the Moodle portal to this course, which can be accessed via http://moodle.njit.edu/.

Evaluation: Grade for this course is the result of the following five components:

20% - CLASS ATTENDANCE & PARTICIPATION

- Students are expected to attend each of the 14 lectures of the course.
- Students are expected to be in class before its start (6:00pm, sharp) and until its end (9:00pm). Grades will reflect lateness in arriving to class (beginning and after breaks) as well as premature departures from class.
- The lectures will be interactive and students are expected to ask questions and provide comments. At least one question will need to be asked by each student (except the presenters) at the end of each presentation.

20% - WEEKLY PAPER ANALYSES

- During weeks 3-8 and 10-14, each week students will read one peer-reviewed paper, study it, and identify the main points/results of the paper. During weeks 4-8 and 10-14, each student will choose one of 2 papers available each week.
- In weeks 4-8 and 10-14, each student will respond a series of questions online about his/her selected paper. The questions will be available during the 2 h before class (4 – 6 pm, Tuesdays) on the course's Moodle portal. Each student will have exactly 30 min to answer the questions, as long as he/she starts responding the questions before 5:30 pm on Tuesday.
- Only questions from weeks 4-8 and 10-14 will count towards the course grade. The questions on week 3 will just be for practice—not for grade.

20% - PAPER PRESENTATION 1 (25% presentation structure + 50% instructor + 25% peer grading); and

20% - PAPER PRESENTATION 2 (25% presentation structure + 50% instructor + 25% peer grading)

- In groups of 2, students will choose one paper offered during weeks 4 – 7 and present it in class.
- The presentation will be 35-40 minutes long with additional 10 minutes for questions. Presentations cannot be longer than 40 minutes.
- Grade for the presentation will result from adhesion to requested structure for the presentation (25% of the presentation grade), the evaluation of the instructor (50% of the presentation grade) and the evaluation of the classmates (25% of the presentation grade).

20% - LABORATORY (there will be **no make-up labs**)

- Students will participate of the lab sessions (2) in groups of 3-4.
- Students are expected to attend the two lab sessions: each lab session corresponds to half of the final grade of the course.
- Grade for the laboratory will result from before-class questions (weeks 8 and 9; 4% of course grade) and the lab report (16% of course grade) that each group will submit no later than 2 weeks after the second lab session.

Honor code: Cheating in any form will be dealt with according to the honor code of NJIT: course failure and suspension or expulsion. Any case of cheating will be passed immediately to the Dean of Students for further investigation. The full text of the NJIT Honor Code is at http://www.njit.edu/academics/honorcode.php