Preliminary Course Syllabus
BMEn 5701 – Cancer Bioengineering
Fall 2013

Location: TBD

Time: WF 9:45-11:00
Office hours: Monday 11:15-12:15

Instructor: Prof. Paolo P. Provenzano

Office: 7-120 Hasselmo Hall
Phone: (612) 624-3279
E-Mail: pprovenz@umn.edu

Course Description: Cancer bioengineering provides a wealth of opportunities for physical scientists to deepen their understanding of fundamental biologic principles while learning how engineering can contribute to oncology. This course will emphasize the understanding of cancer-specific cell, molecular and genetics events and cover quantitative applications of bioinformatics and systems biology, optical imaging, cell and matrix mechanics, and drug transport (with some examination of design of novel therapeutics). At the end of this course students will be able to integrate key aspects of cancer biology and recent bioengineering efforts utilizing engineering analysis and technology to elucidate mechanisms of tumor progression and rationally develop novel diagnostics and therapies.

Prerequisites: Upper division undergraduate or graduate student, or consent of instructor. In addition to previous course work in engineering and/or physics, a working understanding of cell and molecular biology is highly recommended.

Course Goals: The goals of this course are to leave the student with a deep understanding of cancer biology and real-world application of engineering principles and technologies. By focusing on areas where quantitative and engineering tools and analysis have provided, or promise to provide, novel insight into fundamental disease processes the student will learn new engineering principles. The intent is that the focus areas listed in the course description (basic cancer biology, bioinformatics/systems biology, cell mechanics, optical imaging, and physical mechanisms of therapeutic resistance) will help expand, broaden and deepen understanding of both engineering and biology.

Course Expectations: Students should read assigned papers in advance of class. Students are encouraged to form study groups to discuss the paper in advance of class. Prior to the discussion of a paper, a brief lecture will be given to provide additional background and perspective on the topic. The paper will then be discussed in class, section by section. For some topics assigned student groups may lead parts of the discussion. Students are expected to understand what was done, why it was done, and the significance of what was done. If students are unclear on any of these issues, they are expected to ask in class (or in advance of class). Part of the grade for the course will depend on classroom participation. Generally, students should earn full credit for this component. However, if there are lapses in the discussion and no student answers the question posed by the instructor or student leaders, then the instructor will randomly query students from the class list to assess their preparedness. Failure to prepare adequately could result in a lowered score for participation. Students are also encouraged to email questions to the instructor in advance of class.

Textbook (required): Weinberg R.A., The Biology of Cancer, 2007 Garland

Additional Resources:

A standard cell biology textbook is recommended as a reference.

Alberts et al., Molecular Biology of the Cell, Garland.
Bray, D., Cell Movements: From Molecules to Motility, Garland.
Lodish et al., Molecular Cell Biology, W.H. Freeman and Co.

For basic background on cell mechanics, transport, and reaction kinetics/thermodynamics, refer to:

Boal, D., Mechanics of the Cell, 2002, Cambridge Univ. Press.
Howard, J., Mechanics of Motor Proteins and the Cytoskeleton, 2001, Sinauer Assoc.
Truskey A., Transport Phenomena in Biological Systems, 2009, Pearson Prentice Hall

An optional "interesting readings" list will be provided on Moodle for each lectures/section for students to dig deeper into a topic of interest

Course Grading: 50% homework; 40% project (25% written + 15% presentation); participation 10%. Homework will span standard question and answer formats to critical analysis of key papers and concepts in the field. The course project is a short (5 page) grant application, followed by a short presentation, proposing to either apply current engineering principles to a cancer biology problem in a new way or to apply novel engineering strategies to a well studied or understudied cancer biology problem. The deadline for proposal topic selection is Nov. 1st. Project reports are due on Dec. 3rd.

Grading will be on the following scale (using university criteria, which may be found at http://process.umn.edu/groups/senate/documents/policy/gradingpolicy.html):

90-100	A	80-83.3	B	70-73.3	C	<60	F
86.7-89.9	A-	76.7-79.9	B-	67.7-69.9	C-		
83.4-86.6	B+	73.4-76.9	C+	63.4-67.6	D		

Additional Information on BMEn 5701 and its Role in the B.Bm.E. Curriculum: The courses required for the Bachelor of Biomedical Engineering degree program are designed to meet the Program Educational Objectives (PEOs), as defined by the BME Department (BMED), and the Student Outcomes (SOs), as defined by the Accreditation Board for Engineering and Technology (ABET). Achieving the PEOs and SOs is necessary to maintain program accreditation by ABET. For a full description of the PEOs, the SOs, and the accreditation of the program, please refer to the BMED website (bme.umn.edu/undergrad/index.html) and the ABET website (www.abet.org/forms.shtml).

The POs that the BMEn 5701 course is meant to at least partially achieve are that students should have:

(a) an ability to apply knowledge of mathematics, science, and engineering
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course	Title	a	b	c	d	e	f	g	h	i	j	k	l	m
BMEn 5701	Cancer Bioengineering	H		L								M		

H = High priority; M = Medium priority; L = Low priority

Week 1:	**Assigned Reading**
Review of fundamental biologic processes	Hanahan & Weinberg, Hallmarks of Cancer, 2011
Summary overview of each section of the course	
Introduction to cancer biology	
(Basic concepts, diagnostic criteria and stages of disease progression)	
Week2:	
Discuss Hallmarks of Cancer Paper	Eisen et al., 1998, Sorlie et al., 2001
Diversity of Cancer	
(Clustering, clustering metrics, divisive algorithms, systems mapping of cancer genetics)	
Oncogenesis / Oncogenes	
Week 3:	
Oncogenesis / Oncogenes cont.	Kumar et al., 2011; Kim et al., 2007
Growth Factors	
Week 4:	Olive et al., 2004
Growth Factors cont.	
Tumor suppressor genes	
Week 5:	TBD
Apoptosis	
Chemotherapy	
Week 6:	Egeblad et al., 2010
Cancer as an organ/system	
Small molecule therapies	
Week 6	Wirtz & Searson, 2011
Cell motility / migration overview	
Integrins / Focal adhesions (force transducers, signaling)	
Week 7	
Stages of metastasis (biological and physical factors)	Provenzano et al., 2009
Contact guidance	
Week 8	Provenzano et al., 2008, Condeelis, 2004
MPLSM / SHG	
Intravital imaging of invasion and metastasis	
Week 9	Leventhal et al., 2009
Contact Guidance – Rho-mediated contractile force	
Stiffness and migration – durotaxis	
Week 10	
Computational modeling of cell invasion	Zaman et al., 2005, 2006
Project ideas (past and future)	
Week 11	Jain TBD
Tumor microenvironment	
Physical resistance to drug therapy (diffusion and convection)	
Week 12	Olive et al., 2009
Physical resistance to drug therapy (diffusion and convection)	
Stroma targeting therapy - Vascular	
Week 13	Provenzano et al., 2012
Stroma targeting therapy – Fibroblasts	

Stroma targeting therapy – ECM

Week 14 TBD
Drug delivery: Nanoparticles
Immune therapy

Week 15
Project presentations