Syllabus for BIEN 167: Medical Diagnostics

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Fall 2015

Class Schedule

Lecture:	9:10 – 10:00 MWF	SPR 1340
Discussion:	8:10 – 9:00 T	MSE 003

Course description

Provides an overview of medical diagnostics. Topics include methods of biochemical detection, genotyping, DNA sequencing, medical imaging, hematology, microfluidics, epidemiology, diagnostics for point-of-care and resource-limited settings, and case studies of commercially successful diagnostic products. 4 units total: 3 units lecture, 1 unit discussion.

Textbook

None required, but course material will be provided on iLearn, including journal articles, patents, product literature, and example code.

Course outline

Introduction to medical diagnostics. "What kills people?" (survey of leading causes of death globally, by region, and socioeconomic group)

Pneumonia pathology and diagnostics. Blood/sputum cultures. Cell staining and microscopy.

Malaria pathology and diagnostics. Blood films. ELISA. Rapid diagnostic tests (lateral flow assays). World Health Organization criteria for diagnostics in resource-limited settings.

Tuberculosis pathology and diagnostics. Emergence of drug-resistant pathogens. Genetic analysis for pathogen identification. Polymerase chain reaction (PCR). Gel electrophoresis. Case study of Cepheid's GeneXpert genotyping system.

HIV/AIDS pathology, diagnostics, and disease monitoring. Fluorescence-activated cell sorting (FACS). Cell-phone-based cell analyzers.

Smartphones in medical diagnostics: motion sensors. Case study: creating a fall detection app using a sensor logging app.

Smartphones in medical diagnostics: sound sensors. Case study: creating an ultrasound app.

Smartphones in medical diagnostics: light sensors. Case study: creating a photoplethysmography app for measuring heart rate.

Project 1: Smartphone-based medical tools. Students propose, prototype, and present a smartphone-based medical tool.

Introduction to microfluidics. The ASSURED criteria for diagnostics in resource-limited settings. Advantages (and disadvantages) of assay miniaturization.

Current trends in microfluidic diagnostics. A review of recent literature on microfluidic diagnostics.

Microfabrication for microfluidics. Photolithography. Spin coating. Silicon in microfluidics. Terry's miniaturized gas chromatography system. Etching techniques. Bonding. Glass in microfluidics. Silicone rubber in microfluidics.

Simulation of microfluidic systems. Finite element analysis software COMSOL Multiphysics.

Project 2: Microfluidic diagnostics. Students simulate an existing microfluidic diagnostic system, propose an improvement to the system, simulate the improved system, and share results with the class.

Case study: Theranos. An analysis of the rise and fall of a microfluidic medical diagnostic company. Intellectual property.

Diffusion in medical diagnostics. Introduction of model biosensor. Incorporating purely diffusive transport of target in model biosensor. Dimensionless flux of target to biosensor. Case studies of nanowire biosensors, blood glucose meters, and alcohol breathalyzers.

Diffusion + convection in medical diagnostics. Adding convection to model biosensor. Peclet numbers. Case study of microfluidic HIV viral load measurement.

Diffusion + convection + kinetics in medical diagnostics. Adding reaction kinetics to model biosensor. First-order Langmuir binding kinetics. Case study of microscale vs. nanoscale biosensors. The advantages and disadvantages of detecting single molecules.

Grading

- 20% Homework
- 20% Presentation 1
- 20% Presentation 2
- 20% Midterm exam
- 20% Final exam

		A+	$\geq$	97.00
97.00	$>$	A	$\geq$	92.00
92.00	$>$	A–	$\geq$	90.00
90.00	$>$	B+	$\geq$	87.00
87.00	$>$	B	$\geq$	82.00
82.00	$>$	B–	$\geq$	80.00
80.00	$>$	C+	$\geq$	77.00
77.00	$>$	C	$\geq$	72.00
72.00	$>$	C–	$\geq$	70.00
70.00	$>$	D+	$\geq$	67.00
67.00	$>$	D	$\geq$	62.00
62.00	$>$	D–	$\geq$	60.00
60.00	$>$	F		

Homework

- Assigned via iLearn, due one week later by 5pm.
- Solutions posted on iLearn after grading is finished.

Project 1: Smartphone-based medical tools

Students propose, prototype, and present a smartphone-based medical tool. You won't need to program you own apps. I'll show you how to use tools like sensor logger apps, sound recorder apps, and camera apps to acquire medically-meaningful data and import that data into a computer for analysis using tools like MATLAB, Python, ImageJ, Audacity, and others. Around Week 6 you will present your app proposal and preliminary results to the class.

Project 2: Microfluidic diagnostics

Students simulate an existing microfluidic diagnostic system, propose an improvement to the system, simulate the improved system, and share results with the class. I'll give you a crash course in simulating microfluidic chips in COMSOL Mulitphysics. Around Week 10 you will present your simulations and proposed improvements to the class.

Presentation rules

- Brief abstracts on proposed topics are due two weeks before presentations.
- Teams of 1, 2, or 3 persons.
- I'll announce the amount of time allotted for each group's presentation.
- Visuals in PowerPoint, Keynote, PDF, Google Docs, or on the chalkboard. No Prezi or similar tools please.