

**BE.481 / 7.86 / MAS.866**  
**Fundamental limits of biological measurement**

**Instructors:** Scott Manalis (*scottm@media.mit.edu*)  
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**Units:** 3 - 3 - 6

**Time:** Tuesdays and Thursdays, 1:00 - 2:30 pm

**Location:** 56-154

**Prerequisites**

Senior or graduate level status. Course builds upon foundations in physics, math, and biology.

**Goal**

To understand physical principles that govern the ultimate limits for measuring force, charge, and optical signals in biological systems.

**Grading**

50% Problem sets  
25% Lab report  
15% Presentations  
10% Participation

**Course website:** <http://www.media.mit.edu/nanoscale/courses/spring04/index.html>

- Feb 3* | Course Introduction and Case Study: **DNA Microarrays** (*Manalis and Sorger*)
- Feb 5* | Binding affinity and thermodynamics (*Sorger*)
- Feb 10* | The electrical double layer and electrokinetic transport (*Manalis*)
- Feb 12* | Surface functionality and nucleic acid structure (*Manalis and Sorger*)
- Feb 19* | Applications (student presentations)

### **Foundations** (*Parallel tracks*)

- Feb 24* | Fourier Analysis (*Manalis*).....Building a DNA Microarray (*Albeck*)
- Feb 26* | Corr, Conv, and Filters (*Manalis*)....Cell biology (*Sorger*)
- March 2* | Nano/microfabrication (*Manalis*).....Genetics and molecular biology (*Sorger*)

### **Mechanical and Electronic Detection** (*Manalis*)

- March 4* | *Forces and biological systems* (student presentations)
- March 9* | Noise, mechanical systems, and ultimate limits of position and force detection
- March 11* | Random processes and the fluctuation dissipation theorem
- March 16* | Applications of force detection to nuclear magnetic resonance
- March 18* | Detecting charge: the single electron transistor

### **Optical Sensing and Microscopy** (*Sorger*)

- April 1* | *Microscopy and biological systems* (student presentations)
- April 6* | Probes and fluorescence, optical instruments and microscopes
- April 8* | Wave theory, spectra, convolution, and optical systems
- April 13* | Optical systems from fourier and information theory perspectives

### **Diffraction and Imaging** (*Sorger*)

- April 15* | *Information and biological systems* (student presentations)
- April 22* | Ultimate limits of optical detection
- April 27* | Breaking the limits
- April 29* | Xtalography and electron diffraction in biology

### **Measurement Laboratory** (*Manalis*)

- May 4* | Microcantilever I: thermomechanical properties
- May 6* | Microcantilever II: force spectroscopy
- May 11* | Optical trap I: calibration
- May 13* | Optical trap II: pulling DNA
- May 15* | Lab presentations