

Phys / BME 325

Physical Measurements of Biological Systems

[Fluorescence](#); [Molecular & Cellular Force Measurements](#); [FTIR Spectroscopy](#); [NMR Spectroscopy & MRI](#); [Mass Spectrometry](#); [Electrochemical Recording](#); [Microfluidics & Cellular Instrumentation](#); [Electrophysiology](#)

Course Documents

[Syllabus](#)

[Lecture and Presentation Schedule](#) (*this just shows topics, specific readings will be posted below*)

[Major Writing Assignment: Mini NIH-Style Grant Proposal](#)

For guidance on what goes in each section and the criteria by which your proposal will be judged, consult these [excerpts from the NIH's instructions](#).

(*The entire instructions can be found [here](#).*)

Here are some **examples of Specific Aims** pages from recent proposals: [Hutson](#), [Gochberg](#).

I would also suggest consulting this excellent guide to scientific writing in general: "[The Science of Scientific Writing](#)" by George D. Gopen and Judith A. Swan. If you find that interesting, but need more, Gopen has an excellent book available entitled *The Sense of Structure: Writing from the Reader's Perspective*.

[Course blog for answering Warm-Up questions](#)

This Week's Reading

Monday, December 12 at 9:00 AM - Proposals DUE - Please submit ELECTRONICALLY to shane.hutson@vanderbilt.edu

Documents to provide you with some guidance in preparing your proposals

1. Instructions: [Major Writing Assignment: Mini NIH-Style Grant Proposal](#)
2. For guidance on what goes in each section, consult these [excerpts from the NIH's instructions](#). (*The entire instructions can be found [here](#).*)
3. For details on the criteria by which your proposal will be judged, see the NIH's [Research Program Grant Critique Template](#) (editable Word .doc), [critique template instructions](#) and an NIH-provided [example critique](#) (which also has links to descriptions of all the review criteria). You will notice that I have crossed out the Investigator and Environment criteria in the template and example. You will not be evaluated on these criteria.
4. Details and guidance on the [NIH scoring system](#).
5. Everyone should read this very short site from the Vanderbilt library on [Avoiding Plagiarism](#). For more information, you can follow links from the Vanderbilt Writing Studio's [Tips on Avoiding Plagiarism](#).

Sample Proposals:

1. [My last NIH proposal](#) (a bit longer than what I'm asking of you, but it was funded \$\$)
2. Best-scored student proposal from Fall 2009: [Lewis Kraft](#)
3. Best-scored student proposals from Spring 2008: [Carly Anderson](#) and [Ken Lewis](#)
4. Best-scored student proposal from Spring 2006: [Zheming Wu](#)

Thursday, December 15 at 3:00 PM - Mock Study Section

Everyone should read the specific aims section of ALL proposals. In addition, you will each have TWO proposals for which you will write a formal review using the NIH's [Research Program Grant Critique Template](#) (editable Word .doc). To help you, NIH provides an [example critique](#) (which also has links to descriptions of all the criteria you are to consider) and [critique template instructions](#). You will notice that I have crossed out the Investigator and Environment criteria in the template and example. Please ignore these criteria in your critiques.

In addition to the written critique, you will need to decide on scores (1-9, 1 being best) for each remaining criterion and for the overall proposal. The following link provides details and guidance on the [NIH scoring system](#).

In our mock study section, the formal reviews of each proposal will be presented by the two assigned students and then the proposal will be discussed by the entire panel. We will all vote on the quality of the proposal (via a 1-9 score) and average these to come up with an overall priority score. At the end of the session, we will look back on the distribution of priority scores amongst all the proposals (to see who would get \$\$\$).

I will send your review assignments via email. These reviews are single-blind - i.e. you know whose proposal you are reviewing, but you will not know who is reviewing your proposal.

Full Proposals

1. [Bryson Brewer](#)
2. [Juan-Carlos Cordova](#)
3. [Monica Lacy](#)
4. [Nichole Lareau](#)
5. [Ty McCleery](#)
6. [Jessica Moore](#)
7. [Jie Zhao](#)

[Specific Aims of All Proposals](#)

Previous Readings/Lecture Notes

Tuesday, August 30 - Introduction to Fluorophores and Fluorescence - [WARM-UP QUESTION ON COURSE BLOG](#)

Two sections from the [Molecular Expressions](#) website maintained by the Optical Microscopy Division of the National High Magnetic Field Laboratory (at Florida State). In addition to the sections you'll read for my lectures, this site is a great resource if you need background information for your own presentation on fluorescence techniques.

1. [Basic Concepts in Fluorescence](#) If fluorescence is completely new to you, you may want to start with [Introduction to Fluorescence](#) and [Overview of Excitation and Emission Fundamentals](#).
2. [Fluorophores for Confocal Microscopy](#)

Thursday, September 1 - Confocal and Multiphoton Fluorescence Microscopy - [WARM-UP QUESTION ON COURSE BLOG](#)

1. [Introduction to Confocal Microscopy](#) (mostly laser scanning confocal) with an [interactive java tutorial](#).
2. [Introduction to Spinning Disk Confocal Microscopy](#) with a [flash tutorial on the Yokogawa design](#).

3. [Multiphoton Fluorescence Microscopy](#)

Tuesday, September 6 - Fluorescence (or Förster) Resonance Energy Transfer (aka FRET) - [WARM-UP](#)

1. [FRET - Introductory Concepts](#)
2. [Spectral Imaging and Linear Unmixing](#)

Thursday, September 8 - Super-Resolution Fluorescence Microscopy - [WARM-UP](#)

1. [Introduction to Super-resolution Microscopy](#) with [links to several interactive tutorials](#) that cover almost all the super-resolution techniques.

Tuesday, September 13 - Student Presentations - [WARM-UP](#)

1. <Ty> Vogelsang J, Cordes T, Forthmann C, Steinhauer C and Tinnefeld P (2010) [Intrinsically Resolution Enhancing Probes for Confocal Microscopy](#) *Nano Letters* **10**(2): 672-679.
2. <Jessica> Hübner W, McNerney GP, Chen P, Dale BM, Gordon RE, Chuang FYS, Li X-D, Asmuth DM, Huser T and Chen BK (2009) [Quantitative 3D Video Microscopy of HIV Transfer Across T Cell Virological Synapses](#) *Science* **323**(5922): 1743-1747.

Thursday, September 15 - Student Presentations - [WARM-UP](#)

1. <Bryson> Xie C, Hanson L, Cui Y, Cui B (2011) [Vertical nanopillars for highly localized fluorescence imaging](#). *Proc. Natl. Acad. Sci. USA* **108**: 3894–3899.
2. <Nichole> Rust MJ, Bates M, & Zhuang X (2006) [Sub-diffraction-limit imaging by stochastic optical reconstruction microscopy \(STORM\)](#) *Nature Methods* **3**: 793 - 796.

Tuesday, September 20 - Student Presentations - [WARM-UP](#)

1. <Jie> Carrington WA, Lynch RM, Moore ED, Isenberg G, Fogarty KE, Fay FS.(1995) [Superresolution three-dimensional images of fluorescence in cells with minimal light exposure](#). *Science*. 268(5216):1483-7.
2. <Monica> Niino Y, Hotta K, Oka K.(2009) [Simultaneous live cell imaging using dual FRET sensors with a single excitation light](#). *PLoS One* **4**(6): e6036.

Thursday, September 22 - Student Presentations - [WARM-UP](#)

1. <Juan> Mori, T; Vale, RD; Tomishige, M (2007) [How kinesin waits between steps](#) *Nature* 450: 750-U15.
2. <Jie> Gregor, T; Fujimoto, K; Masaki, N; Sawai, S (2010) [The onset of collective behavior in social amoebae](#) *Science* **328**: 1021-1025.

Tuesday, September 27 - Introduction to Optical Tweezers - [WARM-UP](#) - [PPT Slides](#)

1. M.C. Williams, [Optical tweezers: Measuring piconewton forces](#)

Thursday, September 29 - Measurement of Molecular & Cellular Forces - [WARM-UP](#) - [PPT Slides](#)

1. A.D. Mehta, M. Retief and J.A. Spudich, [Biomechanics, one molecule at a time](#), *J. Biol. Chem.* 274: 14517-14520 (1999).
2. A. R. Bausch, F. Ziemann, A. A. Boulbitch, K. Jacobson and E. Sackmann (1998) "[Local Measurements of Viscoelastic Parameters of Adherent Cell Surfaces by Magnetic Bead Microrheometry](#)" *Biophys. J.* 75: 2038-2049.

Tuesday, October 4 - Student Presentations - [WARM-UP](#)

1. <Monica> W. Cheng, S. G. Arunajadai, J. R. Moffitt, I. Tinoco Jr., C. Bustamante, [Single-Base Pair Unwinding and Asynchronous RNA Release by the Hepatitis C Virus NS3 Helicase](#) *Science* 333, 1746-1749 (2011).
2. <Juan> W. J. Greenleaf, M. T. Woodside, E. A. Abbondanzieri, and S. M. Block, [Passive All-Optical Force Clamp for High-Resolution Laser Trapping](#), *Phys. Rev. Lett.* 95: 208102 (2005).

Thursday, October 6 - Fall Break - No Class

Tuesday, October 11 - Student Presentations - [WARM-UP](#)

Tuesday, October 11 - Student Presentations - [WARM-UP](#)

1. <Ty> M. Padgett and R. Bowman, [Tweezers with a twist](#) *Nature Photonics* 5: 343-348 (2011).
2. <Bryson> C. Schulze, F. Wetzel, T. Kueper, A. Malsen, G. Muhr, S. Jaspers, T. Blatt, K.-P. Wittern, H. Wenck, and J. A. Kas, [Stiffening of Human Skin Fibroblasts with Age](#) *Biophysical Journal* 99: 2434-2442 (2010).

Thursday, October 13 - Vibrational Molecular Spectroscopy - [WARM-UP](#)- [PPT SLIDES](#)

1. [Infrared Spectroscopy Primer](#) by William Reusch of Michigan State University (one of several nice spectroscopy links at SpectroscopyNow)
2. [Introduction to FTIR Spectroscopy](#) from Oriel Instruments.
3. [The Fourier Transform Toolkit](#)- you don't have to read this beforehand, but it is a good reference for building intuition about Fourier Transforms (which we will use repeatedly in the spectroscopy and MRI sections). If you aren't really familiar with FTs, it might help you with the reading questions.

Thursday, October 18 - Vibrational Molecular Spectroscopy - [PPT SLIDES](#)

No new reading.

Tuesday, October 25 - Student Presentations - [WARM-UP](#)

1. <Juan> Goldberg, ME; Chaffotte, AF [Undistorted structural analysis of soluble proteins by attenuated total reflectance infrared spectroscopy](#) *Protein Science* 14 (11): 2781-2792 (2005).
2. <Nichole> Kneipp, J; Miller, LM; Spassov, S; et al. [Scrapie-infected cells, isolated prions, and recombinant prion protein: A comparative study](#) *Biopolymers* 74 (1-2): 163-167 (2004) ----AND----- Kneipp, J; Miller, LM; Joncic, M; et al. [In situ identification of protein structural changes in prion-infected tissue](#) *Biochimica et Biophysica Acta* 1639 (3): 152-158 (2003).

Thursday, October 27 - Student Presentations - [WARM-UP](#)

1. <Jessica> Miller, LM; Smith, RJ [Synchrotrons versus globars, point-detectors versus focal plane arrays: Selecting the best source and detector for specific infrared microspectroscopy and imaging applications](#) *Vibrational Spectroscopy* 38 (1-2): 237-240 (2005).
2. <Jie> Sumii, M; Furutani, Y; Waschuk, SA; et al. [Strongly hydrogen-bonded water molecule present near the retinal chromophore of Leptosphaeria rhodopsin, the bacteriorhodopsin-like proton pump from a eukaryote](#) *Biochemistry* 44 (46): 15159-15166 (2005).

Tuesday, November 1 - Magnetic Resonance Imaging - [WARM-UP](#)

Joseph P. Hornak, <http://www.cis.rit.edu/htbooks/mri/inside.htm>

Ch 3, Spin Physics

Ch 6, Imaging Principles

Ch 7, Fourier Transform Imaging Principles

Thursday, November 3 - Student Presentations - [WARM-UP](#)

1. <Ty> S. Ogawa; D. W. Tank; R. Menon; J. M. Ellermann; S.-G. Kim; H. Merkle; K. Ugurbil (1992) "[Intrinsic Signal Changes Accompanying Sensory Stimulation: Functional Brain Mapping with Magnetic Resonance Imaging](#)" *Proc. Natl. Acad. Sci. USA* 89: 5951-5955.
2. <Nichole> D.C. Colvin, T.E. Yankeelov, M.D. Does, Z. Yue, C. Quarles and J.C. Gore (2008) "[New Insights into Tumor Microstructure Using Temporal Diffusion Spectroscopy](#)" *Cancer Research* 68(14): 5941-7.
3. <Bryson> Horch RA, Gochberg DF, Nyman JS, Does MD (2011) "[Non-invasive Predictors of Human Cortical Bone Mechanical Properties: T2-Discriminated 1H NMR Compared with High Resolution X-ray.](#)" *PLoS ONE* 6(1): e16359. doi:10.1371/journal.pone.0016359.

Tuesday, November 8 - Mass Spectrometry - [WARM-UP](#)

- M.A. Baldwin (2005) "[Mass Spectrometers for the Analysis of Biomolecules](#)" *Methods in Enzymology* 402: 3-48.

Thursday, November 10 - Mass Spectrometry (continued)

Monday, November 16 - Mass Spectrometry (continued)

- ["The Science of Scientific Writing"](#) by George D. Gopen and Judith A. Swan
- ABSTRACTS for proposals are due.

Tuesday, November 15 - Student Presentations - [WARM-UP](#)

1. <Nicho> L.S. Fenn and J.A. McLean (2008) "[Biomolecular structural separations by ion mobility–mass spectrometry](#)" *Anal Bioanal Chem* 391: 905–909.
2. <Monica> A.G. Marshall, C.L. Hendrickson and S.D.-H. Shi (2002) "[Scaling MS Plateaus with High-Resolution FT-ICRMS](#)" *Analytical Chem*, May 1, 2002: 25-259.
3. Don't forget that class will be extended to make-up for a previous mixed lecture. We'll spend this time discussing your abstracts in relation to ["The Science of Scientific Writing"](#) by George D. Gopen and Judith A. Swan.

Thursday, November 17 - Student Presentations - [WARM-UP](#)

1. <Jie> Q. Hu, R.J. Noll, H. Li, A. Makarov, M. Hardman and R.G. Cooks (2005) "[The Orbitrap: a new mass spectrometer](#)" *J. Mass Spectrom.* 2005; 40: 430–443.
2. <Ty / Jessica> L.A. McDonnell and R.M.A. Heeren (2007) "[Imaging Mass Spectrometry](#)" *Mass Spectrometry Reviews* 2007, 26, 606– 643.
3. <Jessica> D.R. Ifa, N.E. Manicke, A.L. Dill, R.G. Cooks (2008) "[Latent Fingerprint Chemical Imaging by Mass Spectrometry](#)" *Science* 321: 805.

Thursday, December 1 - Electrochemical Measurements - [WARM-UP](#)

S.R. Mikkelsen, "[Electrochemistry in Bioanalysis](#)" in G.S. Wilson, A.J. Bard and M. Stratman, eds. *Bioelectrochemistry*, Chapter 10, pp. 310-340 (Wiley-VCH, Weinheim, 2002).

Tuesday, December 6 - Student Presentations - [WARM-UP](#)

1. <Juan> B.D. Bath, H.S. White and E.R. Scott, "[Visualization and Analysis of Electroosmotic Flow in Hairless Mouse Skin](#)" *Pharmaceutical Research* 17: 471-475 (2000). For some background/perspective: H.S. White, "[Electrochemical Imaging of Molecular Transport in Skin](#)," *The Electrochemical Society Interface*, **Fall 2003**: 30-34.
2. <Jessica> Ciobanu, M., D.E. Taylor, J.P. Wilburn and D.E. Cliffel "[Glucose and Lactate Biosensors for Scanning Electrochemical Microscopy Imaging of Single Live Cells](#)" *Analytical Chemistry* 80(8): 2717-2727 (2008). For some background/perspective: Bard, A.J., X. Li and W. Zhan "[Chemically imaging living cells by scanning electrochemical microscopy.](#)" *Biosensors & Bioelectronics* 22(4): 461-472 (2006 - Review Article).

Thursday, December 8 - Student Presentations - [WARM-UP](#)

1. <Monica> B.J. Venton and R.M. Wightman (2003) "[Psychoanalytical Electrochemistry: Dopamine and Behavior](#);" *Analytical Chemistry* Oct 1, 2003: 414-421.
2. <Bryson> Spencer E. Hochstetler, Michelino Puopolo, Stefano Gustincich, Elio Raviola, and R. Mark Wightman; "[Real-Time Amperometric Measurements of Zeptomole Quantities of Dopamine Released from Neurons](#);" *Anal. Chem.* 72: 489-496 (2000).

FTIR SPECTROSCOPY

Student Presentation Options

Nienhaus, K; Nienhaus, GU "[A spectroscopic study of structural heterogeneity and carbon monoxide binding in neuroglobin](#)" *Journal of Biological Physics* 31 (3-4): 417-432 (2005).

Lin, M; Krasteva, M; Barth, A "[Interactions of phosphate groups of ATP and aspartyl phosphate with the sarcoplasmic](#)

Liu, M., Krasova, M., Dahi, A. [Interactions of phosphate groups of ATP and aspartyl phosphate with the sarcoplasmic reticulum Ca²⁺-ATPase: An FTIR study](#) *Biophysical Journal* 89 (6): 4352-4363 (2005).

<Jie> Sumii, M; Furutani, Y; Waschuk, SA; et al. [Strongly hydrogen-bonded water molecule present near the retinal chromophore of Leptosphaeria rhodopsin, the bacteriorhodopsin-like proton pump from a eukaryote](#) *Biochemistry* 44 (46): 15159-15166 (2005).

<Juan> Goldberg, ME; Chaffotte, AF [Undistorted structural analysis of soluble proteins by attenuated total reflectance infrared spectroscopy](#) *Protein Science* 14 (11): 2781-2792 (2005).

Masuda, S; Hasegawa, K; Ono, T [Adenosine diphosphate moiety does not participate in structural changes for the signaling state in the sensor of blue-light using FAD domain of AppA](#) *FEBS Letters* 579 (20): 4329-4332 (2005).

<Jessica> Miller, LM; Smith, RJ [Synchrotrons versus globars, point-detectors versus focal plane arrays: Selecting the best source and detector for specific infrared microspectroscopy and imaging applications](#) *Vibrational Spectroscopy* 38 (1-2): 237-240 (2005).

<Nichole> Kneipp, J; Miller, LM; Spassov, S; et al. [Scrapie-infected cells, isolated prions, and recombinant prion protein: A comparative study](#) *Biopolymers* 74 (1-2): 163-167 (2004) ----AND----- Kneipp, J; Miller, LM; Joncic, M; et al. [In situ identification of protein structural changes in prion-infected tissue](#) *Biochimica et Biophysica Acta* 1639 (3): 152-158 (2003).

Hutson, M.S.; Alexiev, U.; Shilov, S.V.; Wise, K.J.; Braiman, M.S. [Evidence for a Perturbation of Arginine-82 in the Bacteriorhodopsin Photocycle from Time-Resolved Infrared Spectra](#) *Biochemistry* 39: 13189-13200 (2000)

Rodig C.; Siebert F. [Errors and Artifacts in Time-Resolved Step-Scan FT-IR Spectroscopy](#) *Applied Spectroscopy* 53 (8): 893-901 (1999).

C.M. Phillips, Y. Mizutani and R.M. Hochstrasser, [Ultrafast thermally induced unfolding of RNase A](#), *Proc. Natl. Acad. Sci. USA* **92**, 7292-7296 (1995).

MOLECULAR & CELLULAR FORCE MEASUREMENTS

Optical Tweezers

E. A. Abbondanzieri, W. J. Greenleaf, J. W. Shaevitz, R. Landick and S. M. Block, [Direct observation of base-pair stepping by RNA polymerase](#), *Nature* 438: 460-465 (2005). There is also a nice review of this work in January's Physics Today : C. Day, [Optical Trap Resolves the Stepwise Transfer of Genetic Information from DNA to RNA](#), *Physics Today*, January 2006, pp. 26-27.

<Juan> W. J. Greenleaf, M. T. Woodside, E. A. Abbondanzieri, and S. M. Block, [Passive All-Optical Force Clamp for High-Resolution Laser Trapping](#), *Phys. Rev. Lett.* 95: 208102 (2005).

H. Higuchi, E. Muto, Y. Inoue, and T. Yanagida, [Kinetics of force generation by single kinesin molecules activated by laser photolysis of caged ATP](#), *Proc. Natl. Acad. Sci. USA* 94, 4395-4400 (1997).

||||| NEW REVIEW ARTICLE -This could make a nice presentation or one could use it to find primary articles of interest. |||||K. Dholakia and T. Cizmar, [Shaping the future of manipulation](#) *Nature Photonics* 5: 335-342 (2011).

||||| NEW REVIEW ARTICLE -This could make a nice presentation or one could use it to find primary articles of interest. |||||M. Badgett and P. Bowman, [Tweezers with a twist](#) *Nature Photonics* 5: 343-348 (2011).

INTEREST. ||||| M. Tauger and R. Dowman, [Tweezers with a twist](#) *Nature Photonics* 5: 543-546 (2011).

||||| NEW ||||| C.O. Mejean, A. W. Schaefer, E. A. Millman, P. Forscher and E. R. Dufresne, [Multiplexed force measurements on live cells with holographic optical tweezers](#) *Optics Express* 17: 6209-6217 (2009).

||||| FOUNDATIONAL ||||| J.E. Curtis, B.A. Koss and D.G. Grier, [Dynamic holographic optical tweezers](#), *Opt. Commun.* 207, 169-175 (2002).

||||| NEW ||||| C. Hodges, L. Bintu, L. Lubkowska, M. Kashlev, C. Bustamante, [Nucleosomal Fluctuations Govern the Transcription Dynamics of RNA Polymerase II](#) *Science* 325, 626-628 (2009). [with a [helpful commentary by Otterstrom and van Oijen](#)].

<Monica> ||||| NEW ||||| W. Cheng, S. G. Arunajadai, J. R. Moffitt, I. Tinoco Jr., C. Bustamante, [Single-Base Pair Unwinding and Asynchronous RNA Release by the Hepatitis C Virus NS3 Helicase](#) *Science* 333, 1746-1749 (2011).

||||| NEW ||||| A. N. Fehr, B. Gutierrez-Medina, C. L. Asbury, and S. M. Block, [On the Origin of Kinesin Limping](#) *Biophysical Journal* 97: 1663-1670 (2009).

||||| NEW ||||| M. T. Valentine and S. M. Block, [Force and Premature Binding of ADP Can Regulate the Processivity of Individual Eg5 Dimers](#) *Biophysical Journal* 97: 1671-1677 (2009).

Magnetic Tweezers and Other Techniques

||||| NEW REVIEW ARTICLE - I wouldn't suggest presenting this specific article, but it has lots of great links to papers that could make very nice presentations. ||||| Brenner, M.D.; Zhou, R.; and Ha, T. [Forcing a Connection: Impacts of Single-Molecule Force Spectroscopy on In Vivo Tension Sensing](#) *Biopolymers* 95(5): 332-344 (2010).

Shroff, H; Reinhard, BM; Siu, M; Agarwal, H; Spakowitz, A; Liphardt, J; [Biocompatible force sensor with optical readout and dimensions of 6 nm\(3\)](#) *Nano Letters* 5 (7): 1509-1514 (2005).

Charvin, G; Strick, TR; Bensimon, D; Croquette, V; [Tracking topoisomerase activity at the single-molecule level](#) *Annual Review of Biophysics and Biomolecular Structure* 34: 201-219 (2005).

Danilowicz, C; Greenfield, D; Prentiss, M; [Dissociation of ligand-receptor complexes using magnetic tweezers](#) *Analytical Chemistry* 77 (10): 3023-3028 (2005).

de Vries, AHB; Krenn, BE; van Driel, R; Kanger, JS; [Micro magnetic tweezers for nanomanipulation inside live cells](#) *Biophysical Journal* 88 (3): 2137-2144 (2005).

Tan, JL; Tien, J; Pirone, DM; Gray, DS; Bhadriraju, K; Chen, CS; [Cells lying on a bed of microneedles: An approach to isolate mechanical force](#) *Proceedings of the National Academy of Sciences, USA* 100 (4): 1484-1489 (2003).

Desprat, N; Richert, A; Simeon, J; Asnacios, A; [Creep function of a single living cell](#) *Biophysical Journal* 88: 2224-2233 (2005).

Wottawah, F; Schlinkinger, S; Lincoln, B; Ananthakrishnan, R; Romeyke, M; Guck, J; Kas, J; [Optical rheology of biological cells](#) *Physical Review Letters* 94: 098103 (2005).

X. Trepatt, M.R.Wasserman, T.E. Angelini, E. Millet, D.A.Weitz, J.P. Butler and J.J. Fredberg (2009) [Physical forces during collective cell migration](#) *Nature Physics* 5: 426-430.

||||| NEW ||||| C. Schulze, F. Wetzel, T. Kueper, A. Malsen, G. Muhr, S. Jaspers, T. Blatt, K.-P. Wittern, H. Wenck, and J. A. Kas, [Stiffening of Human Skin Fibroblasts with Age](#) *Biophysical Journal* 99: 2434-2442 (2010).

||||| FOUNDATIONAL ||||| J. Guck, R. Ananthakrishnan, H. Mahmood, T. J. Moon, C. C. Cunningham and J. Kas, [The Optical Stretcher: A Novel Laser Tool to Micromanipulate Cells](#) *Biophysical Journal* 81: 767-784 (2001).

||||| **NEW** ||||| M. Simon, J. A. North, J. C. Shimko, R. A. Forties, M. B. Ferdinand, M. Manohar, M. Zhang, R. Fishel, J. J. Ottesen, and M. G. Poirier [Histone fold modifications control nucleosome unwrapping and disassembly](#) *Proceedings of the National Academy of Sciences, USA* 108: 12711–12716 (2011).

Laser Microdissection

X. Ma, H.E. Lynch, P.C. Scully and M.S. Hutson (2009) [Probing embryonic tissue mechanics with laser hole drilling](#) *Physical Biology* 6: 036004 (12 pp).

M. Rauzi, P. Verant T. Lecuit and P.-F. Lenne (2008) [Nature and anisotropy of cortical forces orienting *Drosophila* tissue morphogenesis](#) *Nature Cell Biology* 10: 1401-1410.

Farhadifar R, Roper J-C, Aigouy B, Eaton S and Julicher F (2007) [The influence of cell mechanics, cell-cell interactions, and proliferation on epithelial packing](#) *Current Biology* 17 2095–2104.

Kumar S et al (2006) [Viscoelastic retraction of single living stress fibers and its impact on cell shape, cytoskeletal organization, and extracellular matrix mechanics](#) *Biophysical Journal* 90 3762–73.

FLUORESCENCE

Super-resolution Microscopy

<Nichole> ||||| **FOUNDATIONAL** ||||| Rust MJ, Bates M, & Zhuang X (2006) [Sub-diffraction-limit imaging by stochastic optical reconstruction microscopy \(STORM\)](#) *Nature Methods* 3: 793 - 796.

||||| **FOUNDATIONAL** ||||| Hess ST, Girirajan TPK, and Mason MD (2006) [Ultra-High Resolution Imaging by Fluorescence Photoactivation Localization Microscopy \(PALM\)](#) *Biophysical Journal* 91(11): 4258-4272.

||||| **FOUNDATIONAL** ||||| Betzig E, Patterson GH, Sougrat R, Lindwasser OW, Olenych S, Bonifacino JS, Davidson MW, Lippincott-Schwartz J and Hess HF (2006) [Imaging Intracellular Fluorescent Proteins at Nanometer Resolution](#) *Science* 313(5793): 1642-1645.

||||| **NEW** ||||| Huang B, Wang W, Bates M and Zhuang X (2008) [Three-Dimensional Super-Resolution Imaging by Stochastic Optical Reconstruction Microscopy](#) *Science* 319(5864): 810-813.

<Ty> ||||| **NEW** ||||| Vogelsang J, Cordes T, Forthmann C, Steinhauer C and Tinnefeld P (2010) [Intrinsically Resolution Enhancing Probes for Confocal Microscopy](#) *Nano Letters* 10(2): 672-679.

Hell, SW; Schmidt, R; Egner, A (2009) [Diffraction-unlimited three-dimensional optical nanoscopy with opposing lenses](#) *Nature Photonics* 3(7): 381-387.

Shtengel, G; Galbraith, JA; Galbraith, CG, et al.(2009) [Interferometric fluorescent super-resolution microscopy resolves 3D cellular ultrastructure](#) *Proc Natl Acad Sci USA* 106(9): 3125-3130.

Subach, FV; Patterson, GH; Manley, S, et al.(2009) [Photoactivatable mCherry for high-resolution two-color fluorescence microscopy](#) *Nature Methods* 6(2): 153-159.

Pavani, SRP; Thompson, MA; Biteen, JS, et al. (2009) [Three-dimensional, single-molecule fluorescence imaging beyond the diffraction limit by using a double-helix point spread function](#) *Proc Natl Acad Sci USA* 106(9): 2995-2999.

Nagerl, UV; Willig, KI; Hein, B, et al. (2008) [Live-cell imaging of dendritic spines by STED microscopy](#) *Proc Natl Acad Sci USA* 105(48): 18982-18987.

Westphal, V; Rizzoli, SO; Lauterbach, MA, et al. (2008) [Video-rate far-field optical nanoscopy dissects synaptic vesicle](#) *Science* 320(5872): 246-249.

[movement](#) *Science* 320(5815): 240-249.

Biteen, JS; Thompson, MA; Tselentis, NK, et al. (2008) [Super-resolution imaging in live *Caulobacter crescentus* cells using photoswitchable EYFP](#) *Nature Methods* 5(11): 947-949.

||||| FOUNDATIONAL ||||| Hell, SW (2007) [Far-field optical nanoscopy](#) *Science* 316(5828): 1153-1158.

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NMR SPECTROSCOPY & MRI

Helpful Online Tutorials (Supplemental material)

"Understanding NMR Spectroscopy", James Keeler, University of Cambridge
<http://www-keeler.ch.cam.ac.uk/lectures/Irvine/>

"Nuclear Magnetic Resonance (NMR)" in *Biophysics Textbook Online*, David Gorenstein, Volume Editor
<http://www.biophysics.org/btol/NMR.html>

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<http://www.cis.rit.edu/htbooks/mri/inside.htm>

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Student Presentation Options: NMR/EPR/ESR Spectroscopy

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L. Frydman, A. Lupulescu & T. Scherf (2003) "[Principles and Features of Single-Scan Two-Dimensional NMR Spectroscopy](#)" *J. Am. Chem. Soc.* **125**: 9204-9217. AND Y. Schrot & L. Frydman (2004) "[Single-Scan NMR Spectroscopy at Arbitrary Dimensions](#)" *J. Am. Chem. Soc.* **125**: 11385-11396.

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A. Mittermaier & L. E. Kay (2006) "[New Tools Provide New Insights in NMR Studies of Protein Dynamics](#)" *Science* 312: 224-228.

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MICROFLUIDICS & CELLULAR INSTRUMENTATION

Student Presentation Option

M.D. Schmidt, J.W. Jenkins, J.E. Hood, A. Soni, J.P. Wikswow, H. Lipson (2008) "[Automated probing and inference of analytical models for metabolic networks](#)" Submitted to *Molecular Systems Biology*.

W. Georgescu, J. Jourquin, L. Estrada, A.R.A. Anderson, V. Quaranta and J.P. Wikswow (2008) "[Model-controlled hydrodynamic focusing to generate multiple overlapping gradients of surface-immobilized proteins in microfluidic devices](#)" *Lab on a Chip* 8: 238-244.

This review article should not be selected for a presentation, but it does have lots of references that would make good presentation papers:

K.A. Addae-Mensah and J.P. Wikswow (2008) "[Measurement Techniques for Cellular Biomechanics In Vitro](#)" *Experimental Biology and Medicine* (in press).

K. Jo, M.L. Heien, L.B. Thompson, M. Zhong, R.G. Nuzzo & J.V. Sweedler (2007) "[Mass spectrometric imaging of peptide release from neuronal cells within microfluidic devices](#)" *Lab on a Chip* 7: 1454–1460.

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A. Saez, M. Ghibaudo, A. Buguin, P. Silberzan and B. Ladoux (2007) "[Rigidity-driven growth and migration of epithelial cells on microstructured anisotropic substrates](#)" *Proc. Nat. Acad. Sci. USA* 104 (20): 8281–8286.

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ELECTROPHYSIOLOGY

Class Readings/Handouts

Axon Guide for Electrophysiology & Biophysics, 1993, Axon Instruments
(The complete guide is available at www.axon.com/mr_Axon_Guide.html.)

Chapter 1: [Bioelectricity](#)

Chapter 2: [The Laboratory Setup](#)

Chapter 3: [Instrumentation for Measuring Bioelectric Signals from Cells](#)

(Don't get bogged down in the details of Chapter 3)

Chapter 4: [Microelectrodes and Micropipettes](#)

Chapter 12: [Noise in Electrophysiological Measurements](#)

(Chapter 12 is Supplemental Resource Material)

Student Presentation Options

[Noise & Grounding](#), C.J. McKinney, 2001.

“[Noise in amplifiers](#),” S.Letzter and N.Webster, *IEEE Spectrum* August, 67-75 (1970).

“[How to Use Noise Figure Contours](#),” Princeton Applied Research Corporation Application Note T-226-20M-11/69-MB (1969).

“[A low-cost biomagnetic current probe system for the measurement of action currents in biological fibers](#).” Jan M. van Egeraat and John P. Wiksw, Jr., In: *Biomagnetism: Clinical Aspects*, edited by M. Hoke, Elsevier Science Publishers, 1992, p. 895-899.

“[A Model for Axonal Propagation Incorporating Both Radial and Axial Ionic Transport](#),” J.M. van Egeraat and J.P. Wiksw, Jr., *Biophys. J.*, **64**: 1287-1298 (1993). AND J. M. van Egeraat, R.. Stasaski, J. P. Barach, R. N. Friedman, and J. P. Wiksw, Jr. “[The Biomagnetic Signature of a Crushed Axon: A comparison of Theory and Experiment](#).” *Biophys.J.* **64**: 1299-1305 (1993).

“[Elementary Steps in Synaptic Transmission Revealed by Currents Through Single Ion Channels](#),” B. Sakmann, *Science* 256: 503-512 (1992).

ELECTROCHEMICAL RECORDING

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H. Fang, T.L. Vickrey, and B.J. Venton (2011) [Analysis of Biogenic Amines in a Single Drosophila Larva Brain by Capillary Electrophoresis with Fast-Scan Cyclic Voltammetry Detection](#); *Analytical Chemistry* 83: 2258–226.

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Exocytosis Measurements (choose one of the following to present; the others can provide context):

Paula S. Cahill, Q. David Walker, Jennifer M. Finnegan, George E. Mickelson, Eric R. Travis, and R. Mark Wightman; [Microelectrodes for the Measurement of Catecholamines in Biological Systems](#); *Anal. Chem.* **68**: 3180-3186 (1996).

<Bryson> Spencer E. Hochstetler, Michelino Puopolo, Stefano Gustincich, Elio Raviola, and R. Mark Wightman; [Real-Time Amperometric Measurements of Zeptomole Quantities of Dopamine Released from Neurons](#); *Anal. Chem.* **72**: 489-496 (2000).

Karin Pihel, Showchien Hsieh, James W. Jorgenson, and R. Mark Wightman; [Quantal Corelease of Histamine and 5-Hydroxytryptamine from Mast Cells and the Effects of Prior Incubation](#); *Biochemistry* **37**: 1046-1052 (1998).

Electrochemical Imaging of Drug Transport through Skin (these papers go together as a pair for ONE presentation):

<Juan> H.S. White, "[Electrochemical Imaging of Molecular Transport in Skin](#)," *The Electrochemical Society Interface*, Fall 2003: 30-34.

<Juan> B.D. Bath, H.S. White and E.R. Scott, "[Visualization and Analysis of Electroosmotic Flow in Hairless Mouse Skin](#)" *Pharmaceutical Research* **17**: 471-475 (2000).

Multianalyte Microphysiometry (these papers go together as a pair for ONE presentation; the review can help with background/context):

Eklund, S.E., D. Taylor, E. Kozlov, A. Prokop and D.E. Cliffel "[A Microphysiometer for Simultaneous Measurement of Changes in Extracellular Glucose, Lactate, Oxygen, and Acidification Rate](#)" *Analytical Chemistry* **76**: 519-527 (2004).

Eklund, S.E., R. M. Snider, J. Wikswow, F. Baudenbacher, A. Prokop and D.E. Cliffel "[Multianalyte microphysiometry as a tool in metabolomics and systems biology](#)" *Journal of Electroanalytical Chemistry* **587**: 333-339 (2006 - Review Article).

Scanning Electrochemical Microscopy (these papers go together as a pair for ONE presentation; the review can help with background/context):

<Jessica> Ciobanu, M., D.E. Taylor, J.P. Wilburn and D.E. Cliffel "[Glucose and Lactate Biosensors for Scanning Electrochemical Microscopy Imaging of Single Live Cells](#)" *Analytical Chemistry* **80**(8): 2717-2727 (2008).

<Jessica> Bard, A.J., X. Li and W. Zhan "[Chemically imaging living cells by scanning electrochemical microscopy](#)." *Biosensors & Bioelectronics* **22**(4): 461-472 (2006 - Review Article).

MASS SPECTROMETRY

<Jie> Q. Hu, R.J. Noll, H. Li, A. Makarov, M. Hardman and R.G. Cooks (2005) "[The Orbitrap: a new mass spectrometer](#)" *J. Mass Spectrom.* **2005**; **40**: 430-443.

<Jessica> D.R. Ifa, N.E. Manicke, A.L. Dill, R.G. Cooks (2008) "[Latent Fingerprint Chemical Imaging by Mass Spectrometry](#)" *Science* **321**: 805.

<Nichole> L.S. Fenn and J.A. McLean (2008) "[Biomolecular structural separations by ion mobility-mass spectrometry](#)" *Anal Bioanal Chem* **391**: 905-909.

<Ty / Jessica> L.A. McDonnell and R.M.A. Heeren (2007) "[Imaging Mass Spectrometry](#)" *Mass Spectrometry Reviews* **2007**, **26**, 606-643.

H. Steen and M. Mann (2004) "[The ABC'S \(and XYZ'S\) of Peptide Sequencing](#)" *Nature Reviews* **5**: 699-711.

<Monica> A.G. Marshall, C.L. Hendrickson and S.D.-H. Shi (2002) "[Scaling MS Plateaus with High-Resolution FT-ICRMS](#)" *Analytical Chem*, May 1, 2002: 25-259.

[Fluorescence](#); [Molecular & Cellular Force Measurements](#); [FTIR Spectroscopy](#); [NMR Spectroscopy & MRI](#); [Mass Spectrometry](#); [Electrochemical Recording](#); [Microfluidics & Cellular Instrumentation](#); [Electrophysiology](#)