SAMUEL JOSEPH LORD, PH. D. *Curriculum Vitae*

CONTACT

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POSITIONS & RESEARCH EXPERIENCE

Research Specialist, HHMI & UCSF, San Francisco CA **2013–present**

Advisor: Professor R. Dyche Mullins, Cellular and Molecular Pharmacology, HHMI

Fluorescence Microscopy: Optimizing microscopes, building and maintaining new setups, and helping researchers—from planning stages to image acquisition and analysis. Building microscopes with off-the-shelf components, plus simple optics and free-space laser aligning. Coordinating purchase of commercial microscopes and lab equipment.

Postdoctoral Fellowship, University of California, Berkeley CA **2010–2013**

Advisor: Professor Jay T. Groves, Chemistry, HHMI

Spatial Mechanics of Signal Transduction: Worked on two interdisciplinary research teams with the goal to reveal how spatial organization of biomolecules and mechanical forces within and between cells influence cell signaling. Used fluorescence microscopy and supported lipid bilayers as tools to study dynamics during cell–cell interactions. Developed new imaging assays for cellular endocytosis, adhesion, differentiation, and signaling. Coordinated purchases of spinning disk confocal and total internal reflection fluorescence microscopes for live cell imaging and single-molecule spectroscopy, maintained microscopes, trained and assisted users, tested new equipment.

Ph. D. Research, Stanford University, Stanford CA **2004–2010**

Advisor: Professor W. E. Moerner, Chemistry

Design of Photoactivatable Fluorophores: Designed and characterized a new class of photoactivatable single-molecule fluorophores needed for far-field super-resolution microscopies. Reengineered red-emitting push–pull fluorophores so that they are dark until photoactivated with a short burst of low-intensity violet light. Worked in close collaboration with a synthetic lab and cell biologists.

Summer Undergraduate Fellowship, Stanford University, Stanford CA **2003**

Advisors: Professors Eric S. G. Shaqfeh & Steven Chu, Chemical Engineering & Physics

Polymer Dynamics—Microscopy of Single DNA Strands: Experimentally investigated the non-equilibrium dynamics of entangled polymer chains using single-molecule techniques and compared these results to theoretical models. Observed individual lambda-phage DNA molecules in entangled solutions in extensional flow.

B. S. Research, University of North Carolina, Chapel Hill NC **2002–2004**

Advisor: Professor Sergei S. Sheiko, Chemistry

Polymer Physics—Conformations of Single Polymers using AFM: Used atomic force microscopy (AFM) to observe coexistence of two conformational phases within individual polymer brush molecules. Worked independently with guidance from professor and published a paper based on results.

EDUCATION

Ph. D. in Chemistry **2004–2010**

Stanford University, Stanford CA
Advisor: Professor W. E. Moerner
Sub-discipline: Chemical Physics
Dissertation title: "Fluorophores for Single-Molecule Imaging in Living Cells: Characterizing and Optimizing DCDHF Photophysics"

B. S. in Chemistry with Honors and with Distinction **2001–2004**

University of North Carolina, Chapel Hill NC
Advisor: Professor Sergei S. Sheiko
Thesis title: "Gradient Bottle Brushes"

Human Ecology **1999–2001**

College of the Atlantic, Bar Harbor ME
Completed two years toward B. A.

SKILLS & TECHNIQUES

Microscopy: fluorescence microscopy, scientific cameras, single-molecule spectroscopy, spinning disk confocal, super-resolution (PALM, STORM, SIM), lasers, optics, atomic force microscopy. **Physical Chemistry and Analytical Chemistry:** supported lipid bilayers, biosensors, HPLC–MS, gel electrophoresis, Langmuir-Blodgett troughs, rheology, polymer physics. **Cell Biology:** biophysics, cell culture, live-cell imaging, cancer research, gel electrophoresis, mechanobiology, membrane receptor clustering and signaling, quantitative biology. **Computer Analysis:** ImageJ image analysis, Micro-Manager and Metamorph microscopy programs, deconvolution, Matlab, Gaussian, Prism statistics software.

ACADEMIC HONORS

Eighth Biennial Irving S. Sigal Postdoctoral Fellowship, Am. Chem. Soc.	2010–2012
First Biennial Sessler Graduate Student Leadership Award, Stanford	2008
Undergraduate Award for Excellence in Physical Chemistry, UNC	2004
Hypercube Scholar, UNC	2004
National Starch and Chemical Company Award, UNC	2002

TEACHING EXPERIENCE

TA for MBL Physiology Course, Woods Hole **2018**

Fluorescence microscopy, actin imaging, super-resolution microscopy

Guest Lecturer for Instrumental Methods in Analytical Chemistry **2012**

Course: Berkeley CHEM105
Taught several lectures on imaging, instrumentation, and spectroscopy

Guest Lecturer for Advanced Biophysical Chemistry **2010–2011**

Course: Berkeley CHEM270AB
Taught several lectures on molecular fluorescence

Mentor for Young Researchers — 2005–2012

First-year graduate student who joined project in 2008
Three undergraduates for summer research
High-school teacher for summer outreach program

Advanced TA for Statistical Mechanics — 2005–2007

Course: Stanford CHEM175
Taught rotating weekly problem sessions
Helped prepare and grade problem sets and exams

TA for Physical Chemistry Lab — 2005

Course: Stanford CHEM174
Guided and supervised students through various labs

TA for Intro Chemistry — 2004

Course: Stanford CHEM31X
Taught weekly seminar meetings and led review sessions

Head TA for Intro Chemistry Lab — 2003–2004

Course: UNC CHEM11L
Supervised multiple lab section and weekly lecture

SERVICE

Laser and Chemical Safety Officer — 2004–2012

Responsibilities included documentation, waste management, coordinating training, writing standard operating procedures, and maintaining chemical inventory

Coordinator, Student-Hosted Physical Chemistry Seminars — 2005–2010

Organized process for selecting and hosting three speakers annually
Student host for distinguished speakers: James K. Gimzewski, Watt W. Webb, Allen J. Bard

Platform Co-Chair, Biophysical Society 54th Annual Meeting — 2010

Platform N: *Emerging Single Molecule Techniques I*

Founder, Stanford Chemical Physics Journal Club — 2005–2010

Weekly presentations of interesting papers in the field

Elected Member, Chemistry Student Affairs Committee — 2006–2008

Served as an Officer
Liaison between students and faculty & planned events

Volunteer Mentor, Local Middle School Science Fair — 2005

Participated in a program aimed at under-privileged schools
Met with students weekly over multiple months
Guided students in choosing a project and completing their experiments and analysis
Led students on a field trip to a local science museum

PUBLICATION RECORD

Journal Articles, Letters, Proceedings, Reviews, and Book Chapters

22. Three-dimensional actin-based protrusions of migrating neutrophils are intrinsically lamellar and facilitate direction changes.
Fritz-Laylin, L. K.; Riel-Mehan, M.; Chen, B.-C.; **Lord, S. J.**; Goddard, T. D.; Ferrin, T. E.; Nicholson-Dykstra, S. M.; Higgs, H.; Johnson, G.; Betzig, E.; Mullins, R. D. *eLife* **2017**, *6*, e26990. (https://doi.org/10.7554/eLife.26990)
Advanced imaging and image reconstruction revealed that neutrophils crawl by assembling flat sheets that are not templated by an external surface, but likely reflect a linear arrangement of regulatory molecules.

21. Our evolving view of cell motility. Editorial
Fritz-Laylin, L. K.; **Lord, S. J.**; Mullins, R. D. *Cell Cycle* **2017**, online: August 18. (https://doi.org/10.1080/15384101.2017.1360655)

20. WASP and SCAR are evolutionarily conserved in actin-filled pseudopod-based motility.
Fritz-Laylin, L. K.; **Lord, S. J.**; Mullins, R. D. *J. Cell Biol.* **2017**, *216*(6), 1673–1688. (https://doi.org/10.1083/jcb.201701074)
Eukaryotic cells use diverse cellular mechanisms to crawl through complex environments. We defined α-motility as a mode of migration associated with dynamic, actin-filled pseudopods and showed that WASP and SCAR constitute an evolutionary conserved genetic signature of α-motility.

19. Spatial Organization of EphA2 at the Cell-Cell Interface Modulates Trans-Endocytosis of EphrinA1.
Greene, A. C.;* **Lord, S. J.**;* Tian, A.; Rhodes, C.; Kai, H.; Groves, J. T. *Biophys. J.* **2014**, *106*(10), 2196–2205. (http://dx.doi.org/10.1016/j.bpj.2014.03.043) *equal contribution
Developed a 3D imaging assay to quantify endocytosis from a supported lipid membrane into a cell adhered to the membrane. We found that hindering the diffusion of ligands in the membrane inhibited endocytosis of those ligands and their receptors.

18. Azido Push-Pull Fluorogens Photoactivate to Produce Bright Fluorescent Labels.
Lord, S. J.; Lee, H. D.; Samuel, R.; Weber, R.; Liu, N.; Conley, N. R.; Thompson, M. A.; Twieg, R. J.; Moerner, W. E. *J. Phys. Chem. B* **2010**, *114*(45), 14157–14167. (http://dx.doi.org/10.1021/jp907080r)

17. Superresolution Imaging of Targeted Proteins in Fixed and Living Cells Using Photoactivatable Organic Fluorophores.
Lee, H. D.; **Lord, S. J.**; Iwanaga, S.; Zhan, K.; Xie, H.; Williams, J. C.; Wang, H.; Bowman, G. R.; Goley, E. D.; Shapiro, L.; Twieg, R. J.; Rao, J.; Moerner W. E. *J. Am. Chem. Soc.* **2010**, *132*(43), 15099–15101. (http://dx.doi.org/10.1021/ja1044192)
Developed a new class of photoactivatable single-molecule fluorophores, based on a photocleavable azide. In this paper, we used an enzymatic tag to target these fluorophores to specific proteins in fixed and living cells, then performed blink microscopy to image structures below the diffraction limit of a conventional light microscope.

16. Molecules and Methods for Super-Resolution Imaging. Review
Thompson, M. A.; Biteen, J. S.; **Lord, S. J.**; Conley, N. R.; Moerner, W. E. *Methods Enzym.* **2010**, *475*, 27–59. (http://dx.doi.org/10.1016/S0076-6879(10)75002-3)

15. Single-Molecule Spectroscopy and Imaging of Biomolecules in Living Cells. Review
Lord, S. J.; Lee, H. D.; Moerner, W. E. *Anal. Chem.* **2010**, *82*(6), 2192–2203. (http://dx.doi.org/10.1021/ac9024889)
This review discusses the state of the art in single-molecule imaging in living systems, as well as the history of the field. Single-molecule biophysics is an increasingly important field, and we summarized the results and techniques that focused on live cells.

14. Single-Molecule Fluorophores as Environmental Nanoprobes. Proceedings
Liu, N.; Lu, Z.; Ougaddoum, H.; Wang, H.; Weber, R.; Williams, J.; Yang, Z.; Twieg R.; **Lord, S. J.** *Moroccan J. Cond. Matter* **2009**, *11*(2), 90–98. (http://www.fsr.ac.ma/MJCM/Last/Vol11-part02.html)

13. Photoactivatable DCDHF fluorophores for single-molecule imaging. Proceedings
Lord, S. J.; Conley, N. R.; Lee, H. D.; Liu, N.; Samuel, R.; Twieg, R. J.; Moerner, W. E. *Proc. SPIE* **2009**, *7190*, 719013. (http://dx.doi.org/10.1117/12.809257)

12. Three-Dimensional Single-Molecule Fluorescence Imaging Beyond the Diffraction Limit Using a Double-Helix Point Spread Function.
Pavani, S. R. P.; Thompson, M. A.; Biteen, J. S.; **Lord, S. J.**; Liu, N.; Twieg, R. J.; Piestun, R.; Moerner, W. E. *Proc. Natl. Acad. Sci. U.S.A.* **2009**, *106*(9), 2995–2999. (http://dx.doi.org/10.1073/pnas.0900245106)

11. Bright, Red Single-Molecule Emitters: Synthesis and Properties of Environmentally Sensitive Dicyanomethylenedihydrofuran (DCDHF) Fluorophores with Bisaromatic Conjugation.
Lu, Z.; Liu, N.; **Lord, S. J.**; Willets, K. A.; Moerner, W. E.; Twieg, R. J. *Chem. Mater.* **2009**, *21*(5), 797–810. (http://dx.doi.org/10.1021/cm801783f)

10. DCDHF Fluorophores for Single-Molecule Imaging in Cells. Review
Lord, S. J.; Conley, N. R.; Lee, H. D.; Nishimura, S. Y.; Pomerantz, A. K.; Willets, K. A.; Lu, Z.; Wang, H.; Liu, N.; Samuel, R.; Weber, R.; Semyonov, A.; He, M.; Twieg, R. J.; Moerner, W. E. *ChemPhysChem* **2009**, *10*(1), 55–65. (http://dx.doi.org/10.1002/cphc.200800581)

9. A Photoactivatable Push-Pull Fluorophore for Single-Molecule Imaging in Live Cells.
Lord, S. J.; Conley, N. R.; Lee, H. D.; Samuel, R.; Liu, N.; Twieg, R. J.; Moerner, W. E. *J. Am. Chem. Soc.* **2008**, *130*(29), 9204–9205. (http://dx.doi.org/10.1021/ja802883k)
This is the first report of a new type of photoactivatable fluorophore for single-molecule super-resolution imaging. The dark precursor of the molecule contains an azide functional group, which prevents fluorescence; after photocleaving the azide with low-level blue light, the molecule becomes highly fluorescent.

8. Nanophotonics and Single Molecules. Chapter
Moerner, W. E.; Schuck, P. J.; Fromm, D. P.; Kinkhabwala, A.; **Lord, S. J.**; Nishimura, S. N.; Willets, K. A.; Sundaramurthy, A.; Kino, G.; He, M.; Lu, Z.; Twieg, R. J. Chapter in *Single Molecules and Nanotechnology*; R. Rigler and H. Vogel, Eds.; Springer Series in Biophysics, Vol. 12; Springer-Verlag: Berlin, 2008; pp 1–23. (http://dx.doi.org/10.1007/978-3-540-73924-1_1)

7. Photophysical Properties of Acene DCDHF Fluorophores: Long-Wavelength Single-Molecule Emitters Designed for Cellular Imaging.
Lord, S. J.; Lu, Z.; Wang, H.; Willets, K. A.; Schuck, P. J; Lee, H. D.; Nishimura, S. Y.; Twieg, R. J.; Moerner, W. E. *J. Phys. Chem. A* **2007**, *111*(37), 8934–8941. (http://dx.doi.org/10.1021/jp0712598)

6. Modifications of DCDHF Single Molecule Fluorophores to Impart Water Solubility.
Wang, H.; Lu, Z.; **Lord, S. J.**; Moerner, W. E.; Twieg, R. J. *Tetrahedron Lett.* **2007**, *48*(19), 3471–3474. (http://dx.doi.org/10.1016/j.tetlet.2007.03.026)

5. The influence of tetrahydroquinoline rings in dicyanomethylenedihydrofuran (DCDHF) single-molecule fluorophores.
Wang, H; Lu, Z.; **Lord, S. J.**; Willets, K. A.; Bertke, J. A.; Bunge, S. D.; Moerner, W. E.; Twieg, R. J. *Tetrahedron* **2007**, *63*(1), 103–114. (http://dx.doi.org/10.1016/j.tet.2006.10.044)

4. A Long-Wavelength Analogue of PRODAN: Synthesis and Properties of Anthradan, a Fluorophore with a 2,6-Donor–Acceptor Anthracene Structure.
Lu, Z.; **Lord, S. J.**; Wang, H.; Moerner, W. E.; Twieg, R. J. *J. Org. Chem.* **2006**, *71*(26), 9651–9657. (http://dx.doi.org/10.1021/jo0616660)

3. Diffusion of Lipid-like Single-Molecule Fluorophores in the Cell Membrane.
Nishimura, S. Y.; **Lord, S. J.**; Klein, L. O.; Willets, K. A.; Lu, Z.; He, M.; Twieg, R. J.; Moerner, W. E. *J. Phys. Chem. B* **2006**, *110*(15), 8151–8157. (http://dx.doi.org/10.1021/jp0574145)

2. Synthesis, Properties, and Applications of Dicyanomethylenedihydrofuran (DCDHF) Single Molecule Fluorophores. Review
Twieg, R.; Wang, H.; Lu, Z. Kim, S. Y.; **Lord, S.**; Nishimura, S.; Schuck, P. J.; Willets, K. A.; Moerner, W. E. *Nonlinear Opt., Quantum Opt.* **2005**, *34*, 241–246. (http://dx.doi.org/10.1002/chin.200651244)

1. Tadpole conformation of gradient polymer brushes.
Lord, S. J.; Sheiko, S. S.; LaRue, I.; Lee, H. I.; Matyjaszewski, K. *Macromolecules* **2004**, *37*(11), 4235–4240. (http://dx.doi.org/10.1021/ma035989z)
This paper demonstrates that polymer bottle brushes that have a gradient of side-chain density along their backbones exhibit a unique "tadpole" conformation. During a transition from an extended form to a globule upon increasing lateral pressure exerted on the polymer brushes, these gradient chains find a metastable state with a globular head and an extended tail. This state is the result of different balance of entropic and enthalpic contributions to the free energy on the sparse vs. dense side-chain spacing. This paper help confirm a model for pressure-driven conformation changes in bottle brushes.

Patents

2. Fluorogenic Compounds Converted to Fluorophores by Photochemical or Chemical Means and Their Use in Biological Systems.
Twieg, R. J.; Moerner, W. E.; Lord, S. J.; Liu, N.; Samuel, R. US Patent 8,772,048. Filed March 1, 2012; issued July 8, 2014.

1. Fluorogenic Compounds Converted to Fluorophores by Photochemical or Chemical Means and Their Use in Biological Systems.
Twieg, R. J.; Moerner, W. E.; Lord, S. J.; Liu, N.; Samuel, R. U.S. Patent 8,153,446. Filed May 13, 2009; issued April 10, 2012.
Fluorophores derived from photoactivatable azide-pi-acceptor fluorogens or from a thermal reaction of an azide-pi-acceptor fluorogen with an alkene or alkyne are disclosed. Fluorophores derived from a thermal reaction of an alkyne-pi-acceptor fluorogen with an azide are also disclosed. The fluorophores can readily be activated by light and can be used to label a biomolecule and imaged on a single-molecule level in living cells.

Oral Presentations

12. Quantitative Bioimaging Conference
Lord, S. J. Quantifying Endocytosis from the Cell–Cell Interface. Oral Presentation at Quantitative Bioimaging Conference, Paris, France, January 2015.

11. Molecular Foundry Talk Invited
Lord, S. J. Photoactivatable Probes, Mechanobiology of Endocytosis, and AFM on Polymer Bottle Brushes. Oral Presentation at Lawrence Berkeley National Laboratory, Berkeley, CA, March 2013.

10. HGST Invited
Lord, S. J. Photoactivatable Probes, Mechanobiology of Endocytosis, and AFM on Polymer Bottle Brushes. Oral Presentation at HGST, San Jose, CA, February 2013.

9. Synthetic Biology International Workshop Invited
Lord, S. J.; Groves. J. T. Spatial Organization and the Mechanics of Signal Transduction in Cell Membranes. Oral Presentation at the Synthetic Biology International Workshop: "International Synthetic Biology Workshop: A Bio-based Future," Berkeley, CA, August 2011.

8. Biological Membranes and Membrane Proteins
   Lord, S. J.; Groves. J. T. Spatial Organization and the Mechanics of Signal Transduction in Cell Membranes. Oral Presentation at the Conference on Biological Membranes and Membrane Proteins, Snowmass, CO, June 2011.

7. ACS National Meeting
   Lord, S. J.; Conley, N. R.; Lee, H. D.; Lee, M. K.; Liu, N.; Samuel, R.; Twieg, R. J.; Moerner, W. E. Photoactivatable azido push-pull fluorophores for single-molecule imaging in and out of cells. Oral presentation at the ACS 239th National Meeting, San Francisco, CA, March 2010.

6. Biophysical Society National Meeting (Platform Co-Chair)
   Lord, S. J.; Conley, N. R.; Lee, H. D.; Lee, M. K.; Liu, N.; Samuel, R.; Twieg, R. J.; Moerner, W. E. Photoactivatable azido push-pull fluorophores for single-molecule imaging in and out of cells. Oral presentation at the Biophysical Society 54th National Meeting, San Francisco, CA, February 2010.

5. OSA Annual Meeting
   Lord, S. J.; Lee, H. D.; Conley, N. R.; Lee, M. K.; Thompson, M. A.; Samuel, R.; Weber, R.; Liu, N.; Twieg, R. J.; Moerner, W. E. Photoactivatable Push-Pull Fluorophores for Single-Molecule Imaging in and out of Cells. Oral presentation at the 93rd OSA Annual Meeting (Laser Science), San Jose, CA, October 2009.

4. Stanford Molecular Biophysics Seminar
   Lord, S. J.; Lee, M. J.; Conley, N. R.; Lee, H. D.; Thompson, M. A.; Liu, N.; Samuel, R.; Williams, J. C.; Twieg, R. J.; Moerner, W. E. Photoactivatable DCDHF Fluorophores for Single-Molecule Imaging in and out of Cells. Oral presentation at the Stanford Molecular Biophysics Seminar, Stanford, CA, March 2009.

3. SPIE Photonics West Invited
   Lord, S. J.; Conley, N. R.; Lee, H. D.; Liu, N.; Samuel, R.; Twieg, R. J.; Moerner, W. E. Photoactivatable DCDHF Fluorophores for Single-Molecule Imaging. Invited oral presentation at SPIE Photonics West, San Jose, CA, January 2009.

2. Stanford Chemistry Student Summer Seminar Series
   Lord, S. J.; Conley, N. R.; Lee, H. D.; Liu, N.; Samuel, R.; Twieg, R. J.; Moerner, W. E. Photoactivatable DCDHF Fluorophores for Single-Molecule Imaging. Oral presentation for the Stanford Chemistry Student Summer Seminar Series, July 2008.

1. OSA Annual Meeting
   Lord, S. J.; Wang, H.; Liu, N.; Lu, Z.; Twieg, R. J.; Moerner, W. E. DCDHF Fluorophores Designed for Single-Molecule Cellular Imaging. Oral presentation at the 91st OSA Annual Meeting (Frontiers in Optics), San Jose, CA, September 2007.