Jeffrey R. Vieregg

Dept. of Biochemistry and Molecular Biology
University of Chicago
929 E 57th St, GCIS W508A
Chicago, IL 60637

jvieregg@uchicago.edu
home.uchicago.edu/~jvieregg/
Office: (773) 834-0750
Mobile: (312) 401-3121

Research Interests

I am interested in understanding how the sequence of biomolecules encodes their structure and function, and in using that knowledge to design new molecules and self-assembling devices that perform useful tasks in vitro and in vivo. This encompasses traditional aspects of the 'biomolecular folding problem' as well as physical behaviors such as phase separation, with the latter of particular interest. Recent years have greatly expanded our appreciation of the diverse and vital roles that nucleic acids play in healthy cells and in disease. Computational and chemical tools to program structure and function have grown as well, and the challenge before us is to use these tools to create novel measurement techniques, diagnostics, and therapeutic agents for improved understanding and interventions in living systems.

Academic Positions

Staff Scientist, Biochemistry and Molecular Biology; University of Chicago, 2020 – present

Senior Research Scientist, Institute for Molecular Engineering; University of Chicago, 2013 – 2020

Postdoctoral Researcher, Department of Bioengineering; California Institute of Technology, 2008 – 2013; Advisor: Prof. Niles Pierce

Education

Ph. D., Physics – University of California, Berkeley, 2007
Dissertation title: "Single molecule RNA folding studied with optical trapping"
Advisors: Prof. Ignacio Tinoco, Jr. (deceased), Prof. Carlos Bustamante

M.A., Physics – University of California, Berkeley, 2003

S.B., Physics (minor in Chemistry) – Massachusetts Institute of Technology, 2001
Thesis title: "A CW gyrotron oscillator for use in dynamic nuclear polarization NMR"
Advisor: Prof. Richard Temkin

S.B., Humanities and Science – Massachusetts Institute of Technology, 2001

Honors and Awards

National Science Foundation Graduate Fellowship

UCBREP Graduate Research and Education in Adaptive Biotechnology Fellowship

Caltech Project for Effective Teaching Certificate

Best poster award, 4th International Student Seminar, Kyoto University Graduate School

Phi Beta Kappa

Sigma Pi Sigma Physics Honor Society

Publications (h-index: 12, total citations: 762)†; Google Scholar page

1. A.E. Marras, **J.R. Vieregg**, and M.V. Tirrell, Assembly and Characterization of Polyelectrolyte Complex Micelles. *J. Vis. Exp.* **157**, e60894 (2020).
2. A.E. Marras, **J.R. Vieregg**, J.M. Ting, J.D. Rubien, and M.V. Tirrell, Polyelectrolyte complexation of oligonucleotides by charged hydrophobic – neutral hydrophilic block copolymers. *Polymers* **11**, 83 (2019).
3. M. Lueckheide‡, **J.R. Vieregg**‡, A.J. Bologna, and M.V. Tirrell, Structure-property relationships of oligonucleotide polyelectrolyte complex micelles. *Nano Letters* **18,** 7111-17 (2018).
4. **J.R. Vieregg**, M. Lueckheide, A.B. Marciel, L. Leon, A.J. Bologna, J.R. Rivera, and M.V. Tirrell, Oligonucleotide – peptide complexes: phase control by hybridization. *J. Am. Chem. Soc.* **140**, 1632-38 (2018).
5. **J.R. Vieregg**, S.J. Martin, A.P. Breeland, C.M. Weikart, and M.V. Tirrell, Inhibiting sterilization-induced oxidation of large molecule therapeutics packaged in plastic parenteral vials. *PDA J Pharm Sci Tech* **72**, 35-43 (2017).
6. **J.R. Vieregg** and T-Y D. Tang, Polynucleotides in cellular mimics: coacervates and lipid vesicles. *Curr. Opin. Colloid & Interface Science*, **26**, 50-57 (2016).
7. **J.R. Vieregg**, H.M. Nelson, B.M. Stoltz, and N.A. Pierce, Selective nucleic acid capture with shielded covalent probes. *J. Am. Chem Soc.*, **135**, 9691-9699 (2013).
   Featured method in *BioTechniques*, September 2013 issue
8. **J.R. Vieregg**, Nucleic acid structural energetics. *Encyc. Anal. Chem.* (2010).
9. P.T.X. Li, **J.R. Vieregg**, I. Tinoco, Jr., How RNA unfolds and refolds. *Ann. Rev. Biochem.* **77**, 77-100 (2008).
10. **J.R. Vieregg**, W. Cheng, C. Bustamante, I. Tinoco, Jr. Measurement of the effect of monovalent cations on RNA hairpin stability. *J. Am. Chem. Soc.* **129**, 14966-73 (2007).
11. **J. R. Vieregg**, I. Tinoco, Jr. Modelling RNA folding under mechanical tension. *Mol. Phys.* **104**, 1343-52 (2006).
12. N.D. Scielzo, **J.R. Vieregg**, et al. Detecting shake-off electron-ion coincidences to measure β-decay correlations in laser trapped ^{21}Na. *Nucl. Phys. A* **746,** 677-680 (2004**).**
13. V.S. Bajaj, **J.R. Vieregg** et al. Dynamic nuclear polarization at 9 T using a novel 250 GHz gyrotron microwave source. *J. Mag. Res.* **160**, 85-90 (2003).
14. V.S. Morozov, **J. R. Vieregg**, et al. Spin-flipping polarized electrons. *Phys. Rev. ST Accel Beams* **4**, 104002 (2001).
15. M. Schlapp, **J.R. Vieregg**, et al. A new 14 GHz electron-cyclotron-resonance ion source for the heavy ion accelerator facility ATLAS. *Rev. Sci. Inst.* **69**, 631 (1998).

† Based on Google Scholar data as of March 2020

‡ Equal contributions

Manuscripts in preparation

J.R. Vieregg, A. Marras, M. Lueckheide, and M.V. Tirrell, Molecular structure of therapeutic oligonucleotides strongly affects polyelectrolyte complexation properties.

J.R. Vieregg, A. Marras, M. Lueckheide, M. Toure, A.J. Bologna, and M.V. Tirrell, Length effects in complexation of oligoelectrolytes.

Patents

J.R. Vieregg, N.A. Pierce, US Patent # 8,658,780: Triggered Covalent Probes for Imaging and Silencing Gene Expression

Research Experience

The University of Chicago, Institute for Molecular Engineering: 2013 – 2020

Led collaborative research projects with academic and industrial partners:

- Electrostatic interactions of nucleic acids with charged polymers and biomolecular phase transitions (with Prof. Matthew Tirrell, Institute for Molecular Engineering): characterized bulk and micro-scale phase separation of oligonucleotides and cationic peptides; developed design rules for polyelectrolyte complex core micelles for nucleic acid delivery. Designed small-angle scattering (x-ray and neutron) experiments for micelle characterization.
- Long non-coding RNA folding (with Prof. Alex Ruthenburg, Biological Sciences Division): adapted chemical mapping methods and HT sequencing to measure folding of long RNAs.
- Designer actin crosslinkers (with Prof. Margaret Gardel, Physics): Developed site-specific oligonucleotide-protein conjugation methods and designed switchable DNA nanostructures to crosslink actin filaments.
- Oxidative degradation of biologic therapeutic agents (with SiO2 Medical Products, Inc.)

California Institute of Technology, Department of Bioengineering: 2008 – 2013

Dynamic nucleic acid devices for measurement and control of gene expression.

- Developed *Shielded Covalent Probes*, conformation-switching nucleic acid probes that forms (optionally reversible) covalent bonds to RNA and DNA targets with near-quantitative yield and exquisite specificity. Applications include measurement of gene expression, RNA & RNP isolation, enzyme-free gene silencing, and nucleic acid nanotechnology.
- Led collaborations with synthetic organic chemists for probe development and with academic and industry biologists exploring applications.
- Member of Caltech Center of Excellence in Genomic Science collaboration developing methodologies for quantitative *in toto* analysis of vertebrate gene expression; measured expression profiles in whole-mount zebrafish embryos and cultured human cell lines.

Research Experience (continued)

University of California Berkeley, Departments of Physics and Chemistry: 2003 – 2007

Single-molecule studies of RNA folding using optical tweezers.

- Studied thermodynamics and kinetics of RNA secondary structure folding using single-molecule optical trapping techniques. Verified nearest-neighbor thermodynamic model for large hairpins and measured effects of salt and temperature on stability and dynamics.
- Applied recent non-equilibrium statistical physics results (Crooks Fluctuation Theorem) to extract reversible work and equilibrium thermodynamics from folding trajectories.
- Computational modeling of the effect of mechanical force on RNA folding dynamics.

UC Berkeley & Lawrence Berkeley Natl. Lab., Department of Physics: 2001 – 2003

Low-energy tests of fundamental symmetries by measuring β-decay kinematics of optically-trapped nuclei. Advisor: Prof. Stuart Freedman

Massachusetts Institute of Technology, Bates Linear Accelerator Center: 2000 – 2001

Member of group working to integrate, test, and calibrate hardware for BLAST (Bates Large Acceptance Spectrometer Toroid) detector. Advisor: Dr. Timothy Smith

Massachusetts Institute of Technology, Plasma Science and Fusion Center: 1998 – 2000

Designed and built instrumentation and control system for microwave source used in dynamic nuclear polarization nuclear magnetic resonance. Advisor: Dr. Ken Kreischer

Teaching, Mentorship, and Outreach

Direct Student Research Mentorship

Melissa Toure, EBI (France) undergraduate student, Summer 2017

Alex Bologna, University of Chicago undergraduate student (IME), 2016 – 2017

Nayanika Challa, University of Chicago undergraduate student (IME), Fall 2015

Eitamar Nadler, University of Chicago undergraduate student (IME), 2014 – 2015

Victoria Hsiao, Caltech graduate student (Bioengineering), Fall 2011

Yue (Dorothy) Yang, UC Berkeley undergraduate student (Chemical Engineering), 2007

Teaching Assistantships

Introductory Physics: Electromagnetism, Optics, Modern Physics: UC Berkeley

Advanced Atomic, Molecular, and Optical Physics, UC Berkeley

Pedagogy Training

Physics 300: Supervised Teaching of Physics, UC Berkeley, 2003

Caltech Project for Effective Teaching Pedagogy Certificate, 2012

Outreach

Lecturer for SESAME program (STEM middle grade teacher training), 2016 – 2018

Pasadena Public Schools Science Fair Program, Pasadena, CA, 2011 – 2012

Molecular Programming Project Visiting Days, 2009 – 2011

Seminars and Presentations

Drug Carriers in Medicine and Biology Gordon Research Conference; 2018 (poster)

Polymer Physics Gordon Research Conference; 2018 (poster)

Center for Nanomaterials Seminar, Argonne National Laboratory; June 2018

Department of Biomedical Engineering Seminar, Rowan University; December 2017

Department of Chemistry Seminar, University of Massachusetts, Lowell; December 2017

American Institute of Chemical Engineers Annual Meeting; 2017

American Chemical Society Fall Meeting; 2017

Department of Chemical Engineering Seminar, University of Massachusetts, Amherst; June 2017

ACS Colloids Annual Meeting; 2017

American Chemical Society Spring Meeting; 2017

American Physical Society March Meeting; 2017

American Institute of Chemical Engineers Annual Meeting; 2016

American Physical Society March Meeting; 2016

Biophysical Society Annual Meeting; 2016 (poster)

Post-Transcriptional Gene Regulation Gordon Research Conference; 2015 (poster)

Biophysical Society Annual Meeting; 2014 (poster)

American Chemical Society Spring Meeting; 2013

Biophysical Society Annual Meeting; 2013 (poster)

Oligonucleotide Therapeutic Society Annual Meeting; 2012 (poster)

RNA Society Annual Meeting 2012 (poster)

Biophysical Society Annual Meeting 2012

Aspen Center for Physics Single Molecule Biophysics Workshop, 2007

Biophysical Society Annual Meeting 2007 (poster)

4th International Student Seminar, Kyoto University Graduate School of Biostudies and Department of Virology 2006 (best poster award)

Biophysical Society Annual Meeting 2006 (poster)

Professional Affiliations

American Chemical Society

American Institute of Chemical Engineers

American Physical Society

Biophysical Society

RNA Society

Journal Peer Review

Nature Communications

Nature Methods

Nucleic Acids Research

Journal of Physical Chemistry

Chemical Science

ACS Sensors

PLOS ONE

References

Prof. Rama Ranganathan
University of Chicago
Department of Biochemistry / Molecular Biology & Pritzker School of Molecular Engineering
929 E 57th St, GCIS W508
Chicago, IL 60637
(773) 835-1384
ranganathanr@uchicago.edu

Prof. Matthew V. Tirrell
University of Chicago
Pritzker School of Molecular Engineering
Eckhardt Research Center, Room 299C
5640 S Ellis Avenue
Chicago, IL 60637
(773) 834-2001
mtirrell@uchicago.edu

Prof. Niles A. Pierce (postdoctoral advisor)
California Institute of Technology
Department of Bioengineering
165 Broad Center, MC 114-96
Pasadena, CA 91125
(626) 395-8086
niles@caltech.edu

References (continued)

Prof. Brian M. Stoltz (collaborator)
California Institute of Technology
Department of Chemistry
301C Schlinger, MC 101-20
Pasadena, CA 91125
(626) 395-6064
stoltz@caltech.edu

Prof. Scott Fraser (collaborator)
University of Southern California
Departments of Biological Sciences and Biological Engineering
1050 Childs Way, 401 Ray Irani Hall
Los Angeles, CA 90089
(213) 740-2414
sfraser@provost.usc.edu

Prof. Carlos Bustamante (Graduate co-advisor)
University of California Berkeley
Departments of Physics, Chemistry, and Molecular and Cell Biology
608A Stanley Hall
Berkeley, CA 94720
(510) 643-9706
carlosb@berkeley.edu