

Rae M. Robertson-Anderson

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EDUCATION

Ph.D: Physics 2007

University of California, San Diego

Advisor: Dr. Douglas E. Smith

Dissertation Title:

Single-molecule studies of DNA dynamics and intermolecular forces

MS: Physics 2005

University of California, San Diego

BS with honors: Physics 2003

Minors: Mathematics, French

Georgetown University

Thesis Advisor: Dr. Jeffrey Urbach

POST GRADUATE TRAINING

Research Associate 1/2008 – 8/2009

The Scripps Research Institute, La Jolla, CA

Principle Investigator: Dr. David P. Millar

HONORS, AWARDS, FUNDING

- Council on Undergraduate Research Councilor, 2017 – 2020
- APS Woman of the Month, February 2017
- AFOSR Biomaterials Program Grant (\$415K), 2017 – 2020
- NSF CBET Collaborative Grant (\$75K), 2016 – 2019
- Gordon & Betty Moore Foundation Collaborative Innovation Award (\$112K), 2015 – 2017
- USD Outstanding Undergraduate Research Mentor Award 2015
- Research Corporation & Gordon & Betty Moore Foundation Scialog Fellow, 2014 – 2016
- NSF CAREER Award (\$500K), 2013 – 2018
- DOD AFOSR Young Investigator Program Award (\$411K), 2012 – 2015
- Research Corporation Cottrell Scholar
- Gordon & Betty Moore Foundation Scialog Fellow, 2014 – 2017
- NSF-MRI Grant (co-PI) (\$415K), 2013 – 2016
- Research Corporation Cottrell College Science Award (\$45K), 2010 – 2012
- NSF-S-STEM Scholarship Grant (co-PI) (\$600K), 2011 – 2019
- Beckman Scholarship Mentor, 2014 – 2020

- NSF REU (co-PI and mentor), 2015 – 2018
- USD: Faculty Research Grants, 2010, 2014; Teaching and Learning Grants: 2010 – 2015
- National Institutes of Health Postdoctoral Training Fellowship, 2008 – 2009
- National Science Foundation Graduate Research Fellowship, 2004 – 2007
- UCSD GAANN Fellowship, UCSD, 2003 – 2004
- Phi Beta Kappa
- Magna Cum Laude
- Excellence in Undergraduate Research Award, Georgetown University, 2003
- Clare Boothe Luce Undergraduate Scholarship, 2001 – 2003

RESEARCH INTERESTS & TECHNIQUES

My current research interests include using a combination of single-molecule microscopy techniques including force-measuring optical tweezers and fluorescence microscopy to elucidate macromolecule dynamics and interactions underlying complex questions in soft matter, biomaterials and biological physics. These techniques allow us to directly measure intermolecular forces with piconewton precision and image and track single-molecule dynamics with nanometer and millisecond precision.

Specific current projects include:

- active microrheology of entangled DNA and cytoskeleton filament networks
- actin filament deformation dynamics
- diffusion and conformation of DNA in crowded environments mimicking cellular conditions
- microrheology of entangled blends of linear and circular DNA
- microrheology of *Chaetopterus* tube worm mucus and mucins

Specific Techniques

- Force-Measuring Optical Tweezers
- Fluorescence Microscopy (Epi-Fluorescence, Laser Scanning Confocal & Total Internal Reflection)
- Nucleic Acid and Protein Purification, Microsphere Conjugation
- Single-Molecule Imaging and Manipulation
- Particle-tracking and Image Analysis
- Rheology (Micro and Macro)

PUBLICATIONS (N.B. Maiden name is Robertson; **USD undergraduate, *postdoc/graduate student mentored by Robertson-Anderson)

**Weigand, W.J.; **Messmore, A.; Deheyn, D.D.; Morales-Sanz, A.; Blair, D.L.; Urbach, J.S.; Robertson-Anderson, R.M. Active microrheology of *Chaetopterus* mucus determines three intrinsic lengthscales that govern material properties. *PLOS One*, <https://doi.org/10.1371/journal.pone.0176732> (2017).

R. Lamichhane, J. A. Hammond, R. F. Pauszek, R. M. Anderson, I. Pedron, E. van der Schans, J. R. Williamson and D. P. Miller. A DEAD-box protein acts through RNA to promote HIV-1 Rev-RRE assembly. *Nucleic Acids Research*, doi: 10.1093/nar/gkx206 (2017).

*B. Gurmessa, **S. Ricketts, and Rae M. Robertson-Anderson, Nonlinear Molecular Deformations Give Rise to Stress Stiffening, Yielding and Non-uniform stress Propagation in Actin Networks. *Biophysical Journal*, <http://dx.doi.org/10.1016/j.bpj.2017.01.012> (2017).

**K. Regan, **S. Ricketts and R.M. Robertson-Anderson, DNA as a Model for Probing Polymer Entanglements: Circular Polymers and Non-Classical Dynamics, *Polymers, Special Edition: Semiflexible Polymers*, 8(9), 336 (2016). --Invited Review

D.M. Wulstein, **K.E. Regan, R.M. Robertson-Anderson & R. McGorty, Light-sheet microscopy with digital Fourier analysis measures transport properties over large field-of-view, *Optics Express*, **24, 20881-20894 (2016).

*Gurmessa, B.; **Fitzpatrick, R.; Robertson-Anderson, R. M. Entanglement density tunes microscale nonlinear response of entangled actin. *Macromolecules*, **49** (10), 3948–3955 (2016).

Robertson-Anderson, R. M. Book review of “Fundamentals of Polymer Physics and Molecular Biophysics” by Himadri B. Bohidar. *Physics Today*, March Issue (2016).

*Falzone, T.T; Robertson-Anderson, R. M. Active Entanglement-Tracking Microrheology Directly Couples Macromolecular Deformations to Nonlinear Microscale Force Response of Entangled Actin. *Macro Letters*, **4**, 1194–1199 (2015).

Gorczyca, S; *Chapman, C.D.; Robertson-Anderson, R. M. Universal scaling of crowding-induced DNA mobility is coupled with topology-dependent molecular compaction and elongation. *Soft Matter*, **11, 7762 - 7768 (2015).

Li, Y.; Kai-Wen Hsiao, K-W; Brockman, C.A; Yates, D.Y; Robertson-Anderson, R.M. Kornfield, J; San Francisco, M.J.; Schroeder, C.M; McKenna, G.S. When Ends Meet: Circular DNA Stretches Differently in Elongational Flows. *Macromolecules*, **48**, 5997–6001 (2015).

*Falzone, T.T; **Blair, S; Robertson-Anderson, R. M. Entangled F-actin displays a unique crossover to microscale nonlinearity dominated by entanglement segment dynamics. *Soft Matter*, **11**, 4418-4423 (2015).

*Chapman, C.D.; **Gorczyca, S; Robertson-Anderson, R. M. Crowding Induces Complex Ergodic Diffusion and Dynamic Elongation of Large DNA Molecules. *Biophysical Journal*, **108**, 1220-1228 (2015).

*Chapman, C.D.; Robertson-Anderson, R. M. Nonlinear Microrheology Reveals Entanglement-Driven Molecular-Level Viscoelasticity of Concentrated DNA. *Physical Review Letters*, **113**, 098303 (2014).

*Chapman, C.D.; **Lee, K.; **Henze, D.; Smith, D.E.; Robertson-Anderson, R. M. Onset of Non-Continuum Effects in Microrheology of Entangled Polymer Solutions. *Macromolecules*, **3**, 47, 1181–1186 (2014).

*Chapman, C. D.; Shanbhag S.; Smith, D. E.; Robertson-Anderson, R. M. Complex effects of molecular topology on diffusion in entangled biopolymer blends, *Soft Matter*, **8**, 35, 9177 - 9182 (2012).

Pljevaljic, G.; Robertson-Anderson, R.M.; Millar, D.P. Analysis of RNA Folding and Ribonucleoprotein Assembly by Single-Molecule Fluorescence Spectroscopy. *Methods in Molecular Biology: Spectroscopic Methods of Analysis*, **875**, 271- 295 (2012).

Robertson-Anderson, R. M.; Wang, J.; Edgcomb, S. P.; Carmel, A. B.; Williamson, J. R.; Millar, D. P. Single-Molecule Studies Reveal that DEAD-Box Protein DDX1 Promotes Oligomerization of HIV-1 Rev on the Rev Response Element. *Journal of Molecular Biology*, **410**, 5, 959 – 971 (2011).

Pond, S., Ridgeway, W., Robertson, R. M., Wang, J., & Millar, D. Assembly of HIV-1 Rev on the Rev Response Element: One Molecule at a Time. *Proceedings of the National Academy of Sciences U.S.A.*, **106**, 5, 1404 – 1408 (2009).

Robertson, R. M. & Smith, D. E. Direct measurement of the confining forces imposed on a single molecule in a concentrated solution of circular polymers. *Macromolecules*, **40**, 27, 8737-8741 (2007).

Robertson, R. M. & Smith, D. E. Direct measurement of the intermolecular forces confining a single polymer in an entangled polymer solution. *Physical Review Letters*, **99**, 126001 (2007). ****highlighted in the review article: Larson, R. G. Going with the flow. *Science* 318, 5847, 57-58 (2007). **selected for publication in *Virtual Journal of Biological Physics Research* 14, 7 (2007).**

Robertson, R. M. & Smith, D. E. Self-diffusion of entangled linear and circular DNA molecules: Dependence on length and concentration. *Macromolecules* **40**, 3373–3377 (2007).

Robertson, R. M. & Smith, D. E. Strong effects of molecular topology on diffusion of entangled DNA molecules. *Proceedings of the National Academy of Sciences of the United States of America* **104**, 4824-4827 (2007).

Fuller, D. N., Raymer, D. M, Rickgauer, J. P., Robertson, R. M., Catalano, C. E., Anderson, D. L., Grimes, S. & Smith, D. E. Measurements of single DNA molecule packaging dynamics in bacteriophage lambda reveal high forces, high motor processivity, and capsid transformations. *Journal of Molecular Biology*, **373**, 5, 1113-1122 (2007). --featured as cover story of November 9 issue of JMB

Robertson, R. M., Laib, S. & Smith, D. E. Diffusion of isolated DNA molecules: Dependence on length and topology. *Proceedings of the National Academy of Sciences of the United States of America* **103**, 7310-7314 (2006).

Laib, S., Robertson, R. M. & Smith, D. E. Preparation and characterization of a set of linear DNA molecules for polymer physics and rheology studies. *Macromolecules* **39**, 4115-4119 (2006).

P. Melby, F. Vega Reyes, A. Prevost, R. Robertson, P. Kumar, D. A. Egolf, and J. S. Urbach. The dynamics of thin vibrated granular layers. *Journal of Physics: Condensed Matter* **17**, S2689-S2704 (2005).

INVITED TALKS

Interdisciplinary biophysics major with a comprehensive research-based capstone. *American Physical Society March Meeting* (2016).

Building an Artificial Motile Tissue through Self-Organized Rhythmic Contractility. *Gordon and Betty Moore Scialog Conference: Molecules Come to Life* (2016).

Untangling the Dynamics of Entangled Biopolymers. *University of California Los Angeles Biophysics Seminar Series* (2016).

Untangling the Dynamics of Entangled DNA. *Air Force National Research Laboratory* (2016).

Untangling the Dynamics of Entangled DNA. *APS Conference for Undergraduate Women in Physics* (2016).

Untangling the Mechanics of Entangled Biopolymers. *University of California San Diego Bio-Mech Seminar Series* (2015).

Untangling the Dynamics of Entangled DNA. *San Diego State University Physics Colloquium* (2015).

Untangling the Dynamics of Entangled DNA. *University of California San Diego Physics Colloquium* (2014).

Trapping DNA with Invisible Light. *University of San Diego Conversations in the College* (2013).

Untangling the physics of entangled DNA. *Cal State San Marcos Frontiers in Science Seminar Series* (2012).

***article on talk in North County Times**

Playing with DNA. *University of San Diego Conversations in the College* (2011).

Single-Molecule Studies of DNA Dynamics and Intermolecular Forces. *American Physical Society March Meeting* (2010).

One Molecule at a Time: Single-Molecule Studies of the Assembly of HIV-1 Rev on the RRE. *Graduate Women in Science, Tau Chapter October Meeting* (2009).

Single-Molecule Studies of the Assembly of HIV-1 Rev on the RRE. *NIH: Annual Meeting of the Groups Studying the Structures of AIDS-Related Systems and Their Application to Targeted Drug Design* (2009).

CONFERENCE PROCEEDINGS

Research Corporation Scialog Conference: Molecules Come to Life

Years presented: 2015, 2016

student presenters: No

presentation type: talk

American Physical Society March Meeting

Years presented: 2005, 2006, 2010, 2011, 2013 - 2017

student presenters: 16 undergraduates, 1 PhD student, 3 postdocs

presentation type: 15 posters, 6 talks

Air Force Office of Scientific Research NMSE Program Review

Years presented: 2012 - 2015

student presenters: No

presentation type: 3 talks

Gordon Conference on Physics Education and Research

Years presented: 2014

student presenters: No

presentation type: 1 poster

Biophysical Society Annual Meeting

Years presented: 2007, 2012

student presenters: 2 undergraduates, 1 PhD student

presentation type: 1 poster, 1 talk

American Association of Physics Teachers Southern California Annual Conference

Years presented: 2011

student presenters: No

presentation type: 1 oral

NIH Meeting on Structures of AIDS-Related Systems and Their Application to Targeted Drug Design

Years presented: 2008, 2009

presentation type: 1 poster, 1 oral

SPIE: Optics and Photonics

Years presented: 2007

presentation type: 1 oral

Australasian Polymer Society Annual Symposium

Years presented: 2007

presentation type: 1 oral

TEACHING

University of San Diego

2009 - present

- PHYS 270(L): Intro. Mechanics, Wave Motion & Thermodynamics lecture/lab
 - Calculus-based introductory physics course for engineering and physics majors
- PHYS 136(L)/137(L): General Physics I/II lecture/lab
 - 2 semester sequence of calculus-based introductory physics course for life science majors

- PHYS 319: Statistical & Thermal Physics
 - Upper-division statistical physics course for physics and biophysics majors and minors
- PHYS 493: Seminar I: Craft of Scientific Presentations
 - 1st semester of 2-semester capstone course for physics/biophysics majors
- *PHYS 495: Seminar II: Frontiers of Physics (designed/created)*
 - 2nd semester of 2-semester capstone course for physics/biophysics majors in which students attend UCSD physics seminars and meet with speakers and UCSD faculty.
 - awarded 4 USD Teaching and Learning Grants to fund course activities
- *PHYS 340: Biological Physics (designed/created)*
 - Upper division course for physics (elective) and biophysics (requirement) majors
- *PHYS 481W: Experimental Biophysics (designed/created)*
 - Upper division writing-intensive laboratory course *I designed* for biophysics majors
- Community Service Learning Scholar
 - Designed an interdisciplinary scientific course for USD science majors focused on community outreach and awareness of the impact of science on society and vice versa

University of California, San Diego

2003 – 2008

Instructor

- Physics 1A: General Physics I
 - Algebra-based introductory physics course for science majors

Teaching Assistant/Other

- Fun with Physics – lab TA
- Preparing Future Physics Faculty Program – member/contributor

Georgetown University

2000 – 2003

Teaching Assistant/Other

- Principles of Physics I & II (lecture & lab)
- Math Department Tutor

SERVICE

Government/Community

- National Science Foundation Biomaterials Review Panelist 2010 – 2014
- Research Corporation Reviewer 2011 – 2014
- Reviewer: Physical Review (Letters, E), Soft Matter, Macromolecules, Biophysical Journal 2010 –
- Fonds de Recherche du Quebec Reviewer 2011
- Host of workshop for Mater Dei High School students on biophysics research 2012
- Panelist for UC San Diego PhD Career Conference 2013, 2015
- Host/organizer of St. Gregory junior high school physics outreach program 2014 –
- Murdock Charitable Trust Natural/Physical Science Advisory Panel 2016 –
- APS GSOFT Program Committee 2016 –
- Council on Undergraduate Research Councilor 2017 –

University of San Diego

- *Goldwater Scholarship Committee* 2009 – 2016
 - Review scholarship applicants and research proposals; mentor to 2 research students during the application process to help prepare their applications and research essays

- *Preliminary Undergraduate Research Experience Committee Member & Mentor* 2010 – present
 - Interview and choose incoming USD students to conduct scientific research with USD faculty the summer prior to their freshman year. Mentor to 3 PURE students.
- *Summer Undergraduate Research Experience Committee Member & Mentor* 2010 – present
 - Help students write research proposals for SURE program that awards summer stipends to students to conduct research with USD faculty. Review research proposals. Mentor to 7 SURE awardees.
- *Physics and Biophysics Department Student Activities Organizer* 2010 – present
 - Design/organize/advertise/run presentations/demos/lunches each semester designed to recruit physics & biophysics majors.
 - Mentor physics tutors and teaching assistants
 - Designed Speaker Series which brings scientists and alumni from academia and industry to talk about their work/research and career path
- *USD NSF-SSTEM Scholarship Committee* 2011 – present
 - Award scholarships to 20 students who show outstanding promise in STEM and are interested in majoring in Physics, Biophysics, Math or Computer Science. Duties including selecting and mentoring as well as planning and participating in activities.
- *USD Core Planning Committee* 2012 – 2015
 - Member of the Multidisciplinary Clusters, LLC, and Integration subcommittees – researched and developed formal recommendations and models for revising the USD Core. Participated in small group and full CPC meetings, Open Forums, Steering Committee meetings and retreats.
- *Beckman Scholarship Mentor* 2013 - present
 - Participated in successful grant for receiving undergraduate Beckman Scholarships for outstanding STEM students at USD with strong potential for pursuing PhD. Duties include: evaluating candidates, designing/coordinating activities/events, mentoring Beckman scholars.
- *USD CAS Faculty Fundraising Committee* 2013 – present
 - Develop fundraising opportunities, participate in alumni and fundraising events, meet with potential donors as a representative from Physics and other STEM disciplines
- *NSF REU Mentor* 2015 - present
 - Co-PI of successful grant for funding summer research students typically unable to pursue research, including community college students, veterans, and first-generation students. Duties include evaluating candidates, mentor research students, designing/implementing student activities/events
- *Physics and Biophysics Department Chair* 2014 – 2015, 2016 – present
 - Chaired successful search for: 2 tenure-track faculty, 2 lab technicians, 1 executive assistant, 1 full-time benefits-based adjunct faculty
 - Led/Coordinated 2016 Department External Review
 - Implemented formal adjunct faculty evaluation and mentoring policies and procedures
 - Led efforts to revise outdated physics and biophysics curriculum
- *Dean's Advisory Council on Interdisciplinary Programs* 2014 – 2016
- *Hayes Scholarship Committee* 2015
- *USD Fall Virtual Open House Panelist* 2013
 - Answered prospective students' questions regarding Academic Excellence with a focus on undergraduate research
- *Community Service Learning Scholar* 2010 – 2012
 - Designed/implemented an interdisciplinary science course for USD science majors focused on community awareness and outreach
- *Curriculum Committee Member* 2010 – 2011
- *Phi Beta Kappa Members in Course Selection Committee* 2010 – 2012
- *Academic Assembly Teller* 2009 – 2011

University of California, San Diego

- *Young Physicists Program Volunteer* 2006 – 2007
 - graduate student-run program allows local high school students to come to UCSD, participate in physics labs/demos and learn about possible areas of physics research
- *Reach for Tomorrow Volunteer* 2007
 - program exposes underprivileged kids to college and other educational opportunities; led students in interactive demos and discussed the underlying physics behind them
- *Tech Trek Volunteer* 2007
 - program encourages young women to pursue science, duties were the same as above
- *Organizing Committee for NSF CAM Graduate Student Physics Conference* 2004 – 2005
 - one of five members responsible for organizing the 2005 conference designed to promote collaboration/dialogue between North American graduate students
- *Graduate/Undergraduate Connection Program Organizer* 2004 – 2005
 - organized a program in which graduate students speak to undergraduates about topics of interest and encourage continuing in the field of physics; gave multiple presentations on my research, field of biophysics, graduate student life, how to prepare, etc.

RESEARCH ASSISTANT MENTORING (SINCE 2009)

- 1 PhD Student (2010 – 2015, AFOSR-funded research assistant 2012 – 2015, Physics PhD from UCSD awarded March 2015, thesis research conducted in my laboratory under my mentorship)
- 4 Postdoctoral Associates (2013 – present; funded by NSF CAREER, AFOSR YIP, Gordon & Betty Moore)
- 26 Undergraduates (Student Awards: 1 Beckman Scholar, 4 Phi Beta Kappa, 2 USD Hayes Scholars, 8 USD Summer Research (SURE) Fellows, 1 Goldwater Scholarship, 1 APS LeRoy Apker Award)
- 4 High School and Pre-Undergraduate (PURE) Students
- 3 NSF REU Community College Students