Stanford

Alexander Dunn

Associate Professor of Chemical Engineering

NIH Biosketch available Online

Curriculum Vitae available Online

Bio

BIO

Alex Dunn is an Associate Professor in the Department of Chemical Engineering at Stanford University. His research focuses on understanding how living cells sense mechanical stimuli, with particular interests in stem cell biology and tissue engineering. Dr. Dunn worked as a postdoctoral scholar with James Spudich in the Department of Biochemistry at the Stanford University School of Medicine. He received his Ph.D. at the California Institute of Technology under the direction of Harry Gray, where his work focused on understanding the catalytic mechanism selective C-H bond oxidation by cytochrome P450 enzymes. His work has been recognized with numerous awards, including the Hertz Fellowship, the Burroughs Wellcome Career Award at the Scientific Interface, the NIH Director's New Innovator Award, and the HHMI Faculty Scholar Award.

ACADEMIC APPOINTMENTS

- Associate Professor, Chemical Engineering
- Member, Bio-X
- Member, Cardiovascular Institute
- Member, Maternal & Child Health Research Institute (MCHRI)
- Faculty Fellow, Stanford ChEM-H
- Member, Wu Tsai Neurosciences Institute

HONORS AND AWARDS

- Teaching Award, Tau Beta Pi (Stanford) (2018)
- Faculty Scholar Award, HHMI (2016)
- New Innovator Award, National Institutes of Health (2010)
- Career Award at the Scientific Interface, Burroughs Wellcome Foundation (2008)
- Postdoctoral Fellowship, American Heart Association (2007)
- Herbert Newby McCoy Award, McCoy family (2003)
- Jane Coffin Childs Fellowship, Jane Coffin Childs Memorial Fund for Medical Research (2003)
- Fannie and John Hertz Fellowship, Fannie and John Hertz Foundation (1998)

PROFESSIONAL EDUCATION

- PhD, Caltech (2003)

LINKS

- http://dunngroup.stanford.edu: http://dunngroup.stanford.edu

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

The goal of our laboratory is to determine how molecular-scale information encodes the shape and physical properties of cells, tissues, and whole organisms. To do so, we use a combination of sophisticated microscopy, single-molecule biophysics, and theoretical modeling to explore how information propagates upwards across biological length scales. Specific questions we are currently investigating include: 1) How do molecular-scale asymmetries encoded in individual proteins give rise to the emergent physical properties of the cell; and 2) How do cells coordinate their actions to shape organs and tissues? In helping to answer these general questions we hope to understand the physical principles that underlie the construction of complex, multicellular life. We anticipate that this knowledge will be highly relevant to the development of stem-cell-based therapies and to engineering complex, three-dimensional tissues in the laboratory.

Teaching

COURSES

2020-21

- Advanced Cell Biology: BIO 214, BIOC 224, MCP 221 (Win)
- Biochemistry II: CHEM 183, CHEMENG 183, CHEMENG 283 (Win)
- Chemical Kinetics and Reaction Engineering: CHEMENG 320 (Spr)
- Graduate Practical Training: CHEMENG 299 (Sum)
- Special Topics in Advanced Biophysics and Protein Design: CHEMENG 518 (Aut, Win, Spr, Sum)

2019-20

- Advanced Cell Biology: BIO 214, BIOC 224, MCP 221 (Win)
- Biochemistry II: CHEM 183, CHEMENG 183, CHEMENG 283 (Win)
- Chemical Kinetics and Reaction Engineering: CHEMENG 320 (Spr)
- Graduate Practical Training: CHEMENG 299 (Sum)
- Special Topics in Advanced Biophysics and Protein Design: CHEMENG 518 (Aut, Win, Spr, Sum)

2018-19

- Biochemistry II: CHEM 183, CHEMENG 183, CHEMENG 283 (Win)
- Chemical Kinetics and Reaction Engineering: CHEMENG 320 (Spr)
- Special Topics in Advanced Biophysics and Protein Design: CHEMENG 518 (Aut, Win, Spr, Sum)

2017-18

- Biochemistry II: CHEM 183, CHEMENG 183, CHEMENG 283 (Win)
- Chemical Kinetics and Reaction Engineering: CHEMENG 320 (Spr)
- Colloquium: CHEMENG 699 (Aut, Win, Spr)
- Growth and Form: CHEMENG 420 (Aut)
- Special Topics in Advanced Biophysics and Protein Design: CHEMENG 518 (Aut, Win, Spr, Sum)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

Omokolade Adebowale, Julie Chang, Rikki Garner, Vivek Gupta, Ramon Lorenzo Labitigan, Chunzi Liu, Brian Raftrey, Ada Undieh, Jared Weaver, Alex Yoshikawa, Camila de Paula Teixeira

Postdoctoral Faculty Sponsor

Leeya Engel, Carlos Garzon-Coral, Christina Hueschen, Claudia Vasquez, Alex Vlahos

Doctoral Dissertation Advisor (AC)

Derek Huang, Elgin Korkmazhan, Cayla Miller, Vipul Vachharajani, Brian Zhong

Doctoral Dissertation Co-Advisor (AC)

Nick Bax, Kiara Cui, Sarah Hull, Ellie Labuz, Yung-Hao Lin, Amy Wang

Postdoctoral Research Mentor

Leeya Engel, Christina Hueschen, Alex Vlahos

Doctoral (Program)

Eva de la Serna

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Biophysics (Phd Program)

Publications

PUBLICATIONS

- **Regulation and dynamics of force transmission at individual cell-matrix adhesion bonds.** *Science advances*
  Tan, S. J., Chang, A. C., Anderson, S. M., Miller, C. M., Prahl, L. S., Odde, D. J., Dunn, A. R.
  2020; 6 (20): eaax0317
- **Vinculin forms a directionally asymmetric catch bond with F-actin** *SCIENCE*
  Huang, D. L., Bax, N. A., Buckley, C. D., Weis, W. I., Dunn, A. R.
  2017; 357 (6352): 703–6
- **Energetics and forces in living cells** *PHYSICS TODAY*
  Dunn, A. R., Price, A.
  2015; 68 (2): 27-32
- **Cell adhesion. The minimal cadherin-catenin complex binds to actin filaments under force.** *Science*
  Buckley, C. D., Tan, J., Anderson, K. L., Hanein, D., Volkmann, N., Weis, W. I., Nelson, W. J., Dunn, A. R.
  2014; 346 (6209)
- **Molecular tension sensors report forces generated by single integrin molecules in living cells.** *Nano letters*
  Morimatsu, M., Mekhdjian, A. H., Adhikari, A. S., Dunn, A. R.
  2013; 13 (9): 3985-3989
- **Spatially controlled stem cell differentiation via morphogen gradients: A comparison of static and dynamic microfluidic platforms** *JOURNAL OF VACUUM SCIENCE & TECHNOLOGY A*
  Cui, K. W., Engel, L., Dundes, C. E., Nguyen, T. C., Loh, K. M., Dunn, A. R.
  2020; 38 (3)
- **Scaling up single-cell mechanics to multicellular tissues - the role of the intermediate filament-desmosome network.** *Journal of cell science*
  Broussard, J. A., Jaiganesh, A., Zarkoob, H., Conway, D. E., Dunn, A. R., Espinosa, H. D., Janmey, P. A., Green, K. J.
  2020; 133 (6)
- **Perpendicular alignment of lymphatic endothelial cells in response to spatial gradients in wall shear stress.** *Communications biology*
  Michalaki, E., Surya, V. N., Fuller, G. G., Dunn, A. R.
  2020; 3 (1): 57

- **Limited Dishevelled/Axin oligomerization determines efficiency of Wnt/#-catenin signal transduction.** *eLife*
  Kan, W., Enos, M. D., Korkmazhan, E., Muennich, S., Chen, D. H., Gammons, M. V., Vasishtha, M., Bienz, M., Dunn, A. R., Skiniotis, G., Weis, W. I.
  2020; 9

- **Tuning the Antigen Density Requirement for CAR T Cell Activity.** *Cancer discovery*
  Majzner, R. G., Rietberg, S. P., Sotillo, E., Dong, R., Vachharajani, V. T., Labanieh, L., Myklebust, J. H., Kadapakkam, M., Weber, E. W., Tousley, A. M., Richards, R. M., Heitzeneder, S., Nguyen, et al
  2020

- **Binding partner- and force-promoted changes in alphaE-catenin conformation probed by native cysteine labeling.** *Scientific reports*
  Terekhova, K., Pokutta, S., Kee, Y. S., Li, J., Tajkhorshid, E., Fuller, G., Dunn, A. R., Weis, W. I.
  2019; 9 (1): 15375

- **Oscillatory cortical forces promote three dimensional cell intercalations that shape the murine mandibular arch.** *Nature communications*
  Tao, H., Zhu, M., Lau, K., Whitley, O. K., Samani, M., Xiao, X., Chen, X. X., Hahn, N. A., Liu, W., Valencia, M., Wu, M., Wang, X., Fenelon, et al
  2019; 10 (1): 1703

- **Lymphatic endothelial cell calcium pulses are sensitive to spatial gradients in wall shear stress** *MOLECULAR BIOLOGY OF THE CELL*
  Surya, V. N., Michalaki, E., Fuller, G. G., Dunn, A. R.
  2019; 30 (7): 923–31

- **Lymphatic endothelial cell calcium pulses are sensitive to spatial gradients in wall shear stress.** *Molecular biology of the cell*
  Surya, V. N., Michalaki, E., Fuller, G. G., Dunn, A. R.
  2019: mbcE18100618

- **Myosin-II mediated traction forces evoke localized Piezo1-dependent Ca2+ flickers.** *Communications biology*
  Ellefsen, K. L., Holt, J. R., Chang, A. C., Nourse, J. L., Arulmoli, J., Mekhdjian, A. H., Abuwarda, H., Tombola, F., Flanagan, L. A., Dunn, A. R., Parker, I., Pathak, M. M.
  2019; 2 (1): 298

- **Mechanical loading of desmosomes depends on themagnitude and orientation of external stress.** *Nature communications*
  Price, A. J., Cost, A., UngewiSS, H., Waschke, J., Dunn, A. R., Grashoff, C.
  2018; 9 (1): 5284

- **Mechanobiology: ubiquitous and useful.** *Molecular biology of the cell*
  Dunn, A. R.
  2018; 29 (16): 1917–18

- **DACH1 stimulates shear stress-guided endothelial cell migration and coronary artery growth through the CXCL12-CXCR4 signaling axis** *GENES & DEVELOPMENT*
  Chang, A. H., Raftrey, B. C., D'Amato, G., Surya, V. N., Poduri, A., Chen, H. I., Goldstone, A. B., Woo, J., Fuller, G. G., Dunn, A. R., Red-Horse, K.
  2017; 31 (13): 1308–24

- **A cytoskeletal clutch mediates cellular force transmission in a soft, 3D extracellular matrix.** *Molecular biology of the cell*
  Owen, L. M., Adhikari, A. S., Patel, M., Grimmer, P., Leijnse, N., Kim, M. C., Notbohm, J., Franck, C., Dunn, A. R.
  2017

- **Integrin-mediated traction force enhances paxillin molecular associations and adhesion dynamics that increase the invasiveness of tumor cells into a three-dimensional extracellular matrix.** *Molecular biology of the cell*
  Mekhdjian, A. H., Kai, F., Rubashkin, M. G., Prahl, L. S., Przybyla, L. M., McGregor, A. L., Bell, E. S., Barnes, J. M., DuFort, C. C., Ou, G., Chang, A. C., Cassereau, L., Tan, et al
  2017; 28 (11): 1467-1488

- **A semi-interpenetrating network of polyacrylamide and recombinant basement membrane allows pluripotent cell culture in a soft, ligand-rich microenvironment.** *Biomaterials*
  Price, A. J., Huang, E. Y., Sebastiano, V., Dunn, A. R.
  2017; 121: 179-192

- **Genetic defects in beta-spectrin and tau sensitize C.elegans axons to movement-induced damage via torque-tension coupling** *ELIFE*
  Krieg, M., Stuehmer, J., Cueva, J. G., Fetter, R., Spilker, K., Cremers, D., Shen, K., Dunn, A. R., Goodman, M. B.

2017; 6

- **Sphingosine 1-phosphate receptor 1 regulates the directional migration of lymphatic endothelial cells in response to fluid shear stress** *JOURNAL OF THE ROYAL SOCIETY INTERFACE*
  Surya, V. N., Michalaki, E., Huang, E. Y., Fuller, G. G., Dunn, A. R.
  2016; 13 (125)
- **The tubulin repertoire of Caenorhabditis elegans sensory neurons and its context-dependent role in process outgrowth** *MOLECULAR BIOLOGY OF THE CELL*
  Lockhead, D., Schwarz, E. M., O'Hagan, R., Bellotti, S., Krieg, M., Barr, M. M., Dunn, A. R., Sternberg, P. W., Goodman, M. B.
  2016; 27 (23): 3717-3728
- **Single Molecule Force Measurements in Living Cells Reveal a Minimally Tensioned Integrin State.** *ACS nano*
  Chang, A. C., Mekhdjian, A. H., Morimatsu, M., Denisin, A. K., Pruitt, B. L., Dunn, A. R.
  2016: -?
- **Kank2 activates talin, reduces force transduction across integrins and induces central adhesion formation** *NATURE CELL BIOLOGY*
  Sun, Z., Tseng, H., Tan, S., Senger, F., Kurzawa, L., Dedden, D., Mizuno, N., Wasik, A. A., Thery, M., Dunn, A. R., Faessler, R.
  2016; 18 (9): 941-953
- **Multiplexed Fluid Flow Device to Study Cellular Response to Tunable Shear Stress Gradients** *ANNALS OF BIOMEDICAL ENGINEERING*
  Ostrowski, M. A., Huang, E. Y., Surya, V. N., Poplawski, C., Barakat, J. M., Lin, G. L., Fuller, G. G., Dunn, A. R.
  2016; 44 (7): 2261-2272
- **How Hydra Eats.** *Biophysical journal*
  Dunn, A. R.
  2016; 110 (7): 1467-1468
- **Nanoscale Patterning of Extracellular Matrix Alters Endothelial Function under Shear Stress** *NANO LETTERS*
  Nakayama, K. H., Surya, V. N., Gole, M., Walker, T. W., Yang, W., Lai, E. S., Ostrowski, M. A., Fuller, G. G., Dunn, A. R., Huang, N. F.
  2016; 16 (1): 410-419
- **A Force Balance Can Explain Local and Global Cell Movements during Early Zebrafish Development** *BIOPHYSICAL JOURNAL*
  Chai, J., Hamilton, A. L., Krieg, M., Buckley, C. D., Riedel-Kruse, I. H., Dunn, A. R.
  2015; 109 (2): 407-414
- **Visualizing the Interior Architecture of Focal Adhesions with High-Resolution Traction Maps** *NANO LETTERS*
  Morimatsu, M., Mekhdjian, A. H., Chang, A. C., Tan, S. J., Dunn, A. R.
  2015; 15 (4): 2220-2228
- **Mechanical systems biology of C. elegans touch sensation.** *BioEssays*
  Krieg, M., Dunn, A. R., Goodman, M. B.
  2015; 37 (3): 335-344
- **The CDC42-Interacting Protein 4 Controls Epithelial Cell Cohesion and Tumor Dissemination** *DEVELOPMENTAL CELL*
  Rolland, Y., Marighetti, P., Malinverno, C., Confalonieri, S., Luise, C., Ducano, N., Palamidessi, A., Bisi, S., Kajiho, H., Troglio, F., Shcherbakova, O. G., Dunn, A. R., Oldani, et al
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- **Mechanical control of the sense of touch by ß-spectrin.** *Nature cell biology*
  Krieg, M., Dunn, A. R., Goodman, M. B.
  2014; 16 (3): 224-233
- **Mechanical control of the sense of touch by ß-spectrin.** *Nature cell biology*
  Krieg, M., Dunn, A. R., Goodman, M. B.
  2014; 16 (3): 224-233
- **Microvascular Endothelial Cells Migrate Upstream and Align Against the Shear Stress Field Created by Impinging Flow** *BIOPHYSICAL JOURNAL*
  Ostrowski, M. A., Huang, N. F., Walker, T. W., Verwijlen, T., Poplawski, C., Khoo, A. S., Cooke, J. P., Fuller, G. G., Dunn, A. R.
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- **Quantification of nanowire penetration into living cells.** *Nature communications*
  Xu, A. M., Aalipour, A., Leal-Ortiz, S., Mekhdjian, A. H., Xie, X., Dunn, A. R., Garner, C. C., Melosh, N. A.
  2014; 5: 3613-?
- **Conformational Dynamics Accompanying the Proteolytic Degradation of Trimeric Collagen I by Collagenases** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Adhikari, A. S., Glassey, E., Dunn, A. R.
  2012; 134 (32): 13259-13265
- **E-cadherin is under constitutive actomyosin-generated tension that is increased at cell-cell contacts upon externally applied stretch** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Borghi, N., Sorokina, M., Shcherbakova, O. G., Weis, W. I., Pruitt, B. L., Nelson, W. J., Dunn, A. R.
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- **Multiplexed Single-molecule Force Proteolysis Measurements Using Magnetic Tweezers** *JOVE-JOURNAL OF VISUALIZED EXPERIMENTS*
  Adhikari, A. S., Chai, J., Dunn, A. R.
  2012
- **Strain Tunes Proteolytic Degradation and Diffusive Transport in Fibrin Networks** *BIOMACROMOLECULES*
  Adhikari, A. S., Mekhdjian, A. H., Dunn, A. R.
  2012; 13 (2): 499-506
- **Nucleotide Pocket Thermodynamics Measured by EPR Reveal How Energy Partitioning Relates Myosin Speed to Efficiency** *JOURNAL OF MOLECULAR BIOLOGY*
  Purcell, T. J., Naber, N., Franks-Skiba, K., Dunn, A. R., Eldred, C. C., Berger, C. L., Malnasi-Csizmadia, A., Spudich, J. A., Swank, D. M., Pate, E., Cooke, R.
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- **Mechanical Load Induces a 100-Fold Increase in the Rate of Collagen Proteolysis by MMP-1** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Adhikari, A. S., Chai, J., Dunn, A. R.
  2011; 133 (6): 1686-1689
- **Robust Mechanosensing and Tension Generation by Myosin VI** *JOURNAL OF MOLECULAR BIOLOGY*
  Chuan, P., Spudich, J. A., Dunn, A. R.
  2011; 405 (1): 105-112
- **Mechanical force induces a 100-fold increase in the rate of collagen proteolysis by MMP-1** *J. Am. Chem. Soc.*
  Adhikari, A., S., Chai, J., Dunn, A., R.
  2011; 133: 1686-1689
- **Contribution of the myosin VI tail domain to processive stepping and intramolecular tension sensing** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Dunn, A. R., Chuan, P., Bryant, Z., Spudich, J. A.
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- **Electron tunneling through sensitizer wires bound to proteins** *COORDINATION CHEMISTRY REVIEWS*
  Hartings, M. R., Kurnikov, I. V., Dunn, A. R., Winkler, J. R., Gray, H. B., Ratner, M. A.
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- **SINGLE-MOLECULE DUAL-BEAM OPTICAL TRAP ANALYSIS OF PROTEIN STRUCTURE AND FUNCTION** *METHODS IN ENZYMOLOGY, VOL 475: SINGLE MOLECULE TOOLS, PT B*
  Sung, J., Sivaramakrishnan, S., Dunn, A. R., Spudich, J. A.
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- **Force dependence of myosin VI nucleotide binding kinetics** *J. Mol. Biol.*
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  2010; 405: 105-112
- **Nanosecond photoreduction of inducible nitric oxide synthase by a Ru-diimine electron tunneling wire bound distant from the active site** *JOURNAL OF INORGANIC BIOCHEMISTRY*
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2009; 103 (6): 906-911

- **Probing the heme-thiolate oxygenase domain of inducible nitric oxide synthase with Ru(II) and Re(I) electron tunneling wires.** *J. Porphyrins Phthalocyanines*
  Whited, C., A., Belliston-Bittner, W., Dunn, A., R., Winkler, J., R., Gray, H., B.
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- **Predicting allosteric communication in myosin via a pathway of conserved residues** *JOURNAL OF MOLECULAR BIOLOGY*
  Tang, S., Liao, J., Dunn, A. R., Altman, R. B., Spudich, J. A., Schmidt, J. P.
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- **Dynamics of the unbound head during myosin V processive translocation** *NATURE STRUCTURAL & MOLECULAR BIOLOGY*
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- **Single-molecule gold-nanoparticle tracking with high temporal and spatial resolution and without an applied load.** *Laboratory Manual for Single Molecule Studies*
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  Dunn, A., R., Churchman, L., S., Bryant, Z., Spudich, J., A.
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- **Picosecond photoreduction of inducible nitric oxide synthase by rhenium(I)-diimine wires** *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  Belliston-Bittner, W., Dunn, A. R., Nguyen, Y. H., Stuehr, D. J., Winkler, J. R., Gray, H. B.
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- **A flexible domain is essential for the large step size and processivity of myosin VI** *MOLECULAR CELL*
  Rock, R. S., Ramamurthy, B., Dunn, A. R., Beccafico, S., Rami, B. R., Morris, C., Spink, B. J., Franzini-Armstrong, C., Spudich, J. A., Sweeney, H. L.
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- **Ruthenium probes of P450 structure and mechanism.** *Meth. Enzymol.*
  Dmochowski, I., J., Dunn, A., R., Wilker, J., J., Crane, B., R., Green, M., Dawson, J., H.
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  Dunn, A., R., Crane, B., R., Dmochowski, I., J., Winkler, J., R., Gray, H., B.
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- **Probing the open state of cytochrome P450cam with ruthenium-linker substrates.**
  Dunn, A., R., Dmochowski, I., J., Bilwes, A., M., Gray, H., B., Crane, B., R.
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  Dunn, A., R., Crane, B., R., Dmochowski, I., J., Winkler, J., R., Gray, H., B.
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- **Influence of perfluoroarene-arene interactions on the phase behavior of liquid crystalline and polymeric materials.** *Angew. Chem. Int. Ed. Engl.*
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