Matthew D. Shoulders

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Massachusetts Institute of Technology
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APPOINTMENTS

Associate Professor (Tenured), 2019–present
Associate Professor (Without Tenure), 2017–2019
Assistant Professor, 2012–2017
Department of Chemistry, Massachusetts Institute of Technology, Cambridge, MA

Associate Member, 2015–present
Broad Institute, Cambridge, MA

Investigator, Center for Skeletal Research, 2015–present
Massachusetts General Hospital, Boston, MA

Member, Center for Environmental Health Sciences, 2015–present
Massachusetts Institute of Technology, Cambridge, MA

American Cancer Society Postdoctoral Fellow, 2009–2012
Advisors: Profs. Jeffery W. Kelly and R. Luke Wiseman
Departments of Chemistry and Molecular and Experimental Medicine
The Scripps Research Institute, La Jolla, CA

EDUCATION

Ph.D., Organic Chemistry, 2009
Advisor: Prof. Ronald T. Raines
University of Wisconsin–Madison, Madison, WI

B.S., Chemistry, 2004
Summa cum Laude
Class Rank: 1 of 5995
Minor: Biochemistry
Advisor: Prof. Felicia A. Etzkorn
Virginia Tech, Blacksburg, VA

SELECTED HONORS AND AWARDS

- Camille Dreyfus Teacher-Scholar, 2018–2023
- American Cancer Society Research Scholar, 2018–2022
- MIT Committed to Caring Award for Outstanding Graduate Student Mentoring, 2018
- National Science Foundation CAREER Award, 2017–2022
- Whitehead Career Development Professorship, 2016–2019
- d'Arbeloff Fund for Excellence in Education Awardee, 2016
- Journal of Molecular Biology Young Investigator Award, 2016
- National Institutes of Health Director's New Innovator Award, 2015–2020
- Smith Family Foundation Award for Excellence in Biomedical Research, 2014–2016
- Mizutani Foundation Innovation Grant, 2014
- 56th Edward Mallinckrodt Jr. Foundation Faculty Scholar, 2013–2017
- Outstanding Recent Alumnus, Virginia Tech College of Science, 2012
- American Cancer Society Postdoctoral Fellowship, 2010–2012
- Ralph Hirschmann and Daniel Rich Graduate Award in Bioorganic Chemistry Research, 2008
- American Chemical Society Division of Medicinal Chemistry Predoctoral Fellowship, 2007–2008

- United States Department of Homeland Security Graduate Fellowship, 2004–2007
- National Institutes of Health Chemistry-Biology Interface Traineeship, 2004–2007 (funding declined / training program completed)
- University of Wisconsin–Madison McElvain Fellowship, 2004–2005
- B.S. Awarded *Summa cum Laude* (Class Rank 1 of 5995), Virginia Tech, 2004
- James Lewis Howe Award for Outstanding Achievement in Chemistry, Blue Ridge Division of the American Chemical Society, 2004
- Phi Kappa Phi Medallion for highest-ranking senior in the Virginia Tech College of Science, 2004
- Virginia Tech Excellence in Undergraduate Research Award, 2004
- Phi Beta Kappa, 2004
- United States Department of Homeland Security Undergraduate Scholarship, 2003–2004
- Virginia Tech Chemistry Merit Scholar, 2003

PUBLICATIONS

Sebastian, R.M.; **Shoulders, M.D.*** "Chemical Biology Framework to Illuminate Proteostasis" *Annual Review of Biochemistry* **2020**, *90*, in press.

- This review presents a comprehensive experimental framework for applying the methods of chemical biology to the problem of how cells solve protein folding challenges.

Liebelt, F.; Sebastian, R.M.; Moore, C.L.; Mulders, M.P.C.; Ovaa, H.; **Shoulders, M.D.***; Vertegaal, A.C.O.* "SUMOylation and Proteostasis Networks Converge to Minimize Aggregation and Promote Degradation in Response to Heat Shock" *Cell Reports* **2019**, *26*, 236–249. *** = Co-Corresponding Authors.**

- Stress-induced enhancements in SUMOylation inhibit toxic protein aggregation and increase misfolded protein clearance until chaperones can be upregulated to restore proteostasis.

Doan, N.-D.; DiChiara, A.S.; Del Rosario, A.M.; Schiavoni, R.P.; **Shoulders, M.D.*** "Mass Spectrometry-Based Proteomics to Define Intracellular Collagen Interactomes" *Methods in Molecular Biology* **2019**, *1944*, 95–114.

- Design, optimization, and application of strategies for collagen cloning/modification, collagen-producing cell line engineering, and immunoprecipitation-based interactome determination.

Papa, L.J., III; **Shoulders, M.D.*** "Genetic Engineering by DNA Recombineering" *Current Protocols in Chemical Biology* **2019**, *11*, e70.

- Methodology for the rapid, straightforward, and robust genetic engineering of very large DNA sequences using advanced molecular biology strategies.

Wong, M.Y.; **Shoulders, M.D.*** "Targeting Defective Proteostasis in the Collagenopathies" *Current Opinion in Chemical Biology* **2019**, *50*, 80–88.

- This review of the latest advances in collagen biochemistry argues for resculpting the ER proteostasis network as a viable strategy for next-generation therapies for the collagenopathies.

Wong, M.Y.; Chen, K.; Antonopoulos, A.; Kasper, B.T.; Dewal, M.B.; Taylor, R.J.; Whittaker, C.A.; Hein, P.P.; Dell, A.; Genereux, J.C.; Haslam, S.M.*; Mahal, L.K.*; **Shoulders, M.D.*** "XBP1s Activation Can Globally Remodel *N*-Glycan Structure Distribution Patterns" *Proceedings of the National Academy of Sciences, USA* **2018**, *115*, E10089–E10098.

- Discovery that the IRE1-XBP1s axis of the unfolded protein response not only regulates proteostasis but also defines the molecular architecture of the cellular *N*-glycome.

Phillips, A.M.; Doud, M.B.; Gonzalez, L.O.; Butty, V.L.; Lin, Y.-S.; Bloom, J.D.; **Shoulders, M.D.*** "Enhanced ER Proteostasis and Temperature Differentially Impact the Mutational Tolerance of Influenza Hemagglutinin" *eLife* **2018**, *7*, e38795.

- Demonstration that ER chaperones critically define the mutational pathways accessible to an evolving membrane protein, remarkably in precisely the opposite direction of higher temperature.

Phillips, A.M.; Ponomarenko, A.I.; Chen, K.; Ashenberg, O.; Miao, J.; McHugh, S.M.; Butty, V.L.; Whittaker, C.A.; Moore, C.L.; Bloom, J.D.; Lin, Y.-S.; **Shoulders, M.D.*** "Destabilized Influenza Variants Critical for Innate Immune System Escape are Potentiated by Host Chaperones" *PLoS Biology* **2018**, *16*, e3000008.

- Destabilizing variants in influenza nucleoprotein required to escape the human host's innate immune system are made possible by hijacking host chaperones to assist nucleoprotein folding.

DiChiara, A.S.; Li, R.C.; Suen, P.H.; Weickhardt, A.F.; Taylor, R.J.; Malhotra, D.; McCaslin, D.R.; **Shoulders, M.D.*** "A Cysteine-Based Molecular Code Informs Collagen C-Propeptide Assembly" *Nature Communications* **2018**, *9*, e4206.

- The presence or absence of a single sulfur atom in the 30 kDa collagen C-propeptide domain controls the homo- versus hetero-trimerization propensity of all the fibrillar collagens.

Richardson, C.E.R.; Nolan, E.M.; **Shoulders, M.D.***; Lippard, S.J.* "A Sensitive, Non-Radioactive Assay for Zn(II) Uptake into Metazoan Cells" *Biochemistry* **2018**, *57*, 6807–6815. *** = Co-Corresponding Authors.**

- Application of the A12-resin for highly selective Zn(II) depletion from biological media, which was invented by us, to enable an efficient new strategy for quantifying cellular Zn(II) trafficking.

Wong, M.Y.; DiChiara, A.S.; Papa, L.J., III; Cheah, J.H.; Soule, C.K.; Hulleman, J.D.; **Shoulders, M.D.*** "A High-Throughput Assay for Collagen Secretion Reveals an Unanticipated Role for Hsp90 in Collagen Production" *Biochemistry* **2018**, *57*, 2814–2827.

- The first high-throughput screen for small molecules that modulate collagen secretion leads to discovery of a surprising and highly selective function for cytosolic Hsp90 in collagen production.

Cole, K.S.; Grandjean, J.M.D.; Chen, K.; Witt, C.H.; O'Day, J.; **Shoulders, M.D.**; Wiseman, R.L.; Weerapana, E.* "Characterization of an A-Site Selective Protein Disulfide Isomerase A1 Inhibitor" *Biochemistry* **2018**, *57*, 2035–2043.

- An A-site selective protein disulfide isomerase inhibitor selectively activates the IRE1 arm of the unfolded protein response and reduces secretion of amyloidogenic antibody light chains.

Berman, C.M.; Papa, L.J., III; Hendel, S.J.; Moore, C.L.; Suen, P.H.; Weickhardt, A.F.; Doan, N.-D.; Kumar, C.S.; Uil, T.G.; Hoeben, R.C.; **Shoulders, M.D.*** "An Adaptable Platform for Directed Evolution in Human Cells" *Journal of the American Chemical Society* **2018**, *140*, 18093–18103.

- Development of the first human cell-based platform for continuous directed evolution, opening doors to new types of human evolutionary biology and biotechnology experiments.

Moore, C.L.; Papa, L.J., III; **Shoulders, M.D.*** "A Processive Protein Chimera Introduces Mutations across Defined DNA Regions *In Vivo*" *Journal of the American Chemical Society* **2018**, *140*, 2413–2416.

- Introduction of the MutaT7 chimera, a protein capable of delivering mutations to precisely controlled DNA stretches of any desired length to enable rapid evolution in living systems.

Richardson, C.E.R.; Cunden, L.S.; Butty, V.L.; Nolan, E.M.; Lippard, S.J.*; **Shoulders, M.D.*** "A Method for Selective Depletion of Zn(II) Ions from Complex Biological Media and Evaluation of Cellular Consequences of Zn(II) Deficiency" *Journal of the American Chemical Society* **2018**, *140*, 2413–2416.

- Development of the A12-resin for highly specific removal of Zn(II) from diverse and complex biological fluids opens the door to precision studies of biological roles of Zn(II).

Wong, M.Y.; DiChiara, A.S.; Suen, P.H.; Chen, K.; Doan, N.-D.; **Shoulders, M.D.*** "Adapting Secretory Proteostasis and Function Through the Unfolded Protein Response" *Current Topics in Microbiology and Immunology* **2018**, *414*, 1–25.

- This review highlights recent advances in our understanding of the unfolded protein response (UPR), with a focus on potential therapeutic opportunities associated with UPR modulation.

Phillips, A.M.; Gonzalez, L.O.; Nekongo, E.E.; Ponomarenko, A.I.; McHugh, S.M.; Butty, V.; Levine, S.S.; Lin, Y.-S.; Mirny, L.A.; **Shoulders, M.D.*** "Host Proteostasis Modulates Influenza Evolution" *eLife* **2017**, *6*, e28652.

- Discovery that chaperone and quality control mechanisms in the host cell's cytosolic proteostasis network are critical determinants of the mutational landscape accessible to influenza.

Maji, B.; Moore, C.L.; Zetsche, B.; Zhang, F.; **Shoulders, M.D.***; Choudhary, A.* "Multidimensional Chemical Control of CRISPR-Cas9" *Nature Chemical Biology* **2017**, *13*, 9–11. *** = Co-Corresponding Authors.**

- Development of the first method for small molecule-mediated control of Cas9 that confers doseable and rapidly reversible control of orthogonal genome targeting and editing specificity.

DiChiara, A.S.; Taylor, R.J.; Wong, M.Y.; Doan, N.-D.; Del Rosario, A.; **Shoulders, M.D.*** "Mapping and Exploring the Collagen-I Proteostasis Network" *ACS Chemical Biology* **2016**, *11*, 1408–1421.

- Platform for biochemical studies of collagen-I production by human cells enables elucidation of the collagen-I interactome with key implications for the biochemistry of collagen-I production.

Moore, C.L.; Dewal, M.B.; Nekongo, E.E.; Santiago, S.; Lu, N.B.; Levine, S.S.; **Shoulders, M.D.*** "Transportable, Chemical Genetic Methodology for the Small Molecule-Mediated Inhibition of Heat Shock Factor 1" *ACS Chemical Biology* **2016**, *11*, 200–210.

- Development and application of methodology to inducibly and selectively repress the cytosolic proteostasis network reveals mechanistic roles of heat shock factor 1 in protein (mis)folding.

Phillips, A.M.; **Shoulders, M.D.*** "The Path of Least Resistance: Mechanisms to Reduce Influenza's Sensitivity to Oseltamivir" *Journal of Molecular Biology* **2016**, *428*, 533–537.

- Commentary on evolutionary biology and structural approaches to delineate mechanisms of influenza drug resistance, including discussion of key insights and perspective on future goals.

Dewal, M.B.; DiChiara, A.S.; Antonopoulos, A.; Taylor, R.J.; Harmon, C.J.; Haslam, S.M.; Dell, A.; **Shoulders, M.D.*** "XBP1s Links the Unfolded Protein Response to the Molecular Architecture of Mature *N*-Glycans" *Chemistry and Biology* **2015**, *22*, 1301–1312.

- Discovery that stress signaling via the unfolded protein response is a fundamental mechanism employed by cells to regulate protein *N*-glycosylation.

Choudhary, A.; Kamer, K.J.; **Shoulders, M.D.**; Raines, R.T.* "4-Ketoproline: An Electrophilic Proline Analog for Bioconjugation" *Biopolymers: Peptide Science* **2015**, *104*, 110–115.

- In an approach readily extended to a variety of other proteins and peptides, incorporation of 4-ketoproline in collagen permits non-destabilizing, covalent functionalization by nucleophiles.

Genereux, J.C.; Qu, S.; Zhou, M.; Ryno, L.M.; Wang, S.; **Shoulders, M.D.**; Kaufman, R.J.; Lasmézasm C.I.; Kelly, J.W.; Wiseman, R.L.* "Unfolded Protein Response-Induced ERdj3 Secretion Links Endoplasmic Reticulum Stress to Extracellular Proteostasis" *EMBO Journal* **2015**, *34*, 4–19.

- Identification of the first stress-induced secreted chaperone, revealing a direct link between unfolded protein response activation and the adaptation of extracellular proteostasis.

Chen, J.J.; Genereux, J.C.; Hulleman, J.D.; **Shoulders, M.D.**; Wiseman, R.L.* "ATF6 Activation Reduces the Secretion and Extracellular Aggregation of Destabilized Variants of an Amyloidogenic Protein" *Chemistry and Biology* **2014**, *21*, 1564–1574.

- ATF6 activation enhances quality control stringency and shuttles destabilized transthyretin variants to degradation, thereby preventing secretion and subsequent amyloidogenesis.

Ryno, L.M.; Genereux, J.C.; Naito, T.; Morimoto, R.I.; Powers, E.T.; **Shoulders, M.D.**; Wiseman, R.L.* "Characterizing the Altered Cellular Proteome Induced by the Stress-Independent Activation of Heat Shock Factor I" *ACS Chemical Biology* **2014**, *9*, 1273–1283.

- Application of RNA-seq and quantitative proteomics to establish how the cytosolic protein folding environment is modified by heat shock factor I activation.

Shoulders, M.D.; Ryno, L.M.; Cooley, C.B.; Kelly, J.W.; Wiseman, R.L.* "Broadly Applicable Methodology for the Dosable, Rapid, and Small Molecule-Mediated Regulation of Transcription Factors in Human Cells" *Journal of the American Chemical Society* **2013**, *135*, 8129–8132.

- Development of chemical biology methodology to potentially control the activity of any transcription factor of interest within the physiologically relevant regime in any cell model system.

Shoulders, M.D.; Ryno, L.M.; Genereux, J.C.; Moresco, J.J.; Tu, P.G.; Wu, C.; Yates, J.R. III; Su, A.I.; Kelly, J.W.; Wiseman, R.L.* "Stress-Independent Activation of XBP1s and/or ATF6 Reveals Three Functionally Diverse ER Proteostasis Environments" *Cell Reports* **2013**, *3*, 1279–1292.

- Proof-of-principle for a general approach to treat diverse protein misfolding-related diseases by adapting the cell's proteostasis network via selective activation of stress responses.

Krow, G.R.*; **Shoulders, M.D.**; Edupuganti, R.; Gandla, D.; Yu, F.; Sonnet, P.E.; Sender, M.; Choudhary, A.; DeBrosse, C.; Ross, C.W., III; Carroll, P.; Raines, R.T.* "Synthesis of 5-Fluoro- and 5-Hydroxymethanoprolines via Lithiation of *N*-BOC-Methanopyrrolidines. Constrained C^{γ}-Exo and C^{γ}-Endo Flp and Hyp Conformer Mimics" *Journal of Organic Chemistry* **2012**, *77*, 5331–5344.

- Detailed physical organic analyses reveal that proline ring pucker must not be assigned based solely on cis:trans amide preferences.

Krow, G.R.*; Edupuganti, R.; Gandla, D.; Yu, F.; Sender, M.; Sonnet, P.E.; Zdilla, M.J.; DeBrosse, C.; Cannon, K.C.; Ross, C.W., III; Choudhary, A.; **Shoulders, M.D.**; Raines, R.T.* "Synthesis of Conformationally Constrained 5-Fluoro- and 5-Hydroxymethanopyrrolidines. Ring Puckered Mimics of Gauche and Anti-3-Fluoro- and 3-Hydroxypyrrolidines" *Journal of Organic Chemistry* **2011**, *76*, 3626–3634.

- Establishment of baseline amide preferences to enable determination of the contributions of α-ester substituents to cis:trans amide ratios in the methanoprolines.

Shoulders, M.D.; Raines, R.T.* "Interstrand Dipole-Dipole Interactions Can Stabilize the Collagen Triple Helix" *Journal of Biological Chemistry* **2011**, *286*, 22905–22912.

- Electrostatic interactions rescue the stability of triple helices with amino acid sequences expected to be destabilizing, providing a new framework to understand collagen stability.

Shoulders, M.D.; Kotch F.W.; Choudhary, A.; Guzei, I.A.; Raines, R.T.* "The Aberrance of the 4*S* Diastereomer of 4-Hydroxyproline" *Journal of the American Chemical Society,* **2010**, *132*, 10857–10865.

- Hydrogen bonding can compromise the benefits of an underlying stereoelectronic effect for protein conformational stability.

Shoulders, M.D.; Satyshur, K.A.; Forest, K.T.; Raines, R.T.* "Stereoelectronic and Steric Effects in Side Chains Preorganize a Protein Main Chain" *Proceedings of the National Academy of Sciences, USA* **2010**, *107*, 559–564.

- Peptide backbone conformational preorganization via subtle modifications to amino acid side chains can confer extraordinary stability upon proteins without perturbing their structure.

Krow, G.R.*; Liu, N.; Sender, M.; Lin, G.; Centafont, R.; Sonnet, P.E.; DeBrosse, C.; Ross, C.W., III; Carroll, P.J.; **Shoulders, M.D.**; Raines, R.T.* "Oligomers of a 5-Carboxymethanopyrrolidine β-Amino Acid—A Search for Order" *Organic Letters* **2010**, *12*, 5438–5441.

- The highly constrained β-amino acid (1*S*,4*R*,5*R*)-5-syn-carboxy-2-azabicyclo[2.1.1.]hexane enables the preparation of well-defined peptide foldamers in the absence of hydrogen bonds.

Shoulders, M.D.; Kamer, K.J.; Raines, R.T.* "Origin of the Stability Conferred upon Collagen by Fluorination" *Bioorganic and Medicinal Chemistry Letters* **2009**, *19*, 3859–3862.

- (2*S*,4*R*)-4-Fluoroproline stabilizes collagen triple helices by a mechanism distinct from the hydrophobic effect.

Shoulders, M.D.; Raines, R.T.* "Collagen Structure and Stability" *Annual Review of Biochemistry* **2009**, *78*, 929–958.

- Comprehensive and highly cited review of current knowledge regarding the physicochemical basis of collagen structure and stability and the preparation of synthetic collagen mimetics.

Shoulders, M.D.; Raines, R.T.* "Modulating Collagen Triple-Helix Stability with 4-Chloro, 4-Fluoro, and 4-Methylprolines" *Advances in Experimental Medicine and Biology* **2009**, *611*, 251–252.

- Rational application of steric and stereoelectronic effects enables the preparation of synthetic collagen mimetics with predictable thermal stability over a >50 °C range.

Shoulders, M.D.; Guzei, I.A.; Raines, R.T.* "4-Chloroprolines: Synthesis, Conformational Analysis, and Effect on the Collagen Triple Helix" *Biopolymers* **2008**, *89*, 443–454.

- Conclusive demonstration that deleterious steric interactions can overwhelm favorable stereoelectronic effects on triple-helix stability.

Shoulders, M.D.; Hodges, J.A.; Raines, R.T.* "Reciprocity of Steric and Stereoelectronic Effects in the Collagen Triple Helix" *Journal of the American Chemical Society* **2006**, *128*, 8112–8113.

- Fundamental interplay between steric and stereoelectronic effects in proteins provides a new means to modulate the conformational stability of both natural and synthetic proteins.

PATENTS AND PATENT APPLICATIONS

Shoulders, M.D.; Moore, C.L.; Papa, L.J., III "Methods and Kits for Targeted Dynamic Hypermutation" **March 19, 2018**, U.S. Patent Application No. 62/644,736; International Patent Application No. PCT/US2019/022908.

Shoulders, M.D.; Lippard, S.J.; Nolan, E.M.; Richardson, C.E.R.; Cunden, L.S. "Compositions and Methods for Selectively Sequestering Metal Ions" **Jan. 9, 2018**, U.S. Patent Application No. 15/866,179.

Shoulders, M.D.; Berman, C.; Papa, L.J., III; Hendel, S.; Moore, C.L. "Methods and Compositions for Performing Continuous Directed Evolution" **Oct. 27, 2017**, U.S. Patent Application Nos. 62/577,867 and 62/734,520; International Patent Application No. PCT/US2018/057683.

Raines, R.T.; **Shoulders, M.D.**; Hodges, J.A. "Collagen Mimics" **Sept. 12, 2017**, U.S. Patent No. 9,758,569.

SELECTED PRESENTATIONS

Boston College Department of Chemistry, Chestnut Hill, MA, 2019
Broad Institute Infectious Disease & Microbiome Program Meeting, Cambridge, MA, 2019
Boston Glycobiology Discussion Group, Cambridge, MA, 2019
258th National Meeting of the American Chemical Society, San Diego, CA, 2019
RTR-60 Chemical Biology Symposium, Broad Institute, Cambridge, 2019
FASEB ER Conference: From Unfolded Proteins to Disease, Snowmass Village, CO, 2019
19th Annual PROTEO Symposium, Quebec City, Quebec, Canada, 2019
257th National Meeting of the American Chemical Society, Orlando, FL, 2019
Harvard Medical School Division of Genetics, Boston, MA, 2019
University of California–Berkeley College of Chemistry, Berkeley, CA, 2018
The Scripps Research Institute Department of Chemistry, La Jolla, CA, 2018
256th National Meeting of the American Chemical Society, Boston, MA, 2018
National Tsing-Hua University Department of Chemistry, Hsinchu City, TW, 2018
Caltech Division of Chemistry and Chemical Engineering, Pasadena, CA, 2018
Northwestern University Department of Molecular Biosciences, Evanston, IL, 2018
UCSF Department of Pharmaceutical Chemistry, San Francisco, CA, 2018
Stanford University Department of Chemical and Systems Biology, Stanford, CA, 2018
Northwestern University Department of Molecular Biosciences, Evanston, IL, 2018
Princeton University Department of Chemistry, Princeton, NJ, 2018
Yale University Chemical Biology Institute, New Haven, CT, 2018
UCLA Department of Chemistry and Biochemistry, Los Angeles, CA, 2018
University of California–San Diego Department of Chemistry, San Diego, CA, 2018
University of Wisconsin–Madison Department of Chemistry, Madison, WI, 2018
Cornell University Department of Chemistry and Chemical Biology, Ithaca, NY, 2018
The Scripps Research Institute Department of Chemistry, Jupiter, FL, 2018

Protein Homeostasis in Health and Disease Meeting, Cold Spring Harbor, NY, 2018
UCSB Department of Chemistry and Biochemistry, Santa Barbara, CA, 2018
University of California–Irvine Department of Chemistry, Irvine, CA, 2018
New York University Department of Chemistry, New York, NY, 2018
Pennsylvania University Department of Chemistry, Philadelphia, PA, 2018
255th National Meeting of the American Chemical Society, New Orleans, LA, 2018
University of Washington–Seattle Department of Chemistry, Seattle, WA, 2018
University of Massachusetts–Amherst Institute for Applied Life Sciences, Amherst, MA, 2018
University of Southern California Department of Chemistry, Los Angeles, CA, 2018
Simon Fraser University Department of Molecular Biology and Biochemistry, Burnaby, BC, CA, 2018
Indiana University Department of Chemistry, Bloomington, IN, 2017
Oxford University Ludwig Center for Cancer Research, Oxford, UK, 2017
Imperial College–London Department of Life Sciences, London, UK, 2017
Cambridge University Institute for Medical Research, Cambridge, UK, 2017
Society for Glycobiology Meeting, Portland, OR, 2017
University of Vermont Department of Biology, Burlington, VT, 2017
FASEB From Unfolded Proteins in the ER to Disease Conference, Saxton's River, VT, 2017
University of Melbourne Murdoch Childrens Research Institute, Melbourne, AU, 2017
3rd Annual Meeting of the Biophysical Society of Canada, Montreal, Quebec, CA, 2017
CPhI North America, Philadelphia, PA, 2017
National Meeting of the American Society of Biochemistry and Molecular Biology, Chicago, IL, 2017
University of Nebraska Department of Chemistry, Lincoln, NE, 2017
Creighton University Department of Chemistry, Omaha, NE, 2017
Pennsylvania State University Department of Chemistry, State College, PA, 2017
253rd National Meeting of the American Chemical Society, San Francisco, CA, 2017
Virginia Tech Department of Chemistry, Blacksburg, VA, 2017
MIT Center for Environmental Health Sciences Advisory Board Meeting, Cambridge, MA, 2017
FASEB Protein Folding in the Cell Conference, Saxton's River, VT, 2016
Harvard University School of Dental Medicine, Boston, MA, 2016
University of Massachusetts Medical School, Worcester, MA, 2016
The Scripps Research Institute, La Jolla, CA, 2016
251st National Meeting of the American Chemical Society, San Diego, CA, 2016
Quebec & Ontario Mini-Symposium on Bioorganic and Organic Chemistry, Quebec, CA, 2015
Leiden University Medical Center, Leiden, Netherlands, 2015
Collagen Gordon Research Conference, New London, NH, 2015
The Genome Institute of Singapore, Singapore, 2015
Duke-National University of Singapore Graduate Medical School, Singapore, 2015
Harvard Medical School, Boston, MA, 2015
Campus for Research Excellence and Technological Enterprise, Singapore, 2014
Broad Institute, Cambridge, MA, 2014
Proteostasis Therapeutics, Inc., Cambridge, MA, 2014
Protein Folding and Viral Evolution Meeting, Cambridge, MA, 2014
MIT Center for Environmental Health Sciences, Cambridge, MA, 2014
University of Massachusetts Department of Chemistry, Lowell, MA, 2013
Mount Holyoke College Department of Chemistry, South Hadley, MA, 2013
243rd National Meeting of the American Chemical Society, San Diego, CA, 2012
ER Stress Association Meeting, Sanford-Burnham Medical Research Institute, La Jolla, CA, 2012

TEACHING AND EDUCATION AT MIT

- Chemistry 5.302: Introduction to Experimental Chemistry (Laboratory short course providing MIT undergraduates a stimulating, hands-on experience with chemical phenomena; IAP (Independent Activities Period – January) 2019
- Chemistry 5.111: Principles of Chemical Science (MIT General Institute Requirement; up to 370 students per semester in Spring 2013, 2014, and 2015; Fall 2015, 2016, 2018, and 2019)

- Chemistry 5.54: Frontiers in Chemical Biology (PhD-level course in Fall 2013, 2014, 2015, 2016, 2018, and 2019; co-created course content with Prof. Brad Pentelute; Most recent iteration was the highest-rated full-term course in the MIT Chemistry Department)
- Chemistry 5.921: Seminar in Biological Chemistry (Fall 2013, 2014, 2015, 2016, 2017, 2018, and 2019; Spring 2017 and 2018)
- MOOC-Development – Chemistry 5.01x: Currently leading the development and implementation of a publicly available, first-semester General Chemistry course for the MITx Platform
- MOOC-Development – Chemistry 5.02x: Currently recording content and leading the development and implementation of a publicly available, second-semester General Chemistry course for the MITx Platform
- Led the development of a Fundamental Chemistry Knowledge Module delivered on the MITx platform that serves to fill gaps in student understanding of background material required for success in fulfilling MIT's Chemistry General Institute Requirement
- Co-led the development of a suite of MITx problems and other content to support a publicly available General Chemistry course to be delivered by MIT on the EdX platform

SELECTED ACTIVE RESEARCH AND EDUCATION GRANTS

John W. Jarve Seed Fund for Science Innovation Grant "New Strategies for Directed Evolution *In Vivo*" 2019–2020, $150,000 Role: **Principal Investigator**

Camille Dreyfus Teacher-Scholar Award "Molecular Mechanisms of Protein Folding and Evolution in Living Cells" 2018–2023, $75,000 Role: **Principal Investigator**

American Cancer Society – Ellison Foundation Research Scholar Grant RSG-18-122-01-CSM "New Connections: Stress, Proteostasis, Sugars, and Cancer" 2018–2022, $792,000 Role: **Principal Investigator**

G. Harold and Leila Y. Mathers Foundation Research Grant "Aging, Proteostasis Collapse, and Osteoarthritis: A New Perspective on an Old Disease" 2018–2021, $750,000 Role: **Principal Investigator**

National Institutes of Health / National Institute of Arthritis, Musculoskeletal, and Skin Diseases 1R01AR071443 "Defining and Modulating Mechanisms of Collagen Proteostasis" 2017–2022, $1,701,000 Role: **Principal Investigator**

National Science Foundation / Division of Molecular and Cellular Biosciences Grant 1652390 "CAREER: Integrating Chemical Biology Methods and RNA Virus Models to Elucidate How the Metazoan Proteostasis Network Modulates Protein Evolutionary Landscapes" 2017–2022, $1,034,621 Role: **Principal Investigator**

MIT International Science and Technology Initiatives-Imperial College London Seed Funds for Collaborative Research "Factors that Define the Molecular Architecture of the N-Glycome" 2017–2018, $45,000 Role: **Principal Investigator**

National Institutes of Health / Office of the Director's New Innovator Award 1DP2GM119162 "Continuous Directed Evolution of Biomolecules in Human Cells for Medical Research" 2015–2020, $2,340,000 Role: **Principal Investigator**

COMPLETED RESEARCH AND EDUCATION GRANTS

National Institutes of Health / National Institute of Arthritis, Musculoskeletal, and Skin Diseases 1R03AR067503 "Unveiling the Proteostasis Network of Normal and Disease-Causing Collagen-I" 2015–2018, $234,000 Role: **Principal Investigator**

MIT International Science and Technology Initiatives Global Seed Funds for Collaborative Research "Induced Pluripotent Stem Cells, Proteomics, and the Collagen Misfolding-Related Diseases" 2016–2018, $26,000 Role: **Principal Investigator**

56th Edward Mallinckrodt Jr. Foundation Faculty Scholar Award "Peering Beyond the Elements of the Central Dogma for the Disease Therapies of Tomorrow" 2013–2017, $400,000 Role: **Principal Investigator**

d'Arbeloff Fund for Excellence in Education Grant "Leveraging MITx to Deliver Foundational Knowledge Essential for Success in MIT's Chemistry General Institute Requirement" 2016–2017, $63,000 Role: **Principal Investigator** (co-PI: Van Voorhis, MIT)

Jeptha H. and Emily V. Wade Award for Creative Research "Irreversible Proteome Dysfunction Triggered by Protein Aggregates" 2016–2017, $75,000 Role: **Principal Investigator**

Smith Family Foundation Excellence in Biomedical Research Award "Hijacking the Host Cell's Protein Homeostasis Network to Potentiate Viral Evolution" 2014–2016, $300,000 Role: **Principal Investigator**

Singapore-MIT Alliance for Research and Technology Phase 2 Grant "Chemical Biology Strategies to Improve the Efficacy, Enhance the Stability, and Reduce the Immunogenicity of Dengue Virus-Targeting Therapeutic Monoclonal Antibodies" 2014–2015, $230,000 Role: **Principal Investigator**

Mizutani Foundation for Glycoscience Innovation Grant "Protein Homeostasis Network-Mediated Remodeling of the N-Glycoproteome" 2014–2015, $50,000 Role: **Principal Investigator**

Royal G. and Mae H. Westaway Family Memorial Fund Grant "A Humanized Directed Evolution Platform to Unveil Oncogenic Subversion of the Proteostasis Network" 2014–2015, $75,000 Role: **Principal Investigator**

MIT Center for Environmental Health Sciences Pilot Grant "Understanding and Ameliorating Arsenic-Induced Protein Misfolding" 2014–2015, $41,000 Role: **Principal Investigator**

MIT International Science and Technology Initiatives Global Seed Funds for Collaborative Research "Elucidating How Adenoviral Evolution is Enabled by the Host Cell's Protein Folding Machinery" 2013–2015, $15,000 Role: **Principal Investigator**

Singapore-MIT Alliance for Research and Technology Phase 1 Grant "Chaperone Hijacking: Influenza Adaptation, Drug Resistance, and the Host's Proteostasis Network" 2014, $24,000 Role: **Principal Investigator**

American Cancer Society Postdoctoral Fellowship "Novel Cancer Therapies: Selective Inhibition of Pro-Survival Unfolded Protein Response Signaling" 2010–2012, $150,000 Role: **Principal Investigator**

COMMITTEES, SERVICE, AND AFFILIATIONS

MIT Institute-Wide Service

- Committed to Caring Faculty Mentor, 2019–present
- MIT First-Year Undergraduate Student Advisor, 2019–present
- Faculty Mentor for the MIT Postdoctoral Association Mentoring Program, 2019–present
- Committee on the Assessment of Biohazards & Embryonic Stem Cell Research Oversight at MIT, 2013–present
- MIT Steering Committee on Community Giving, 2014–2017
- MIT International Science and Technology Initiatives Grant Review, 2014, 2018, & 2019MIT Howard Hughes Medical Institute Graduate Fellowship Selection Committee, 2014–2015
- MIT Global Classroom Fund Grant Review, 2018

MIT Departmental Service

- Coordinator, "Introducing the Chemistry GIR" Video Project, 2019
- Department of Chemistry Junior Faculty Search Committee – Chemical Biology Lead, 2019
- Department of Chemistry Quality of Life Committee, Member 2015–2019; **Chair** 2019–present Department of Chemistry Instrumentation Facility Faculty Committee, 2014–present
- Chemical Biology Seminar Series Coordinator, 2013–present
- Chemistry Undergraduate Major Advisor, 2013–present

- Department of Chemistry Environmental Health and Safety Committee, 2012–present
- Department of Chemistry Graduate Admissions Committee, 2012–2019
- DOW-MIT ACCESS Program Applications Review, 2017
- Department of Chemistry Committee on Joint and Flex Chemistry Majors, 2015–2017

Professional Service and Affiliations

- Session Organizer/Presider, 255th and 256th National Meetings of the American Chemical Society
- Ad Hoc Reviewer for the National Institutes of Health, European Research Council, Natural Sciences and Engineering Research Council of Canada, Swiss National Science Foundation, Alberta Alzheimer's Research Program, Army Research Office Core Programs, Center for the Advancement of Science in Space, Dystonia Medical Research Foundation, Wellcome Trust/DBT India Alliance Intermediate Fellowships
- Panelist for NSF Graduate Research Fellowship Program
- Guest Editor, *eLife*
- Peer review for assorted professional journals
- Member: Phi Beta Kappa; American Association for the Advancement of Science; American Chemical Society; American Society for Biochemistry and Molecular Biology; American Society for Matrix Biology; Protein Society