

Nathan M. Ennist, PhD

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Experience

University of Washington, Seattle, WA September 2022 – present
Acting Instructor with research funding from Advanced
Research Projects Agency-Energy (ARPA-E)

University of Washington, Seattle, WA September 2017 – August 2022
Postdoc in laboratory of David Baker

Education

University of Pennsylvania, Philadelphia, PA August 2009 – May 2017
PhD, Biochemistry and Molecular Biophysics
Overall GPA: 3.58/4.00

Dissertation: Research Advisor, Professor P. Leslie Dutton, Ph.D.
“Design, Structure, and Action of an Artificial Photosynthetic Reaction Center”

Emory University, Atlanta, GA August 2005 – May 2009
Bachelor of Science, Chemistry
Bachelor of Arts, Physics (*Magna cum laude*)
Minor in Spanish
Overall GPA: 3.65/4.00

Honors Thesis in Physics: Research Advisor, Professor Kurt Warncke, Ph.D.
“Developing a Biologically-Inspired Molecular Solar Energy Conversion Device:
Formation and Reaction of Cob(I)alamin and Cob(I)inamide with Carbon Dioxide in
Solution and in the EutB Protein of Ethanolamine Ammonia Lyase”

Related Courses

Rosetta 2018 Boot Camp, Pyrosetta 2019 Boot Camp, Macromolecular Biophysics I and II, Cell
Biology, Molecular Spectroscopy, Statistical Mechanics, Quantum Chemistry, Macromolecular
Crystallography, Advanced X-ray Diffraction, Bioinorganic Chemistry, Computer Programming
for Biochemists and Biophysicists, Fundamentals of Magnetic Resonance, Physical Principles of
Mechano-Enzymes, Ion Channels and Pumps, Physical-Organic Chemistry, Current Biochemical
Topics

Research Experience

- Computational design of chlorophyll-binding proteins for artificial photosynthesis using Rosetta, AlphaFold, and other protein design and structure prediction software
- Designed multi-cofactor binding proteins for catalysis of light-driven electron transfer and binding of oxygen
- Crystallized and solved X-ray crystal structures of designed proteins with and without multiple cofactors and deposited structures in the Protein Data Bank
- Demonstrated long-lived charge separation (hundreds of milliseconds) in designed reaction center protein maquette involving reduced heme and oxidized tyrosine/metal ions using transient absorption spectroscopy
- Proficient in biochemical techniques including ultraviolet/visible absorption spectroscopy, circular dichroism spectroscopy, fluorescence spectroscopy, X-ray crystallography, negative stain electron microscopy, transient absorption spectroscopy, small angle X-ray scattering, MALDI mass spectrometry, isothermal titration calorimetry, spectroelectrochemistry, anaerobic techniques, stopped flow, molecular biology, high-throughput protein expression and purification

Publications

Ennist, N. M., Wang, S., Kennedy, M. A., Curti, M., Sutherland, G. A., Vasilev, C., Redler, R. L., Maffei, V., Shareef, S., Sica, A. V., Hua, A. S., Deshmukh, Moyer, A. P., Hicks, D. R., Swartz, A., Cacho, R. A., Novy, N., Bera, A. K., Kang, A., Sankaran, B., Johnson, M. P., Phadkule, A. A., Reppert, M., Ekiert, D., Bhabha, G., Stewart, L., Caram, J. R., Stoddard, B. L., Romero, E., Hunter, C. N., Baker, D. (2024). De novo design of proteins housing excitonically coupled chlorophyll special pairs. *Nature Chemical Biology*. <https://doi.org/10.1038/s41589-024-01626-0>

Kalvet, I., Ortmayer, M., Zhao, J., Crawshaw, R., **Ennist, N. M.**, Levy, C., Roy, A., Green, A. P., and Baker, D. (2023). Design of Heme Enzymes with a Tunable Substrate Binding Pocket Adjacent to an Open Metal Coordination Site. *Journal of the American Chemical Society* **145**(26), 14307-14315. <https://doi.org/10.1021/jacs.3c02742>

Ennist, N. M., Zhao, Z., Stayrook, S. E., Discher, B. M., Dutton, P. L., Moser, C. C. (2022). De novo protein design of photochemical reaction centers. *Nature Communications* **13**(1), 4937. <https://doi.org/10.1038/s41467-022-32710-5>

Ennist, N. M., Stayrook, S. E., Dutton, P. L., Moser, C. C. (2022). Rational design of photosynthetic reaction center protein maquettes. *Frontiers in Molecular Biosciences*, **9**. <https://doi.org/10.3389/fmolb.2022.997295>

Ennist, N. M., Mancini, J. A., Auman, D. B., Bialas, C. P., Iwanicki, M. J., Esipova, T. V., Discher, B. M., Moser, C. C., Dutton, P. L. (2017). "Maquette Strategy for Creation of Light- and Redox-Active Proteins." *Photosynthesis and Bioenergetics*. Ed. Barber, J. and Ruban, A.V. World Scientific Publishers. https://doi.org/10.1142/9789813230309_0001

Moser, C. C., **Ennist N. M.**, Mancini, J. M., Dutton, P. L. (2017). “Making Maquette Models of Bioenergetic Structures.” Mechanisms of Primary Energy Transduction in Biology. Ed. Wikström, Marten: Royal Society of Chemistry. <https://doi.org/10.1039/9781788010405-00001>

Moser C. C., Sheehan M. M., **Ennist N. M.**, Kodali G., Bialas C. P., Englander M. T., Discher, B. M., Dutton, P. L. (2016). De Novo Construction of Redox Active Proteins. *Methods in Enzymology* **580**, 365-88. <https://doi.org/10.1016/bs.mie.2016.05.048>

Farid, T. A., Kodali, G., Solomon, L. A., Lichtenstein, B. R., Sheehan, M. M., Fry, B. A., Bialas, C. P., **Ennist, N. M.**, Siedlecki, J. A., Zhao, Z. Y., Stetz, M. A., Valentine, K. G., Anderson, J. L. R., Wand, A. J., Discher, B. M., Moser, C. C., and Dutton, P. L. (2013). Elementary Tetrahelical Protein Design for Diverse Oxidoreductase Functions. *Nature Chemical Biology* **9**(12), 826-833. <https://doi.org/10.1038/nchembio.1362>

Lichtenstein, B. R., Farid, T. A., Kodali, G., Solomon, L. A., Anderson, J. L. R., Sheehan, M. M., **Ennist, N. M.**, Fry, B. A., Chobot, S. E., Bialas, C. P., Mancini, J. A., Armstrong, C. T., Zhao, Z. Y., Esipova, T. V., Snell, D., Vinogradov, S. A., Discher, B. M., Moser, C. C., and Dutton, P. L. (2012). Engineering Oxidoreductases: Maquette Proteins Designed from Scratch. *Biochemical Society Transactions* **40**(3), 561-566. <https://doi.org/10.1042/BST20120067>

Manuscripts in Preparation

Ennist, N. M., Swartz, A., Liu, C., Curti, M., Sutherland, G. A., Hunter, C. N., Reppert, M., Baker, D. De novo design of multi-chromophoric light harvesting proteins that assemble chlorophyll and carotenoid rings.

Patents

Kodali, G., Sheehan, M. M., Mancini, J. A., Discher, B. M., Magaraci, M., **Ennist, N. M.**, Chow, B. Y., Dutton, P. L., Moser, C. C., University of Pennsylvania, 2021. “Artificial proteins and compositions and methods thereof.” U.S. Patent Application 17/362,552.

Baker, D., **Ennist, N. M.**, Wang, S., Hicks, D., Moyer, A., University of Washington, 2024. “*De novo* designed chlorophyll special pair proteins.” U.S. Provisional Patent Application 63/636,001.

Invited Talks

Ennist, N. M. (2022) “Designing proteins for photosynthesis”, Institut Català d'Investigació Química Seminar, February 23, Tarragona, Spain.

Ennist, N. M. (2019) “Designing light harvesting proteins *de novo*”, Photosynthesis Gordon Research Seminar, July 20, Newry, ME.

Ennist, N. M. (2019) “Designing LH2-like chlorophyll-binding proteins for efficient energy transfer”, Symposium in Honor of P. Leslie Dutton, May 31, Philadelphia, PA.

Ennist, N. M., Stayrook, S. E., Moser, C. C., and Dutton, P. L. (2017) “Developing an Artificial Photosynthetic System”, Photosynthetic Antenna Research Center All Hands Meeting, June 21, St. Louis, MO.

Ennist, N. M. (2017) “Design, structure, and action of an artificial photosynthetic reaction center”, Imperial College London, June 9, London, United Kingdom.

Ennist, N. M., Stayrook, S. E., Moser, C. C., and Dutton, P. L. (2016) “Engineering a new photosystem”, Friday Research Discussions, May 13, Philadelphia, PA.

Ennist, N. M., Stayrook, S. E., Moser, C. C., and Dutton, P. L. (2014) “Photosystem II as a model for solar energy conversion”, Friday Research Discussions, December 12, Philadelphia, PA.

Ennist, N. M., Stayrook, S. E., Moser, C. C., and Dutton, P. L. (2014) “Engineering a new photosystem: Crystal structure and functional studies”, Dr. George W. Raiziss Retreat, November 20-21, Skytop, PA.

Ennist, N. M., Stayrook, S. E., Moser, C. C., and Dutton, P. L. (2014) “Designing man-made photosystem II”, Johnson Foundation Britton Chance Research Discussions, April 22, Philadelphia, PA.

Ennist, N. M., Kodali, G., Stayrook, S. E., Moser, C. C., and Dutton, P. L. (2014) “A manmade protein engineered for solar energy conversion”, Friday Research Discussions, March 7, Philadelphia, PA.

Poster Presentations

Ennist, N. M., Swartz, A., Lund-Andersen, P., Sutherland, G. A., Morey-Burrows, F. S., Wang, S., Liu, C., Curti, M., Maffei, V., Shareef, S., Kennedy, M. A., Moyer, A. P., Hicks, D. R., Ahern, W., Wang, J., Vasilev, C., Redler, R. L., Ekiert, D., Bhabha, G., Stewart, L., Stoddard, B. L., Romero, E., Hunter, C. N., Baker, D. (2023) “*De novo* design of proteins for light harvesting and charge separation”, Gordon Research Conference on Photosynthesis, July 23-28, Newry, ME.

Ennist, N. M., Wang, S., Swartz, A., Sutherland, G. A., Kennedy, M. A., Moyer, A. P., Hicks, D. R., Curti, M., Sica, A. V., Hua, A. S., Deshmukh, A. P., Lund-Andersen, P., Vasilev, C., Redler, R. L., Ekiert, D., Bhabha, G., Stewart, L., Caram, J. R., Stoddard, B. L., Romero, E., Hunter, C. N., Baker, D. (2023) “*De novo* designed proteins for artificial photosynthesis”, ARPA-E Energy Innovation Summit, March 22-24, National Harbor, MD.

Ennist, N. M., Brunette, T. J., Xu, C., Lu, P., Hicks, D., Cacho, R., Moyer, A., and Baker, D. A. (2019) “Designing LH2-like chlorophyll-binding proteins for excitonic coupling and efficient energy transfer”, Gordon Research Conference on Photosynthesis, July 21-26, Newry, ME.

Ennist, N. M., Moyer, A., Hicks, D., Xu, C., Brunette, T. J., and Baker, D. A. (2019) “Design of light harvesting proteins for photosynthesis”, 33rd Annual Symposium of the Protein Society, June 30-July 3, Seattle, WA.

Ennist, N. M., Moyer, A., Hicks, D., Cacho, R., Roy, A., Brunette, T. J., and Baker, D. A. (2018) “Designed multi-ligand symmetric complexes for artificial photosynthesis”, RosettaCon, August 7-10, Leavenworth, WA.

Ennist, N. M., Stayrook, S. E., Moser, C. C., and Dutton, P. L. (2017) “Design, structure, and action of an artificial photosynthetic reaction center”, Gordon Research Conference on Photosynthesis, July 16-21, Newry, ME.

Kodali, G., Solomon, L. A., Englander, M. T., Lichtenstein, B. R., Farid, T. A., Anderson, J. L. R., Sheehan, M. M., **Ennist, N. M.**, Fry, B. A., Bialas, C., Mancini, J. A., Zhao, Z., Discher, B. M., Moser, C. C., Dutton, P. L. (2014) “Design and engineering of man-made protein maquettes for diverse functions”, 247th American Chemical Society National Meeting & Exposition, March 16-20, Dallas, TX.

Ennist, N. M., Kodali, G., Moser, C. C., and Dutton, P. L. (2013) “Assembly of a photoactivatable cofactor triad within a designed protein”, Biophysical Society 57th Annual Meeting, February 2-6, Philadelphia, PA.

Ennist, N. M., Zhao, Z. Y., Farid, T. A., Solomon, L. A., Kodali, G., Moser, C. C., and Dutton, P. L. (2012) “Cofactor dyad and triad assembly in designed proteins”, Dr. George W. Raiziss 29th Annual Retreat, June 14-15, Swarthmore, PA.

Kodali, G., Farid, T. A., Solomon, L. A., Lichtenstein, B. R., Anderson, J.R., Mass, O.A., Esipova, T. V., Patole, S., Sheehan, M. M., **Ennist, N. M.**, Fry, B. A., Bialas, C. P., Mancini, J. A., Zhao, Z., Vinogradov, S. A., Hunter, C. N., Lindsey, J. S., Discher, B. M., Moser, C. C., and Dutton, P. L. (2012) “Single designed protein platform with multiple functionalities: Oxidoreductase, oxygen transport, light-harvesting, and light activated electron transfer”, 244th American Chemical Society National Meeting & Exposition, August 19-23, Philadelphia, PA.

Ennist, N. M., Farid, T. A., Kodali, G., and Dutton, P. L. (2012) “Design and characterization of a multi-cofactor binding protein with implications for photoactivated water oxidation”, Biophysical Society 56th Annual Meeting, February 25-29, San Diego, CA.

Ennist, N. M., Robertson, W. D., and Warncke, K. (2009) “Developing a Biologically-Inspired Molecular Solar Energy Conversion Device: Formation and Reaction of Cob(I)alamin with Carbon Dioxide in Solution and in the EutB Protein of Ethanolamine Ammonia-Lyase”, Emerson Awards Symposium, March 2, Atlanta, GA.

Recognitions and Awards

- Homeworld Collective grant*** “De novo protein design for photochemical water oxidation and renewable solar fuels”
Principal Investigator of a \$93,866 grant to design new proteins that assemble high-potential metal-oxo clusters with the goal of photochemical water oxidation, [DOI: 10.18258/56489](https://doi.org/10.18258/56489)
January 15, 2024 —
January 15, 2025
- Manifest Climate grant:*** “Enhancing photosynthesis through de novo protein design”
Principal Investigator of a \$38,500 grant to design high-potential bacteriochlorophyll proteins thermodynamically capable of water oxidation using near-infrared light
October 2023 —
December 2025
- Pacific Northwest Center for Cryo-EM (PNCC) General Access grant*** “De novo design of photosynthetic proteins for efficient light harvesting, charge separation, and fuel production”
Applied for and was awarded 120 hours of cryo-EM microscope time.
December 14, 2023 —
December 14, 2025
- Advanced Research Projects Agency-Energy (ARPA-E) grant:*** “Harvesting Infrared Light to Improve Photosynthetic Biomass Production”
Wrote research proposal on behalf of Baker group and was awarded \$1,347,122 grant to computationally design and test near-infrared-powered photosystem proteins for artificial photosynthesis
March 28, 2022 —
March 27, 2025
- Photosynthetic Antenna Research Center Newsletter Featured Researcher of the Month***
Recognition for research excellence in the field of light harvesting for photosynthesis.
July 2017
- Photosynthetic Antenna Research Center Scientific Exchange Program Award***
Award to study engineering of photosynthetic processes in laboratory of Neil Hunter at the University of Sheffield, UK. Funds were provided by the Energy Frontier Research Center parent grant.
May 15, 2017 —
June 15, 2017
- Sigma Pi Sigma—The Physics Honor Society***
Membership for outstanding academic performance in physics
May 2008 — present
- National Society of Collegiate Scholars***
Award for scholarship, leadership, and service
April 2007 — present
- Jackson Fellowship***
Grant from Emory University Department of Physics to research reactivity of cob(I)alamin with carbon dioxide for fuel production
May 2008 — August 2008

NCAA Division III All-Academic Cross-Country Team
 Recognition for outstanding academic performance and overall finish
 at NCAA Regional and National Cross-Country Championships

2007, 2008

Professional Societies

Biophysical Society (BPS), member since 2011
 American Association for the Advancement of Science (AAAS), member since 2009
 American Chemical Society (ACS), member since 2009

Teaching and Mentorship Experience

<p><i>Mentorship at the Institute for Protein Design</i> Mentoring of two Ph.D. students and two undergraduate students working on protein design for solar energy conversion with funding from the Advanced Research Projects Agency-Energy.</p>	<p>Fall 2020 – present</p>
<p><i>Science Teaching Experience Program – Working in Science Education (STEP-WISE) Fellowship</i> Designed and taught an undergraduate seminar course on renewable energy which was featured in an article on the University of Washington Bothell website: https://www.uwb.edu/news/february-2020/postdoc-teaching-experience Worked closely with mentor Dr. Rebecca Price to train in scientific teaching with inclusive, student-centered pedagogies.</p>	<p>Fall 2019 – Spring 2020</p>
<p><i>Invited Guest Microbiology Lecturer at Pacific Lutheran University</i> Invited to teach an undergraduate class on photosynthetic bacteria implementing active learning strategies</p>	<p>Winter 2020</p>
<p><i>Review Committee Member for IPD Undergraduate Summer Research Fellowship</i></p>	<p>Winter 2020</p>
<p><i>Biomedical Research Integrity Discussion Facilitator</i> Led a series of discussions on responsible conduct of research and conflicts of interest for postdocs and graduate students.</p>	<p>Summer 2019</p>
<p><i>Calculus I and II Teaching Assistant</i> Organized and taught review sessions for Emory Calculus I and II students. Received Certificate of Excellence.</p>	<p>Fall 2006 – Spring 2007</p>

Extracurricular Activities

Member of Birds Connect Seattle (formerly Seattle Audubon Society)

2019 – present

Member of the Meadowbrook Community Garden and Orchard	2018 – 2022
Friends of the Wissahickon Valley Park	2015 – 2017
Philadelphia Runner Track Club	2010 – 2017
Penn Running Club	Fall 2011 – Spring 2016
Emergency Medical Technician (EMT Intermediate-85)	Spring 2008
Certification in National Registry of Emergency Medical Technicians	
Emory University Varsity Cross-Country and Track & Field teams	Fall 2005 – Spring 2009