Prof. Frances Hamilton Arnold
Linus Pauling Professor of Chemical Engineering, Bioengineering and Biochemistry, Nobel laureate in Chemistry, 2018

Most important awards, prizes and academies

Membership of Professional Societies: Royal Academy of Engineering (UK); American Philosophical Society; American Academy of Arts and Sciences; National Academy of Sciences (USA); National Academy of Medicine (USA); National Academy of Engineering (USA); American Chemical Society; American Institute of Chemical Engineers; Fellow, American Association for the Advancement of Science Fellow, American Society for Microbiology; Fellow, American Institute for Medical and Biological Engineering. Honours (Citations, Awards, etc.) 2019 Honorary Doctorate, Technical University of Denmark; 2019 SynBioBeta Pioneer in Synthetic Biology Award; 2019 Bower Award for Advancement in Science, Franklin Institute; 2018 Nobel Prize in Chemistry, Royal Swedish Academy of Sciences; 2018 International Fellow, UK Royal Academy of Engineering; 2018 American Philosophical Society; 2017 Society of Women Engineers Lifetime Achievement Award; 2017 Margaret H Rousseau Pioneer Award, AIChE; 2017 Rotary Humanitarian Heroes of Science & Technology Award; 2017 Robert Fletcher Award and Honorary Doctorate, Dartmouth University; 2017 National Academy of Sciences Sackler Prize in Convergence Research; 2016 Millennium Technology Prize, Technology Academy Finland; 2016

Honorary Doctorate, University of Chicago; 2015 Honorary Doctorate, ETH Zurich; 2015 Elmer Gaden Award, Biotechnology & Bioengineering; 2014 Fellow, National Academy of Inventors; 2014 Golden Plate Award, Academy of Achievement; 2014 US National Inventors Hall of Fame; 2013 Eni Prize in Renewable and Nonconventional Energy; 2013 Doctorate honoris causa, Stockholm University; 2011 US National Medal of Technology and Innovation; 2011 Charles Stark Draper Prize of the National Academy of Engineering; 2011 Fellow, American Academy of Arts and Sciences; 2009 Fellow, American Association for the Advancement of Science; 2009 Fellow, American Academy of Microbiology; 2008 Elected to the National Academy of Sciences; 2008 Technology Review TR10 (10 emerging technologies for 2008); 2007 Enzyme Engineering Award, Engineering Foundation; 2007 FASEB Excellence in Science Award; 2005 Garvin-Olin Medal, American Chemical Society; 2005 Food, Pharmaceuticals, and Bioengineering Division Award, AIChE 2004 Elected to the Institute of Medicine of the National Academies; 2003 Carothers Award, American Chemical Society Delaware Division; 2003 David Perlman Lecture Award, American Chemical Society, BIOT; 2001 Fellow, American institute for Medical and Biological Engineering; 2000 Elected to the National Academy of Engineering; 2000 Professional Progress Award, American Institute of Chemical Engineers; 1995 American Institute of Chemical Engineers, Separations Division Graduate Research; Paper Award (with V. Sundaresan); 1989 NSF Presidential Young Investigator Award; 1989 David and Lucile Packard Fellowship in Science and Engineering; 1989 Whitaker Foundation Investigator; 1988 Office of Naval Research Young Investigator Award (Molecular Biology) 1979 Phi Beta Kappa, Tau Beta Pi.

Summary of scientific research

We study Nature’s powerful biological design process, evolution. We use it to optimize existing proteins and create new ones, thereby circumventing our profound ignorance of how sequence encodes function. With ‘directed evolution’ and chemical understanding, we have generated whole new enzyme families that catalyze synthetically important chemical reactions not known in biology. These new capabilities increase the scope of molecules and materials we can build using biological systems and move us closer to a sustainable world where chemical synthesis can be fully programmed in DNA.

Selected Peer-reviewed Publications

C.N. Bedbrook, K. Yang, J.E. Robinson, V. Gradinaru, F.H. Arnold. “Machine Learning-Guided Channelrhodopsin Engineering Enables Minimally-Invasive Optogenetics. *Nature Methods*, published online October 14, 2019: https://www.nature.com/articles/s41592-019-0583-8; I. Cho, Z.-J. Jia, F.H. Arnold “Site-Selective Enzymatic C-H Amidation for Synthesis of Diverse Lactams.” *Science* 364, 575-578 (2019). doi: 10.1126/science.aaw9068; Z. Wu, S.B.J. Kan, R.D. Lewis, B.J. Wittmann, F.H. Arnold “Machine-Learning-Assisted Directed Protein Evolution with Combinatorial Libraries.” *Proceedings of the National Academy of Sciences* 116(18), 8852-8858 (2019). doi: 10.1073/pnas.1901979116; R.K. Zhang, K. Chen, X, Huang, L. Wohlschlager, H. Renata, F.H. Arnold. "Enzymatic Assembly of Carbon-Carbon Bonds via Iron-Catalysed *sp3* C-H

Functionalization" *Nature* 565, 67-72 (2019). doi: 10.1038/s41586-018-0808-5; K. Chen, X. Huang, S.B.J. Kan, R.K. Zhang, F.H. Arnold, “Enzymatic Construction of Highly Strained Carbocyles.” *Science* 360, 71-75 (2018). doi: 10.1126/science.aar4239; S.B.J. Kan, X. Huang, Y. Gumulya, K. Chen, F.H. Arnold, “Genetically Programmed Chiral Organoborane Synthesis.” *Nature* 552, 132-136 (2017). doi: 10.1038/nature24996; C.K. Prier, R.K. Zhang, A.R. Buller, S. Brinkmann-Chen, F.H. Arnold, “Enantioselective, Intermolecular Benzylic C-H Amination Catalyzed by an Engineered Iron-Haem Enzyme.” *Nature Chemistry* 9, 629-634 (2017). doi:10.1038/NCHEM.2783; S.B.J. Kan, R.D. Lewis, K. Chen, F.H. Arnold. “Directed Evolution of Cytochrome *c* for Carbon–Silicon Bond Formation: Bringing Silicon to Life.” *Science* 354, 1048-1051 (2016). doi:10.1126/science.aah6219; J.K.B. Cahn, S. Brinkmann-Chen, A.R. Buller, F.H. Arnold, “Artificial Domain Duplication Replicates Evolutionary History of Ketol-Acid Reductoisomerases.” *Protein Science* 25, 1241-1248 (2016). doi:10.1002/pro.2852; A.R. Buller, S. Brinkmann-Chen, D.K. Romney, M. Herger, J. Murciano-Calles, F.H. Arnold, “Directed Evolution of the Tryptophan Synthase b-Subunit for Stand-Alone Function Recapitulates Allosteric Activation.” *Proceedings of the National Academy of Sciences USA* 112, 14599-14604 (2015). doi:10.1073/pnas.1516401112; J.A. McIntosh, P.S. Coelho, C.C. Farwell, Z.J. Wang, J.C. Lewis, T.R. Brown, F.H. Arnold, “Enantioselective Intramolecular C-H Amination Catalyzed by Engineered Cytochrome P450 Enzymes *in vitro* and *in vivo*.” *Angewandte Chemie International Edition* 52*, 9309-9312 (2013)*; P. S. Coelho, E. M. Brustad, A. Kannan, F.H. Arnold. “Olefin Cyclopropanation via Carbene Transfer Catalyzed by Engineered Cytochrome P450 Enzymes.” *Science* 339, 307-310 (2013); P.A. Romero, A. Krause, F.H. Arnold, “Navigating the Protein Fitness Landscape with Gaussian Processes.” *Proc. Natl. Acad. Sci. USA* 110(3), E193-E201 (2012); R. Fasan, Y. T. Meharenna, C.D. Snow, T.L. Poulos, F.H. Arnold, “Evolutionary History of a Specialized P450 Propane Monooxygenase.” *J. Mol. Biol.* 383(5): 1069-1080 (2008); J. D. Bloom, S. Labthavikul, C. R. Otey, F. H. Arnold, “Protein Stability Promotes Evolvability.” *Proceedings of the National Academy of Sciences* 103, 5869-5874 (2006); D.A. Drummond, J.D. Bloom, C. Adami, C. Wilke, F.H. Arnold, “Why Highly Expressed Proteins Evolve Slowly.” *Proc. Natl. Acad. Sci.,* 102**,** 14338-14343 (2005); D.A. Drummond, J.J. Silberg, M.M. Meyer, C.O. Wilke, F.H. Arnold, “On the Conservative Nature of Intragenic Recombination.” *Proc. Natl. Acad. Sci.* 102**,** 5380-5385 (2005); J.D. Bloom, J.J. Silberg, C.O. Wilke, D.A. Drummond, C. Adami, F.H. Arnold, “Thermodynamic Prediction of Protein Neutrality.” *Proc. Natl. Acad. Sci.* 102**,** 606-611 (2005); S. Basu, Y. Gerchman, C.H. Collins, F.H. Arnold, R. Weiss, “A Synthetic Multicellular System for Programmed Pattern Formation.” *Nature* 434, 1130-1134 (2005); L. You, R. S. Cox III, R. Weiss, F. H. Arnold, “Programmed Population Control by Cell-Cell Communication and Regulated Killing.” *Nature* 428**,** 868-871 (2004); Y. Yokobayashi, R. Weiss, F.H. Arnold, “Directed Evolution of a Genetic Circuit,” *Proceedings of the National Academy of Sciences USA* 99, 16587-16591 (2002); C.A. Voigt, C. Martinez, Z.-G. Wang, S. L. Mayo, F.H. Arnold, “Protein Building Blocks Preserved by Recombination.” *Nature Structural Biology* 9, 553-558 (2002); T. Thorsen, R.W. Roberts, F.H. Arnold, S.R. Quake, “Dynamic Pattern Formation in a Vesicle-Generating Microfluidic Device,” *Physical Review Letters* 86, 4163-4166 (2001); C. Schmidt-Dannert, D. Umeno, F.H. Arnold, “Molecular Breeding of Carotenoid Biosynthetic

Pathways.” *Nature Biotechnology* 18, 750-753 (2000); B. Spiller, A. Gershenson, F.H. Arnold, R.C. Stevens, “A Structural View of Evolutionary Divergence.” *Proceedings of the National Academy of Sciences USA* 96, 12305-12310 (1999); L. Giver, A. Gershenson, P.-O. Freskgard, F.H. Arnold, “Directed Evolution of a Thermostable Esterase.” *Proc. Natl. Acad. Sci. USA* 95, 12809-12813 (1998); H. Zhao, L. Giver, Z. Shao, J.A. Affholter, F.H. Arnold, "Molecular Evolution by Staggered Extension Process (StEP) *in vitro* Recombination." *Nature Biotechnology* 16, 258-262 (1998); F.H. Arnold, "Design by Directed Evolution." *Accounts of Chemical Research* 31, 125-131 (1998); J.C. Moore, F.H. Arnold, "Directed Evolution of a para-Nitrobenzyl Esterase for Aqueous-Organic Solvents." *Nature Biotechnology* 14, 458-467 (1996); K. Chen, F.H. Arnold, "Tuning the Activity of an Enzyme for Unusual Environments: Sequential Random Mutagenesis of Subtilisin E for Catalysis in Dimethylformamide." *Proc. Natl. Acad. Sci. USA* 90, 5618-5622 (1993). *Selected Book Chapters, Reviews, Commentaries, Editorials*: F.H. Arnold, “Innovation by Evolution: Bringing New Chemistry to Life (Nobel Lecture).” *Angewandte Chemie Int. Ed.* 58, 2-9 (2019). doi: 10.1002/anie.201907729; F. H. Arnold, “The Library of Maynard-Smith: My Search for Meaning in the Protein Universe"; J. D. Bloom, F. H. Arnold, “In the Light of Directed Evolution: Pathways of Adaptive Protein Evolution.” *PNAS* 106 (suppl. 1), 9995-10000 (2009); F.H. Arnold, P.L. Wintrode, K. Miyazaki, A. Gershenson,“ How Enzymes Adapt: Lessons from Laboratory Evolution.” *Trends in Biochemical Sciences* 26, 100-106 (2001); F.H. Arnold, "Directed Evolution: Creating Biocatalysts for the Future," *Chemical Engineering Science* 51, 5091-5102 (1996).