

Curriculum Vitae

David R. Liu

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EDUCATION

- Ph.D. in Organic Chemistry, University of California at Berkeley, May 1999
- B.A. in Chemistry, *Summa Cum Laude*, Harvard College, June 1994 (ranked 1st out of 1,641)
- High School-University Program at University of California, Riverside
- Riverside Poly High School, Riverside, CA (ranked 1st out of 397)

RESEARCH INTERESTS

Chemical biology; novel therapeutics; molecular evolution; genome editing; macromolecule delivery *in vitro* and *in vivo*; cellular RNA; organic chemistry

TRAINING

- 1991-1994
(B.A. research) Conducted research in synthetic organic chemistry, biochemistry, and molecular biology on 2,3-oxidosqualene cyclase, a key enzyme in steroid biosynthesis, under the guidance of Professor E. J. Corey at Harvard University.
- 1994-1999
(Ph.D. research) Probed the mechanism of chorismate mutases using site-directed natural and unnatural amino acid mutagenesis; initiated the first general effort to incorporate unnatural amino acids site-specifically into proteins in living cells. Research conducted under the guidance of Professor Peter G. Schultz at the University of California, Berkeley.

POSITIONS

- 1999-2003 Assistant Professor of Chemistry and Chemical Biology, Harvard University
- 2003-2004 John L. Loeb Associate Professor of the Natural Sciences and Associate Professor of Chemistry and Chemical Biology, Harvard University
- 2005-present Professor of Chemistry and Chemical Biology, Harvard University
- 2005-present Investigator, Howard Hughes Medical Institute
- 2005-2015 Senior Associate Member of the Broad Institute of Harvard and MIT (2010-present); Associate Member of the Broad Institute of Harvard and MIT (2005-2010)
- 2006-2011 Co-Director, Chemical Biology Graduate Program, a trans-school graduate program of Harvard's Faculty of Arts and Sciences and the Harvard Medical School
- 2007-2010 Harvard College Professor, Harvard University
- 2012-present Associate Faculty Member, Harvard Microbial Sciences Initiative
- 2015-present Institute Member, Broad Institute of Harvard and MIT
- 2016-present Associate Faculty Member, Wyss Institute for Biologically Inspired Engineering

- 2016-present Core Institute Member and Vice-Chair of the Faculty, Broad Institute of Harvard and MIT
- 2016-present Director, Chemical Biology and Therapeutics Science (CBTS) Program at the Broad Institute
- 2017-present Richard Merkin Professor and Director of the Merkin Institute of Transformative Technologies in Healthcare at the Broad Institute of Harvard and MIT

DISTINCTIONS (FOR ACADEMICS AND RESEARCH)

- 1990 Westinghouse National Science Talent Search, second place in the U.S.
- 1990 One of 20 high school students in the U.S. named to the *USA Today* All-USA 1st Academic High School Team (21 May 1990 issue of *USA Today*)
- 1990 One of five students in the U.S. selected to attend the 1990 Nobel Prize Award Ceremonies in Stockholm, Sweden
- 1990 Harvard Detur Prize recipient
- 1990 National Merit Scholar; Barry M. Goldwater National Scholar for excellence in science
- 1992-3 Pfizer Corporation Central Research Undergraduate Summer Research Fellow (two years)
- 1993 Elected to Phi Beta Kappa as one of twelve Junior Men at Harvard;
- 1994 Thomas T. Hoopes Prize for outstanding senior thesis, "Studies on 2,3-Oxidosqualene Cyclase: A Synthetic and Molecular Biological Approach", shared with Professor E. J. Corey
- 1994 One of 20 college students in the U.S. named to the *USA Today* All-USA 1st Academic College Team (4 Feb 1994 issue of *USA Today*)
- 1994 Sophia Freund Prize winner as the top-ranking graduate of Harvard College, class of 1994
- 1994 National Defense Science and Engineering Graduate Fellowship (1994-1995)
- 1995 Howard Hughes Medical Institute Predoctoral Fellowship (1995-1999)
- 1997 Roche Award for Excellence in Organic Chemistry
- 1998 Elected to the Harvard Society of Fellows as a Harvard Junior Fellow (declined)
- 1999 Awarded a Life Sciences Research Foundation Postdoctoral Fellowship (declined)
- 1999 Research Corporation Research Innovation Award
- 2000 Searle Scholars Program Awardee
- 2000 Office of Naval Research Young Investigator Award
- 2001 American Cancer Society Research Scholar
- 2001 NSF CAREER Award
- 2002 Arnold and Mabel Beckman Foundation Young Investigator
- 2002 Alfred P. Sloan Foundation Research Fellow
- 2003 AstraZeneca Pharmaceuticals Excellence in Chemistry Award
- 2003 Merck Genome-Related Pilot Research Award
- 2003 *Synlett* and *Synthesis* Editorial Board Assistant Professor Journal Award
- 2004 *Small Times* Magazine Researcher of the Year (Nov./Dec. 2004 issue)
- 2004 Named to the *Popular Science* "Brilliant 10" recognizing ten scientists in the U.S. (Oct. 2004 issue)
- 2004 Named to the MIT *Technology Review* TR100 as "one of the world's top young innovators"
- 2004 Glaxo-Smith-Kline Chemistry Scholarship Award
- 2004 American Chemical Society Arthur C. Cope Young Scholar Award
- 2005 World Technology Award Fellow in Materials
- 2005 Yoshimasa Hirata Memorial Lecture (Nagoya University, Japan; lecture given in 2006)

- 2005 Selected to be a Howard Hughes Medical Institute Investigator
- 2006 American Chemical Society Pure Chemistry Award
- 2008-9 Member of the Defense Sciences Study Group (DSSG)
- 2009 Joined JASON, academic advisors to the U. S. government on science and technology
- 2015 Jack J. Fox Visiting Professor Lecture, Memorial Sloan-Kettering Cancer Center
- 2016 George Stamatoyannopoulos Lecture, American Society of Gene & Cell Therapy
- 2016 Named to the *Nature Biotechnology* Top 20 Translational Researchers of 2015
- 2017 Alvin Taurog Lecture in Pharmacology (University of Texas Southwestern Medical Center)
- 2017 Named to the *Foreign Policy* Leading Global Thinkers of 2017
- 2017 Named to the *Nature's* 10 (ten researchers in the world) of 2017
- 2017 Base editing named one of four 2017 Breakthrough of the Year finalists by *Science*
- 2018 Cornell University Halocarbon Lecturer
- 2018 Ronald Breslow Award for Achievement in Biomimetic Chemistry
- 2018 National Institutes of Health Marshall W. Nirenberg Lecturer
- 2018 Xconomy Big Idea Award Winner

DISTINCTIONS (FOR TEACHING AND TRAINING)

- 2003 Roslyn Abramson Award for undergraduate teaching at Harvard (university-wide, one of two in 2003)
- 2003 Thomas T. Hoopes prize shared with Yi-Ching Ong for her outstanding Senior Thesis
- 2004 Thomas T. Hoopes prize shared with Rozalina Grubina for her outstanding Senior Thesis; Rozalina's thesis also earned the 2004 Lawrence J. Henderson Prize as the "best in the Biochemical Sciences"
- 2004 Camille Dreyfus Teacher-Scholar Award
- 2005 Former Liu Group graduate student Dr. Zev Gartner named one of four worldwide winners of the 2005 IUPAC Prize for Young Chemists for "best Ph.D. thesis in the chemical sciences"
- 2007 Senior faculty awardee of the 2007 Joseph R. Levenson Memorial Teaching Prize for undergraduate teaching (university-wide, chosen by the undergraduate student body)
- 2007 Appointed as a Harvard College Professor in recognition of undergraduate teaching, graduate-student teaching, and research accomplishments
- 2009 Thomas T. Hoopes prize shared with Meera Atreya for her outstanding Senior Thesis
- 2011 Former Liu Group graduate student Dr. Kevin Esvelt received a Harold W. Weintraub Graduate Student Award, a national honor to recognize outstanding achievement in graduate research
- 2011 Former Liu Group graduate student Dr. Kevin Esvelt received the Fannie and John Hertz Foundation Doctoral Thesis Prize to recognize "overall excellence and pertinence to high-impact applications of the physical sciences"
- 2017 Former Liu Group graduate student Ahmed Badran was one of 10 finalists in the world for the 2017 Reaxys Ph.D. Prize, recognizing outstanding Ph.D. research in the chemical sciences

SERVICE AND ACTIVITIES OUTSIDE HARVARD UNIVERSITY

- Editorial Advisory Board, *ACS Central Science* (American Chemical Society)
- Editorial Advisory Board, *ACS Combinatorial Science*
- Editorial Board, *ACS Synthetic Biology* (American Chemical Society)
- Editorial Board, *Current Opinion in Chemical Biology* (Elsevier)
- Editorial Board, *Cell Chemical Biology* (formerly *Chemistry and Biology*)
- Editorial Advisory Board, *Chemical Reviews* (American Chemical Society)

- Editorial Advisory Board, *ChemBioChem* (Wiley-VCH)
- Ad hoc member, Bioorganic Chemistry and Natural Products (BNP), Synthetic and Biological Chemistry A (SBCA), and Synthetic and Biological Chemistry B (SBCB) NIH study sections
- Founder, and Chair of Scientific Advisory Board, Ensemble Therapeutics (Cambridge, MA)
- Founder, and Chair of Scientific Advisory Board, Permeon Biologics (Cambridge, MA)
- Co-Founder, and Scientific Advisory Board Member, Editas Medicine (Cambridge, MA)
- Co-Founder, and Scientific Advisory Board Member, Pairwise Plants (Cambridge, MA)
- Co-Founder, and Chair of Scientific Advisory Board, Beam Therapeutics (Cambridge, MA)
- Scientific Advisory Board Member, Moderna Therapeutics (Cambridge, MA) (2011-2015)
- Scientific Advisory Board Member, Tevard Biosciences (Cambridge, MA)
- Scientific Advisory Board Member, Wuxi Biologics (Shanghai, China)
- Member, JASON (2009-present); Steering Committee Member, JASON (2014-present)
- Member, Defense Sciences Study Group (DSSG, 2008-2009)

TEACHING EXPERIENCE

Fall 1999-2000, Fall 2000-2001, Fall 2002-2003, Fall 2003-2004, Fall 2016-2017, Fall 2017-2018: Chemistry 170 (Chemical Biology). I wrote this graduate-level course from hundreds of papers in the primary chemical and biological literature. Topics included: physical properties of nucleic acids and proteins, non-natural nucleotides, novel biosyntheses of proteins, mechanistic enzymology, *de novo* protein design, protein engineering, nucleic acid catalysis, emerging roles of RNA (including RNAi), molecular evolution, DNA damage and repair, novel natural proteins (GFP, inteins, catalytic antibodies, and prions), metabolic engineering, molecular mechanisms of drug resistance, rational design of macromolecular ligands, combinatorial approaches to small molecule discovery, chemical genetics, introduction to genomics, introduction to proteomics. Enrollment is approximately 60 students (two-thirds undergraduates). Committee for Undergraduate Education (CUE) instructor rating by students (out of 5.0): 4.5 ('99-'00); 4.6 ('00-'01); 4.6 ('02-'03); 4.6 ('03-'04); 4.7 ('16-'17); 3.9 ('17-'18).

Spring 2001-2002: Chemistry 27 (Organic Chemistry of Life). This course presents the organic chemistry behind many fundamental biological processes and was first developed by colleagues including Professor Stuart Schreiber and Professor Matthew Shair. Topics include protein structure, peptide sequencing, polypeptide synthesis, proteases, enzyme mechanisms, cofactors, signal transduction, nucleic acid structure and synthesis, DNA-damaging reagents, nonribosomal peptide biosynthesis, polyketide biosynthesis, and terpene biosynthesis. Enrollment is approximately 230 undergraduates. Committee for Undergraduate Education (CUE) instructor rating by students (out of 5.0): 4.1 ('01-'02).

Fall 2005-2006, Spring 2005-2006, Fall 2006-2007: Life Sciences 1a (An Integrated Introduction to the Life Sciences). I co-created this new course—the largest natural science course offered at Harvard—to combine key components of general chemistry, organic chemistry, molecular biology, and cell biology into an integrated introduction to the life sciences. What are the fundamental features of living systems? What are the molecules that impart these features, and how do their chemical properties explain their biological roles? The answers to these questions form the basis for an understanding of the molecules of life, the cell, diseases, and medicines. In contrast with a traditional presentation of relevant scientific disciplines in separate courses, the above concepts are examined through an integrated presentation of concepts framed within central problems such as HIV and cancer. Enrollment is approximately 600 undergraduates (predominantly first-year undergraduates). Committee for Undergraduate Education (CUE) instructor rating by students (out of 5.0): 4.6 (fall '05-'06); 4.8 (spring '05-'06); 4.2 (fall '06-'07).

Fall 2008-2009, Fall 2009-2010, Fall 2010-2011, Fall 2011-2012, Fall 2012-2013, Fall 2013-2014, Fall 2014-2015: Science of Living Systems 11 (Molecules of Life). This course, co-created and co-taught with Professor Jon Clardy, is one of the first General Education courses offered at Harvard. It evolved from an earlier Core Curriculum class (Science B-47) co-taught by Professor Jon Clardy and Professor Stuart Schreiber. SLS11 explores the relationships between large molecules and small molecules in living systems. Illustrative examples come

from sexual development, metabolism, behavior, nerve transmission, infectious disease, cancer, diabetes, and stem cells. The course also emphasizes the increasing importance of genetic studies in identifying the molecular alterations underlying differences in human behavior, susceptibility to disease, and methods of drug discovery. As a General Education course, SLS11 relates these scientific concepts to problems of wide concern, and presents their historical, social, economic, or ethical context. Weekly hands-on activities, including simple experiments and roleplaying exercises, are integrated with lecture concepts. This course seeks to prepare students for civic engagement by equipping them with a basic understanding of the scientific principles underlying genes, proteins, and medicines, and also by identifying specific social issues at the crossroads of science and society such as privacy in the era of the inexpensive genome, the ways genes and small molecules combine to govern human behavior, and the extraordinary challenges associated with fighting disease and developing new drugs. Enrollment is approximately 100-250 undergraduates. Committee for Undergraduate Education (CUE) instructor rating by students (out of 5.0): 4.7 ('08-'09); 4.2 ('09-'10); 4.2 ('10-'11); 4.6 ('11-'12); 4.5 ('12-'13); 4.6 ('13-'14); 4.5 ('14-'15)

PUBLICATIONS (FROM B.A. AND PH.D. RESEARCH)

1. "The Methyl Group at C(10) of 2,3-Oxidosqualene Is Crucial to the Correct Folding of This Substrate in the Cyclization-Rearrangement Step of Sterol Biosynthesis" Corey, E. J.; Virgil, S. C.; Liu, D. R.; Sarshar, S. J. *Am. Chem. Soc.* **114**, 1524-1525 (1992).
2. "First Demonstration of a Carbocation-Olefin Cyclization Route to the Lanosterol Series" Corey, E. J.; Lee, J. M.; Liu, D. R. *Tetrahedron Lett.* **35**, 9149-9152 (1994).
3. "Molecular Cloning of the Human Gene Encoding Lanosterol Synthase From a Liver cDNA Library" Baker, C. H.; Matsuda, S. P.; Liu, D. R.; Corey, E. J. *Biochem. Biophys. Res. Comm.* **213**, 154-160 (1995).
4. "Mutagenesis Study of Active Site Residues in Chorismate Mutase from *Bacillus Subtilis*" Cload, S. T.; Liu, D. R.; Pastor, R. M.; Schultz, P. G. *J. Am. Chem. Soc.* **118**, 1787-1788 (1996).
5. "Analysis of Active Site Residues in *Escherichia coli* Chorismate Mutase by Site-Directed Mutagenesis" Liu, D. R.; Cload, S. T.; Pastor, R. M.; Schultz, P. G. *J. Am. Chem. Soc.* **118**, 1789-1790 (1996).
6. "Development of Improved tRNAs for *In Vitro* Biosynthesis of Proteins Containing Unnatural Amino Acids" Cload, S. T.; Liu, D. R.; Froland, W. A.; Schultz, P. G. *Chem. Biol.* **3**, 1033-1038 (1996).
7. "Characterization of an 'Orthogonal' Suppressor tRNA Derived from *E. coli* tRNA^{Gln}" Liu, D. R.; Magliery, T. J.; Schultz, P. G. *Chem. Biol.* **4**, 685-691 (1997).
8. "Engineering a tRNA and Aminoacyl-tRNA Synthetase for the Site-Specific Incorporation of Unnatural Amino Acids into Proteins *in Vivo*" Liu, D. R.; Magliery, T. J.; Pastrnak, M.; Schultz, P. G. *Proc. Natl. Acad. Sci.* **94**, 10092-10097 (1997).
9. "Generating New Molecular Function: A Lesson from Nature" Liu, D. R. and Schultz, P. G. *Angew. Chem. Intl. Ed. Engl.* **38**, 36-54 (1999).
10. "Progress Towards the Evolution of an Organism with an Expanded Genetic Code" Liu, D. R. and Schultz, P. G. *Proc. Natl. Acad. Sci. USA*, **96**, 4780-4785 (1999).
11. "A New Functional Suppressor tRNA/Aminoacyl-tRNA Synthetase Pair for the *in Vivo* Incorporation of Unnatural Amino Acids into Proteins" Wang, L.; Magliery, T. J.; Liu, D. R.; Schultz, P. G. *J. Am. Chem. Soc.* **122**, 5010-5011 (2000).

PUBLICATIONS (AS A PRINCIPAL INVESTIGATOR)

12. "Enzyme Mechanisms for Polycyclic Triterpene Formation" Wendt, K. U.; Schulz, G. E.; Corey, E. J.; Liu, D. R. *Angew. Chem. Intl. Ed. Engl.* **39**, 2813-2833 (2000).
13. "The Generality of DNA-Templated Synthesis as a Basis for Evolving Non-Natural Small Molecules" Gartner, Z. J. and Liu, D. R. *J. Am. Chem. Soc.* **123**, 6961-6963 (2001). A Highlight describing this work appears in *Angew. Chem. Intl. Ed.* **41**, 89-90 (2002).

14. "An *In Vivo* Selection System for Homing Endonuclease Activity" Gruen, M.; Chang, K.; Serbanescu, I.; Liu, D. R. *Nucleic Acids Research* **30**, e29 (2002).
15. "Recent Advances in the *In Vitro* Evolution of Nucleic Acids" Bittker, J. A.; Phillips, K. J.; Liu, D. R. *Curr. Opin. Chem. Biol.*, **6**, 367-374 (2002).
16. "Expanding the Reaction Scope of DNA-Templated Synthesis" Gartner, Z. J.; Kanan, M. W.; Liu, D. R. *Angew. Chem. Int. Ed.*, **41**, 1796-1800 (2002). This work is featured in an online *Nature Science Update* (http://www.nature.com/nsu/nsu_pf/020527/020527-1.html).
17. "Nucleic Acid Evolution and Minimization by Nonhomologous Random Recombination" Bittker, J. A.; Le, B. V.; Liu, D. R. *Nat. Biotechnol.* **20**, 1024-1029 (2002).
18. "Multistep Small-Molecule Synthesis Programmed by DNA Templates" Gartner, Z. J.; Kanan, M. W.; Liu, D. R. *J. Am. Chem. Soc.*, **124**, 10304-10306 (2002). News stories describing this work appear in *Chem. & Eng. News* **80** [34] 12 (2002), and in *Science*, **300**, 242 (2003).
19. "Directing Otherwise Incompatible Reactions in a Single Solution Using DNA-Templated Organic Synthesis" Calderone, C. T.; Puckett, J. W.; Gartner, Z. J.; Liu, D. R. *Angew. Chem. Int. Ed.* **41**, 4104-4108 (2002). This work is featured as an Editor's Choice in *Science* **298** [5598], 1517 (2002).
20. "Two Enabling Architectures for DNA-Templated Organic Synthesis" Gartner, Z. J.; Grubina, R.; Calderone, C. T.; Liu, D. R. *Angew. Chem. Int. Ed.* **42**, 1370-1375 (2003). A Science and Technology Concentrate describing this work appears in *Chem. & Eng. News* **81** [13] 24 (2003).
21. "*In Vivo* Evolution of an RNA Transcriptional Activator" Buskirk, A. R.; Kehayova, P. D.; Landrigan, A.; Liu, D. R. *Chem. Biol.* **10**, 533-540 (2003). This paper is noted as an article of interest in *Cell* **113** (7) and previewed in a separate article in *Chem. Biol.* **10**, 584-585 (2003).
22. "Stereoselectivity in DNA-Templated Organic Synthesis and Its Origins" Li, X. and Liu, D. R. *J. Am. Chem. Soc.* **125**, 10188-10189 (2003).
23. "Highly Sensitive *In Vitro* Selections for DNA-Linked Synthetic Small Molecules with Protein Binding Affinity and Specificity" Doyon, J. B.; Snyder, T. M.; Liu, D. R. *J. Am. Chem. Soc.* **125**, 12372-12373 (2003).
24. "Efficient and Sequence-Specific DNA-Templated Polymerization of PNA Aldehydes" Rosenbaum, D. M. and Liu, D. R. *J. Am. Chem. Soc.* **125**, 13924-13925 (2003). This work is highlighted in a Science and Technology story in *Chem. & Eng. News* **82** [3] 64 (2004).
25. "Expanding the Genetic Code *In Vitro* and *In Vivo*" Magliery, T. J.; Liu, D. R. in *The Genetic Code and the Origin of Life* Ed. Ribas de Pouplana, L. Landes Bioscience and Springer, (2004).
26. "Translation of DNA into Synthetic *N*-Acyloxazolidines" Li, X.; Gartner, Z. J.; Tse, B. N.; Liu, D. R. *J. Am. Chem. Soc.* **126**, 5090-5092 (2004).
27. "DNA-Templated Organic Synthesis: Nature's Strategy for Controlling Chemical Reactivity Applied to Synthetic Molecules" Li, X.; Liu, D. R. *Angew. Chem. Int. Ed.* **43**, 4848-4870 (2004). This paper was selected by the *Angewandte Chemie* Editorial Board as one of the 12 best *Angewandte Chemie* review articles in 2004.
28. "Directed Evolution of Protein Enzymes Using Nonhomologous Random Recombination" Bittker, J. A.; Le, B. V.; Liu, J. M.; Liu, D. R. *Proc. Natl. Acad. Sci. USA* **101**, 7011-7016 (2004).
29. "Engineering a Ligand-Dependent RNA Transcriptional Activator" Buskirk, A. R.; Landrigan, A.; Liu, D. R. *Chem. Biol.* **11**, 1157-1163 (2004). This work is featured in a Research Highlight in *Nat. Methods* **1**, 6-7 (2004).
30. "Directed Evolution of Ligand Dependence: Small Molecule-Dependent Protein Splicing" Buskirk, A. R.; Ong, Y.-C.; Gartner, Z. J.; Liu, D. R. *Proc. Natl. Acad. Sci. USA* **101**, 10505-10510 (2004).

31. "DNA-Templated Organic Synthesis and Selection of a Library of Macrocycles" Gartner, Z. J.; Tse, B. N.; Grubina, R.; Doyon, J. B.; Snyder, T. M.; Liu, D. R. *Science* **305**, 1601-1605 (2004). Featured as a Research Highlight in *Nat. Biotechnol.* **22**, 1247 (2004).
32. "Reaction Discovery Enabled by DNA-Templated Synthesis and In Vitro Selection" Kanan, M. W.; Rozenman, M. M.; Sakurai, K.; Snyder, T. M.; Liu, D. R. *Nature* **431**, 545-549 (2004). This work is featured in a news focus article in *Science* **305**, 1558 (2004), in a Science and Technology Concentrate in *Chem. & Eng. News* **82** [40], 31 (2004), and in a News and Views commentary in *Nat. Biotechnol.* **22**, 1378-1379 (2004).
33. "Nucleic Acid-Templated Synthesis as a Model System for Ancient Translation" Calderone, C. T. and Liu, D. R. *Curr. Opin. Chem. Biol.* **8**, 645-653 (2004).
34. "In Vitro Characterization of IroB, a Pathogen-Associated C-Glycosyltransferase" Fischbach, M. A.; Lin, H.; Liu, D. R.; Walsh, C. T. *Proc. Natl. Acad. Sci. USA* **102**, 571-576 (2005).
35. "Creating Small Molecule-Dependent Switches to Modulate Biological Functions" Buskirk, A. R. and Liu, D. R. *Chem. Biol.* **12**, 151-161 (2005).
36. "DNA-Templated Functional Group Transformations Enable Sequence-Programmed Synthesis Using Small-Molecule Reagents" Sakurai, K.; Snyder, T. M.; Liu, D. R. *J. Am. Chem. Soc.* **127**, 1660-1661 (2005).
37. "Functional Dissection of sRNA Translational Regulators Using Nonhomologous Random Recombination and In Vivo Selection" Liu, J. M.; Bittker, J. A.; Lonshteyn, M.; Liu, D. R. *Chem. Biol.* **12**, 757-767 (2005).
38. "In Vitro Characterization of Salmochelin and Enterobactin Trilactone Hydrolases IroD, IroE, and Fes" Lin, H.; Fischbach, M. A.; Liu, D. R.; Walsh, C. T. *J. Am. Chem. Soc.* **127**, 11075-11084 (2005).
39. "Ordered Multistep Synthesis in a Single Solution Directed by DNA Templates" Snyder, T. M. and Liu, D. R. *Angew. Chem. Int. Ed.* **44**, 7379-7382 (2005).
40. "Small-Molecule Diversification From Iterated Branching Reaction Pathways Enabled by DNA-Templated Synthesis" Calderone, C. T. and Liu, D. R. *Angew. Chem. Int. Ed.* **44**, 7383-7386 (2005).
41. "DNA-Templated Synthesis in Organic Solvents" Rozenman, M.; Liu, D. R. *ChemBioChem* **7**, 253-256 (2006).
42. "Enzymatic Tailoring of Enterobactin Alters Membrane Partitioning and Iron Acquisition" Luo, M.; Lin, H.; Fischbach, M. A.; Liu, D. R.; Walsh, C. T.; Groves, J. T. *ACS Chem. Biol.* **1**, 29-32 (2006).
43. "Directed Evolution and Substrate Specificity Profile of Homing Endonuclease I-SceI" Doyon, J.; Pattanayak, V.; Meyer, C. B.; Liu, D. R. *J. Am. Chem. Soc.* **128**, 2477-2484 (2006).
44. "How Pathogenic Bacteria Evade Mammalian Sabotage in the Battle for Iron" Fischbach, M. A.; Lin, H.; Liu, D. R.; Walsh, C. T. *Nat. Chem. Biol.* **2**, 132-138 (2006).
45. "A Protein Interaction Surface in Nonribosomal Peptide Synthesis Mapped by Combinatorial Mutagenesis and Selection" Lai, J. R.; Fischbach, M. A.; Liu, D. R.; Walsh, C. T. *Proc. Natl. Acad. Sci. USA* **103**, 5314-5319 (2006).
46. "Control of Transcription Factor Activity and Osteoblast Differentiation in Mammalian Cells Using an Evolved Small-Molecule-Dependent Intein" Yuen, C. M.; Rodda, S. J.; Vokes, S. A.; McMahon, A. P.; Liu, D. R. *J. Am. Chem. Soc.* **128**, 8939-8946 (2006). This work is featured in a Science and Technology Concentrate in *Chem & Eng. News* **84** [26], 34 (2006), as a Spotlight in *ACS Chem. Biol.* **1**, 328 (2006), and as a News and Views article in *Nature* **442**, 517-518 (2006).
47. "Bromoenterobactins as Potent Inhibitors of a Pathogen-Associated, Siderophore-Modifying C-Glycosyltransferase" Lin, H.; Fischbach, M. A.; Gatto Jr., G. J.; Liu, D. R.; Walsh, C. T. *J. Am. Chem. Soc.* **128**, 9324-9325 (2006).
48. "Localized Protein Interaction Surfaces on the EntB Carrier Protein Revealed by Combinatorial Mutagenesis and Selection" Lai, J. R.; Fischbach, M. A.; Liu, D. R.; Walsh, C. T. *J. Am. Chem. Soc.* **128**, 11002-11003 (2006).

49. "Binding and Stability Determinants of the PPAR γ Nuclear Receptor/Coactivator Interface as Revealed by Shotgun Alanine Scanning and In Vivo Selection" Phillips, K. J.; Rosenbaum, D. M.; Liu, D. R. *J. Am. Chem. Soc.* **128**, 11298-11306 (2006).
50. "The Pathogen-Associated *iroA* Gene Cluster Mediates Bacterial Evasion of Lipocalin 2" Fischbach, M.A.; Lin, H.; Zhou, L.; Yu, Y.; Abergel, R. J.; Liu, D. R.; Raymond, K. N.; Wanner, B. L.; Strong, R. K.; Walsh, C. T.; Aderem, A.; Smith, K. D. *Proc. Natl. Acad. Sci. USA* **103**, 16502-16507 (2006).
51. "In Vivo Evolution of an RNA-Based Transcriptional Silencing Domain in *S. cerevisiae*" Kehayova, P. D. and Liu, D. R. *Chem. Biol.* **14**, 65-74 (2007). This work is featured in a Research Highlight in *Nat. Methods* **4**, 297 (2007).
52. "Synthesis of Acyclic α,β -Unsaturated Ketones via Pd(II)-Catalyzed Intermolecular Reaction of Alkynamides and Alkenes" Momiyama, N.; Kanan, M. W.; Liu, D. R. *J. Am. Chem. Soc.* **129**, 2230-2231 (2007).
53. "Solving Chemical Problems Through the Application of Evolutionary Principles" Rozenman, M. M.; McNaughton, B. R.; Liu, D. R. *Curr. Opin. Chem. Biol.* **11**, 259-268 (2007).
54. "Directed Evolution Can Rapidly Improve the Activity of Chimeric Assembly-Line Enzymes" Fischbach, M. A.; Lai, J. R.; Roche, E. D.; Walsh, C. T.; Liu, D. R. *Proc. Natl. Acad. Sci. USA* **104**, 11951-11956 (2007).
55. "Supercharging Proteins Can Impart Extraordinary Resilience" Lawrence, M. S.; Phillips, K. J.; Liu, D. R. *J. Am. Chem. Soc.* **129**, 10110-10112 (2007). This work is featured in a Research Highlight in *Nature* **448**, 973 (2007) and in a News & Views article in *Nature* **449**, 555 (2007).
56. "Identification of Eukaryotic Promoter Regulatory Elements Using Nonhomologous Random Recombination" Doyon, J. B.; Liu, D. R. *Nucleic Acids Res.* **35**, 5851-5860 (2007).
57. "Dissecting Protein Structure and Function Using Directed Evolution" Yuen, C. M.; Liu, D. R. *Nat. Methods* **4**, 995-997 (2007).
58. "Discovery of a mRNA Mitochondrial Localization Element in *Saccharomyces cerevisiae* by Nonhomologous Random Recombination and In Vivo Selection" Liu, J. M.; Liu, D. R. *Nucleic Acids Res.* **35**, 6750-6761 (2007).
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1. Adenosine nucleobase editors and uses thereof	10,113,163
2. Cas9 proteins including ligand-dependent inteins	10,077,453
3. <i>In situ</i> interaction determination	10,053,725
4. Reactivity-dependent and interaction-dependent PCR	10,011,868
5. Delivery of negatively charged proteins using cationic lipids	9,999,671
6. Methods for nucleic acid editing	9,840,699
7. Apparatus for continuous directed evolution of proteins and nucleic acids	9,771,574
8. Use of cationic lipids to deliver Cas9	9,737,604
9. Macrocyclic insulin-degrading enzyme inhibitors and uses thereof	9,610,322
10. Delivery system for functional nucleases	9,526,784
11. Protein surface remodeling	9,434,774
12. Continuous directed evolution	9,394,537
13. Cas9-recombinase fusion proteins and uses thereof	9,388,430
14. Engineered transcription activator-like effector (TALE) domains and uses thereof	9,359,599
15. Extended DNA-sensing gRNAs	9,340,800
16. mRNA-sensing switchable gRNAs	9,340,799
17. Cas9-FokI fusions proteins and uses thereof	9,322,037
18. Evaluation and improvement of nuclease cleavage specificity	9,322,006
19. Evolution of bond-forming enzymes	9,267,127
20. Macrocyclic insulin-degrading enzyme (IDE) inhibitors and uses thereof	9,243,038
21. Switchable gRNAs comprising aptamers	9,228,207
22. Supercharged proteins for cell penetration	9,221,886
23. Small molecule-dependent inteins and uses thereof	9,200,045
24. Reactivity-dependent and interaction-dependent PCR	9,753,340
25. Methods for identifying a target site of a Cas9 nuclease	9,163,284
26. Methods and compositions for orthogonal tRNA-aminoacyl tRNA synthetase pairs	9,163,271
27. Protein surface remodeling	9,150,626
28. Methods for correcting presenilin point mutations	9,068,179
29. Continuous directed evolution of proteins and nucleic acids	9,023,594
30. Macrocyclic kinase inhibitors and uses thereof	8,975,232
31. Reaction discovery system	8,691,729
32. Evolving new molecular function	8,206,914
33. Iterated branching reaction pathways via nucleic acid-mediated chemistry	8,183,178
34. Methods and composition for orthogonal tRNA-aminoacyl tRNA synthetase pairs	8,183,012
35. <i>In vivo</i> incorporation of unnatural amino acids	8,173,392
36. Methods and composition for orthogonal tRNA-aminoacyl tRNA synthetase pairs	8,173,364
37. <i>In vivo</i> incorporation of unnatural amino acids	8,114,648
38. <i>In vivo</i> incorporation of unnatural amino acids	8,030,074
39. RNA-based transcriptional regulators	8,017,755
40. Free reactant use in nucleic acid-templated synthesis	8,017,323

41. Methods and compositions for orthogonal tRNA-aminoacyl-tRNA synthetase pairs	8,012,739
42. Evolving new molecular function	7,998,904
43. In vivo incorporation of unnatural amino acids	7,915,025
44. Palladium-catalyzed carbon-carbon bond forming reactions	7,851,658
45. Directed evolution of proteins	7,807,408
46. Evolving new molecular function	7,771,935
47. Methods and composition for orthogonal tRNA-aminoacyl tRNA synthetase pairs	7,713,721
48. Nucleic acid shuffling	7,678,554
49. In vivo incorporation of unnatural amino acids	7,638,300
50. Evolving new molecular function	7,557,068
51. Ligand-dependent protein splicing	7,541,450
52. Evolving new molecular function	7,491,494
53. Nucleotide analogs	7,476,734
54. In vivo selection system for enzyme activity	7,476,500
55. Evolving new molecular function	7,442,160
56. In vivo incorporation of unnatural amino acids	7,368,275
57. Methods and composition for orthogonal tRNA-aminoacyl tRNA synthetase pairs	7,354,761
58. Evolving new molecular function	7,223,545
59. Ligand-dependent protein splicing	7,192,739
60. Methods and compositions for orthogonal tRNA-aminoacyl tRNA synthetase pairs	7,083,970
61. Evolving new molecular function	7,070,928
62. In vivo incorporation of unnatural amino acids	7,045,337