Stanford

Drew Endy

Associate Professor of Bioengineering

Bio

BIO

Drew Endy is a member of the bioengineering faculty at Stanford University and BioBricks Foundation president (biobricks.org). His research teams pioneered amplifying genetic logic, rewritable DNA data storage, reliably-reuseable standard biological parts, and genome refactoring. Drew helped launch the new undergraduate majors in bioengineering at both MIT and Stanford; he also co-founded the iGEM competition, a global genetic engineering “olympics” now engaging over 6,000 students annually (igem.org). In 2013 the White House recognized Drew for his work on open-source biotechnology and, more recently, he received an honorary doctorate from the Technische Universiteit Delft. Drew has served on the US National Science Advisory Board for Biosecurity and the Committee on Science, Technology, & Law; he currently serves on the World Health Organization’s Smallpox Advisory Committee. Drew lives in Menlo Park, California with Christina Smolke (Stanford colleague & Antheia, Inc., CEO), their two boys, and two cats. Drew was a co-founder of Gen9, Inc., a DNA construction company; he returned to serve as a director while Gen9 was successfully acquired. Drew worked briefly with the Rapid Evaluation team at Google [X] and also served on the building project team for the Shriram Center at Stanford. He is a founding co-director of the NIST/Stanford Joint Initiative for Metrology in Biology (jimb.stanford.edu). Esquire magazine recognized Drew as one of the 75 most influential people of the 21st century.

ACADEMIC APPOINTMENTS

- Associate Professor, Bioengineering
- Member, Bio-X

ADMINISTRATIVE APPOINTMENTS

- President, The BioBricks Foundation, (2006- present)
- Co-Director, Joint Initiative for Metrology in Biology (Stanford/NIST), (2015- present)

HONORS AND AWARDS

- CORES Champion, Stanford Data Science Initiative (2021)
- Elected Fellow, American Institute for Medical and Biological Engineering (2021)
- Honorary Doctorate, Technische Universiteit Delft (TU Delft) (2017)
- Presidential Champion of Change, The White House (2013)
- The Seymour Benzer Lectureship, US National Academy of Sciences (2013)
- Most Influential People of the 21st Century, Esquire (2009)
- Certificate of Appreciation, Synthetic Biology Study Chair, DARPA (2003)
- Kavli Fellow, US National Academies of Sciences (2012)
- Best Research Article for 2012, Journal of Biological Engineering (2012)

- Best Research Article for 2011, Journal of Biological Engineering (2011)
- Terman Fellow, Stanford University (2008)
- Best & Brightest, Esquire (2007)
- Cabot Career Development Award, MIT (2005)
- WIRED Rave Awards, WIRED (2005)
- Certificate of Service, DARPA ISAT (2004)
- Goodrich Prize, Thayer School, Dartmouth College (1998)
- Darling Fellowship, Thayer School, Dartmouth College (1994)
- Arthur Humphrey Teaching Award, Lehigh University (1993)

BOARDS, ADVISORY COMMITTEES, PROFESSIONAL ORGANIZATIONS

- Member, IUCN Taskforce on Synthetic Biology and Biodiversity Conservation, International Union for Conservation of Nature (2018 - present)
- Committee Member, WHO Advisory Committee on Variola Virus Research, World Health Organization (2016 - present)

PROFESSIONAL EDUCATION

- PhD, Dartmouth , Biotechnology & Biochemical Engineering (1998)
- MS, Lehigh , Environmental Engineering (1994)
- BS, Lehigh , Civil Engineering (1992)

LINKS

- http://endy.web.stanford.edu/: http://endy.web.stanford.edu/

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

We work to strengthen the foundations and expand the frontiers of synthetic biology. Our foundational work includes (i) advancing reliable reuse of bio-measurements and -materials via standards that enable coordination of labor, and (ii) developing and integrating measurement and modeling tools for representing and analyzing living matter at whole-cell scales. Our work beyond the frontiers of current practice includes (iii) bootstrapping biotechnology tools in unconventional organisms (e.g., mealworms, wood fungus, skin microbes), and (iv) exploring the limits of whole-genome recoding and building cells from scratch. We also support strategy and policy work related to bio-safety, security, economy, equity, justice, and leadership.

Teaching

COURSES

2021-22

- Introduction to Bioengineering (Engineering Living Matter): BIOE 80 (Spr)
- Inventing the Future: BIOE 177 (Win)

2020-21

- Ethics in Bioengineering: BIOE 131 (Spr)
- Introduction to Bioengineering (Engineering Living Matter): BIOE 80 (Sum)
- Inventing the Future: BIOE 177 (Win)

2019-20

- Bioengineering Departmental Research Colloquium: BIOE 393 (Aut)

- Introduction to Bioengineering (Engineering Living Matter): BIOE 80, ENGR 80 (Spr)
- Inventing Synthetic Biosystems: BIOE 199A (Spr)

2018-19

- Bioengineering Departmental Research Colloquium: BIOE 393 (Aut)
- Educational Practice in Bioengineering: BIOE 296 (Aut)
- Introduction to Bioengineering (Engineering Living Matter): BIOE 80, ENGR 80 (Spr)

STANFORD ADVISEES

Med Scholar Project Advisor

Akshay Maheshwari

Doctoral Dissertation Reader (AC)

Alp Sunol

Doctoral Dissertation Advisor (AC)

Kaisha Benjamin, Jonathan Calles, Anton Jackson-Smith, Akshay Maheshwari

Doctoral Dissertation Co-Advisor (AC)

Leron Perez

Doctoral (Program)

Jonathan Calles, Michael Chavez, Jesse Gibson, Anton Jackson-Smith, Luis Mille Fragoso, Vivian Zhong

Publications

PUBLICATIONS

- **Modeling the colloidal physics of translation elongation in E. coli**
  Maheshwari, A., Gonzalez-Gonzalez, E., Sunol, A. M., Endy, D., Zia, R. N.
  CELL PRESS.2022: 122

- **Correction to 'Fail-safe genetic codes designed to intrinsically contain engineered organisms'.** *Nucleic acids research*
  Calles, J., Justice, I., Brinkley, D., Garcia, A., Endy, D.
  1800

- **Growing a circular economy with fungal biotechnology: a white paper.** *Fungal biology and biotechnology*
  Meyer, V., Basenko, E. Y., Benz, J. P., Braus, G. H., Caddick, M. X., Csukai, M., de Vries, R. P., Endy, D., Frisvad, J. C., Gunde-Cimerman, N., Haarmann, T., Hadar, Y., Hansen, et al
  2020; 7: 5

- **A View from the Counter Terrorism Foxhole: Drew Endy** *Counter Terrorism Center at West Point Sentinel (CTC Sentinel)*
  Hummel, S., Cruickshank, P., Rassler, D.
  2020; 13 (10): 23-34

- **Enabling community-based metrology for wood-degrading fungi.** *Fungal biology and biotechnology*
  Perez, R., Luccioni, M., Kamakaka, R., Clamons, S., Gaut, N., Stirling, F., Adamala, K. P., Silver, P. A., Endy, D.
  2020; 7: 2

- **Development of CRISPR as an Antiviral Strategy to Combat SARS-CoV-2 and Influenza.** *Cell*
  Abbott, T. R., Dhamdhere, G. n., Liu, Y. n., Lin, X. n., Goudy, L. n., Zeng, L. n., Chemparathy, A. n., Chmura, S. n., Heaton, N. S., Debs, R. n., Pande, T. n., Endy, D. n., La Russa, et al
  2020

- **Permutational analysis of Saccharomyces cerevisiae regulatory elements.** *Synthetic biology (Oxford, England)*

Dhillon, N., Shelansky, R., Townshend, B., Jain, M., Boeger, H., Endy, D., Kamakaka, R.
2020; 5 (1): ysaa007

- **Colloidal hydrodynamics of biological cells: A frontier spanning two fields** *PHYSICAL REVIEW FLUIDS*
Maheshwari, A. J., Sunol, A. M., Gonzalez, E., Endy, D., Zia, R. N.
2019; 4 (11)

- **Definitive demonstration by synthesis of genome annotation completeness.** *Proceedings of the National Academy of Sciences of the United States of America*
Jaschke, P. R., Dotson, G. A., Hung, K. S., Liu, D., Endy, D.
2019

- **Modeling the Brownian hydrodynamics of intracellular motion**
Zia, R., Maheshwari, A., Endy, D., Gonzalez, E., Sunol, A.
AMER CHEMICAL SOC.2019

- **MILESTONE MEETINGS** *NATURE*
Gewin, V., Karim, Q., Endy, D., Taylor, J., Schultz, J.
2019; 571 (7766): S86–S87

- **Author Correction: Reconstruction of cysteine biosynthesis using engineered cysteine-free enzymes.** *Scientific reports*
Fujishima, K., Wang, K. M., Palmer, J. A., Abe, N., Nakahigashi, K., Endy, D., Rothschild, L. J.
2019; 9 (1): 6242

- **Reconstruction of cysteine biosynthesis using engineered cysteine-free enzymes (vol 8, 1776, 2018)** *SCIENTIFIC REPORTS*
Fujishima, K., Wang, K. M., Palmer, J. A., Abe, N., Nakahigashi, K., Endy, D., Rothschild, L. J.
2019; 9

- **Fail-safe genetic codes designed to intrinsically contain engineered organisms.** *Nucleic acids research*
Calles, J. n., Justice, I. n., Brinkley, D. n., Garcia, A. n., Endy, D. n.
2019

- **Tools for Multispecies Futures** *Journal of Design and Science*
Haraway, D., Endy, D.
2019; 1 (4)

- **MILESTONE MEETINGS** *NATURE*
Gewin, V., Karim, Q., Endy, D., Taylor, J., Schultz, J.
2018; 564 (7736): S86–S87

- **Opening options for material transfer.** *Nature biotechnology*
Kahl, L., Molloy, J., Patron, N., Matthewman, C., Haseloff, J., Grewal, D., Johnson, R., Endy, D.
2018; 36 (10): 923–27

- **Reconstruction of cysteine biosynthesis using engineered cysteine-free enzymes.** *Scientific reports*
Fujishima, K. n., Wang, K. M., Palmer, J. A., Abe, N. n., Nakahigashi, K. n., Endy, D. n., Rothschild, L. J.
2018; 8 (1): 1776

- **Measurements of translation initiation from all 64 codons in E. coli** *NUCLEIC ACIDS RESEARCH*
Hecht, A., Glasgow, J., Jaschke, P. R., Bawazer, L. A., Munson, M. S., Cochran, J. R., Endy, D., Salit, M.
2017; 45 (7): 3615-3626

- **Artificial Symmetry-Breaking for Morphogenetic Engineering Bacterial Colonies.** *ACS synthetic biology*
Nuñez, I. N., Matute, T. F., Del Valle, I. D., Kan, A., Choksi, A., Endy, D., Haseloff, J., Rudge, T. J., Federici, F.
2017; 6 (2): 256-265

- **Artificial Symmetry-Breaking for Morphogenetic Engineering Bacterial Colonies** *ACS SYNTHETIC BIOLOGY*
Nunez, I. N., Matute, T. F., Del Valle, I. D., Kan, A., Choksi, A., Endy, D., Haseloff, J., Rudge, T. J., Federici, F.
2017; 6 (2): 256-265

- **When Wavelengths Collide: Bias in Cell Abundance Measurements Due to Expressed Fluorescent Proteins** *ACS SYNTHETIC BIOLOGY*
Hecht, A., Endy, D., Salit, M., Munson, M. S.

2016; 5 (9): 1024-1027

- **Measurement and modeling of intrinsic transcription terminators.** *Nucleic acids research*
  Cambray, G., Guimaraes, J. C., Mutalik, V. K., Lam, C., Mai, Q. A., Thimmaiah, T., Carothers, J. M., Arkin, A. P., Endy, D.
  2016; 44 (14): 7006
- **Voices of biotech.** *Nature biotechnology*
  Amit, I., Baker, D., Barker, R., Berger, B., Bertozzi, C., Bhatia, S., Biffi, A., Demichelis, F., Doudna, J., Dowdy, S. F., Endy, D., Helmstaedter, M., Junca, et al
  2016; 34 (3): 270-275
- **Detection of pathological biomarkers in human clinical samples via amplifying genetic switches and logic gates** *SCIENCE TRANSLATIONAL MEDICINE*
  Courbet, A., Endy, D., Renard, E., Molina, F., Bonnet, J.
  2015; 7 (289)
- **The Synthetic Biology Open Language (SBOL) provides a community standard for communicating designs in synthetic biology** *NATURE BIOTECHNOLOGY*
  Galdzicki, M., Clancy, K. P., Oberortner, E., Pocock, M., Quinn, J. Y., Rodriguez, C. A., Roehner, N., Wilson, M. L., Adam, L., Anderson, J. C., Bartley, B. A., Beal, J., Chandran, et al
  2014; 32 (6): 545-550
- **One-step cloning and chromosomal integration of DNA.** *ACS synthetic biology*
  St-Pierre, F., Cui, L., Priest, D. G., Endy, D., Dodd, I. B., Shearwin, K. E.
  2013; 2 (9): 537-541
- **Composability of regulatory sequences controlling transcription and translation in Escherichia coli** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Kosuri, S., Goodman, D. B., Cambray, G., Mutalik, V. K., Gao, Y., Arkin, A. P., Endy, D., Church, G. M.
  2013; 110 (34): 14024-14029
- **Amplifying genetic logic gates.** *Science*
  Bonnet, J., Yin, P., Ortiz, M. E., Subsoontorn, P., Endy, D.
  2013; 340 (6132): 599-603
- **Measurement and modeling of intrinsic transcription terminators** *NUCLEIC ACIDS RESEARCH*
  Cambray, G., Guimaraes, J. C., Mutalik, V. K., Lam, C., Quynh-Anh Mai, Q. A., Thimmaiah, T., Carothers, J. M., Arkin, A. P., Endy, D.
  2013; 41 (9): 5139-5148
- **Quantitative estimation of activity and quality for collections of functional genetic elements** *NATURE METHODS*
  Mutalik, V. K., Guimaraes, J. C., Cambray, G., Quynh-Anh Mai, Q. A., Christoffersen, M. J., Martin, L., Yu, A., Lam, C., Rodriguez, C., Bennett, G., Keasling, J. D., Endy, D., Arkin, et al
  2013; 10 (4): 347-?
- **Precise and reliable gene expression via standard transcription and translation initiation elements** *NATURE METHODS*
  Mutalik, V. K., Guimaraes, J. C., Cambray, G., Lam, C., Christoffersen, M. J., Quynh-Anh Mai, Q. A., Tran, A. B., Paull, M., Keasling, J. D., Arkin, A. P., Endy, D.
  2013; 10 (4): 354-?
- **Switches, Switches, Every Where, In Any Drop We Drink** *MOLECULAR CELL*
  Bonnet, J., Endy, D.
  2013; 49 (2): 232-233
- **A survey of enabling technologies in synthetic biology.** *Journal of biological engineering*
  Kahl, L. J., Endy, D.
  2013; 7 (1): 13-?
- **A fully decompressed synthetic bacteriophage empty setX174 genome assembled and archived in yeast** *VIROLOGY*
  Jaschke, P. R., Lieberman, E. K., Rodriguez, J., Sierra, A., Endy, D.
  2012; 434 (2): 278-284
- **Refactored M13 Bacteriophage as a Platform for Tumor Cell Imaging and Drug Delivery** *ACS SYNTHETIC BIOLOGY*
  Ghosh, D., Kohli, A. G., Moser, F., Endy, D., Belcher, A. M.

2012; 1 (12): 576-582

- **Rewritable digital data storage in live cells via engineered control of recombination directionality** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Bonnet, J., Subsoontorn, P., Endy, D.
  2012; 109 (23): 8884-8889
- **Engineered cell-cell communication via DNA messaging.** *Journal of biological engineering*
  Ortiz, M. E., Endy, D.
  2012; 6 (1): 16-?
- **Design and analysis of genetically encoded counters** *3rd International Winter Conference of the Neural-Network-Society (INNS-WC) / 11th International Conference on Bioinformatics (InCoB) / 3rd International Conference on Computational Systems-Biology and Bioinformatics (CSBio)*
  Subsoontorn, P., Endy, D.
  ELSEVIER SCIENCE BV.2012: 43–54
- **Engineered cell-cell communication via DNA messaging** *JOURNAL OF BIOLOGICAL ENGINEERING*
  Ortiz, M. E., Endy, D.
  2012; 6 (1)
- **Scaffold number in yeast signaling system sets tradeoff between system output and dynamic range** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Thomson, T. M., Benjamin, K. R., Bush, A., Love, T., Pincus, D., Resnekov, O., Yu, R. C., Gordon, A., Colman-Lerner, A., Endy, D., Brent, R.
  2011; 108 (50): 20265-20270
- **Can we grow buildings? Concepts and requirements for automated nano- to meter-scale building** *ADVANCED ENGINEERING INFORMATICS*
  Rebolj, D., Fischer, M., Endy, D., Moore, T., Sorgo, A.
  2011; 25 (2): 390-398
- **Editorial-Synthetic Biology** *NUCLEIC ACIDS RESEARCH*
  Collins, J. J., Endy, D., Hutchison, C. A., Roberts, R. J.
  2010; 38 (8): 2513-2513
- **Gemini, a Bifunctional Enzymatic and Fluorescent Reporter of Gene Expression** *PLOS ONE*
  Martin, L., Che, A., Endy, D.
  2009; 4 (11)
- **Measuring the activity of BioBrick promoters using an in vivo reference standard.** *Journal of biological engineering*
  Kelly, J. R., Rubin, A. J., Davis, J. H., Ajo-Franklin, C. M., Cumbers, J., Czar, M. J., de Mora, K., Glieberman, A. L., Monie, D. D., Endy, D.
  2009; 3: 4-?
- **Determination of cell fate selection during phage lambda infection** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  St-Pierre, F., Endy, D.
  2008; 105 (52): 20705-20710
- **The Alpha Project: a model system for systems biology research** *1st q-bio Conference on Cellular Information Processing*
  Yu, R. C., Resnekov, O., Abola, A. P., Andrews, S. S., Benjamin, K. R., Bruck, J., Burbulis, I. E., Colman-Lerner, A., Endy, D., Gordon, A., Holl, M., Lok, L., Pesce, et al
  INST ENGINEERING TECHNOLOGY-IET.2008: 222–33
- **Refinement and standardization of synthetic biological parts and devices** *NATURE BIOTECHNOLOGY*
  Canton, B., Labno, A., Endy, D.
  2008; 26 (7): 787-793
- **Genomics - Reconstruction of the Genomes** *SCIENCE*
  Endy, D.
  2008; 319 (5867): 1196-1197
- **Stimulus design for model selection and validation in cell signaling** *PLOS COMPUTATIONAL BIOLOGY*
  Apgar, J. F., Toettcher, J. E., Endy, D., White, F. M., Tidor, B.

2008; 4 (2)

- **Engineering BioBrick vectors from BioBrick parts.** *Journal of biological engineering*
  Shetty, R. P., Endy, D., Knight, T. F.
  2008; 2: 5-?
- **TABASCO: A single molecule, base-pair resolved gene expression simulator** *BMC BIOINFORMATICS*
  Kosuri, S., Kelly, J. R., Endy, D.
  2007; 8
- **Synthetic genomics - Options for governance** *BIOSECURITY AND BIOTERRORISM-BIODEFENSE STRATEGY PRACTICE AND SCIENCE*
  Garfinkel, M. S., Endy, D., Epstein, G. L., Friedman, R. M.
  2007; 5 (4): 359-361
- **DNA synthesis and biological security** *NATURE BIOTECHNOLOGY*
  Bugl, H., Danner, J. P., Molinari, R. J., Mulligan, J. T., Park, H., Reichert, B., Roth, D. A., Wagner, R., Budowle, B., Scripp, R. M., Smith, J. A., Steele, S. J., Church, et al
  2007; 25 (6): 627-629
- **Engineering life: Building a fab for biology** *SCIENTIFIC AMERICAN*
  Baker, D., Group, B. I., Church, G., Collins, J., Endy, D., Jacobson, J., Keasling, J., Modrich, P., Smolke, C., Weiss, R.
  2006; 294 (6): 44-51
- **Foundations for engineering biology** *NATURE*
  Endy, D.
  2005; 438 (7067): 449-453
- **Regulated cell-to-cell variation in a cell-fate decision system** *NATURE*
  Colman-Lerner, A., Gordon, A., Serra, E., Chin, T., Resnekov, O., Endy, D., Pesce, C. G., Brent, R.
  2005; 437 (7059): 699-706
- **Refactoring bacteriophage T7** *MOLECULAR SYSTEMS BIOLOGY*
  Chan, L. Y., Kosuri, S., Endy, D.
  2005; 1
- **Signal transduction - Molecular monogamy** *NATURE*
  Endy, D., Yaffe, M. B.
  2003; 426 (6967): 614-615
- **Signal transduction. Decoding NF-kappaB signaling.** *Science*
  Ting, A. Y., Endy, D.
  2002; 298 (5596): 1189-1190
- **Modelling cellular behaviour** *NATURE*
  Endy, D., Brent, R.
  2001; 409 (6818): 391-395
- **Computation, prediction, and experimental tests of fitness for bacteriophage T7 mutants with permuted genomes** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Endy, D., You, L. C., Yin, J., Molineux, I. J.
  2000; 97 (10): 5375-5380
- **Toward antiviral strategies that resist viral escape** *ANTIMICROBIAL AGENTS AND CHEMOTHERAPY*
  Endy, D., Yin, J.
  2000; 44 (4): 1097-1099
- **Intracellular kinetics of a growing virus: A genetically structured simulation for bacteriophage T7** *BIOTECHNOLOGY AND BIOENGINEERING*
  Endy, D., Kong, D., Yin, J.
  1997; 55 (2): 375-389

PRESENTATIONS

- Synthetic Biology: What Should We Be Vibrating About? - Stanford University