

# Jared Toettcher

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<http://molbio.princeton.edu/faculty/molbio-faculty/795-toettcher>

## EDUCATION

|   |                              |
|---|------------------------------|
| <b>Massachusetts Institute of Technology</b><br>Ph.D., Biological Engineering                             | Cambridge, MA<br>2004 – 2009 |
| <b>University of California, Berkeley</b><br>B.Sc. with High Honors, Bioengineering<br>Minor: Mathematics | Berkeley, CA<br>2000 – 2004  |

## PROFESSIONAL EXPERIENCE

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| <b>Princeton University</b><br>Assistant Professor of Molecular Biology<br>Associated Faculty, Chemical and Biological Engineering<br>Associated Faculty, Lewis Sigler Institute for Integrative Genomics<br>Member, Cancer Institute of New Jersey | Princeton, NJ<br>2015-present |
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## RESEARCH POSITIONS AND TRAINING

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|--|--------------------------------|
| <b>University of California, San Francisco</b><br>Cancer Research Institute Postdoctoral Fellow<br><i>Mentors:</i> Prof. Wendell Lim and Prof. Orion Weiner<br><i>Topic:</i> Optogenetic approaches for interrogating intracellular signaling                    | San Francisco, CA<br>2009-2014 |
| <b>Massachusetts Institute of Technology</b><br>Graduate Student, Biological Engineering<br><i>Thesis advisors:</i> Prof. Bruce Tidor and Prof. Galit Lahav (Harvard Medical School)<br><i>Thesis:</i> Relating topology and dynamics in cell signaling networks | Cambridge, MA<br>2004 – 2009   |
| <b>University of California, Berkeley</b><br>Undergraduate Student<br><i>Advisors:</i> Prof. Adam Arkin and Prof. David Schaffer<br><i>Topic:</i> Stochastic gene expression in an HIV-1 transcriptional positive feedback loop                                  | Berkeley, CA<br>2002 – 2004    |

## AWARDS AND FELLOWSHIPS

|   |           |
|---|-----------|
| James A. Elkins '41 Preceptorship in Molecular Biology, Princeton Univ. | 2018-2021 |
| NSF CAREER Award  | 2018-2023 |
| NIH Director's New Innovator Award                                      | 2016-2021 |
| Cancer Research Institute Postdoctoral Fellowship                       | 2010-2013 |

NIH Kirschstein Postdoctoral Fellowship  
MIT Presidential Graduate Fellowship  
UC Berkeley Regents' Scholarship

(declined)  
2004  
2000

## PUBLICATIONS

Peer-Reviewed Research Articles:

1. Bugaj LJ, Sabnis A, Mitchell A, Garbarino J, Toettcher JE<sup>\*\*</sup>, Bivona TG<sup>\*\*</sup>, Lim WA<sup>\*\*</sup>. Cancer mutations and targeted drugs can disrupt dynamic signal encoding by the Ras/Erk pathway. **Science** 361:eaao3048 (2018). (\*\* Co-corresponding authors)
  - *Commentary*: Kolch W, Kiel C. From oncogenic mutation to dynamic code. *Science* 361:844-845 (2018).
2. Winer BY, Shirvani-Dastgerdi E, Bram Y, Sellau J, Low BE, Johnson HE, Huang T, Hrebikova G, Heller B, Sharon Y, Giersch K, Gerges S, Seneca K, Pais M-A, Frankel AS, Chiriboga L, Cullen J, Nahass RG, Lutgehetmann M, Toettcher JE, Wiles MV, Schwartz RE, Ploss A. Preclinical assessment of antiviral combination therapy in a genetically humanized mouse model for hepatitis delta virus infection. **Science Translational Medicine** 10:eaap9328 (2018).
3. Tanner LB, Goglia AG, Wei MH, Sehgal T, Parsons L, Park JO, White E, Toettcher JE, Rabinowitz JD. Flux control in mammalian glycolysis resides in a few key pathway steps. **Cell Systems** 7:1-14 (2018).
4. Barrio-Real L, Lopez-Haber C, Casado-Medrano V, Goglia AG, Toettcher JE, Caloca MJ, Kazanietz MG. P-Rex1 is dispensable for Erk activation and mitogenesis in breast cancer. **Oncotarget** 9:28612-24 (2018).
5. Dine E, Gil AA, Uribe G, Brangwynne CP, Toettcher JE. Protein phase separation provides long-term memory of transient spatial stimuli. **Cell Systems** 6:655-663 (2018).
6. Zhao E, Zhang Y, Mehl J, Park H, Lalwani MA, Toettcher JE<sup>\*\*</sup>, Avalos JL<sup>\*\*</sup>. Optogenetic regulation of engineered cellular metabolism for microbial chemical production. **Nature** 555:683-687 (2018). (\*\* Co-corresponding authors)
7. Wilson MZ, Ravindran PT, Lim WA, Toettcher JE. Tracing information flow from Erk to target gene induction reveals mechanisms of dynamic and combinatorial control. **Molecular Cell** 67:1-13 (2017).
8. Johnson HE, Goyal Y, Pannucci N, Schupbach G, Shvartsman SY, Toettcher JE. The spatiotemporal limits of developmental Erk signaling. **Developmental Cell** 40:185-192 (2017).
  - *Commentary*: Shilo BZ, Barkai N. Lighting up ERK activity. *Developmental Cell* 40:115-116 (2017).
  - *Selected by Developmental Cell as one of 12 "Best Of" papers in 2017.*
9. Shin Y, Berry J, Pannucci N, Haataja M, Toettcher JE<sup>\*\*</sup>, Brangwynne CP<sup>\*\*</sup>. Spatiotemporal control of intracellular phase transitions using light-activated optoDroplets. **Cell** 168: 159-171 (2017). (\*\* Co-corresponding authors)
  - *Commentary*: Paci G, Lemke EA. Shining a light on phase separation in the cell. *Cell* 168:11-13 (2017).

10. Diner BA, Lum KK, Toettcher JE, Cristea IM. Viral DNA sensors IF16 and cyclic GMP-AMP synthase possess distinct functions in regulating viral gene expression, immune defenses, and apoptotic responses during herpesvirus infection. **mBio** 7: e01553-16 (2016).
11. Gordley RM, Williams RE, Bashor CJ, Toettcher JE, Yan S, Lim WA. Engineering dynamic control of cell fate switching using synthetic phospho-regulons. **Proc Natl Acad Sci** 113:13528-13533 (2016).
12. Hoeller O\*, Toettcher JE\*, Cai H, Sun Y, Freyre M, Zhou M, Devreotes PN, Weiner OD. G $\beta$  regulates coupling between actin oscillators for cell polarity and directional migration. **PLoS Biology** 14, e1002381 (2016). (\* Co-first authors)
13. Toettcher JE, Weiner OD, Lim WA. Using optogenetics to interrogate the dynamic control of signal transmission by the Ras/Erk module. **Cell** 155:1422-1434 (2013).
  - *Commentary: Featured as "Editor's Choice" in Berndt JD. The lights on Ras avenue. Science Signaling* 10:ec298 (2013).
14. Toettcher JE, Gong D, Lim WA, Weiner OD. Light-based feedback for controlling intracellular signaling dynamics. **Nature Methods** 8:837-839 (2011).
  - *Commentary: Haugh, J. Cells see the light to bring signaling under control. Nature Methods* 8:808-809 (2011).
15. Toettcher JE, Castillo A, Tidor B, White JK. Oscillator sensitivity analysis in the presence of hidden conservation constraints. In **Proceedings of the 48th IEEE Design Automation Conference**, p. 806-811, June 2011.
16. Toettcher JE, Mock C, Batchelor E, Loewer A, Lahav G. A synthetic-natural hybrid oscillator in human cells. **Proc Natl Acad Sci** 107:17047-17052 (2010).
  - *Commentary: Featured as "Editor's Choice" in Ray LB. Oscillator fine-tuning. Science Signal.* 3:ec315 (2010).
17. Toettcher JE\*, Loewer A\*, Ostheimer GJ, Yaffe MB, Tidor B, Lahav G. Distinct mechanisms act in concert to mediate cell cycle arrest. **Proc Natl Acad Sci** 16:785-790 (2009). (\* Co-first authors)
18. Apgar JF, Toettcher JE, Endy D, White FM, Tidor B. Stimulus design for model selection and validation in cell signaling. **PLoS Comput Biol** 4: e30 (2008).
19. Weinberger LS, Burnett JC, Toettcher JE, Arkin AP, Schaffer DV. Stochastic gene expression in a lentiviral positive-feedback loop: HIV-1 Tat fluctuations drive phenotypic diversity. **Cell** 122:169-82 (2005).

Review Articles, Methods Articles and Book Chapters:

1. Dine E, Toettcher JE. Optogenetic reconstitution for determining the form and function of membraneless organelles. **Biochemistry** 57:2432-2436 (2018).
2. Johnson HE, Toettcher JE. Illuminating developmental biology with cellular optogenetics. **Curr Opin Biotechnol** 52:42-48 (2018).
3. Goglia AG, Wilson MZ, DiGiorno DB, Toettcher JE. Optogenetic control of Ras/Erk signaling Using the Phy-PIF system. **Methods Mol Biol.**1636:3-20 (2017).
4. Johnson HE, Toettcher JE. The duty of an intracellular signal: illuminating calcium's role in transcriptional control. **Cell Systems** 2:223-224 (2016).

5. Toettcher JE, Gong D, Lim WA, Weiner OD. Light control of plasma membrane recruitment using the Phy-PIF system. **Methods in Enzymology** 497, 409-423 (2011).
6. Toettcher JE, Apgar JF, Castillo AR, Tidor B, White J. Recycling circuit simulation techniques for mass-action biochemical kinetics. In: Li P, Silveira LM, Feldman P (Eds.), **Advanced Simulation and Verification of Electronic and Biological Systems**. Springer, p. 115-136 (2011).
7. Toettcher JE, Voigt CA, Weiner OD, Lim WA. The promise of optogenetics in cell biology: interrogating molecular circuits in space and time. **Nature Methods** 8, 35-38 (2011).

## PATENTS & PATENT APPLICATIONS

1. Brangwynne CP, Toettcher JE, Shin Y. "Optogenetic tool for rapid and reversible clustering of proteins", US Patent Application No. 20170355977, December 14, 2017.
2. Avalos JL, Toettcher JE, Zhao EM. "System and method of optogenetically controlling metabolic pathways for the production of chemicals", WO 2017177147, October 12, 2017.

## INVITED TALKS AND SEMINARS

|   |                |
|---|----------------|
| Gairdner Awards Symposium on Optogenetics, Toronto, Canada                      | October 2018   |
| BIRS meeting: Mathematics of the Cell, Banff, Canada                            | August 2018    |
| EMBO Workshop: Imaging Mouse Development, Heidelberg, Germany                   | July 2018      |
| Seminar, UConn Health Center, Farmington CT                                     | May 2018       |
| Frontiers in Nanoscience (FNANO) 2018, Snowbird, UT                             | April 2018     |
| Seminar, University of Arizona, Tucson AZ                                       | March 2018     |
| Winter q-Bio Meeting, Wailea, HI  | February 2018  |
| Seminar, Mount Sinai School of Medicine, New York NY                            | February 2018  |
| Seminar, B-SSE Biosystems Dept, ETH Zurich, Switzerland                         | October 2017   |
| Signals from the Invisible Symposium, BIOS Center, Freiburg, Germany            | October 2017   |
| Seminar, Mathematical Biosciences Institute, Ohio State Univ., OH               | September 2017 |
| Seminar, UT Southwestern Dept of Cell Biology, Dallas, TX                       | September 2017 |
| EMBO Practical Course: Optogenetics and Cell Signalling ( <i>co-organizer</i> ) | September 2017 |
| World Economic Forum Meeting of the New Champions, Dalian, China                | June 2017      |
| SignGene Winter School, Eilat, Israel ( <i>seminar and workshop</i> )           | March 2017     |
| Seminar, Caltech Chemical Physics, Pasadena CA                                  | February 2017  |
| ASCB 2016, San Francisco CA ( <i>mini-symposium co-chair and speaker</i> )      | December 2016  |
| Janelia Workshop: Imaging Mouse Development, Ashburn VA                         | June 2016      |
| EMBO Practical Course: Optogenetics and Cell Signalling ( <i>co-organizer</i> ) | May 2016       |
| Seminar, Middle Tennessee State University, Nashville TN                        | April 2016     |
| Seminar, UPenn Center for Molecular Studies, Philadelphia PA                    | April 2016     |
| Lorentz Workshop on Optogenetics, Leiden, Netherlands                           | March 2016     |
| Keystone Symposium on Optogenetics, Denver CO                                   | March 2015     |
| Western Association of Core Directors meeting, Davis CA                         | September 2014 |
| FASEB Meeting on Protein Phosphorylation and Signal Rewiring, Aspen CO          | July 2014      |
| iCEMS Symposium on Light Control in Cell Biology, Kyoto, Japan                  | June 2014      |
| CSHL Meeting on Computational Cell Biology, Cold Spring Harbor NY               | March 2013     |
| INSERM Workshop on Optogenetics, Bordeaux, France                               | September 2012 |

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| LAMPP Seminar, UC Irvine, Irvine CA                                | May 2012      |
| Seminar, NASA Ames Research Center, Mountain View CA               | February 2012 |
| Gordon Research Symposium on Photoreceptor Signaling, Galveston TX | January 2012  |
| 1st Engineering in Medicine and Biology Conference, Boston MA      | August 2011   |
| 48th Design and Automation Conference, San Diego CA                | June 2011     |
| Society of Toxicology, Washington DC                               | March 2011    |
| CSHL Meeting on Computational Cell Biology, Cold Spring Harbor NY  | March 2009    |
| Merck-MIT Symposium, Boston MA                                     | November 2008 |

## **TEACHING EXPERIENCE**

|  |   |
|--|---|
| <b>MOL 518</b> (co-taught with Coleen Murphy, Mohamed Donia)   | Princeton University                    |
| Quantitative Methods in Molecular Biology  | Spring 2017-present                     |
| Graduate course to gain an understanding of modern, quantitative experimental and computational methods in molecular biology. The course places a special emphasis on practical, hands-on training in scientific programming for genomics, data mining, biochemical modeling and image analysis. |   |
| <b>MOL 215</b> (co-taught with Alexei Korennykh)   | Princeton University                    |
| Quantitative Principles in Cell & Molecular Biology  | Fall 2016-present                       |
| Undergraduate course tailored to freshman/sophomore life science and engineering majors. Covers central concepts and experiments in cellular, molecular, and developmental biology with an emphasis on underlying physical and engineering principles.   |   |
| <b>EMBO Workshop: Non-Neuronal Optogenetics</b>  | Heidelberg, Germany                     |
| Co-organizer; instructor   | June 2016                               |
| Co-organizer; instructor   | September 2017                          |
| Co-organizer; instructor   | <i>to be held March 2019</i>            |
| <b>MBL Physiology Course</b>   | Woods Hole, MA                          |
| Teaching Assistant   | Summer 2015                             |
| <b>UCSF/PKU Team Challenge Workshop</b>  | Beijing, China                          |
| Workshop Instructor  | Summer 2012                             |
| <b>UCSF/Lincoln High School iGEM Team</b>  | University of California, San Francisco |
| Instructor / Mentor  | Summer 2010                             |
| <b>SMA5301: Computation and Systems Biology</b>  | National University of Singapore        |
| Teaching Assistant   | Summer 2008                             |
| <b>CME5238: Computational Linear Algebra</b>   | National University of Singapore        |
| Teaching Assistant   | Summer 2008                             |
| <b>20.482: Foundations of Algorithms and Computational Techniques in Systems Biology</b>   | MIT                                     |
| Teaching Assistant   | Spring 2005                             |
| <b>20.420: Biomolecular Kinetics and Cellular Dynamics</b>   | MIT                                     |
| Teaching Assistant   | Fall 2005                               |

## **MENTORSHIP**

### **Graduate students**

|  |              |
|--|--------------|
| Alex Goglia (NIH F30 recipient)                                | 2015-present |
| Evan Zhao (Maeder Graduate Fellow in Energy & the Environment) | 2016-present |
| Elliot Dine  | 2016-present |
| Siddhartha Jena  | 2017-present |
| Ping Wu  | 2017-present |
| Whitney Warren   | 2017-present |
| Sarah McFann (Hertz and NSF fellowship recipient)              | 2017-present |
| Payam Farhani (NSF fellowship recipient)                       | 2018-present |
| Emily Mesev  | 2018-present |

### **Postdoctoral fellows**

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| Max Wilson, PhD                        | 2015-2018    |
| Heath Johnson, PhD (NIH F32 recipient) | 2015-present |
| Agnieszka Gil, PhD (NIH F32 recipient) | 2016-present |

### **Undergraduate thesis students**

|                         |              |
|-------------------------|--------------|
| Daniel DiGiorno '16     | 2014-2016    |
| Jennifer Lee '17        | 2015-2017    |
| Jillian Silbert '18     | 2015-2018    |
| Joshua Kim '18          | 2017-2018    |
| Pavithran Ravindran '19 | 2015-present |
| Danielle Isakov '19     | 2018-present |
| Annan Timon '19         | 2018-present |
| Kirit Limperis '19      | 2018-present |
| Giselle Uribe '20       | 2017-present |
| Haeun Jung '20          | 2017-present |
| Linda Nie '21           | 2018-present |

**Faculty fellow, Scholars Institute Fellows Program (SIFP)** 2017-present

The SIFP program is a Princeton-wide initiative to support first-generation and low-income college students during their time at the University. My responsibilities include mentorship of 10-15 STEM undergraduates through monthly group meetings, one-on-one meetings by appointment, and participation in mixers and workshops designed to improve student networking skills. These events are further complemented with panel discussions to support other aspects of graduate/undergraduate life, such as applying for fellowships or seeking out research opportunities.