David Doty CV

3041 Kemper Hall
University of California, Davis
One Shields Ave.
Davis, CA 95616, USA

Assistant Professor
Department of Computer Science
doty@ucdavis.edu
http://web.cs.ucdavis.edu/~doty/

Research interests

- chemical reaction networks, distributed computing, algorithmic self-assembly, algorithmic information theory, computational complexity

Academic positions

- **University of California, Davis**, Davis, California, USA
  Jul. 2015 – present
  Assistant Professor of Computer Science
- **California Institute of Technology**, Pasadena, California, USA
  Sep. 2010 – Jul. 2015
  Senior Research Fellow/Postdoctoral Scholar in Computing and Mathematical Sciences
  Supervisor: Erik Winfree
- **University of Western Ontario**, London, Ontario, Canada
  Sep. 2009 – Sep. 2010
  Postdoctoral Fellow in Computer Science
  Supervisor: Lila Kari

Education

- **Iowa State University**, Ames, Iowa, USA
  Ph.D. in Computer Science, 2009
  Ph.D. Thesis: *Applications of the theory of computation to nanoscale self-assembly*
  Advisors: Jack Lutz and James Lathrop
- **Iowa State University**, Ames, Iowa, USA
  M.S. in Computer Engineering, 2002
  Master's Thesis: *Genetic algorithm-based simulation of electric power markets*
  Advisor: Gerald Sheblé
- **Iowa State University**, Ames, Iowa, USA
  B.S. in Computer Engineering, 2001
  Honors Thesis: *Evolving 3-D tic-tac-toe strategies*
  Honors Advisor: Daniel Ashlock

Awards

- Best paper award at DISC 2014, "Speed faults in computation by chemical reaction networks", with Ho-lin Chen, Rachel Cummings, and David Soloveichik
- Aalto Science Fellowship, 2012, 3-year postdoc fellowship to pursue independent research at Aalto University, Helsinki, Finland, awarded to 3 recipients out of 167 applicants (declined)
- CCC-CRA-NSF Computing Innovation Fellowship, 2010, 2-year postdoc fellowship
- Iowa State Univ. Teaching Excellence Award, 2007
- Pioneer Hi-Bred/National Science Foundation Graduate Research Fellowship (2005–2006)
- National Science Foundation Integrative Graduate Education and Research Traineeship (IGERT) Fellowship (2002–2004)
- Iowa State Univ. Electrical and Computer Engineering Graduate Excellence Fellowship (2002)
- Iowa State Univ. National Merit Undergraduate Scholarship (1997–2001)
- Union Pacific Undergraduate Scholarship (1997–2001)

Note on author order: In most cases my co-authors and I have followed the common mathematics/theoretical computer science convention of alphabetically-ordered authors. Exceptions are marked with [β].

PUBLICATIONS

◇ Amanda Belleville, David Doty, and David Soloveichik.
Hardness of computing and approximating predicates and functions with leaderless population protocols.
ICALP 2017: *Proceedings of the 44^{th} International Colloquium on Automata, Languages and Programming.*

◇ Ho-Lin Chen and David Doty.
Parallelism and time in hierarchical self-assembly.
SICOMP 2017: *SIAM Journal on Computing*, 46(2):661-709, 2017.

◇ David Doty and Andrew Winslow.
Design of geometric molecular bonds.
T-MBMC 2017: *IEEE Transactions on Molecular, Biological, and Multiscale Communications* 3(1):13-23. Invited paper.

◇ David Doty and David Soloveichik.
Stable leader election in population protocols requires linear time.
DIST to appear: *Distributed Computing*, to appear. Special issue of invited papers from DISC 2015.

◇ Ho-Lin Chen, Rachel Cummings, David Doty, and David Soloveichik.
Speed faults in computation by chemical reaction networks.
DIST to appear: *Distributed Computing*, to appear. Special issue of invited papers from DISC 2014.

◇ Robert Brijder, David Doty, and David Soloveichik.
Robustness of expressivity in chemical reaction networks.
DNA 2016: *Proceedings of the 22nd International Meeting on DNA Computing and Molecular Programming.*

◇ David Doty.
Hierarchical self-assembly.
EoA 2016: *Encyclopedia of Algorithms*, pp. 903-909, 2016. Invited book chapter.

◇ David Doty.
Randomized self-assembly.
EoA 2016: *Encyclopedia of Algorithms*, pp. 1759-1767, 2016. Invited book chapter.

◇ David Doty and Andrew Winslow.
Design of geometric molecular bonds.
ISIT 2016: *Proceedings of the 2016 IEEE International Symposium on Information Theory.*

◇ Ho-Lin Chen, David Doty, Ján Maňuch, Arash Rafiey, and Ladislav Stacho.
Pattern overlap implies runaway growth in hierarchical tile systems.
JoCG 2016: *Journal of Computational Geometry*, 7(2):3-18, 2016. Special issue of invited papers from SoCG 2015.

◇ David Doty.
Producibility in hierarchical self-assembly.
NaCo 2016: *Natural Computing*, 15(1):41-49, 2016. Special issue of invited papers from UCNC 2014.

◇ Rachel Cummings, David Doty, and David Soloveichik.
Probability 1 computation with chemical reaction networks.
NaCo 2016: *Natural Computing*, 15(2):245-261, 2016. Special issue of invited papers from DNA 2014.

- ◇ David Doty and David Soloveichik.
  Stable leader election in population protocols requires linear time.
  DISC 2015: *Proceedings of the 29th International Symposium on DIStributed Computing.*
- ◇ [β] Rebecca Schulman and David Doty.
  Designing ordered nucleic acid self-assembly processes.
  COSTBI 2015: *Current Opinion in Structural Biology* 31: 57-63, 2015. Invited review article.
- ◇ Ho-Lin Chen, David Doty, Ján Maňuch, Arash Rafiey, and Ladislav Stacho.
  Pattern overlap implies runaway growth in hierarchical tile systems.
  SoCG 2015: *Proceedings of the 31st International Symposium on Computational Geometry.*
- ◇ David Doty and Monir Hajiaghayi.
  Leaderless deterministic chemical reaction networks.
  NaCo 2015: *Natural Computing* 14(2):213-223, 2015. Special issue of invited papers from DNA 2013.
- ◇ Ho-Lin Chen, David Doty, and Shinnosuke Seki.
  Program size and temperature in self-assembly.
  Algorithmica 2015: *Algorithmica* 72(3):884-899, 2015.
- ◇ Ho-Lin Chen, Rachel Cummings, David Doty, and David Soloveichik.
  Speed faults in computation by chemical reaction networks.
  DISC 2014: *Proceedings of the 28th International Symposium on DIStributed Computing.*
  Best paper award.
- ◇ Rachel Cummings, David Doty, and David Soloveichik.
  Probability 1 computation with chemical reaction networks.
  DNA 2014: *Proceedings of the 20th International Meeting on DNA Computing and Molecular Programming.*
- ◇ Ho-Lin Chen, David Doty, Dhiraj Holden, Chris Thachuk, Damien Woods, and Chun Tao Yang.
  Fast algorithmic self-assembly of simple shapes using random agitation.
  DNA 2014: *Proceedings of the 20th International Meeting on DNA Computing and Molecular Programming.*
- ◇ David Doty.
  Producibility in hierarchical self-assembly.
  UCNC 2014: *Proceedings of the 13^{th} International Conference on Unconventional Computation and Natural Computation.*
- ◇ Ho-Lin Chen, David Doty, and David Soloveichik.
  Rate-independent computation in continuous chemical reaction networks.
  ITCS 2014: *Proceedings of the 5^{th} Innovations in Theoretical Computer Science Conference.*
- ◇ David Doty.
  Timing in chemical reaction networks.
  SODA 2014: *Proceedings of the 25^{th} ACM-SIAM Symposium on Discrete Algorithms.*
- ◇ Ho-Lin Chen, David Doty, and David Soloveichik.
  Deterministic function computation with chemical reaction networks.
  NaCo 2014: *Natural Computing* 13(4):517-534, 2014. Special issue of invited papers from DNA 2012.
- ◇ David Doty and Monir Hajiaghayi.
  Leaderless deterministic chemical reaction networks.
  DNA 2013: *Proceedings of the 19^{th} International Meeting on DNA Computing and Molecular Programming.*
- ◇ David Doty, Lila Kari, and Benoît Masson.
  Negative interactions in irreversible self-assembly.
  Algorithmica 2013: *Algorithmica* 66(1): 153-172, 2013.

- ◇ Nathaniel Bryans, Ehsan Chiniforooshan, David Doty, Lila Kari, and Shinnosuke Seki.
  The power of nondeterminism in self-assembly.
  ToC 2013: *Theory of Computing* 9(1): 1-29, 2013.
- ◇ David Doty, Jack H. Lutz, Matthew J. Patitz, Robert T. Schweller, Scott M. Summers, and Damien Woods.
  The tile assembly model is intrinsically universal.
  FOCS 2012: *Proceedings of the 53rd IEEE Symposium on Foundations of Computer Science.*
- ◇ Ho-Lin Chen, David Doty, and David Soloveichik.
  Deterministic function computation with chemical reaction networks.
  DNA 2012: *Proceedings of the 18th International Meeting on DNA Computing and Molecular Programming.*
- ◇ David Doty.
  Theory of algorithmic self-assembly.
  CACM 2012: *Communications of the ACM* 55(12): 78-88, 2012. Invited review article.
  7-minute video to introduce article: https://vimeo.com/54214122
- ◇ Ho-Lin Chen and David Doty.
  Parallelism and time in hierarchical self-assembly.
  SODA 2012: *Proceedings of the 23rd ACM-SIAM Symposium on Discrete Algorithms.*
- ◇ Ho-Lin Chen, David Doty, and Shinnosuke Seki.
  Program size and temperature in self-assembly.
  ISAAC 2011: *Proceedings of the 22nd International Symposium on Algorithms and Computation.*
- ◇ David Doty, Matthew J. Patitz, and Scott M. Summers.
  Limitations of self-assembly at temperature 1.
  TCS 2011: *Theoretical Computer Science* 412(1-2):145-158, 2011. Special issue of invited papers from Complexity of Simple Programs workshop in Cork, Ireland, 2008.
- ◇ Nathaniel Bryans, Ehsan Chiniforooshan, David Doty, Lila Kari, and Shinnosuke Seki.
  The power of nondeterminism in self-assembly.
  SODA 2011: *Proceedings of the 22nd ACM-SIAM Symposium on Discrete Algorithms.*
- ◇ David Doty.
  Randomized self-assembly for exact shapes.
  SICOMP 2010: *SIAM Journal on Computing* 39(8):3521-3552, 2010.
- ◇ David Doty, Matthew J. Patitz, Dustin Reishus, Robert T. Schweller, and Scott M. Summers.
  Strong fault-tolerance for self-assembly with fuzzy temperature.
  FOCS 2010: *Proceedings of the 51st IEEE Symposium on Foundations of Computer Science.*
- ◇ Ehsan Chiniforooshan, David Doty, Lila Kari, and Shinnosuke Seki.
  Scalable, time-responsive, digital, energy-efficient molecular circuits using DNA strand displacement.
  DNA 2010: *Proceedings of the 16th International Meeting on DNA Computing and Molecular Programming.*
- ◇ David Doty, Lila Kari, and Benoît Masson.
  Negative interactions in irreversible self-assembly.
  DNA 2010: *Proceedings of the 16th International Meeting on DNA Computing and Molecular Programming.*
- ◇ David Doty, Jack H. Lutz, Matthew J. Patitz, Scott M. Summers, and Damien Woods.
  Intrinsic universality in self-assembly.
  STACS 2010: *Proceedings of the 27th International Symposium on Theoretical Aspects of Computer Science.* Invited to the special issue of Theory of Computing Systems containing the best papers from STACS 2010 (declined).

- ◇ David Doty.
  Randomized self-assembly for exact shapes.
  FOCS 2009: *Proceedings of the 50th IEEE Symposium on Foundations of Computer Science.*
- ◇ David Doty, Jack H. Lutz, Matthew J. Patitz, Scott M. Summers, and Damien Woods.
  Random number selection in self-assembly.
  UC 2009: *Proceedings of the 8th International Conference on Unconventional Computation.*
- ◇ David Doty and Matthew J. Patitz.
  A domain-specific language for programming in the tile assembly model.
  DNA 2009: *Proceedings of the 15th International Meeting on DNA Computing and Molecular Programming.*
- ◇ David Doty, Matthew J. Patitz, and Scott M. Summers.
  Limitations of self-assembly at temperature 1.
  DNA 2009: *Proceedings of the 15th International Meeting on DNA Computing and Molecular Programming.*
- ◇ Laurent Bienvenu, David Doty, and Frank Stephan.
  Constructive dimension and Turing degrees.
  ToCS 2009: *Theory of Computing Systems* 45(4):740–755, 2009. Special issue of invited papers from Computability in Europe 2007.
- ◇ David Doty.
  Dimension extractors and optimal decompression.
  ToCS 2008: *Theory of Computing Systems* 43(3–4):425–463, 2008. Special issue of invited papers from Computability in Europe 2006.
- ◇ David Doty, Jack H. Lutz, and Satyadev Nandakumar.
  Finite-state dimension and real arithmetic.
  I&C 2007: *Information and Computation* 205(11):1640–1651, 2007.
- ◇ David Doty and Jared Nichols.
  Pushdown dimension.
  TCS 2007: *Theoretical Computer Science* 381(1–3):105–123, 2007.
- ◇ David Doty and Philippe Moser.
  Feasible depth.
  CiE 2007: *Proceedings of the 3rd Conference on Computability in Europe.*
- ◇ Laurent Bienvenu, David Doty, and Frank Stephan.
  Constructive dimension and weak truth-table degrees.
  CiE 2007: *Proceedings of the 3rd Conference on Computability in Europe.*
- ◇ David Doty, Jack H. Lutz, and Satyadev Nandakumar.
  Finite-state dimension and real arithmetic.
  ICALP 2006: *Proceedings of the 33rd International Colloquium on Automata, Languages and Programming.*
- ◇ David Doty.
  Every sequence is decompressible from a random one.
  CiE 2006: *Proceedings of the 2nd Conference on Computability in Europe.*
- ◇ David Doty, Xiaoyang Gu, Jack H. Lutz, Elvira Mayordomo, and Philippe Moser.
  Zeta-dimension.
  MFCS 2005: *Proceedings of the 30th Symposium on Mathematical Foundations of Computer Science.*
- ◇ David Doty.
  Non-local evolutionary adaptation in gridplants.
  CEC 2004: *Proceedings of the 2004 IEEE Congress on Evolutionary Computation.*

◇ Dan Ashlock, Dean C. Adams, and David Doty.
Morphometric grayscale texture analysis using foot patterns.
CEC 2003: *Proceedings of the 2003 IEEE Congress on Evolutionary Computation.*

INVITED TALKS

◇ "No we can't": Impossibility of efficient leader election by chemical reactions.
Workshop on advances in numerical and analytic approaches for the study of non-spatial stochastic dynamical systems in molecular biology, Isaac Newton Institute for Mathematical Sciences, University of Cambridge, Apr 2016.

◇ Design of geometric molecular bonds, à la Reed-Solomon.
Workshop on Coding Techniques for Synthetic Biology, University of Illinois at Urbana-Champaign, Oct 2015.

◇ Programming with chemical kinetics.
Workshop on kinetic networks: From topology to design, Santa Fe Institute, Sept 2015.

◇ Computation by (not about) chemistry.
Workshop on mathematical trends in reaction network theory, University of Copenhagen, July 2015.

◇ Algorithmic self-assembly with DNA single-stranded tiles.
Genome Center Systems and Synthetic Biology Seminar Series, University of California–Davis, Feb 2015.

◇ Rate independent computation by mass-action chemistry.
48th Annual Asilomar Conference on Signals, Systems, and Computers, Asilomar, California, Nov 2014.

◇ (Tutorial) Agents and reagents: Distributed systems in a test tube. (with David Soloveichik)
DISC 2014: *28th International Symposium on DIStributed Computing*, Austin, Texas, Oct 2014.

◇ Deterministic function computation with chemical reaction networks.
CS Departmental Seminar, University of British Columbia, Sept 2012.

◇ Deterministic computation with chemical reaction networks.
CS Departmental Seminar, Aalto University, Helsinki, Finland, Jun 2012.

◇ (Tutorial) Theory of Algorithmic Self-Assembly with DNA Tiles
DNA 2011: *17th International Meeting on DNA Computing and Molecular Programming*, Pasadena, CA, Sept 2011.

◇ The state of algorithmic self-assembly at Iowa State.
FNANO 2010: *7th Conference on Foundations of Nanoscience.* Track on Principles and Theory of Self-Assembly, Apr 2010.

◇ Coevolution and non-local adaptation in gridplants.
Pioneer Hi-Bred Bioinformatics Group, Johnston, IA, Mar 2004.

GRANTS

◇ **Principal investigator**

· *Kinetics and Thermodynamics of Chemical Computation*, $250,000, National Science Foundation CISE/CCF/AF grant, 2016-2019, NSF award #CCF-1619343

· *Theory of Molecular Programming: Computability and Complexity*, $425,000, National Science Foundation CISE/CCF/AF grant, 2012-2015, (co-PI: Damien Woods), NSF award #CCF-1219274

◇ **Co-principal investigator**

· *Student Travel Support for BIRS Workshop on Programming Chemical Reaction Networks*, $5000, National Science Foundation CISE/CCF/AF grant, 2014, (PI: Lulu Qian, co-PIs: David Doty, Chris Thachuk), NSF award #CCF-1442454

- *Scaling Up Programmable and Algorithmic DNA Self-Assembly*, $400,000, National Science Foundation CISE/CCF/AF grant, 2012-2015, (PI: Erik Winfree, co-PIs: David Doty, Damien Woods), NSF award #CCF-1162589
- *Future directions for molecular programming: DNA17 special session*, $15,000, National Science Foundation, 2011, (PI: Erik Winfree, co-PIs: David Doty, Niles Pierce, Damien Woods), NSF award #CCF-1143993
- *Student Travel Support for DNA17*, $12,000, National Science Foundation, 2011, (PI: Erik Winfree, co-PIs: David Doty, Niles Pierce, Damien Woods), NSF award #CCF-1137770

Students supervised

◇ **Master's**

- Amanda Belleville, 2016-present, UC-Davis
- Shaopeng Zhu, 2016-present, UC-Davis

◇ **Undergraduate**

- Vishal Chakraborty, 2016, UC-Davis Honors thesis, theory of chemical reaction networks
- Nicholas Schiefer, 2015, Caltech SURF (Summer undergraduate research fellowship), theory of algorithmic self-assembly/chemical reaction networks
- Aakash Indurkhya, 2013, Caltech SURF (Summer undergraduate research fellowship), theory of computation with chemical reaction networks
- Felix Zhou, 2012, Caltech SURF (Summer undergraduate research fellowship), experiments with algorithmic self-assembly of DNA single-stranded tiles

◇ **Thesis committee**

- Rafael Bravo, M.S. committee, Master's advisor: Jeffery Schank, UC-Davis, 2016

Service

◇ **Program committee**

- **OPODIS 2017**: 21st International Conference on Principles of Distributed Systems
- **DISC 2017**: 29th International Symposium on DIStributed Computing
- **DNA 2017**: 23rd Meeting on DNA Computing and Molecular Programming
- **DNA 2016**: 22nd Meeting on DNA Computing and Molecular Programming
- **CiE 2016**: 12th Computability in Europe Conference
- **DNA 2015**: 21st Meeting on DNA Computing and Molecular Programming
- **UCNC 2015**: 14th Conference on Unconventional Computation/Natural Computation
- **DNA 2014**: 20th Meeting on DNA Computing and Molecular Programming
- **DNA 2012**: 18th Meeting on DNA Computing and Molecular Programming
- **UCNC 2012**: 11th Conference on Unconventional Computation/Natural Computation
- **DNA 2011**: 17th Meeting on DNA Computing and Molecular Programming

◇ **Organizing committee**

- Minisymposium on Algorithmic Chemical Reaction Networks, **CanaDAM 2015**: 5th Canadian Discrete and Algorithmic Mathematics Conference
- Programming with Chemical Reaction Networks: Mathematical Foundations, 2014 Workshop at Banff International Research Station for Mathematical Innovation and Discovery
- **DNA 2011**: 17th Meeting on DNA Computing and Molecular Programming

◇ **Conference reviewer**: STOC: *ACM Symposium on Theory of Computing*, FOCS: *IEEE Symposium on Foundations of Computer Science*, SODA: *ACM-SIAM Symposium on Discrete Algorithms*, PODC: *ACM Symposium on Principles of Distributed Computing*, ICALP:

International Colloquium on Automata, Languages, and Programming, ESA: *European Symposium on Algorithms*, SPAA: *ACM Symposium on Parallelism in Algorithms and Architectures*, CCC: *International Conference on Computational Complexity*, STACS: *International Symposium on Theoretical Aspects of Computer Science*, POPL: *Principles of Programming Languages*, ISAAC: *International Symposium on Algorithms and Computation*, DNA: *DNA Computing and Molecular Programming*, CiE: *Computability in Europe*, RECOMB: *Research in Computational Molecular Biology*

- ◇ **Journal referee**: *Nature Communications*, CACM: *Communications of the ACM*, SICOMP: *SIAM Journal on Computing*, *PLOS ONE*, *Journal of the Royal Society: Interface*, JoVE: *Journal of Visualized Experiments*, DIST: *Distributed Computing*, *Algorithmica*, I&C: *Information and Computation*, IPL: *Information Processing Letters*, TCS: *Theoretical Computer Science*, ToCS: *Theory of Computing Systems*, JCB: *Journal of Computational Biology*, NaCo: *Natural Computing*, *IEEE Transactions on NanoBioscience*, *International Journal of Computer Mathematics*, *Mathematics and Computers in Simulation*, *BioSystems*, *IET Nanobiotechnology*, *Information*, *Chaos*, *Advanced Science Letters*
- ◇ **National Science Foundation panelist**
- ◇ **University service**:
  - · Faculty search committee, Computer Science, University of California, Davis, 2017
  - · Grad admissions committee, Computer Science, University of California, Davis, 2016
  - · Grad admissions committee, Computer Science, Caltech, 2013, 2014
- ◇ **Media**: Video introducing algorithmic self-assembly to a (mostly) lay audience, made to accompany a review article on the same subject: https://vimeo.com/54214122
- ◇ **Interviews**:
  - · Machine Intelligence Research Institute: Luke Muehlhauser, on algorithmic self-assembly http://intelligence.org/2014/04/23/dave-doty/
- ◇ **Outreach**:
  - · Story consultant for Isa, made-for-TV movie on SyFy, 2014 (main character is a gifted Latina high school student interested in computer science and mathematics)
  - · Judge for 2013 Caltech SURF (Summer Undergraduate Research Fellowship) poster competition
  - · Speaker and discussion leader at 2012 Siemens Competition in Math, Science, and Technology
  - · Hosted Pasadena high school biology students in lab for educational seminar about careers in science

Teaching experience

- ◇ **Instructor**, University of California, Davis (as faculty), Fall 2015 – present
  - · Theory of Computation (graduate)
  - · Theory of Computation (undergraduate)
  - · Theory of Molecular Computation (graduate)
- ◇ **Instructor**, Iowa State University (as a Ph.D. student), Summer 2006 – Spring 2009
  - · Theory of Computation (undergraduate)
  - · Introduction to Object-Oriented Programming in Java
  - · Data Structures in Java
  - · Programming for non-CS-majors in Java
  - · Developed programs to support grading and feedback:

  - **Simulators for Theory of Computing:** Simple web applications for simulating deterministic and nondeterministic finite automata, regular expressions, and Turing machines. They are used by my Theory of Computation students for creating and testing automata to submit for homework. I also use them in conjunction with Gradescope (https://gradescope.com/) for automated grading of homework. http://web.cs.ucdavis.edu/~doty/automata/

◇ **Graduate teaching assistant**, Iowa State University, Summer 2001, Spring 2002, Fall 2004 – Spring 2005, Summer 2007

  · Introduction to Circuits for non-EE-majors
  · System Modeling, Simulation, and Optimization
  · Programming for non-majors in Java
  · Introduction to Object-oriented Programming in Java
  · Data Structures in Java

◇ **Developed course materials** for introductory programming and data structures courses on a grant from Caterpillar, Inc. during Summer 2005, Iowa State University

◇ **Tutor**, Iowa State University, Spring 1999, Spring 2000

  · Classical Physics
  · Introduction to Digital Design
  · Algorithm Design and Analysis