

Heather J. Goldsby

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EDUCATION

- **Jan. 2006 - May 2011** **Ph.D.**,
Dual Ph.D.s in: Computer Science & Engineering and
Ecology, Evolutionary Biology, & Behavior,
Michigan State University, East Lansing, Michigan
Dissertation: *The Evolution of Division of Labor in Digital Organisms*
- **Jan. 2002 - May 2004** **M.S.**,
Computer Science & Engineering,
Michigan State University, East Lansing, Michigan
M.S. Thesis: *Automating the generation of implementation code from UML diagrams.*
- **Aug. 1999 - Dec. 2001** **B.S.**,
Computer Science & Engineering,
Michigan State University, East Lansing, Michigan.

PROFESSIONAL EXPERIENCE

- **Postdoctoral Fellow** (August 2014–present)
BEACON Center for Evolution in Action, Michigan State University, East Lansing, Michigan
- **Assistant Professor** (August 2014–December 2014)
Department of Computer Science and Software Engineering, Miami University, Oxford, Ohio
- **NSF Postdoctoral Fellow** (August 2011–August 2014)
Transformative Computational Science using CyberInfrastructure (CI TraCS) \$240,000 USD.
Kerr Laboratory, Biology, University of Washington, Seattle, Washington
- **Teaching Assistant** (August. 2011–December 2011; Jan. 2010–May 2010)
 - Computer Science 801: Computational Science for Evolutionary Biologists
 - Computer Science 231: Introduction to ProgrammingDepartment of Computer Science, Michigan State University, East Lansing, Michigan
- **Instructor of Record - Computer Science 410: Operating Systems** (May 2010–August 2010)
Department of Computer Science, Michigan State University, East Lansing, Michigan
- **Research Assistant** (Nov. 2005–August 2011; Jan. 2002–May 2004)
Digital Evolution Laboratory, Michigan State University, East Lansing, Michigan
Software Engineering and Network Systems Laboratory, Michigan State University, East Lansing, Michigan
- **Information Technologist - Business Continuity Coordinator** (Nov. 2005–December, 2009)
Academic Technical Services, Michigan State University, East Lansing, Michigan
- **Information Technology Management Development Program** (May 2004–Nov. 2005)
DaimlerChrysler, Auburn Hills, Michigan

GRANTS, PROFESSIONAL ACTIVITIES, AND HONORS

- 2016-2017 Contributor to BEACON grant entitled “Does Phenotypic Plasticity Promote Evolvability” funded for \$59,526.
- 2015-2016 Contributor to BEACON grant entitled “Developmental Evolution in Action: Testing the Hourglass Model”.
- 2014-2015 Contributor to BEACON grant entitled “Studying Major Transitions In Evolution Using Digital Organisms” funded for \$94,240.
- 2011-2014 National Science Foundation Postdoctoral Research Fellowship for Transformative Computational Science using CyberInfrastructure (CI TraCS) \$240,000.
- 2013-2014 Contributor to BEACON grant entitled “The Evolutionary Origins of Phenotypic Plasticity” funded for \$87,299.

- 2013-2014 Contributor to BEACON grant entitled “Signaling with Symbionts: Testing the hologenome model of evolution using songbirds and digital organisms” funded for \$99,738.
- 2013-2014 Contributor to BEACON grant entitled “Inquiry-Based Evolutionary Science Curriculum for High School Classrooms Using Intuitive Computational Simulations and Classroom Plant-Rhizobia Experiments” funded for \$37,913.
- 2012-2013 Contributor to BEACON grant entitled “Slow and steady wins the race? Adaptation in structured worlds” funded for \$202,048.
- 2010-2011 Ecology, Evolutionary Biology, and Behavior Seminar Series student speaker.
- 2010 Fitch Beach Award Winner for Most Outstanding Research performed by an Engineering Ph.D. Student.
- 2010 Outstanding Graduate Student in Computer Science and Engineering.
- 2010 Michigan State Representative for Coalition for National Science Foundation (CNSF) Day on Capitol Hill.
- 2009 Max Planck Summer Institute on Bounded Rationality Attendee.
- Best Paper/Presentation Award, Proceedings of the 5th International Conference on Autonomic Computing (ICAC 2008).
- Best Paper Award, Models in Software Engineering Workshops and Symposia at MoDELS 2007.
- Reviewer for Artificial Life 13 (2012, 2014), European Conference on Artificial Life (2009, 2011), Transactions on Evolutionary Computation.

MANUSCRIPTS & PUBLICATIONS

Ph.D. Dissertation:

Heather J. Goldsby. “The Evolution of Division of Labor in Digital Organisms,” Ph.D. Dissertation, May 2011

M.S. Thesis:

Heather J. Goldsby. “Automating the generation of implementation code from UML diagrams,” M.S. Thesis, May 2004

Peer Reviewed Publications:

34. Heather J. Goldsby, Arend Hintze. “A Comparison of Approaches to Evolving Artificial Tissues,” *In Preparation*.
33. Anya E. Vostinar, Heather J. Goldsby, Charles Ofria. “Programmed Cell Death Can Evolve in Unicellular Organisms Due Solely to Kin Selection,” *In Preparation*.
32. David B. Knoester, Heather J. Goldsby, Christoph C Adami. “Leveraging Evolutionary Search to Discover Self-Adaptive and Self-Organizing Cellular Automata,” *In Preparation*.
31. Heather J. Goldsby, David B. Knoester, Charles Ofria, and Benjamin Kerr. “The Evolutionary Origin of Somatic Cells Under the Dirty Work Hypothesis,” *PLoS Biology*, **12**(5):e102713, 2014.
30. Heather J. Goldsby, David B. Knoester, Benjamin Kerr, and Charles Ofria. “The Effect of Conflicting Pressures on the Evolution of Division of Labor,” *PLoS One*, **9**(8):e1001858, 2014.
29. Anya E. Johnson, Heather J. Goldsby, Sherri Goings, and Charles Ofria. “Exploring the Evolution of Kin Inclusivity Using Digital Organisms,” *Proceedings of the 2014 Conference on Genetic and Evolutionary Computation*, Vancouver, Canada, July, 2014.
28. Anya E. Johnson, Eli Strauss, Rodney Pickett, Chris Adami, and Heather J. Goldsby. “More Bang For Your Buck: Quorum-Sensing Capabilities Improve the Efficacy of Suicidal Altruism,” *ALIFE 14: Proceedings of the Fourteenth International Conference on the Synthesis and Simulation of Living Systems*, New York, NY, August, 2014.
27. David B. Knoester, Heather J. Goldsby, and Philip K. McKinley. “Genetic Variation and the Evolution of Consensus in Digital Organisms,” *IEEE Transactions on Evolutionary Computation*, **17**(3):403-417, 2013.
26. Heather J. Goldsby, Anna Dornhaus, Benjamin Kerr, and Charles Ofria. “Task-Switching Costs Promote the Evolution of Division of Labor and Shifts in Individuality,” *Proceedings of the National Academy of Sciences*, **109**(34):13686-13691, 2012.
25. Heather J. Goldsby, Neem Serra, Fred Dyer, Benjamin Kerr, and Charles Ofria. “The Evolution of Temporal Polyethism,” *Proceedings of Artificial Life XIII (Alife 13)*, East Lansing, Michigan, July 2012.

24. Sherri Goings, Heather Goldsby, Betty H.C. Cheng and Charles Ofria. "An Ecology-Based Evolutionary Algorithm to Evolve Solutions to Complex Problems," *Proceedings of Artificial Life XIII (Alife 13)*, East Lansing, Michigan, July 2012.
23. Adam C. Jensen, Betty H.C. Cheng, Heather J. Goldsby, and Edward C. Nelson. "A Toolchain for the Detection of Structural and Behavioral Latent System Properties," *Proceedings of the ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MoDELS 2011)*, Wellington, New Zealand, October 2011.
22. Jeff Clune, Heather J. Goldsby, Charles Ofria, and Robert T. Pennock. "Selective pressures for accurate altruism targeting: Empirical support for difficult-to-test aspects of inclusive fitness theory," *Proceedings of the Royal Society*, 2011.
21. Heather J. Goldsby and Betty H.C. Cheng. "Automatically Discovering Properties that Specify the Latent Behavior of UML Models," *Proceedings of the ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MoDELS 2010)*, Oslo, Norway, October 2010.
20. Heather J. Goldsby, David B. Knoester, and Charles Ofria. "Evolution of Division of Labor in Genetically Homogenous Groups," *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO 2010)*, Portland, Oregon, July 2010.
19. David B. Knoester, Heather J. Goldsby, and Philip K. McKinley. "Neuroevolution of Mobile Ad Hoc Networks," *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO 2010)*, Portland, Oregon, July 2010.
18. Heather J. Goldsby, David B. Knoester, Jeff Clune, Philip K. McKinley, and Charles A. Ofria. "The Evolution of Division of Labor," *Proceedings of the 10th European Conference on Artificial Life (ECAL 2009)*, Budapest, Hungary, September 2009.
17. Heather J. Goldsby, Sherri Goings, Jeff Clune, and Charles Ofria. "Problem Decomposition Using Indirect Reciprocity in Evolved Populations," *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO 2009)*, Montreal, Canada, July 2009.
16. Ji Zhang, Heather J. Goldsby, and Betty H.C. Cheng. "Modular Verification of Dynamically Adaptive Systems," *Proceedings of the ACM International Conference on Aspect-Oriented Software Development (AOSD 2009)*, Charlottesville, Virginia, March 2009.
15. Heather J. Goldsby, Betty H.C. Cheng, and Ji Zhang. "Amoeba-RT: Run-time Verification of Adaptive Software," *Models in Software Engineering Workshops and Symposia at MoDELS 2007*, Springer Verlag, 2008. (Received Best Paper Award)
14. Heather J. Goldsby and Betty H. C. Cheng. "Automatically Generating Behavioral Models of Adaptive Systems to Address Uncertainty," *Proceedings of the ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MoDELS 2008)*, Toulouse, France, October 2008.
13. Heather J. Goldsby and Betty H. C. Cheng. "Avida-MDE: A Digital Evolution Approach to Generating Models of Adaptive System Behavior," *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO 2008)*, Atlanta, Georgia, July 2008.
12. Heather J. Goldsby, Betty H. C. Cheng, Philip K. McKinley, David B. Knoester, and Charles Ofria. "Digital Evolution of Behavioral Models for Autonomic Systems," *Proceedings of the 5th International Conference on Autonomic Computing (ICAC 2008)*, Chicago, Illinois, June 2008. *Best Paper/Presentation Award Winner*.
11. Heather J. Goldsby, Pete Sawyer, Nelly Bencomo, Betty H. C. Cheng, and Danny Hughes. "Goal-based Modeling of Dynamically Adaptive System Requirements," *Proceedings of the Engineering of Computer-Based Systems (ECBS08)*, Belfast, Northern Ireland, April 2008.
10. Philip K. McKinley, Betty H.C. Cheng, Charles A. Ofria, David B. Knoester, Benjamin Beckman, and Heather J. Goldsby. "Harnessing Digital Evolution," *IEEE Computer*, vol. 37, no. 7, pp. 56-64, January 2008.
9. Heather J. Goldsby, Sascha Konrad, and Betty H. C. Cheng. "Goal-Oriented Patterns for UML-Based Modeling of Embedded Systems Requirements," *Proceedings of the IEEE High Assurance Systems Engineering Symposium (HASE 2007)*, Dallas, Texas, November 2007.
8. Pete Sawyer, Nelly Bencomo, Danny Hughes, Paul Grace, Heather J. Goldsby, and Betty H.C. Cheng. "Visualizing the Analysis of Dynamically Adaptive Systems Using i* and DSLs," *Proceedings of the International Workshop on Requirements Engineering Visualization (REV 2007) as part of the 15th IEEE International Requirements Engineering Conference (RE'07)*, New Delhi, India, October 2007.
7. Ji Zhang, Betty H. C. Cheng, and Heather J. Goldsby. "Amoeba-RT: Run-time Verification of Adaptive Software," *Proceedings of the International Workshop on models@run.time as part of the ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MoDELS 2007)*, Nashville, TN, October 2007.

6. Sascha Konrad, Heather J. Goldsby, and Betty H. C. Cheng. “i2MAP: An Incremental and Iterative Modeling and Analysis Process,” *Proceedings of the ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MoDELS 2007)*, Nashville, TN, October 2007.
5. Heather J. Goldsby, David B. Knoester, Betty H. C. Cheng, Philip K. McKinley, and Charles A. Ofria. “Digitally Evolving Models for Dynamically Adaptive Systems,” *Proceedings of ICSE 2007 Workshop on Software Engineering for Adaptive and Self-Managing Systems (SEAMS)*, Minneapolis, MN, May 2007.
4. Heather J. Goldsby, Sascha Konrad, Betty H. C. Cheng, and Stephane Kamdoun. “A Visualization Framework for the Modeling and Formal Analysis of High Assurance Systems,” *Proceedings of the ACM/IEEE International Conference on Model Driven Engineering Languages and Systems (MODELS 2006)*, Genova, Italy, October 2006.
3. Sascha Konrad, Heather J. Goldsby, Karli Lopez, and Betty H.C. Cheng. “Visualizing Requirements in UML Models,” *Proceedings of the RE 2006 Workshop on Requirements Engineering Visualization (REV’06)*, Minneapolis/St. Paul, MN, September 2006.
2. Heather J. Goldsby and Betty H.C. Cheng, “Goal-oriented Modeling of Requirements Engineering for Dynamically Adaptive Systems,” *Proceedings of the IEEE International Requirements Engineering Conference (RE06)*, Minneapolis/St. Paul, MN, September 2006. (Poster summary.)
1. Greg Brown, Heather J. Goldsby, Betty H.C. Cheng, and Ji Zhang. “Goal-oriented Specification of Adaptation Semantics in Adaptive Systems,” *Proceedings of the ICSE 2006 Workshop on Software Engineering for Adaptive and Self-Managing Systems (SEAMS)*, Shanghai, China, May 2006.

Popular Press

- Science Daily: Delegating dirty work is key to evolution: Working cells allow organisms to evolve.
<https://www.sciencedaily.com/releases/2014/05/140522141453.htm>
- Accumulating Glitches; Exploring the Gradear of Evolution: Evolving Separate Tasks How Somatic and Germ Cells Parted Ways.
http://www.nature.com/scitable/blog/accumulating-glitches/evolving_separate_tasks_8212_how
- PLoS Biology Synopsis: A Fool to Do Your Dirty Work?
<http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1001859>
- AstroBiology Magazine: Division of Labor and Multicellular Life.
<http://www.astrobio.net/topic/origins/origin-and-evolution-of-life/division-of-labor-and-multicellular-life/>
- Science Daily: Division of labor offers insight into the evolution of multicellular life.
<https://www.sciencedaily.com/releases/2012/08/120807132211.htm>
- Ecology Today: Division of Labor Offers Insight into the Evolution of Multicellular Life.
<http://www.ecology.com/2012/08/07/division-labor-evolution-multicellular-life/>
- UANews: Division of Labor: Key to Evolution of Multicellular Life?
<https://uanews.arizona.edu/story/division-of-labor-key-to-evolution-of-multicellular-life>
- Live Science: Digital Organisms Shed Light on Mystery of Altruism.
<http://www.livescience.com/8870-digital-organisms-shed-light-mystery-altruism.html>

Skills

Software Development: I have over 10 years of experiencing developing software within both industrial and academic settings. I use a variety of languages including C++, Java, Python, Haskell, R, SQL, Perl, C, and Objective C. I am also familiar with many additional tools including UML, shell scripts, scipy, numpy, Boost, pandas, and Processing. I have contributed to several open source projects, including EALib (a generic Evolutionary Algorithms LIBrary <http://github.com/dknoester/ealib>) and Avida (a platform for artificial life <http://avida.devosoft.org>).

Data Analysis and Visualization: The core of many of my research projects revolves around generating, processing, and visualizing massive quantities of data. As such, I am familiar with data pipelines that make use of a variety of tools ranging from high performance computing to generate data, Python and shell scripts to clean and manipulate data, using Python, R, and Matlab to analyze data, and using Python, R, Matlab, and Processing to visualize data. For examples, please look at my publications, including “The Evolutionary Origin of Somatic Cells under the Dirty Work Hypothesis,” (<http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1001858>) and “Task-Switching Costs Promote the Evolution of Division of Labor and Shifts in Individuality” (<http://www.pnas.org/content/109/34/13686.abstract>).

Machine Learning: A central component of my research is using machine learning techniques to address challenging problems within computer science, engineering, and biology. I am familiar with many techniques including supervised learning, unsupervised learning, artificial neural networks, evolutionary algorithms, etc. I have focused on using evolutionary machine learning approaches (e.g., genetic algorithms, genetic programs, artificial life, artificial neural networks, and rule-based approaches) to address problems, including identifying latent errors within software, developing controllers for robots, and evolving division of labor strategies.

Statistical Analysis: To draw valid statistical conclusions from research data, I perform many statistical analyses, including checking for the normality of the data, performing both parametric and non-parametric assessments of hypothesis testing, multiple comparison, and developing linear regression models.

Mentoring and Teaching: Part of my role is fostering the understanding of those around me. This I have accomplished in formal teaching settings, including teaching the operating systems class, as well as less formal mentorship settings. As a mentor, I strive to train my junior colleagues to become independent thinkers, researchers, and writers.

Presenting: A key aspect of my role is to disseminate results through presentations. As such, I have presented at over 20 different universities and conference venues. My speaking has won awards and has also resulted in me giving an invited talk on how to present at the BEACON Congress in August, 2016.

References available upon request.