Mary J. Dunlop

Email: mjdunlop@gmail.com, Phone: 626-818–8680, Web: http://keaslinglab.lbl.gov/wiki/index.php/Mary_Dunlop

EDUCATION

CALIFORNIA INSTITUTE OF TECHNOLOGY
Ph.D., Mechanical Engineering (emphasis: Control Theory & Synthetic Biology) June 2008
M.S., Mechanical Engineering (emphasis: Biological Modeling) June 2004

PRINCETON UNIVERSITY
B.S.E., Mechanical and Aerospace Engineering (major), Computer Science (minor) June 2002

SUMMARY OF TECHNICAL QUALIFICATIONS & HIGH-END PROFICIENCIES

Technical Skills
- **Laboratory Skills**: Bacterial cell culture, experience with *E. coli* and *B. subtilis*, single-cell microscopy, cloning, site-directed mutagensis, plasmid and chromosomal integration, dynamic fluorescence measurements
- **Modeling**: nonlinear ordinary differential equations, stochastic differential equations, stochastic modeling using chemical master equation
- **Analysis**: dynamic systems methods, bifurcation diagrams, stability analysis, parameter and system identification, sensitivity analysis
- **Programming Languages**: C, Matlab, Perl, Fortran, Processing

Leadership & Communication Skills
- 7+ years of leadership and project management experience
- 8+ years of technical writing and presentations including experience writing funding proposals

RESEARCH & PROFESSIONAL EXPERIENCE

JOINT BIOENERGY INSTITUTE, LAWRENCE BERKELEY NATIONAL LAB
Postdoctoral Scholar 2008-Present
Project: Reducing Fuel Toxicity to Microbes using Efflux Pumps
- *Purpose*: Although microbes are capable of producing small amounts of biofuels naturally, increasing fuel production can be toxic to the microorganism when fuel builds up within the cell. Efflux pumps are channels in the cell membrane that excrete toxic substances including antibiotics and solvents like biofuels. By controlling the expression of efflux pumps, both from E. coli and other organisms, we hope to reduce the toxic stress that microbes experience when producing biofuels.

CALIFORNIA INSTITUTE OF TECHNOLOGY
Graduate Research Assistant 2004-2008
Project/Thesis: Dynamics and Noise in Gene Regulation
Advisors: Michael Elowitz (Biology, Applied Physics), Richard Murray (Control & Dynamical Systems)
- *Purpose*: Cells use many genetic control mechanisms to respond to changes in their environment. To conserve resources only a subset of these control systems are active at a given time. Goal was to discriminate between active and inactive forms of genetic control, while preserving the context in which the gene circuit naturally operates.
- *Impact*: Developed a non-invasive method for determining gene circuit activity that uses temporal correlations in expression noise. Method requires no external inputs or modifications to the existing gene circuit.
- Built and measured genetic regulatory networks in *E. coli* bacteria in a synthetic biology lab.
- Collected dynamic, time-lapse data of gene expression in single cells using microscopy methods.
- Developed an analytic framework for understanding how noise affects temporal correlations in gene expression.
- Created a small library of genetic variants to test hypothesis about correlation measurements.
- Built and simulated a non-linear, stochastic model for gene expression.
- Developed experience by writing NSF grant proposal.

LOS ALAMOS NATIONAL LABORATORY
Computational Science Graduate Fellowship Practicum Summer 2004
Project: Multiple Functions of a Feed-Forward Loop Gene Circuit

Advisor: Michael Wall (Computer, Computational, and Statistical Sciences Division)

- *Purpose*: Cells commonly use feed-forward loops to control gene expression. We explored the range of functions that can be produced by feed-forward loops and determined how sensitive the results were to genetic parameters.
- *Impact*: Showed that there is a very limited set of possible behaviors that can be produced by a feed-forward loop. Some functions are very robust to parameter variation, while others are extremely fragile.
- Used principle component analysis to group genetic circuits with similar functions together.
- Extended previous mathematical models of feed-forward loops to include signaling dynamics.

CALIFORNIA INSTITUTE OF TECHNOLOGY
Graduate Research Assistant 2003-2004

Project: Aerodynamic Modeling of Insect Flight
Advisors: Michael Dickinson (Bioengineering), Richard Murray (Control & Dynamical System)

- *Purpose*: Show that insects can fly using simple control laws and basic visual sensors. Ideas could be transferred to micro-air vehicles that require only small computers on board.
- *Impact*: Built a biologically inspired model that showed how robust flight could be achieved with minimal computation and sensory input.
- Worked as part of a team to build a closed-loop model of insect flight. Was responsible for modeling insect aerodynamics.

CALIFORNIA INSTITUTE OF TECHNOLOGY
Graduate Research Assistant 2002-2003

Project: Computational Fluid Dynamics Models of Airplane Engine Noise
Advisor: Tim Colonius (Mechanical Engineering)

- *Purpose*: Use measurements close to an airplane jet engine to predict noise heard far away from the airplane. Predictions lay groundwork to reduce noise produced by an airplane by controlling flow of air near the engine.
- *Impact*: Accurately predicted jet noise using a computational model, found minimal distance away from jet engine where measurements would still produce accurate predictions of noise heard far away.
- Used a computational fluid dynamics model to explore how jet engine noise heard on the ground correlates with measurements near the engine.
- Compared computational predictions with experimental researchers at United Technologies Research Center.

PRINCETON UNIVERSITY
Independent Research 2000-2002

Project: Analysis of a Sailboat Design Using Computational Fluid Dynamics
Advisor: Luigi Martinelli (Mechanical and Aerospace Engineering)

- *Purpose*: Model flow of water over a proposed America's Cup sailboat hull design. Use results to choose optimal racing conditions that minimize drag.
- *Impact*: Quantified drag over a range of sailboat heeling angles to determine best racing conditions.
- Used computational fluid dynamics to understand drag forces on a sailboat hull. Validated computational methods using experimental results from a simple sailboat hull design.

NORTHROP GRUMMAN CORPORATION
Technical Student, Advanced Design Department Summer 2001

- *Purpose*: Understand resonance caused by air flow over a sensor pod on a test aircraft. Determine flight conditions (e.g. aircraft speed, pitch angles) that avoid dangerous resonance conditions.
- *Impact*: Used computational modeling to reproduce observations and identify resonance-free flight conditions.
- Performed aerodynamic modeling and analysis of airplanes using computational fluid dynamics. Wrote automated script for testing computer models of aircraft over a range of flight conditions.

PENNSYLVANIA STATE UNIVERSITY
Fluid Mechanics Research Internship, Applied Research Laboratory Summer 2000

- *Purpose*: Quantify and reduce drag forces on a flat plate at high Reynolds number. Eventual application to ship and submarine designs to reduce fuel usage.
- *Impact*: Decreased drag in test conditions by using controlled injection of fluid at the boundary layer
- Conducted experimental research in water tunnel facility. Measured drag forces on a flat plate and tracked flow using digital particle image velocimetry. Tested flow control methods that manipulate boundary layer flow.

PUBLICATIONS

THESIS

M. J. DUNLOP. "Dynamics and Correlated Noise in Gene Expression." California Institute of Technology, Ph.D. Thesis. 2008.

JOURNAL PAPERS

M. J. DUNLOP, R. S. Cox, J. H. Levine, R. M. Murray, M. B. Elowitz. "Regulatory Activity Revealed by Dynamic Correlations In Gene Expression Noise." Nature Genetics (to appear).

R. S. Cox, **M. J. DUNLOP**, M. B. Elowitz. "A Synthetic Three-Color Reporter Framework for Monitoring Genetic Regulation and Noise." (in preparation, available upon request)

M. E. Wall, **M. J. DUNLOP**, W. S. Hlavacek. "Multiple Functions of a Feed-Forward Loop Gene Circuit." Journal of Molecular Biology. 349, 501-514. 2005.

CONFERENCE PAPERS

M. J. DUNLOP, E. Franco, R. M. Murray. "A Multi-Model Approach to Identification of Biosynthetic Pathways." In Proceedings of the 26th American Control Conference 2007.

J. Ugander, **M. J. DUNLOP**, R. M. Murray. "Analysis of a Digital Clock for Molecular Computing." In Proceedings of the 26th American Control Conference 2007.

M. J. DUNLOP, M. E. Wall. "Robustness in Gene Circuits: Clustering of Functional Responses." In Proceedings of the 24th American Control Conference 2005.

M. B. Reiser, J. S. Humbert, **M. J. DUNLOP**, D. Del Vecchio, R. M. Murray, M. H. Dickinson. "Vision as a Compensatory Mechanism for Disturbance Rejection in Upwind Flight." In Proceedings of the 23rd American Control Conference 2004.

T. Colonius, **M. J. DUNLOP**, R. Reba, S. Narayanan. "A Study of the Role of Organized Structures in Jet Noise Generation." AIAA Paper 2003-3314. 2003.

LEADERSHIP EXPERIENCE

CALTECH PROJECT FOR EFFECTIVE TEACHING (CPET)

President, Member of Organizational Committee 2006-Present

- Organized the Teaching Assistant training program for all incoming graduate students (Fall 2006).
- Worked with faculty and administrators to expand the Teaching Assistant training program, substantially increasing the number of graduate students who receive training, and expanding the program to include undergraduates.
- Coordinated and developed a seminar series that brought speakers together to talk about teaching strategies, integrating teaching and research, and novel pedagogical methods.

MECHANICAL ENGINEERING STUDENT SEMINAR SERIES 2003-2004

- Coordinated a weekly departmental seminar series where graduate students give informal talks about their research for the benefit of other students in the department.

TEACHING & MENTORING EXPERIENCE

CALIFORNIA INSTITUTE OF TECHNOLOGY

Research Mentor Summer 2007

Project: Predictive Models for Investigating Modularity in Gene Circuits

Head Teaching Assistant Fall 2006

Course: Analysis and Design of Feedback Systems

- Supervised team of 4 teaching assistants for a class of 75 students.

Research Mentor 2006-2007

Project: Dynamic Systems Analysis of the Influenza Virus

Research Mentor Summer 2006

Project: Design of a Digital Clock for Molecular Computing
Teaching Assistant Fall 2005
Course: Analysis and Design of Feedback Systems
Research Mentor Summer 2005
Project: Evolvability and Robustness in Synthetic Genetic Circuits
Teaching Assistant Winter 2005
Course: Introduction to Control Theory

PRESENTATIONS

Talks

"Regulation Revealed by Correlations in Gene Expression Noise." *Q-bio Conference*, Santa Fe, NM. 2007.

"A Multi-Model Approach to Identification of BioSynthetic Pathways." *American Control Conference*, New York, NY. 2007.

"Correlation and Causality in Genetic Networks." *Institute for Collaborative Biotechnologies Student Seminar*, Caltech, Pasadena, CA. 2007.

"System Identification for Genetic Regulatory Networks." *Computational Science Graduate Fellowship Conference*, Washington DC. 2006.

"Robustness in Gene Circuits: Clustering of Functional Responses." *American Control Conference*, Portland, OR. 2005.

"Inferring Function from Structure in Genetic Regulatory Feed-forward Loops." *Southern California Nonlinear Controls Conference*, UCLA, Westwood, CA. 2004.

Posters

"Regulatory Activity Revealed by Dynamic Correlations in Gene Expression Noise." *Synthetic Biology 4.0*, Hong Kong. 2008.

"Regulation Revealed by Correlations in Gene Expression Noise." *Q-bio Conference*, Santa Fe, NM. 2008.

"Correlation and Causality in Genetic Networks." *Synthetic Biology 3.0*, Zurich, Switzerland. 2007.

"A Multi-Model Approach to Identification of Bio-Synthetic Pathways." *Engineering Principles in Biology*, Cold Spring Harbor Laboratory, NY. 2006.

"System Identification for Genetic Regulatory Networks." *Synthetic Biology 2.0*, Berkeley, CA. 2006.

"Reengineering Genetic Circuits." *Computational Science Graduate Fellowship Conference*, Washington DC. 2005.

"Design Principles for Gene Circuits: Ideas from Engineering." *Computational Science Graduate Fellowship Conference*, Washington DC. 2004.

"A Study of the Role of Organized Structures in Jet Noise Generation." *Computational Science Graduate Fellowship Conference*, Washington DC. 2005.

HONORS & AWARDS

Dean's Award for Community Service, California Institute of Technology (out of all Caltech graduates) 2008
Computational Science Graduate Fellowship, U.S. Dept. of Energy (5% acceptance rate) 2002-2006
Best Student Paper, American Control Conference (out of 250 papers considered) 2004
John Marshall II Memorial Prize for Independent Research, Princeton University (out of 25 students) 2002
George J. Mueller Award, Princeton University School of Engineering and Applied Science 2002
Sigma Xi Scientific Research Society 2002

ATHLETICS & HOBBIES

Nationally ranked epee fencer (1996-2002); Princeton women's fencing team captain (2001-2002); Backpacked 80-mile High Sierra Trail (2008); Backpacked 270-mile Vermont Long Trail (2002); Caltech Y hike leader (2002-2008); Princeton Outdoor Action backpacking trip leader (1999-2002), Caltech women's ultimate frisbee (2005-present); Voted most valuable defensive player (2007-2008).