CMACS Education Program

Nancy Griffeth
Educational Program Director

Flavio Fenton, Andre Platzer
Co-Directors

November 3, 2011
Objectives

- Motivate students to work in STEM fields
- Broaden understanding of STEM disciplines and research
- Encourage participation from under-represented groups
- Find graduate students for CMACS institutions
Outcomes

• Successful workshops based on challenge problems:
  – 2010 Workshop on Signaling Pathways and Pancreatic Cancer
  – 2011 Workshop on Atrial Fibrillation
  – 2012 Workshop on Signaling Pathways and Pancreatic Cancer (being planned)

• Students attracted to STEM fields and graduate work with CMACS

• Course materials, modules and curricula
# Outcomes

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<tr>
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Outline

• 2010 Workshop on Signaling Pathways and Pancreatic Cancer
• 2011 Workshop on Atrial Fibrillation
• Impacts of Workshops on Students
• Course materials
• Program Outcomes
• Future plans
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• 2010 Workshop on Signaling Pathways and Pancreatic Cancer
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2010 Workshop Contributors

Chris Langmead  
CMU

Jim Faeder  
Pitt

Nancy Griffeth  
Lehman

Bud Mishra  
NYU

Ziping Liu  
CUNY

Loes Loohuis  
CUNY, NYU

Fred Dieckamp  
Hunter
Lectures and Readings

NSF-CMACS Workshop -- Winter 2010

I. Introduction

Additional Reading:

A. The life cycle of a cell
B. Mac OS X and Unix
C. The role of signaling in the cell's life cycle
D. Discussion slides for modeling
E. Modeling Biochemical Systems
F. Chemical kinetics
G. Exercise: Modeling a toy signaling pathway
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
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<tbody>
<tr>
<td>II.</td>
<td><strong>Visiting lecture by Jim Faeder: Using Modeling to Bridge Scales in Biology</strong></td>
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<tr>
<td>III.</td>
<td><strong>Wiring Diagrams</strong></td>
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<td>IV.</td>
<td><strong>A normal signaling pathway: the unreplicated DNA checkpoint (G2 to M)</strong></td>
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<tr>
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<td><strong>A. Exercise:</strong></td>
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<td>» <strong>G2 Checkpoint in the Frog Cell Cycle</strong></td>
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<td></td>
<td>» <strong>G2 Checkpoint Exercises</strong></td>
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<td></td>
<td>» <strong>Using Mathematical Modeling for Understanding Cell Behavior</strong></td>
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<tr>
<td></td>
<td><strong>B. Additional Reading:</strong></td>
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<tr>
<td></td>
<td>» <strong>Novak and Tyson (1993), M-phase control</strong></td>
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<td></td>
<td>» <strong>Csikasz-Nagy et. al., Analysis of a generic Model of Eukaryotic Cell-Cycle Regulation</strong></td>
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<td>» <strong>On-line supplement to Csikasz-Nagy et. al.</strong></td>
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<td>V.</td>
<td><strong>Model checking to understand signaling pathways that lead to cancer</strong></td>
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<tr>
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<td><strong>A. Temporal Logic</strong></td>
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<td></td>
<td><strong>B. Model Checking</strong></td>
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<td><strong>C. Extending the model of the EGFR signaling pathway</strong></td>
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Reading: **A Model of the Epidermal Growth Factor Receptor (EGFR) Pathway**
Student projects on EGFR Pathway

The effect of stimulation on Sos activation: Parameter scan of EGF (ligand) concentration

**Total Sos activation against dose**
Time = 100

**Total Sos activation against egf dose**
Time = 200
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2011 Workshop Contributors

Scott Smolka
Cornell
Stony Brook

Flavio Fenton

Nancy Griffeth
Lehman

James Glimm
Stony Brook

Radu Grosu
Stony Brook

Ezio Bartocci
Stony Brook

Kai Zhao
CUNY

Aron Wolinetz
Lehman

Terri Grosso
CUNY

Robert Gilmour
Cornell
Lectures and Readings

Week 1

Monday (Jan 3):

» Introduction (Nancy Griffeth)
» The Secret Life of Chaos (video)
» Excitable Systems (Flavio Fenton)

Tuesday (Jan 4):

» Spiral Waves and Modeling Action Potentials (Flavio Fenton)
» Saline Density Oscillator (Rupinder Singh)
» Pictures of the Saline Oscillator in the Lab

Wednesday (Jan 5):

» Simplified Models of Cardiac Action Potentials (Flavio Fenton)
» Pictures of Oscillations in Fluids in the Lab

Thursday (Jan 6):

» More Complex Cardiac Models (Flavio Fenton)
» Robert Gilmour Lecture
Saline Oscillator:

- A “hydrodynamic curiosity” first described by Seelye Martin in 1970.\(^1\)

- S. Martin observed that a partially submerged syringe of salt water in fresh water exhibits oscillations.
  - downward jet of salt water followed by an upward jet of fresh water

- Oscillations were discovered by accident while setting up a demonstration of a buoyant jet for a class in meteorology.\(^2\)


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Student Projects on Spiral Waves

• 2011
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Requirements and Expectations

- Inquiry-based learning
  - Small projects
  - Final presentation
- Team-oriented
- Active participation expected
- Some preliminary reading
- $1000 stipend
NSF CMACS Workshops

• 15 students a year for five years (2010-2014)

<table>
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<tr>
<th>Career Plans</th>
<th>Current Status</th>
<th>Under-represented Groups</th>
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<tbody>
<tr>
<td>Medical</td>
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<td>CS/Comp Bio</td>
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<tr>
<td>Math</td>
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<td>10</td>
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Workshop Impacts
Teaching cardiac electrophysiology modeling to undergraduate students: Lab exercises and GPU programming for the study of arrhythmias and spiral wave dynamics

Ezio Bartocci\textsuperscript{1}, Rupinder Singh\textsuperscript{2}, Frederick B. von Stein\textsuperscript{3}, Avessie Amedome\textsuperscript{4}, Alan Joseph J. Caceres\textsuperscript{4}, Juan Castillo\textsuperscript{4}, Evan Closser\textsuperscript{4}, Gabriel Deards\textsuperscript{4}, Andriy Golts\textsuperscript{4}, Roumelle Sta. Ines\textsuperscript{4}, Cem Isbildir\textsuperscript{4}, Joan K. Marc\textsuperscript{4}, Diquan Moore\textsuperscript{4}, Dana Pardi\textsuperscript{4}, Sandeep Sadhu\textsuperscript{4}, Samuel Sanchez\textsuperscript{4}, Pooja Sharma\textsuperscript{4}, Anoopa Singh\textsuperscript{4}, Joshua Rogers\textsuperscript{4}, Aron Wolinetz\textsuperscript{4}, Terri Grosso-Applewhite\textsuperscript{4}, Kai Zhao\textsuperscript{4}, Andrew B. Filipski\textsuperscript{5}, Robert F. Gilmour Jr\textsuperscript{3}, Radu Grosu\textsuperscript{5}, James Glimm\textsuperscript{1}, Scott A Smolka\textsuperscript{5}, Elizabeth M. Cherry\textsuperscript{3,7}, Edmund M. Clarke\textsuperscript{8}, Nancy Griffeth\textsuperscript{4}, Flavio H. Fenton\textsuperscript{3}

\textsuperscript{1}Department of Applied Mathematics and Statistics, Stony Brook University, NY. \textsuperscript{2}Department of Biomedical Engineering, Cornell University, Ithaca, NY. \textsuperscript{3}Department of Biomedical Sciences, Cornell University, NY. \textsuperscript{4}The City University of New York. \textsuperscript{5}Department of Software Engineering, Rochester Institute of Technology, NY. \textsuperscript{6}Department of Computer Science, Stony Brook University, NY. \textsuperscript{7}Department of Applied Mathematics, Rochester Institute of Technology, NY. \textsuperscript{8}Computer Science Department, Carnegie Mellon University, PA
Best things about workshop...

• Learning experience
  – A ground-up exposure to the process of formulating a model
  – Using the tools
  – Learning how fibrillation/signaling works
  – Learning about the resources and technology ... necessary for ... research
  – Applications of parallel computation

• Collaboration
  – The opportunity to collaborate with other peers in different disciplines.
  – Seeing how every area of science (Biology, Math) work together to solve the real world problems from very distinguished professors

• Future plans
  – This workshop inspired me to pursue information outside of my own discipline.
  – Getting a sense that I am capable of doing similar research
Evaluations

Continuing in STEM
Attend another
Worthwhile
Confidence

Workshop Impacts: Evaluations
Unsolicited Student Comments

... the workshop is still my favorite thing about this year

... After the workshop, I realized that this was something that I could see myself doing. ... none of this would be possible without that winter CMACS workshop. I guess the workshop "worked." :)

...Congratulations to Flavio
Flavio’s fibrillation work
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New Courses and Programs

• Lehman College
  – New course “Simulation and Modeling of Biological Systems” (Griffeth)
  – New minor “Quantitative and Systems Biology” (Griffeth/Redenti)

• CMU
  – New course Logical Analysis of Hybrid Systems (Platzer)
  – Abstract interpretation added to Model-Checking courses (Clarke)

• NYU
  – Special topics course “Signals and Cancer” (Mishra)
Course Module

- Atrial Fibrillation module
  - NSF CMACS Workshops (week 1)
  - Campus Bio-Medico University in Rome (~60 students)
  - Ernie Davis Middle School (~15 students)
  - Lehman College (~8 high school students)
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Future Plans

• Workshops
• Additional course modules from workshop materials and from CMACS research
• Additional courses
• Curriculum recommendations for a program in Complex Systems Science and Engineering (CSSE)
• Summer REU program at Carnegie Mellon
Future Workshops

• 2012 Workshop
  – Tape/broadcast live
  – Project: Completion time distributions for FCeRI pathway

• 2013 Workshop – Atrial fibrillation

• 2014 Workshop – Signaling pathways
Curriculum Recommendations

• Investigate current programs in computational biology and embedded systems engineering
• Interview industry figures about skills needed
• Incorporate courses and course modules developed by CMACS researchers