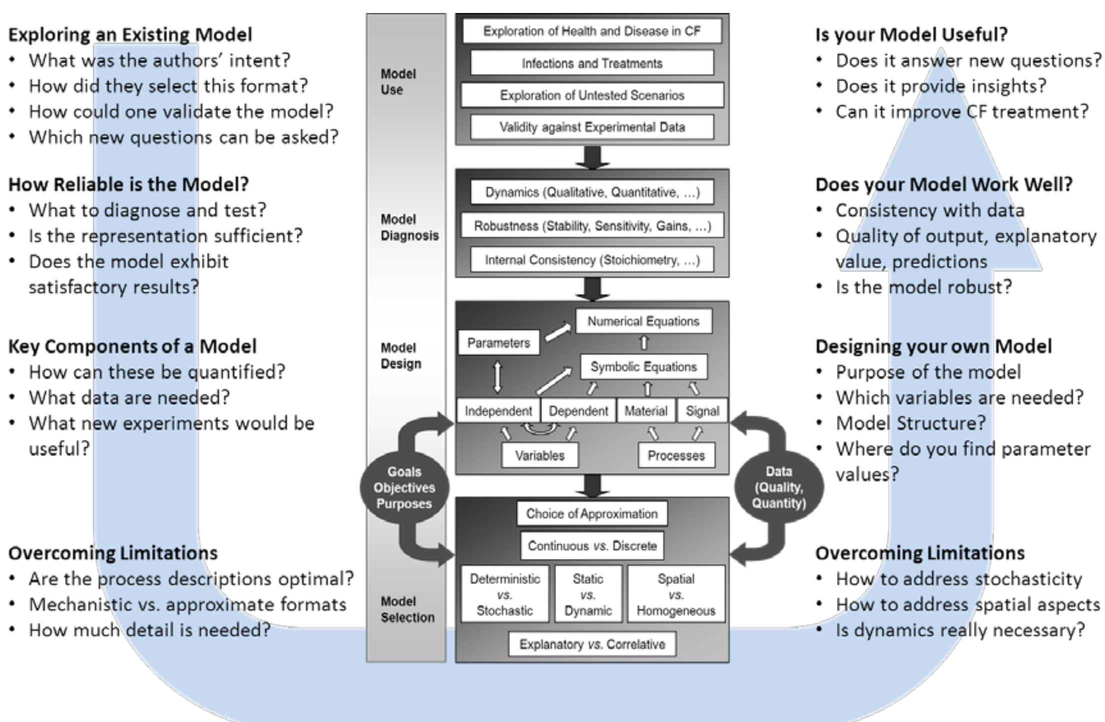
Course Description: Problem Solving with Computational Models

Department: Biomedical Engineering, Georgia Institute of Technology
Instructors: Melissa Kemp, Eberhard Voit, Wendy Newstetter
Meeting times: Twice a week; 1½ hours each
Prerequisites: Admission to a Graduate Program in Engineering, Science, or Computing

Learning Objectives:

- Understand and articulate fundamental issues of modeling in biology
- Be able to critically read, evaluate, and review modeling and experimental papers
- Be able to pose a well-developed research question that can be addressed through mathematical and computational modeling
- Have an understanding and appreciation for the value and limitations of mathematical modeling and quantitative approaches to biomedical research and engineering

Format:
The format for this class departs from convention in computational modeling courses and is designed to be accessible to BME and non-BME majors who wish to gain a fundamental understanding of how to assess biological questions with computational tools. Our approach is to introduce the material in a top-down manner, first through the use of an available model of a disease and then by developing modeling expertise that ultimately permits the design of new models. The syllabus is summarized in the diagram below.



Grading: There will be no in-class exams or final in this class. Your grade is based on the components below:

40%: final project grade
30%: in class presentations and participation
20%: written homework (assignments designated in attachment)
10%: peer review evaluations

Class Schedule (Fall 2011)

Date	Class	Topic	Assignments and Notes
8/23	1	Structure and expectations of course Why modeling? Examples of models: Purpose, goals, assumptions, etc. Objectives of course and class structure	Assigned reading for class 2: two CF papers
8/25	2	Clinical and biological overview of cystic fibrosis (CF)	Assigned reading for class 6: four CF biology papers
8/30	3	ODE modeling (mass action, power-law, other) Intro to the PLAS platform Intro to base CF model Typical simulations (bolus, persistent, …)	Assignment: Implement model in PLAS (or other software); simulate
9/1	4	How to critique a paper	Assigned reading: Vodovotz *et al.*, *Math. Biosc.* **217**, 1-10, 2009.
9/6	5	Criteria/features of systems; steady states, types of stability, sensitivities	HW for class 7: features/tasks to be tested with CF model
9/8	6	Journal club with 4 presentations on CF biology	
9/13	7	Other types of dynamic behavior in models: bifurcations, oscillations, toggle switches, chaos; Discussion of CF model simulations with 4 brief presentations	HW for class 9: explore small non-CF models
9/15	8	Tools used for mathematical description: Representations of mechanisms (Michaelis-Menten, physics based) Approximations in systems biology	HW for class 12: Replace functions in CF model

9/20	9	Bistability in biological systems	
9/22	10	Intro to Simbiology platform (held in BME Computer Lab)	HW for class 14: Translate CF model from PLAS into Simbiology
9/27	11	Intro to additional Matlab features, held in BME Computer Lab	HW for class 14: Translate CF model from PLAS or Simbiology into Matlab
9/29	12	Bottom-up. Top-down, Middle-out modeling; Parameter Estimation; how-to and different methods	HW for class 16: Parameter estimation using non-linear regression
10/4	13	Data management in Matlab; Q&A: PLAS, Simbiology, Matlab; Simple nonlinear regression (held in BME Computer Lab)	
10/6	14	Discussion with 4 presentations on HW from classes 8, 10, 11	
10/11	15	Thinking like an experimentalist; Data types, availability and quality	HW for class 16: Literature examples where data have been converted into models
10/13	16	Discussion with 4 presentations on HW from classes 13 and 14; Brainstorming session: intrinsic limitations of ODE models	HW for class 18 : Find CF literature as a basis of what to model and identify modeling needs
10/18	—	Fall break	
10/20	17	Monte Carlo methods	HW for class 21: Implement MC simulation in MatLab
10/25	18	Short presentations; discussion of individual ideas for modeling CF	Every student presents for 5 to 8 minutes
10/27	19	Other model types: Boolean networks; discrete, recursive models	HW for class 21: explore logistic map
11/1	20	Intro to agent-based models (ABM)	HW for class 24: ABM toy model implementation
11/3	21	Discussion with 4 presentations on HW from classes 17 and 19	Start forming tentative teams for CF modeling
11/8	22	Stochastic process models: Gambler's ruin, Poisson, Binomial examples	HW for class 24: Stochastic toy models
11/10	23	Brainstorm of non-ODE based representation in CF	
11/15	24	Discussion with 4 presentations on HW from classes 20 and 22	

11/17	25	Finalize project selection	
11/22	26	Open-ended problem-based learning (PBL) with team projects; short presentations on progress	
11/24	—	Thanksgiving	
11/29	27	Open-ended PBL with team projects; short presentations in progress	
12/1	28	Open-ended PBL with team projects; short presentations in progress	
12/6	29	Presentations of projects	
12/8	30	Presentations of projects	
12/12-12/16		Finals Week	Written reports due