BIEN 271: Multi-scale Analysis of Biological Systems
Video Bio-Informatics (VBI)-1
Spring 2015

COURSE OUTLINE

Course Time: 1:10 p.m. -3:00 p.m. M HMNSS 1502

Instructor: V. G. J. Rodgers (victor.rodgers@ucr.edu)

Suggested Supplemental Books:
Multiscale Modeling of Developmental Systems, Volume 81 (Current Topics in Developmental Biology) by Santiago Schnell (Editor), Philip Maini (Editor), Stuart A. Newman (Editor), Timothy Newman (Editor), Gerald P. Schatten (Series Editor) Academic Press; 1 edition (January 1, 2008), ISBN-10: 0123742536, ISBN-13: 978-0123742537

Multiscale Problems in the Life Sciences: From Microscopic to Macroscopic, V. Capasso (Editor), M. Lachowicz (Editor), Springer-Verlag Berlin Heidelberg (2008), ISBN:978-3-540-78360-2

Biological Physics of the Developing Embryo by Gabor Forgacs (Author), Stuart A. Newman (Author), Cambridge University Press (December 12, 2005), ISBN-10: 0521783372, ISBN-13: 978-0521783378

Modeling Biology: Structures, Behaviors, Evolution (Vienna Series in Theoretical Biology) by Manfred D. Laubichler (Editor), Gerd B. Müller (Editor), The MIT Press; 1 edition (October 31, 2007), ISBN-10: 026212291X, ISBN-13: 978-0262122917

Transport Phenomena in Biological Systems, G. Truskey, F. Yuan, D.F. Katz, Pearson Prentice Hall, New Jersey, 2004, ISBN: 0-13-042204-5

Textbook of in vivo Imaging in Vertebrates by Vasilis Ntziachristos (Editor), Anne Leroy-Willig (Editor), Bertrand Tavitian (Editor), Wiley; 1 edition (September 10, 2007), ISBN-10: 0470015284, ISBN-13: 978-0470015285

Course Description:
This introductory, project-based course of the NSF IGERT Video Bio-Informatics (VBI) will introduce the student to the significant range for both the time and spatial scales of biological systems and how these scales are analyzed, via imaging techniques, for a better understanding of biological function.

Biological processes, such as the human body, can function for decades under a variety of external inputs. Yet critical elements of life must occur at time scales on the order of nanoseconds to seconds to maintain life.

As an example, in Figure 1 below, the schematic illustrates the importance of the redox reactions in the mitochondria that occurs in nearly all cells. These reactions occur during respiration and are critical in controlling superoxide (an anti-oxidant process). Here some of the reactions are represented as a system of transient non-linear differential equations that describe the kinetics of these unstable species. The time scales for these reactions are on the order of nanoseconds to seconds. However, because of species transport and reaction, they can have impact on the living system (such as cancer development) with time scales on the order of hours, days, months and years.

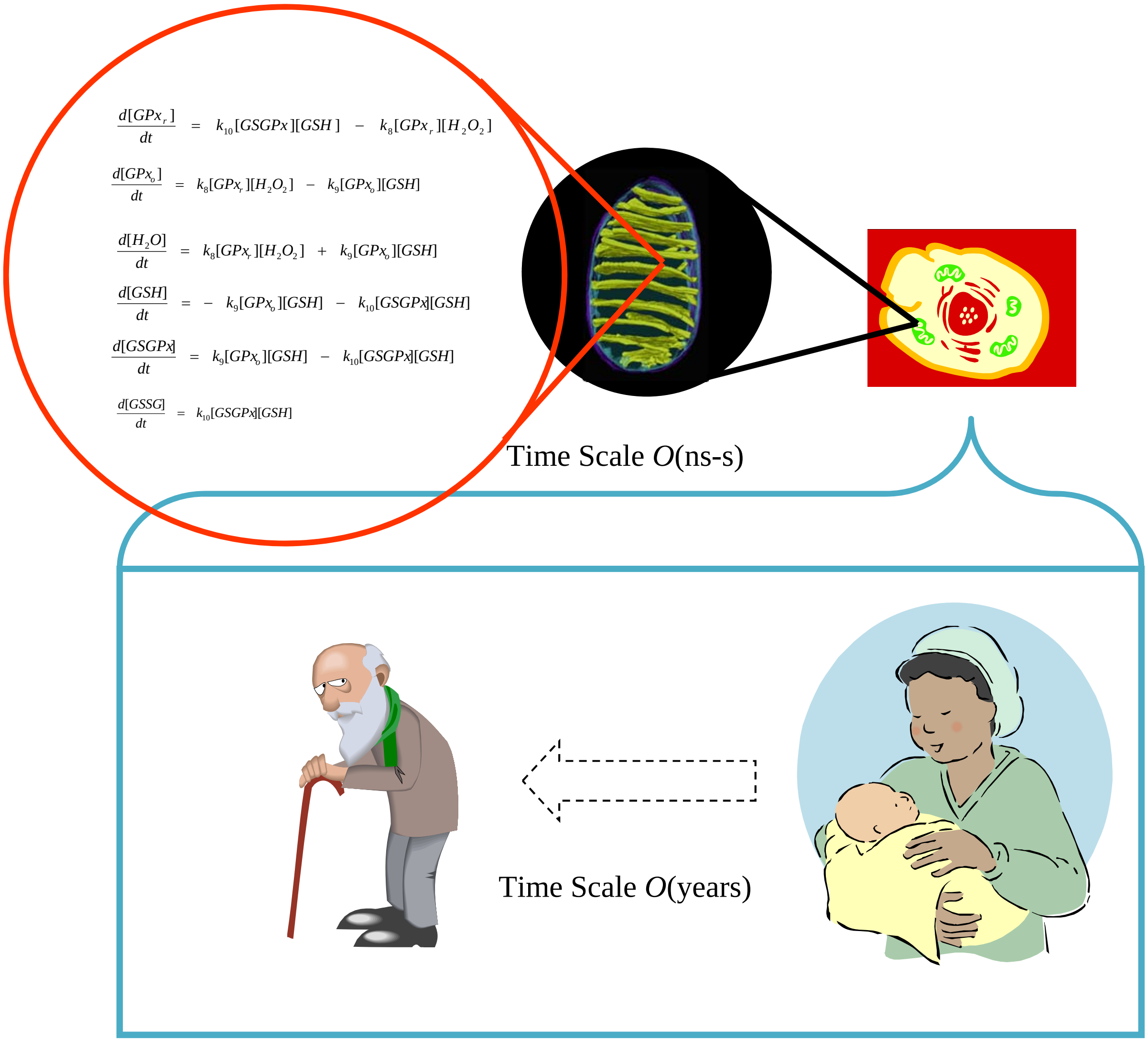

Figure 1. Illustrates an example of the importance of multi-scale processes in biological system. Here the free radical reactions (in the mitochondria of cells) will impact cell viability, affecting the organism for years. (Mitochondria image from Perkins et al., (1997)[1]).

It is the goal of this course to provide basic analytical tools for analyzing the multi-scale processes in biological systems as well as provide the background needed to invoke advanced imaging techniques to properly analyze those systems. Since VBI is interdisciplinary, one of the goals of this course is to move the NSF IGERT Fellows to a common background that will allow them to communicate, be confident, and be effective in researching interdisciplinary topics involving biological video information.

This is a goal-orientated course, and, as such, it is project based. However, so that the student has formal development of fundamental training, ongoing projects and assignments will be given throughout the quarter. The quarter-long projects will be to develop an NIH proposal, suggested by the students, that

[1] Perkins G, Renken C, Martone ME, Young SJ, Ellisman M, Frey T. (1997). Electron tomography of neuronal mitochondria: three-dimensional structure and organization of cristae and membrane contacts. *J Structural Biol.* **119**: 260-272.

uses video bioinformatics to address a relevant biological problem that spans at least two scales in time or space. The proposal must:

1. be in the standard NIH R01 format,
2. specify the appropriate specific aims that couples the problem with the goals of this class,
    a. relate work to at least to video imaging techniques,
    b. relate work to at least two scales in space or time,
3. provide a working imaging analysis algorithm, and,
4. provide working computational modeling analysis.

Examples of previous proposal titles include:

- Quantifying Toxicant Effects on Human Embryonic Stem Cells
- *In Planta* Examination of Root-Knot Nematode, *Meloidogyne incognita*, Secretome Proteins
- Multiscale analyses of polarized growth in Mutants involved in Heterotrimeric G Protein Signaling in *Neurospora crassa*
- Multi-scale Imaging and Data Analysis of Atherosclerosis: Correlating Molecular and Cellular Variations
- Understanding the Roles of Ions in Glial Cell Swelling
- Characterization of Anterior-Posterior Patterning in *Drosophila melanogaster* using Video-bioinformatics
- Examination of nematode-plant interactions: Characterization of root-knot nematode feeding on plant cells

A series of short presentations will be used for the student groups to develop the project as well as share with the class what they are doing. Two project reports are also required, one mid-term and the final professional report. The final presentation of the project will be presented at the end of the quarter and the IGERT community will be invited to attend.

Homework assignments will be given to develop specific area in basic mathematical modeling and analysis. The homework will be reviewed with the primary concern being effort and professionalism rather than correctness. This is because the philosophy of graduate education is to develop the ability to teach ourselves new subject matter and to be accountable for our technical performance. Thus students will not be penalized for incorrectness during the "intermediate stages" of learning (homework) but they will be accountable for knowing the correct approach to a problem in the projects. Therefore it is essential to the student that they are responsible for their understanding of the problems and their assigned purpose.

This course will be rigorous but in a supportive setting. To this end, I will have an open-door policy for help and support with any aspect of this course. Take advantage of soliciting for help as often as necessary. Answers to the homework (where available) will be made available on for the course the day after the homework is due. Professional and technical qualities are of the utmost importance.

Exam Schedule and Grading:

EXAM	**POINT**	**DATE and DATE**
Project Assignment	0	Monday, March 30, 2015
Project Topic Confirmed	0	Monday, April 6, 2015
Presentation I (Preliminary)	500	Monday, April 13, 2015
NIH Proposal Intermediate	500	Monday, May 11, 2015
Presentation II (Intermediate)	500	Monday, May 11, 2015
Project NIH Proposal Final	1000	Week of Monday, June 8, 2015
Presentation Final	500	Week of Monday, June 8, 2015
TOTAL	**3000**	

Collaboration Policy:

Any questions about homework problems should be addressed to Professor Rodgers. Discussion of homework problems with other students in the class is acceptable but direct copying of complete or part of an assignment is ***not*** allowed. Cheating on exams and/or plagiarism in projects will result in an **F** grade given for the course.

Suggested Topics Schedule

Week	Topic	Material
1	Introduction to Spatial and Time Scales of the Biological System	References, Notes
2	Systems of Ordinary Differential Equations/ Matlab Applications	Notes
2	Modeling Considerations/Biological Pattern Formation	(M) Ch. 15, Notes, References
3	Setting up Spatial and Time Dependent Systems of Equations	Notes
3	Integrating Morphogenesis with Mechanics and Cell Biology	(M) Ch. 2, Notes
4	Understanding Regression	Notes
4	Lung Branching Morphogenesis	(M) Ch. 10, References
5	Multi-Scale Modeling Methods	Notes
6	Multiscale Models of Brain Development	References, (M) Ch. 1
7	Tumor Cell Growth	Notes, References, (M) Ch. 5
8	Putting Modeling and Experimental Strategies Together	Notes
8	Relating Biophysical Properties across Scales	(M) Ch. 16
9	Stem Cell Motility	References, (M) Ch. 1
10	Complex Multicellular System and Immune Competition	(M) Ch. 17

(M) *Multiscale Modeling of Developmental Systems, Volume 81* (Current Topics in Developmental Biology) by Santiago Schnell (Editor), Philip Maini (Editor), Stuart A. Newman (Editor), Timothy Newman (Editor), Gerald P. Schatten (Series Editor) Academic Press; 1 edition (January 1, 2008), ISBN-10: 0123742536, ISBN-13: 978-0123742537