November 3, 2009

Syllabus: Spring 2010 MATH4024/BIOL4800sec7
Mathematical Modeling in Cellular Biology

Course Number: MATH4024/BIOL4800sec7
Course Credit: 3 credit hours
Course Title: Mathematical Modeling in Cellular Biology
Enrollment Limit: 15
Meeting Days and Time: Tuesday and Thursday 12 : 10 pm – 1 : 30 pm
Meeting Room: xxxx

Instructor 1: Hongyu He, Ph.D.
Assistant Professor, Department of Mathematics, LSU
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Office Hours:
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Instructor 2: Naohiro Kato, Ph.D.
Assistant Professor, Department of Biological Sciences, LSU
Office: Room 226, Life Sciences Building, LSU, Baton Rouge, LA
Office Hours: Friday 9 am – 12 pm (a small message board is available on the office door in case of absence) or By Appointments
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Website: http://www.biology.lsu.edu/faculty_listings/fac_pages/nkato.html

Cell biologists try to understand a cellular function of their interest by analyzing the function of individual molecules. They are trained to extract information from the cells and often describe their findings in graphs and diagrams. Mathematicians try to understand complicated phenomenon of their interest by drawing graphs and solving equations. They are trained to construct equations from graphs and diagrams and analyze the variables and parameters in the equations. When these two sciences come together, it is possible to identify the fundamental rule that governs the complicated cellular function.

Course Objective:
The objective of this course is to understand the mathematical translation of cellular biology. Students will learn how a diagrammatic explanation of molecular functions is translated into a set of nonlinear differential equations that describe the dynamics of the functional interactions. At the end of the course, the students will be able to 1) understand current questions in the cellular biology field, 2) translate a diagram into a set of nonlinear differential equations and 3) analyze the cellular function mathematically and computationally.

Course Description:
Two scientists, one who is specialized in cellular biology and the other in mathematics, will give lectures on math modeling in cell biology. The biologist will explain the background and questions in cellular biology covered in class. The mathematician will explain how diagrams presented by the biologist can be translated into equations and how to analyze them. The students in the class will form small groups in which math and biology majors are mixed. They will carry on a research project in which a biological finding is translated into mathematical equations, and present their analysis to the class.

Topics Covered:

Mathematical Topics Instructed by Dr. He	Biological Topics Instructed by Dr. Kato
1. Basics of ODE	1. Molecular diffusion and number
2. Exponential Decay and Growth	2. Cell cycle
3. Linear First order ODE	3. Enzyme reaction
4.	4. Transcription
5. From Network Diagram to ODE	5. Protein modification (phosphorylation)
6. Logistic Differential Equation	6. Lactose operon
7. Basics of Vector Field-Qualitative Results	7. MAPKinse signal transduction
8. Equilibrium and Partial Equilibrium	8. Artificial gene expression
9. Analysis on the Phase Space	9. cAMP signaling system
10. Stability	10. $Ca2^{+}$ signaling
11. The Oscillator	11. Circadian rhythm (PER-protein)
12. Bifurcation	12. p53, DNA repair, PTEN, PIP3, Mdm2
13. Analysis on Complex Biological systems--Theoretic Methods	
14. Analysis on Complex Biological systems--Numerical Methods	
15. Diffusion Equation	

Prerequisites:
Basic knowledge of molecular biology and calculus are required. BIOL3090 (Cell Biology) and MATH1550 (Calculus) or equivalent, are required for biology major students. BIOL1001 (General Biology) or equivalent is required for math major students. Contact the instructors, kato@LSU.edu or Hongyu@math.LSU.edu, before registration if your qualification is not certain.

Course Materials:
System Modeling in Cellular Biology: From Concepts to Nuts and Bolts (ISBN-10: 0262195488) will be used as a guideline. Lecture notes will also be provided through Moodle.

Course Resources:

Recommended Internet Site for biology major students:
http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=mcb.TOC
http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=mboc4.TOC&depth=2
Recommended Internet Site for math major students:
Calculus for Biology and Medicine (ISBN-10: 0130455164)

Course Management System:
Announcements will be made in class as well as on Moodle.
Visit Moodle (http://moodle.lsu.edu/) between each class session.

Project Assignment:
All students must **report** and **present** a research project in which cellular biological phenomenon in a peer-reviewed paper will be studied and analyzed mathematically. Active readings and group meetings outside class will be required.

Grading Polices:
Grading is based on class participation and the project achievement of **individual** students.

A: Outstanding Achievement
B: Above Expectation (High Achievement)
C: Satisfactory Achievement
D: Below Expectation
F: Unsatisfactory Achievement

Course Legal Statements:
Withdraw:
A student may withdraw from the class on and before January 26, 2010 without receiving a grade of "W".
Equal Opportunity:
All qualified students have equal opportunity in class without regard to race, creed, color, marital status, sexual orientation, religion, sex, national origin, age, or veteran's status.
Disabilities:
A student having learning disabilities should consult the instructor and Office of Disability Services (http://appl003.lsu.edu/slas/ods.nsf/index/) before registration.
Academic Integrity and Civility:
Code of Student Conduct issued by the Office of the Chancellor (http://www.lsu.edu/saa/Code%20of%20Student%20Conduct%20August%2009.pdf/) will be applied.

Memo:

Spring 2010 Math4024/BIOL4800sec7: Mathematical Modeling in Cellular Biology Tentative Schedule

Session	Date	Week	Calendar note	Research Project	Text Book section	Mathematical Topic Instructed by Dr. He	Biological Topics Instructed by Dr. Kato
1	1/19/10	Tuesday			6.1 Introduction		1. Molecular diffusion and number
2	1/21/10	Thursday			6.2.1 From a Writing Diagram to a Set of ODEs	1. Basics of ODE	2. Cell cycle I
3	1/26/10	Tuesday			6.2.2 Constant Synthesis	2. Exponential Decaying and Growth	2. Cell cycle II
4	1/28/10	Thursday			6.2.3 Linear Degradation		2. Cell cycle III
5	2/2/10	Tuesday			6.2.4 Autocatalytic Production	3. Linear First order ODE	2. Cell cycle IV
6	2/4/10	Thursday			6.2.5 Dimerization	4. Logistic Differential Equation	3. Enzyme reaction I
7	2/9/10	Tuesday			6.2.6 Michaelis-Menten Kinetics	5. From Network Diagram to ODE	3. Enzyme reaction II
8	2/11/10	Thursday			6.3.1 Synthesis and Degradation	6. Linear First order ODE II	4. Transcription
	2/16/10	Tuesday	**Mardi Gras Holiday**				
9	2/18/10	Thursday			6.3.2 Phosphorylation and Dephosphorylation	7. Logistic Differential Equation	5. Protein modification (phosphorylation)
10	2/23/10	Tuesday			6.4 Networks with Feedback	8. Basics of Vector Field-Qualitative Results	
11	2/25/10	Thursday			6.4.1 What is Feedback		6. Lactose operon
12	3/2/10	Tuesday			6.4.2 Negative Feedback		7. MAPKinse signal transduction
13	3/4/10	Thursday		**Student presentation 1**			
14	3/9/10	Tuesday	**Midterm Exam Week**	**Student presentation 2**			
15	3/11/10	Thursday	**Midterm Exam Week**	**Student presentation 3**			
16	3/16/10	Tuesday			6.4.3 Phase Planes, Vectors fields, and Nullcilines	9. Equilibrium and Partial Equilibrium	8. Artificial gene expression I
17	3/18/10	Thursday			6.4.4 Positive Feedback		8. Artificial gene expression II
18	3/23/10	Tuesday			6.4.5 Mutual Antagonism	10. Analysis on the Phase Space	9. cAMP signaling system I
19	3/25/10	Thursday			6.5 Networks That Oscillate	11. Stability	9. cAMP signaling system II
20	3/30/10	Tuesday			6.5.1 Activator-Inhibitor	12. The Oscillator	10. $Ca2^+$ signaling I
21	4/1/10	Thursday			6.5.2 Substrate-Dependent	13. Bification	10. $Ca2^+$ signaling II
	4/6/10	Tuesday	**Spring Break**				
	4/8/10	Thursday	**Spring Break**				
22	4/13/10	Tuesday			6.5.3 Delay Negative Feedback		11. Circadian rhythm (PER-protein)
23	4/15/10	Thursday			6.6 A Multiple-Feedback Network: P53 and Mdm2		12. p53, DNA repair, PTEN, PIP3, Mdm2
24	4/20/10	Tuesday				14. Analysis on Complex Biological systems--Theoretic Methods	
25	4/22/10	Thursday				15. Analysis on Complex Biological systems--Numerical Methods	
26	4/27/10	Tuesday				16. Diffusion Equation	
27	4/29/10	Thursday		**Student presentation 4**			
28	5/4/10	Tuesday		**Student presentation 5**			
29	5/6/10	Thursday		**Student presentation 6**			
	5/10/10	Tuesday	**Final Exam Week**				