An Introduction to Systems Biology:
Genomics, Proteomics, & Bioinformatics (etc.)

Course Description: An introduction to integrative biological study using principles of systems biology. Systems biology is a new field which explores the world of genomes and post-genomic datasets and large databases. The goal of systems biology is to comprehensively understand development, physiology, metabolic and gene regulatory networks, by looking at all genes, proteins and metabolites in an organism simultaneously, rather than focusing on just one or two. A foundation will be set to understand the connectivity of “-omics” technologies (genomics, transcriptomics, proteomics, metabolomics, etc) for assessment of problems challenging living systems. The focus will be directed on the ‘why’ rather than the ‘how’ to use these technologies. Critical thinking and analytical skills are practiced through evaluation of primary literature and completion of instructor assigned activities. Prerequisites: BIOL 2416 AND either BIOL 3410 or CHEM 4401 (or the equivalent of these courses).

Life is a relationship among molecules and not a property of any molecule.
- Linus Pauling

LEARNING OUTCOMES

- Evaluate what is systems biology and propose challenges and opportunities
- Compile and differentiate metabolic, signaling and gene regulatory networks
- Employ protein interactome data
- Predict test outcomes by interpreting genome, transcriptome, proteome, metabolome and interactome level information
- Recognize scientific problems in post-genomic biology
- Critically evaluate the use of these research tools in published investigations
- Exposure to bottom-up and top-down design and analysis strategies for systems biology
- Recognize the importance of mathematical frameworks used to understand and design biological circuits
- Appraise the current and future need of systems biology in solving health problems
- Develop a research proposal that supports a coordinated systems biology approach
- Prepare and employ active-learning into explaining systems biology principles

LECTURE SYLLABUS
Assessment Exam 1: October 24, 2013
Tidbit: Arranging the puzzle pieces: Concept Map.
‘Systems Biology’ Chapters 1-4; 6-8
Complete assessment of primary articles as directed
Quizzes and In-class assessment questions will be derived from End-of-Chapter Exercises and Primary Articles
October 22, 2013: Turn in narrative report that outlines the opinion of the professor of your choice regarding your “Goldilocks Proposal”

1. What is systems biology?
   * Introduction to biological systems
     i. Describe the generic features of biological systems
     ii. Explain the goals of systems biology
     iii. Identify those challenges of systems biology that cannot be solved with intuition alone.
     iv. Assemble a “to-do” list for the field of systems biology

2. How does math work with systems biology?
   * Project Runway: Modeling in systems biology
     i. Describe the modeling process in generic terms
     ii. Know some of the important types of mathematical models in systems biology
     iii. Understand the basic concepts of graphs and how they are applied to biological networks
     iv. Describe typical examples of static networks in different fields of biology
     v. Understand basic modeling approaches
     vi. Describe the differences and relationships between linear and nonlinear models
     vii. Identify the steps of a typical biological systems analysis

3. How well do you know the Central Dogma?
   * Gene systems
     i. Discuss the Central Dogma of molecular biology, as well as modern amendments and refinements
     ii. Describe the key features of DNA and RNA
     iii. Identify the roles of different types of RNAs
     iv. Outline the principles of gene regulation
     v. Set up simple models of gene regulation
     vi. Summarize current methods for assessing gene expression and its location, along with their advantages and drawbacks

4. How could you develop a protein atlas?
   * Protein Systems
i. Discuss types of proteins and their roles
ii. Describe the basic chemical properties of proteins
iii. Explain the four hierarchical levels of protein structure
iv. Retrieve from databases information about the crystal structure of proteins
v. Outline concepts of protein separation and proteomic techniques
vi. Discuss the basic concepts of protein structure prediction and protein localization
vii. Describe interactions among proteins and between proteins and other molecules

5. **What are the primary inputs and outputs that control living systems?**
   * **Metabolic Systems**
     i. Identify and characterize the components of metabolic systems
     ii. Describe conceptually how the components of metabolic systems interact
     iii. Understand the basics of mass action and enzymes kinetics
     iv. Be aware of various data sources supporting metabolic analysis
     v. Associate different types of metabolic data with different modeling tasks
     vi. Explain different purposes of metabolic analysis

**Assessment Exam II: December 10, 2013**

Tidbit: Blowing Chunks
Tidbit: Connecting the dots to find your way.
‘Systems Biology’ Chapters 9; 11; 14&15
Complete assessment of primary articles as directed
Quizzes and In-class assessment questions will be derived from End-of-Chapter Exercises and Primary Articles

**December 5, 2005**: “Goldilocks Proposal” should be complete and turned in for my assessment

1. **How do you decide which directions to follow to arrive at an unknown destination?**
   * **Signaling Systems**
     i. Understand the fundamentals of signal transduction systems
     ii. Discuss the advantages and disadvantages of discrete and continuous models of signal transduction
     iii. Describe the role of G-proteins
     iv. Solve problems involving Boolean models
     v. Discuss quorum sensing
     vi. Analyze differential equation models of two-component signal transduction systems
     vii. Analyze differential equation models of the MAPK signal transduction system

2. **Evaluate how these systems converge to allow solid predictions.**
   * **Integrative analysis of genome, protein and metabolite data**
i. Discuss the steps for converting diverse experimental data into a computational model
ii. Describe how available data and research goals define the focus and scope of a model
iii. Match different types with suitable modeling methods
iv. Identify the main components of the heat stress response in yeast
v. Describe responses on different timescales and their impact on modeling analysis
vi. Explain the role of trehalose in heat stress responses
vii. Set up a metabolic model of the heat stress response from metabolic data
viii. Set up a metabolic model of the heat stress response based on gene expression data
ix. Discuss the advantages and limitations of time-series data for metabolic modeling

3. **How do you run the diagnostics when the check engine light comes on in a human?**
   * Design of biological systems
     i. Recognize the importance of studying design principles
     ii. Identify concepts and basic tools of design analysis
     iii. Discuss different types of motifs in biological networks and systems
     iv. Set up static and dynamic models for analyzing design principles
     v. Describe methods for manipulating biological systems toward a goal
     vi. Understand the concepts and basic tools of synthetic biology
     vii. Characterize the role of systems and synthetic biology in metabolic engineering

4. **Defend the need for further funding into systems biology.**
   * Emerging topics in systems biology
     i. Present an overview of the current state of the art in systems biology
     ii. State some of the pressing challenges for systems biology in the near future
     iii. Explain why some application areas are difficult to analyze and in need of systems analysis
     iv. Explain where current modeling techniques fall short and what could be done to remedy them
     v. Discuss what a theory of biology would entail

Students will be required to write a 1.5-page practice “Goldilocks Proposal” based on a real NIH call for proposals in systems biology. You will be provided with the call for proposals and a breakdown of the purpose, process and set-up of the proposal. (Point Value: 150)

Students will be required to be primary contributors in the development of an active-learning module and assist in implementation of the module. (Point Value: 100)
Major Course Requirements

Tentative Evaluation:  Your final grade will be based on the percentage you earn out of the total possible points. Individual extra credit is not possible, but bonus points may be built into exams or other assignments. Statistical manipulations, if used (at the Instructor’s discretion), will be performed only once, at the end of the semester. A 10-point grading scale will be used:

A = 90 - 100 %
B = 80 - 89.9 %
C = 70 - 79.9 %
D = 60 - 69.9 %
F = 0 - 59.9 %

Components of Course Grade (Tentative)

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Assessment Exam I</td>
<td>100</td>
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<tr>
<td>Assessment Exam II</td>
<td>100</td>
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<tr>
<td>Final Exam</td>
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<tr>
<td>Quizzes</td>
<td>150</td>
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<td>Research Proposal</td>
<td>150</td>
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<tr>
<td>Activity Development</td>
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<tr>
<td>Homeworks or Other Assignments</td>
<td>100</td>
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<tr>
<td>Attendance/Participation</td>
<td>50</td>
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TENTATIVE TOTAL = 950

The time schedule may require adjustment. Should this be the case, the assignments and weighting may change. Additional assignments may or may not be provided at the Instructor’s discretion and depending upon opportunities. Such assignments might include seminar attendance, homeworks, group projects, reading assignments, quizzes, etc.

An assignment will likely be due during the last week of class.

Every attempt will be made to follow the time and evaluation schedules shown here. It is the student’s duty to attend each class session and be aware of all assignments, deadlines, changes, etc.

Exams will be a mixture of multiple choice, matching, fill-in the blank, short answer, labeling, calculations and essay questions. Some will require analysis and interpretation of data or experimental design to assess critical thinking skills. The Final Exam (Tuesday, Dec. 17 from 11:00 AM - 1:30 PM) will contain new material from the end of the semester.
Quizzes may be given at any time in class. There will be no makeups. **Homeworks and other assignments** may be given in class. The other assignments may include seminar attendance, data interpretation, experimental design, calculations, opinion papers, research article summaries, etc. They will generally be due at the start of lecture class the following week. You are encouraged to get together and work on them as a group. However, unless specified otherwise, the assignments must be turned in individually and be written **in your own words, NOT COPIED.** An assignment grade of ZERO will be given if the work is not in your own words.

**Attendance to class is required.** Each student will be given a 2-absence grace allowance before losing attendance points.

### Readings, Resources & Supplies


**Text-Associated Website:** [http://garlandscience.com/index.jsf](http://garlandscience.com/index.jsf)

**Required Journal Reading:** Access to the journals will be provided

**Recommended or Supplemental Reading:**


**BlackBoard:** Course-associated site for posting notes, readings, labs, data, etc.

### List of Supplies

- You must have access to a computer and internet.
- Index cards (3x5)

### Suggestions

If you are having trouble in this class don’t hesitate to communicate with me.

### Course Policies

**ALL E-MAIL COMMUNICATIONS WITH THE INSTRUCTOR MUST BE MADE THROUGH YOUR OFFICIAL UNIVERSITY E-MAIL (@ISLANDER), BY UNIVERSITY RULE.**

**Attendance/tardiness, Late work and Make-up Exams** You are expected to attend all classes and labs in a timely manner. Important new material, as well as schedule
changes and quizzes may occur at any time. It is expected that you will take notes, ask/answer questions, and participate in group activities.

**LATE WORK will not be accepted, except as below, or unless otherwise specified.**
Attendance is the student’s responsibility. You are responsible for the material covered in every lecture, even if it is not in the book, regardless of your attendance. Nothing missed during an unexcused absence can be made up. An excused absence allows us to make alternative arrangements to complete an assignment. Only unavoidable absences are excused. Routine events (holiday travel, non-emergency medical visits, parent-teacher conferences, household or auto repairs) should be scheduled to avoid conflicts with class. An acceptable excuse must be:
- from an appropriate source (doctor, dentist, funeral director) stating the nature of the event
- In writing, on official letterhead, and signed (it will not be returned)
- presented prior to, or within 1 week of, the absence
- It must state the dates for which the excuse applies

There are No make-up examinations: For some scheduled events, you may arrange to take a lecture exam before, but not after, its scheduled time. Quizzes cannot be made-up.

**Expectations:**
You are responsible for your own education. Take notes in class as new information, not in the textbook, may be presented. Lecture notes from the instructor, when made available, do not represent everything you need to know. Read the book, assigned readings and handouts for further detail not covered in class. If you don’t understand, then please ask, or see the instructor after class. Don’t allow yourself to fall behind. Be diligent and thorough on written assignments and examination answers. If you are not sure of an answer, at least try. For many people, putting anything down on paper clarifies their thinking and helps with recall. Also:
- Be aware of university-imposed deadlines (ie drop dates)
- Be aware of test times and dates, including changes which may be announced in class
- Check your exams for clerical errors. The test score is not the end of the learning process. Review tests to determine why you missed an answer. Correcting your mistakes is an effective way to learn material (reflective learning).
- Work on all assigned homework problems in a timely manner. Seek tutorial help from classmates or the Instructor.
- Keep track of your progress in class.

The following procedures will be enforced:
- All major exams are the property of the instructor and may not be removed from class, copied, reproduced or photographed in any way. Violations will result in a grade of “F”.
* You must be prepared to present a photo ID at all examinations
* If you leave an examination room—for any reason—you must hand in your test and you will not be allowed to resume the examination. Attend to personal matters (e.g., restroom visits) before the examination.

**Cell Phone/Electronic Device Usage Policy on Disruptive Behavior:**
As adult university students, you are expected to act with courtesy and common sense. Disruptive, disrespectful, or abusive language/behavior towards anyone in class (student, staff, faculty) will not be tolerated and could result in permanent removal from class. This includes tardiness to class, talking in class, insubordination, and electronic disturbances (cell phones, ipods, crackberries, etc). **Turn it off.** Children are not allowed in class.

**Academic Integrity/Plagiarism.**
University students are expected to conduct themselves in accordance with the highest standards of academic honesty. Academic misconduct for which a student is subject to penalty includes all forms of cheating, such as illicit possession of examinations or examination materials, falsification, forgery, complicity or plagiarism. (Plagiarism is the presentation of the work of another as one’s own work.) In this class, academic misconduct or complicity in an act of academic misconduct on an assignment or test will result in appropriate action at the discretion of the instructor, including failure of the course. **Everything should be in your own words.**

**Dropping a Class**
I hope that you never find it necessary to drop this or any other class. However, events can sometimes occur that make dropping a course necessary or wise. Please consult with me before you decide to drop to be sure it is the best thing to do. Should dropping the course be the best course of action, you must initiate the process to drop the course by going to the Student Services Center and filling out a course drop form. Just stopping attendance and participation WILL NOT automatically result in your being dropped from the class. Be aware of the last day to drop a class with an automatic grade of “W”.

**Preferred methods of scholarly citations**  *(Format from OMICS: A Journal of Integrative Biology)*

**Grade Appeals***
As stated in University Rule 13.02.99.C2, Student Grade Appeals, a student who believes that he or she has not been held to appropriate academic standards as outlined in the class
syllabus, equitable evaluation procedures, or appropriate grading, may appeal the final grade given in the course. The burden of proof is upon the student to demonstrate the appropriateness of the appeal. A student with a complaint about a grade is encouraged to first discuss the matter with the instructor. For complete details, including the responsibilities of the parties involved in the process and the number of days allowed for completing the steps in the process, see University Rule 13.02.99.C2, Student Grade Appeals, and University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures. These documents are accessible through the University Rules Web site at http://www.tamucc.edu/provost/university_rules/index.html. For assistance and/or guidance in the grade appeal process, students may contact the Office of Student Affairs.

**Disabilities Accommodations***
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please call or visit Disability Services at (361) 825-5816 in Driftwood 101.

If you are a returning veteran and are experiencing cognitive and/or physical access issues in the classroom or on campus, please contact the Disability Services office for assistance at (361) 825-5816.