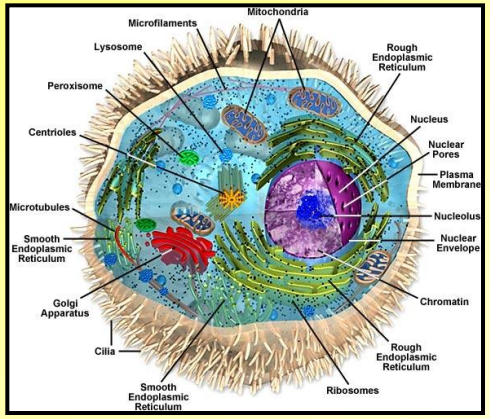
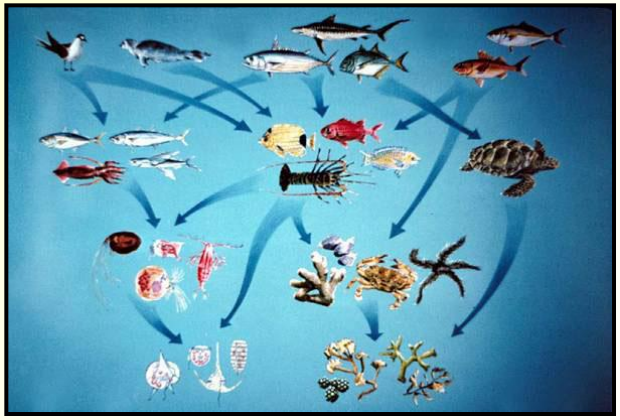
IB115
Introduction to systems in biology and medicine

Course Outline



molecular and genetic systems

physiological systems



ecological systems

IB115 Overview

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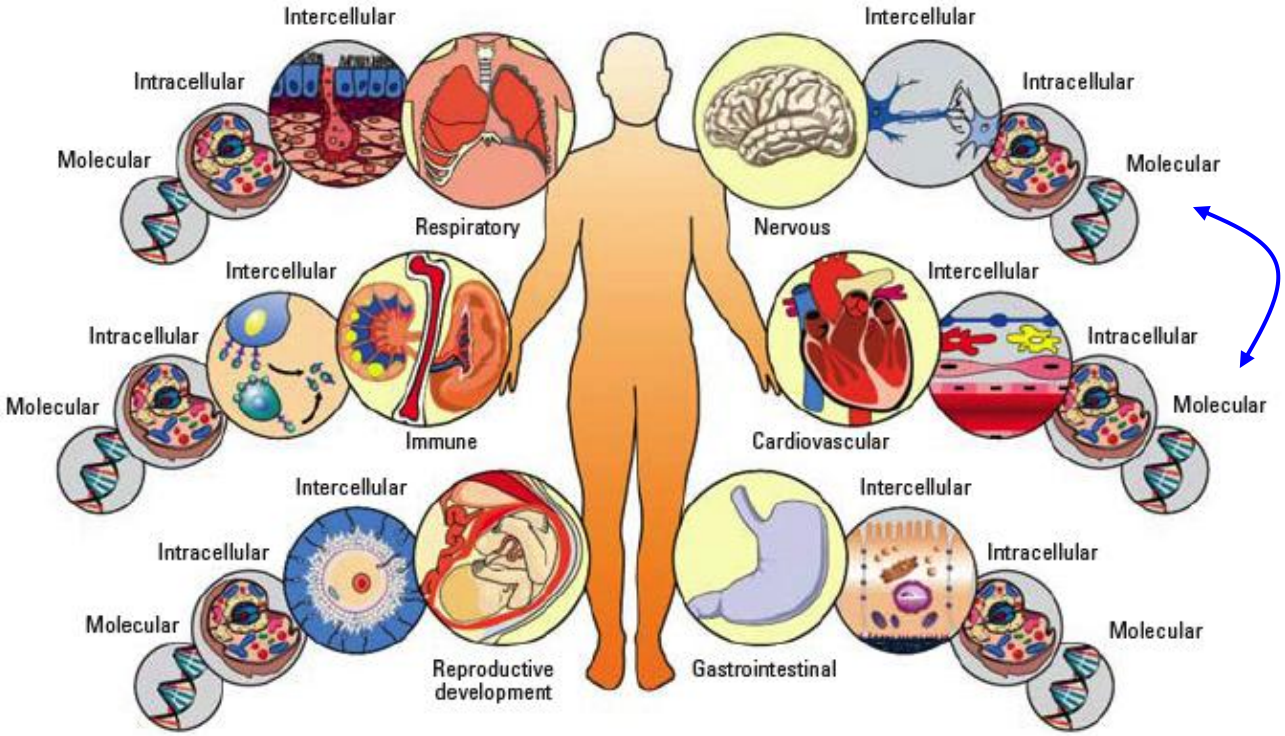
IB115 Overview

Biology and Human Health depends on the complex interactions that take place within multiple interacting systems each built from layer upon layer of smaller scale systems…



Interactions also occur between these systems

Figure 1. Systems biology framework for the individual. Current systems biology methodologies take advantage of high-throughput data generated at the molecular level in the hope of one day translating these maps of molecular interactions into cellular-level responses, then intercellular responses, and finally to an organ-level response. The interconnections between organ systems will need to be elucidated to understand an organism-level system.

(Julia M. Gohlke and Christopher J. Portier)

IB115 Overview

…all of which takes place in environmental and social systems.

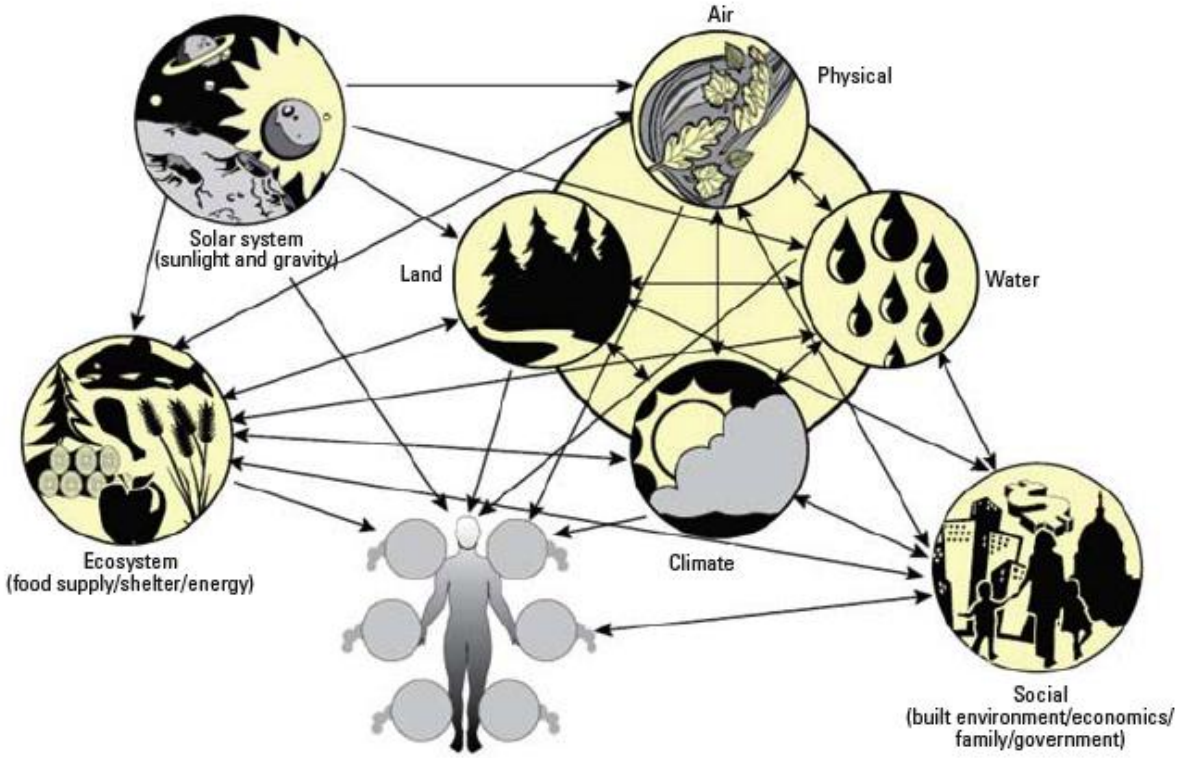


Figure 2. Interaction network between our environment and our health. Human health is determined not only by various molecular, cellular, and organ system–level systems, but by our environment, including social (all interaction within our species), ecosystem (all interactions with other life on earth), physical (all interactions with nonliving components of the earth), and extraterrestrial (planetary position, energy from sun, gravity). Arrows indicate major highways of interaction determining potential routes of global or local changes within these systems. All systems have the potential to affect the individual's health status.

(Julia M. Gohlke and Christopher J. Portier)

Why study biology as systems? (2)

*"Organisms function in an integrated manner – our senses, our muscles, our metabolism and our minds work together seamlessly. But biologists have historically studied organisms part by part and celebrated the modern ability to study them molecule by molecule, gene by gene,… [**systems biology** is] a new science, a critical science of the future that seeks to understand the integration of the pieces to form biological systems."*

David Baltimore (Nobel Laureate in Medicine and Physiology).

Why study biology as systems? (2)

*“..systems are comprised of parts which interact. The interaction of these parts gives rise to new properties and functions which are key to the system. We call these new properties and functions "**emergent properties**". Because emergent properties are the result of interactions between the parts, they can not be attributed to any single parts of the system. This makes systems **irreducible**. A system is unlikely to be fully understood by taking it apart and studying each part on its own. (We cannot understand an author's message by studying individual words; we cannot appreciate a forest by looking at individual trees.) To understand systems, and to be able to fully understand a system's emergent properties, systems need be studied as a whole…”*

Leroy Hood, Institute for Systems Biology

Announcements

- This week's lab is a tutorial on the basics of programming and Matlab. **It is very important!** If you are confident with Matlab I have set an extra problem for you to work on and you can gain credit by helping other students.
- Please don't swap lab classes without permission of the GSI
- GSI will schedule office hours

Goals of the course

General Goal:

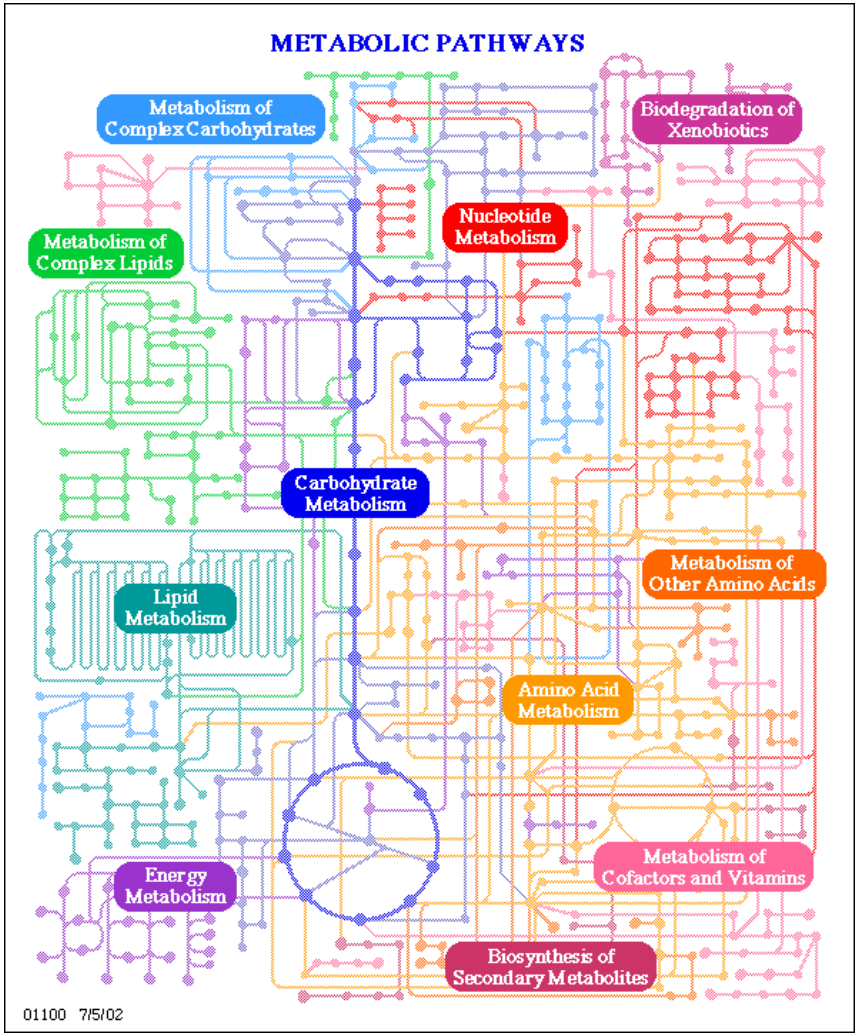
To teach undergraduate and graduate students, from diverse biological and physical sciences backgrounds, how to create simple mathematical models to better understanding biological systems.

Specific goals:

1. How to model biological systems using differential equations.
2. To use Matlab to simulate and analyze biological systems.
3. Common properties of biological systems.
4. Role of randomness in biological systems.
5. Critical thinking and problem-solving.

Why use math?

Quantitative models allow more precise descriptions of systems and their properties and therefore they are essential to truly understanding biological systems which are generally complex. From a practical perspective this is very important, for example, a patient needs to know exactly how much drug to take not simply a “bit more”.



IB115 Overview

Syllabus (1)

Week	Date	Lecture Topics (Mon 12 – 2pm)	Date	Lab
1	01/19/15	**No class.** *Academic and Administrative Holiday*	01/20/15	**No Lab.**
2	01/26/15	Introduction to biological models. Part I: Simple Dynamics *Example: Population growth and quorum sensing.*	01/29/15 %	Introduction to programming and Matlab. Create a simple model of exponential growth.
3	02/02/15	Introduction to biological models. Part II: Coupled equations *Example: Bacterial persistence.*	02/05/15 %	Introduction to the ODE (ordinary differential equation) solver in Matlab (Part I). Create a model of bacterial persistence.
4	02/09/15	Introduction to biological models. Part III: Modeling interactions between species *Example: Chemical kinetics*	02/12/15 %	Introduction to the ODE (ordinary differential equation) solver in Matlab (Part II). Model prion disease as an autocatalytic process.
5	02/16/15	**No class.** *Academic and Administrative Holiday*	02/19/15	**No Lab.**
6	02/23/15	Introduction to biological models. Part IV: Modeling systems with multiple compartments *Example: Pharmacokinetics.*	02/26/15 %	Introduction to the ODE (ordinary differential equation) solver in Matlab (Part III). Simulate drug dosing and metabolism.
7	03/02/15	Modeling HIV infection	03/05/15 %	Explore the dynamics of HIV infection.
8	03/09/15	**Midterm**	03/12/15	**No Lab.**
9	03/16/15	Biological networks and modules Part I. Hill function, feedback regulation	03/19/15 %	Model simple biological circuits

% Lab is graded

A. IB115 Overview

Syllabus (2)

Week	Date	Lecture Topics	Date	Lab
10	03/23/15	**Spring Break**	03/26/15	**No Lab.**
11	03/30/15	Biological networks and modules Part II: Boolean logic and FFL **Project Outline Due 12:20 pm.**	04/02/15 %	Explore the properties of different types of feed forward loops.
12	04/06/15	Project	04/09/15 %	Graded project preparation.
13	04/13/15	Randomness in Biology	04/16/15 %	Monte Carlo simulations of gene expression
14	04/20/15	TBD	04/23/15	Time provided for students to work on their projects. (Strongly recommended that students attend)
15	04/27/15	Biological clocks and Review **Completed Project Due 12:20 pm.**		

% Lab is graded

Syllabus (3)

Textbook

This is a relatively new field of biology and there is no appropriate undergraduate level textbook. Instead readings are provided on bspace that cover the material at an introductory level. Original papers and reviews are also provided if you are interested in reading more about the topics we cover in class.

Matlab

You must have access to Matlab to complete the labs, homework assignments and the project.

Additional Readings

These are provided at the end of the lecture for those want to find out more about a topic or want some further readings to help their understanding. Material in the readings that is not in the lectures or lab is not examinable.

Assessment (1)

- **This in an introductory course for undergraduates.**
- You need some basic knowledge of biology and calculus.
- **You do not need previous experience in programming or Matlab.**
- **We will teach all the programming you will need.**
- **Undergraduate biology majors have historically done very well (equal or better than math and bioengineering majors and graduate students).**

Assessment (2)

Lab/Homework assignments	20%
Mid-term (Short answer)	15%
Final Exam (Short answer)	30%
Project outline	5%#
Final Project	30%#

Further details in Week 7 lecture.

Completed Project Due: 12:20 pm 04/27/2015.

SEE LATE SUBMISSION POLICY ON bCourses in Week 7 lecture notes.

Exams require pencil, calculator and ruler.

Assessment (3)

Exams

All lecture and lab material is examinable.

Questions will focus on concepts and understanding. You also **need** to know the details of some of the examples covered in class.

Mid-term and final exams will **not** include questions requiring a knowledge of Matlab code.

Make-up exams

These will be held after the scheduled time and involve an **oral** plus a written examination.

****Special requirements for exams/instruction – please let me know this week.****

The honor code at UC Berkeley:

"As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others."