# Calculating Biological Quantities

## CSCI 2897

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**Lecture 1**

# Calculating Biological Quantities

# Lecture 1 Plan

1. **Course mechanics & setup**
    1. Website
    2. Syllabus
    3. Canvas
2. **Schedule & Syllabus Review**
3. **Textbooks**
4. **A tour of mathematical models and linear algebra**
5. **About me**

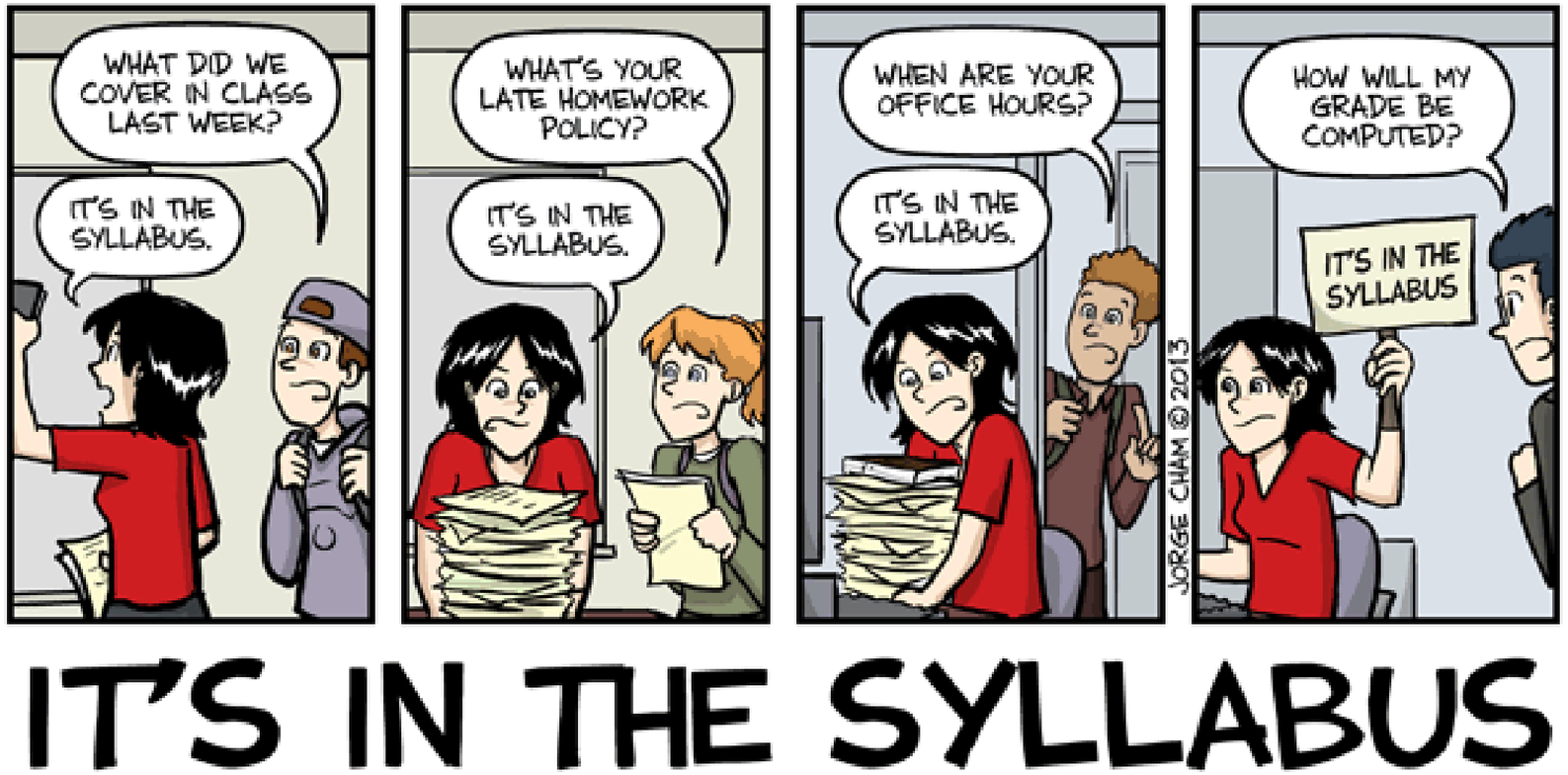
# Course Mechanics

- Website: https://github.com/dblarremore/CSCI2897
  - Homework & reading posted
  - Code examples
  - Class notes
- Syllabus: https://github.com/dblarremore/CSCI2897#syllabus
- Canvas:
  - Turn in homeworks
  - Lecture links
  - Check grades
- Slack:
  - Q&A
  - Swap files

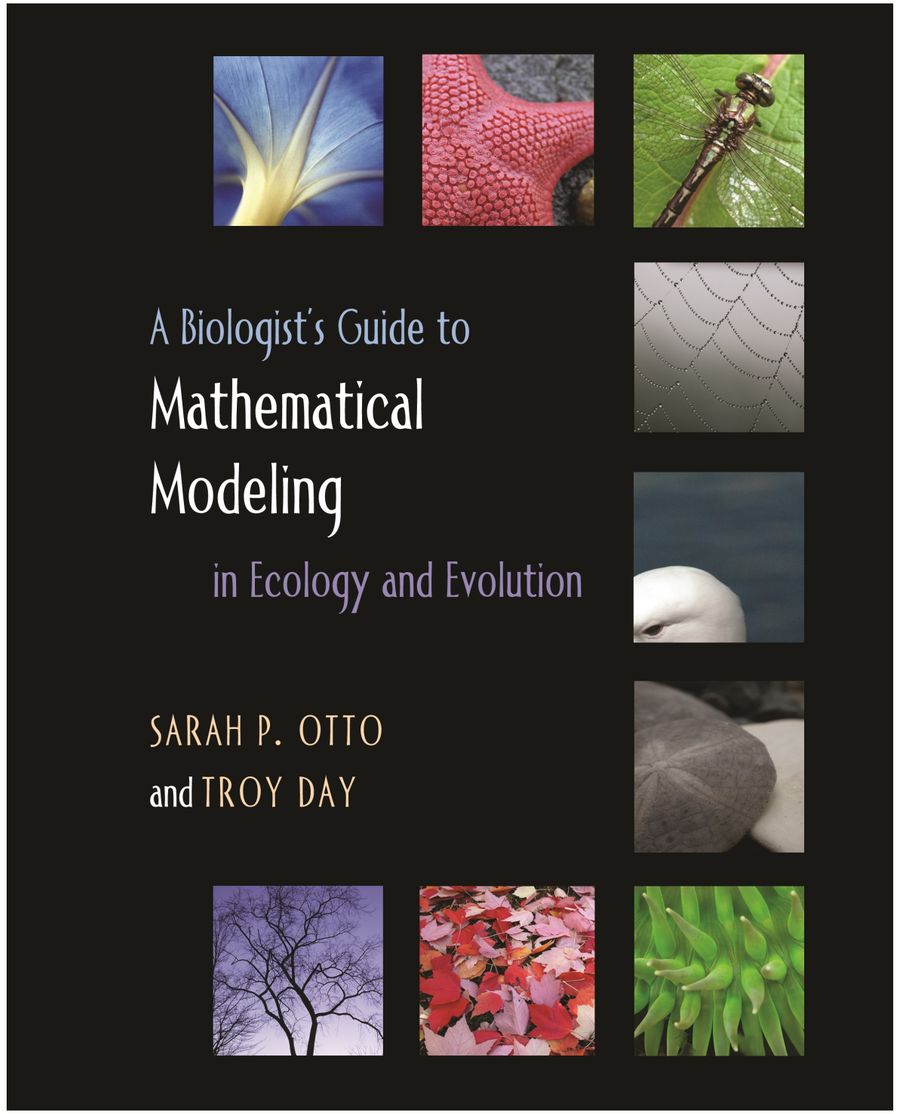
# Schedule & Syllabus Review

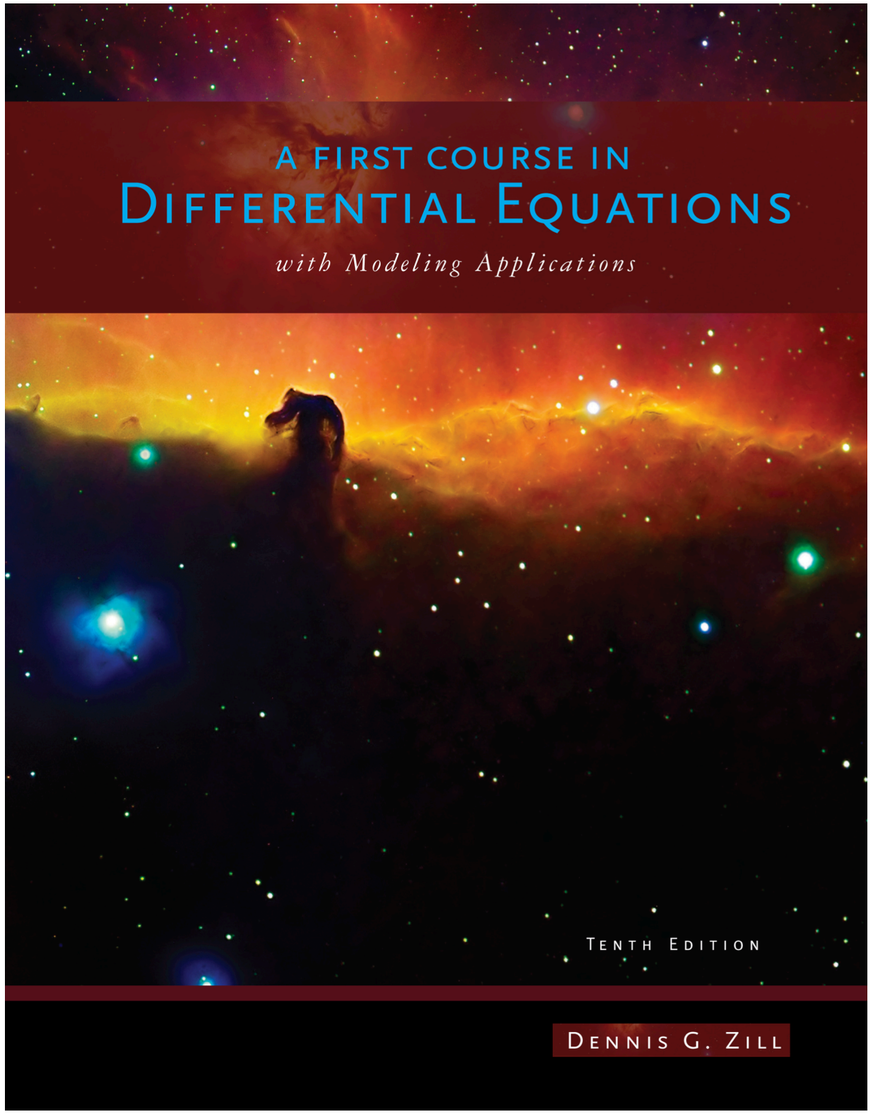
- https://github.com/dblarremore/CSCI2897

**Piled Higher and Deeper** ***by Jorge Cham*** **www.phdcomics.com**



# Textbooks


A Biologist's Guide to
Mathematical
Modeling
in Ecology and Evolution
SARAH P. OTTO
and TROY DAY


A FIRST COURSE IN
DIFFERENTIAL EQUATIONS
with Modeling Applications
TENTH EDITION
DENNIS G. ZILL

# Quiz

# Mathematical models & linear algebra

Point 1: Our understanding of biology *is* a model—an abstraction or simplification.
*Not all models are mathematical.*

# Mathematical models & linear algebra

Point 2: Mathematical models are wonderful.

We get *quantitative predictions* and *mechanism*.

# Key modeling vocabulary

**Variable**: a quantity that changes (e.g. over time). *Vary* is in the name.

**Dynamics**: the patterns of changes that occur over time.

**Parameter**: a quantity in a model that remains constant over time.

# Some of the classics:

Population growth: $n(t+1) = Rn(t)$

Logistic growth: $n(t+1) = n(t) + rn(t)\left(1 - \frac{n(t)}{K}\right)$

Disease dynamics: $\dot{S} = -\beta SI$

$\dot{I} = \beta SI - \gamma I$

$\dot{R} = \gamma I$

FitzHugh Nagumo Neuron: $\dot{v} = v - \frac{v^3}{3} - w + RI_{\text{ext}}$

$\tau \dot{w} = v + a - bw$

# Mathematical models & linear algebra

Point 3: Mathematical models are stories we tell about how the future comes about.
Sometimes *being wrong is the point!*

# Models. Great. So…why linear algebra too?

# Linear algebra is…algebra.

But simplified (or lazy? or elegant?)

$$3x + 5y = 8$$

$$x + 2y = 11$$

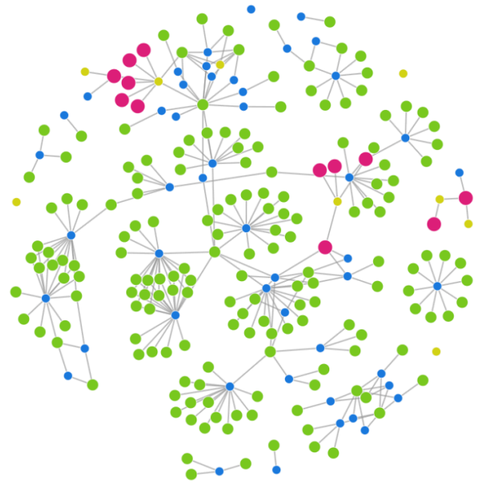
$$x_{n+1} = x_n + x_{n-1}$$

# Linear algebra comes up *everywhere*


Computer Graphics

AI & Machine Learning


PCA & Clustering

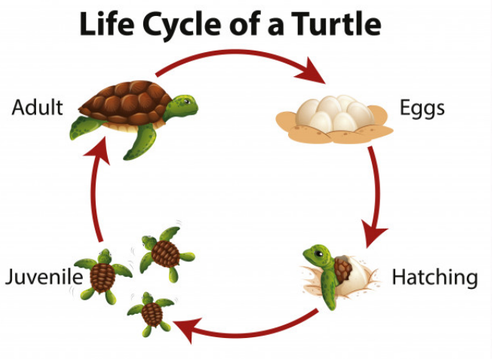


Networks

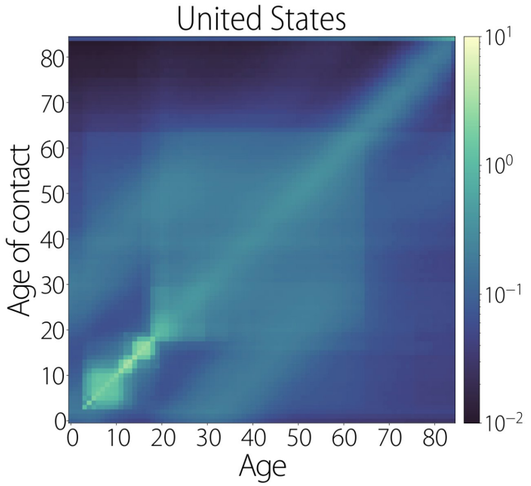
Google

Technology company

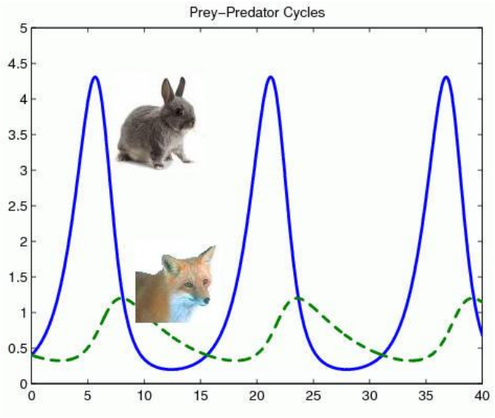
Web Search




Population Structure




Age-structured models




Predator-prey dynamics

# In this course…

Dynamic Models
in Biology

Mathematical Approaches
to Analysis

Demystifying Jargon
and Vocabulary

Coding to Explore
and Understand

Concept, Application, Practice

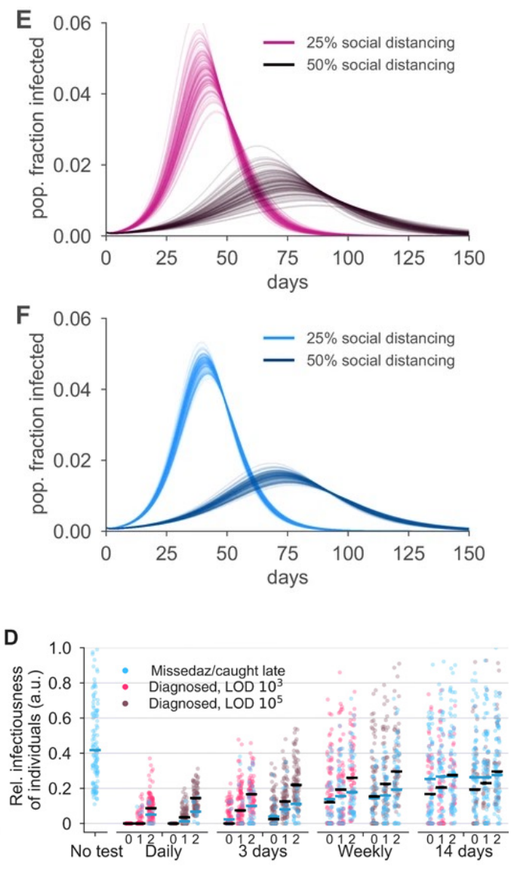
# Questions & Answers

# About me

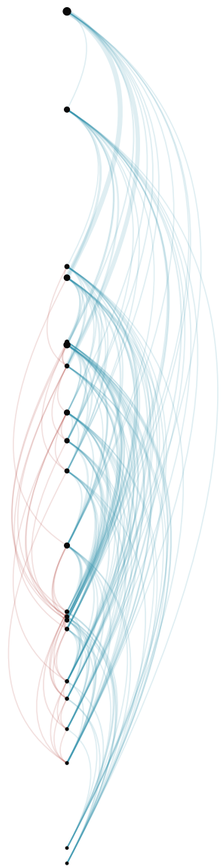
Assistant Professor, BioFrontiers Institute & Department of Computer Science

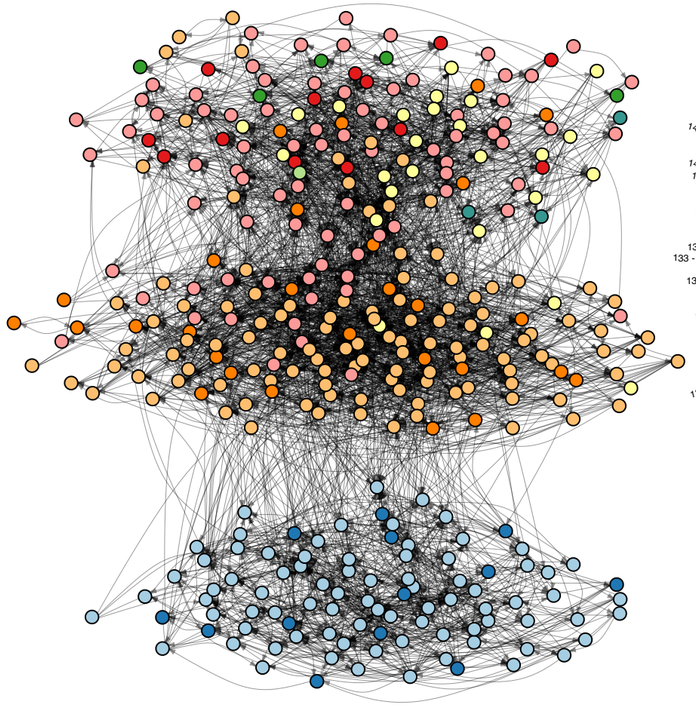
External Faculty: Harvard School of Public Health — Center for Communicable Disease Dynamics

## infectious disease epidemiology




## mathematical methods for statistical inference/analysis





## the scientific ecosystem & the science of science


**research: LarremoreLab.github.io**

# Research should be **fun**

**Epidemiology & Applied Math**

**Networks & Theory**

**Computational Social Science**

malaria **parasite evolution** and epidemiology

optimal **vaccine prioritization** for SARS-CoV-2 vaccine rollout

prestige & gender inequality in academic **faculty hiring**

structured hierarchy in **online dating** markets

provably optimal play in generalized *misere* **Connect 4**

the dominance hierarchy in the network of **hockey fighters**

# Homework

**Before next class**:

1. Join the CBQ Slack.
2. Go to the github and bookmark it. github.com/dblarremore/CSCI2897
3. Download the textbooks.
4. Read the Twitter Thread on the schedule.
    1. Write a paragraph in response — exciting? inspiring? dorky? confusing? why?
    2. Print your response, with your name on it.
    3. Bring it to my office and hand it to me or slip it under my door.
5. Read Otto & Day Chapter 1