Welcome to 20.109

Laboratory Fundamentals of Biological Engineering

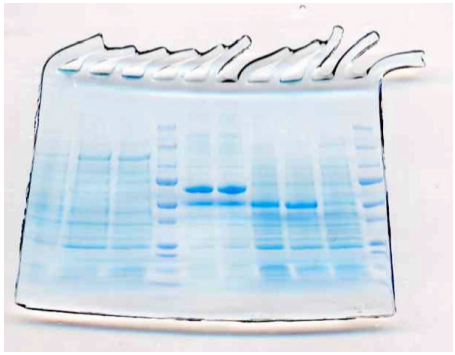
Orientation Lecture

Spring 2009

Introducing 20.109

- Why you're here
  - course mission
  - principles of investigation

- What you'll do
  - three experimental modules
  - assessments/communication
  - course logistics



Course Mission for 20.109

- To teach cutting edge research skill and technology through authentic investigation
- To inspire rigorous data analysis and its thoughtful communication
- To prepare students to be the future of Biological Engineering

Olivia's experiment: an 8th-grader poses a question

- Effect of R&B vs. classical (CL) music on heart-rate

- Hypothesis 1: R&B will ↑ heart-rate, CL will ↓
- Other hypotheses: (2) opposite effect

no change (null)

H2 assume tempo is key parameter

experiences → definitions / biases

Olivia's experiment: controls and interpretation of data

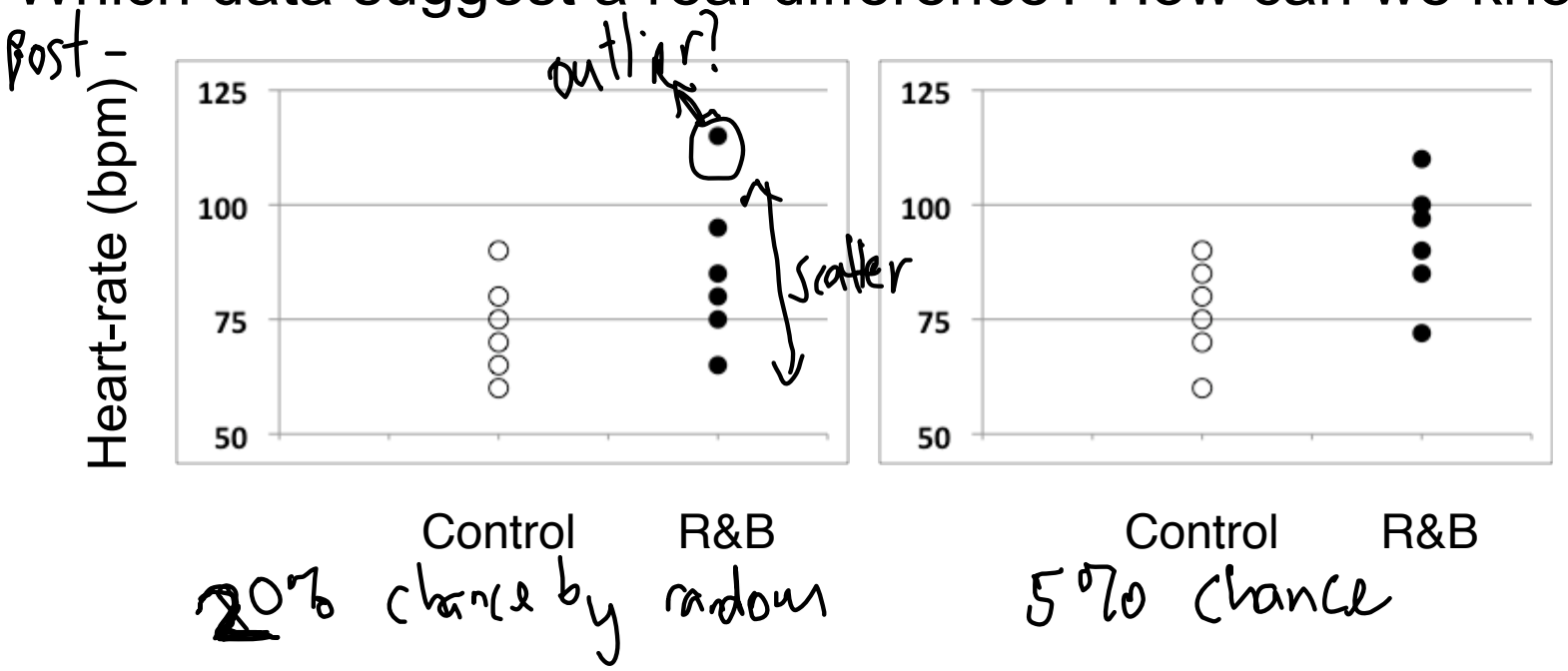
- Experimental design: → internal control
  - Measure heart-rate before and after exposure
  - How many groups? (1) pre → R&B → CL
    (2) A/R&B B/CL } matched (sex, age ...)

3rd group - external control: "mock" 2 min. w/ headphones

- What if heart-rate is unchanged in all 3 cases?
  null (reject others)
- What if heart-rate *increases* is in 3 cases?
  stress exp. conditions

Olivia's experiment: quantification

- Which data suggest a real difference? How can we know?

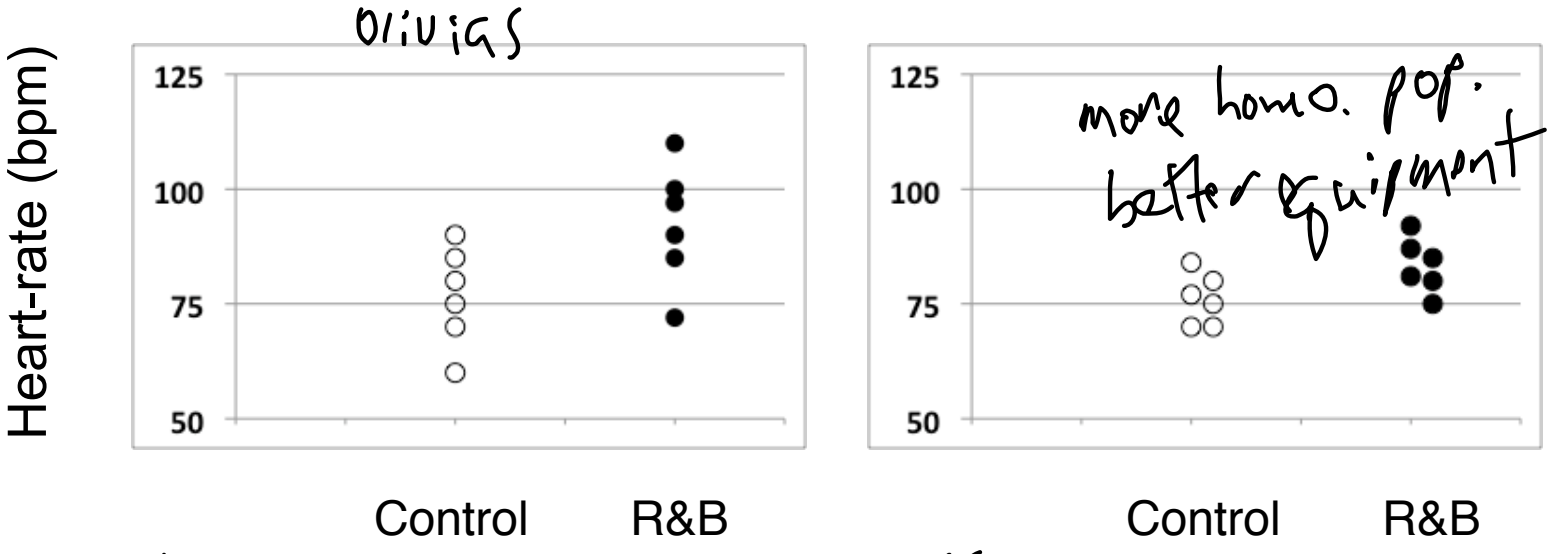


- Ways to process the raw data:

change in ♡-rate - not - → normalization

Olivia's experiment: community

- What if her classmate got very different results?



lack of reproducibility → differences, is I reliable?
→ repeat, revised
+ sample size

Olivia's experiment: what does all this have to do with 20.109?

- Posing a good question:
  - Consider interest and impact
  - Recognize your assumptions
  - Seek out prior knowledge
- Interpretation of data:
  - Develop good controls
  - Understand each collection step
  - Perform quantitative analysis
  - Peer review

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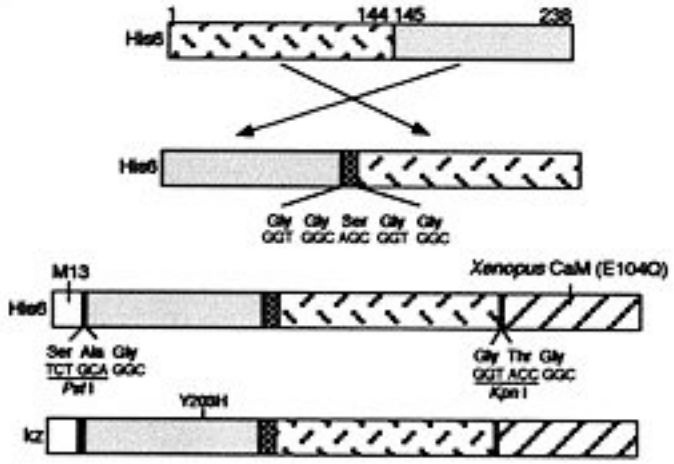
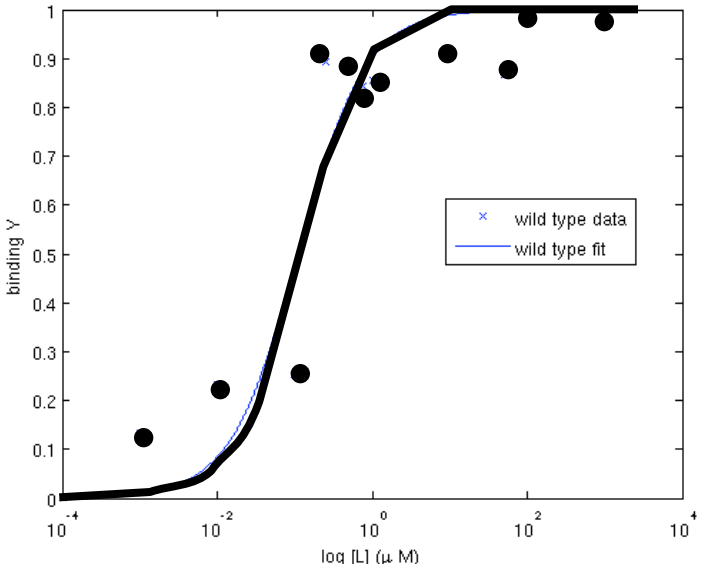
Engineering Principles + Modern Biology

Manipulate and Make



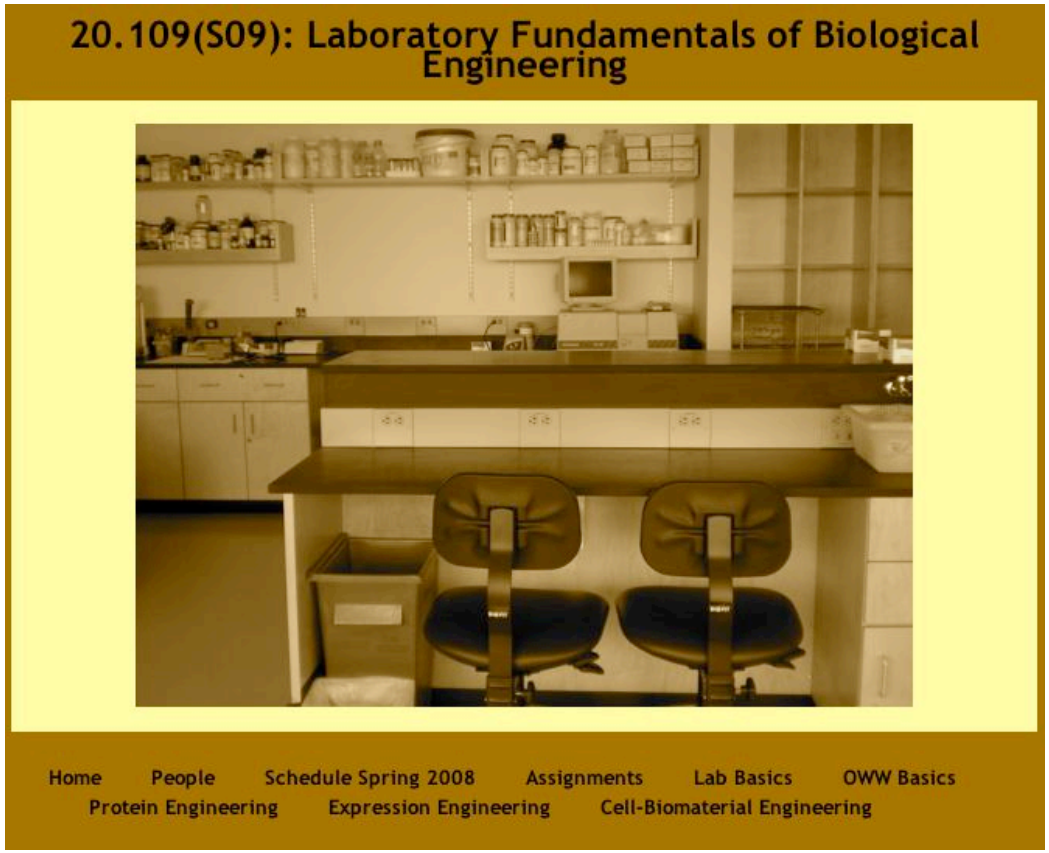
Nagai *et al.*

Measure ⟷ Model



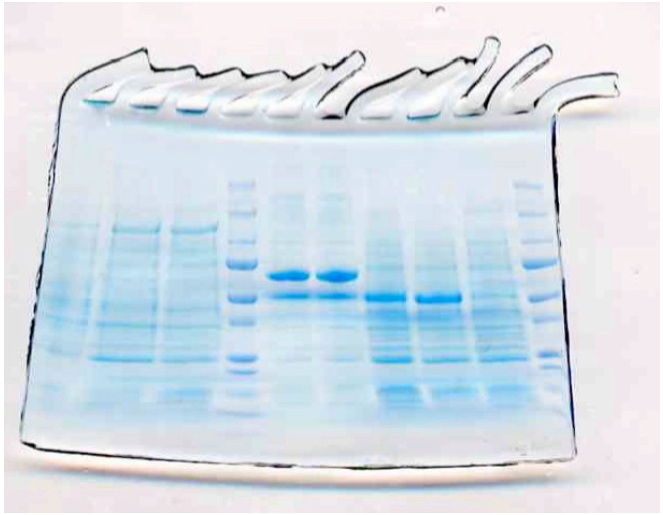
Myriad length scales, systems, and applications

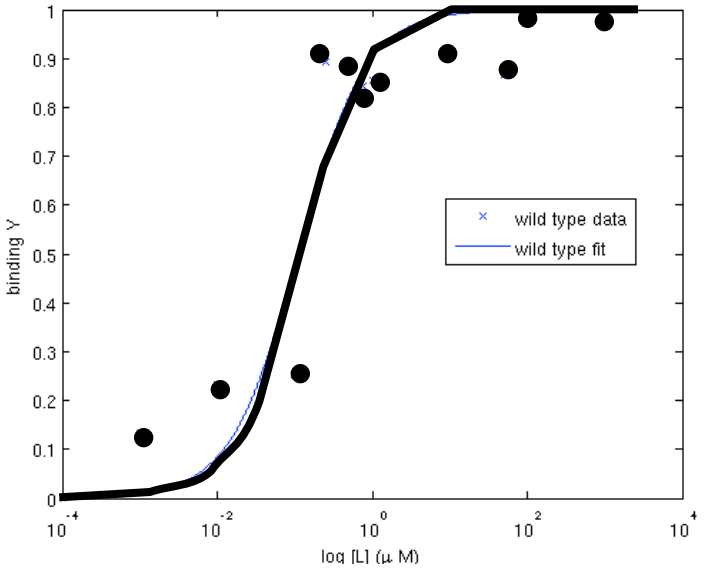
openwetware.org/wiki/20.109(S09)



Module 1	Protein Engineering (A. Jasanoff)
Module 2	Expression Engineering (L. Samson)
Module 3	Cell-Biomaterial Engineering (A. Stachowiak)

Protein Engineering: calcium sensor redesign





Experimental Goals

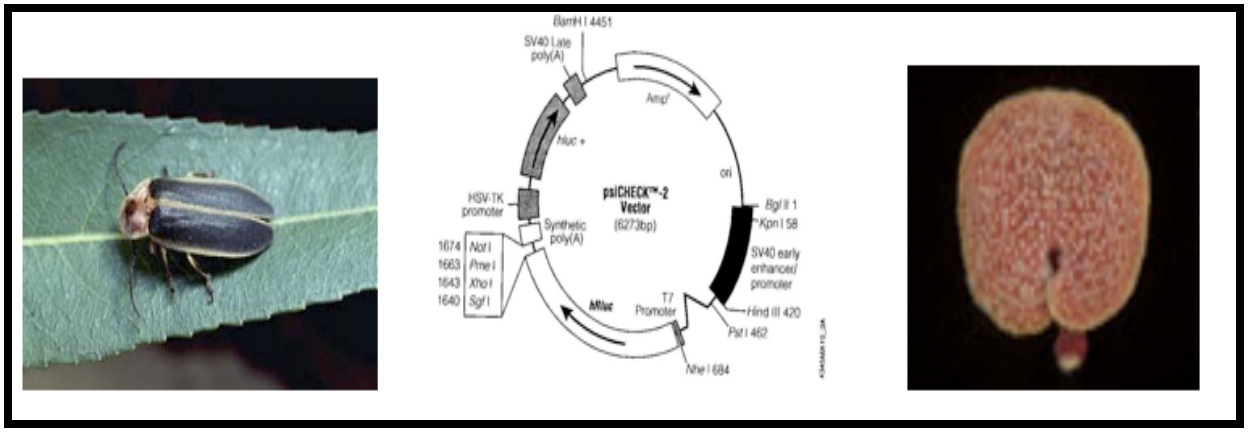
Design: Modify DNA + protein

- Mutagenize wild-type plasmid
- Express and purify protein
- Assess effect on protein

Lab+Analytical Skills

- Bacterial cell culture
- DNA manipulation and analysis
- Protein characterization
- MATLAB modeling
- Discuss primary research article

Expression Engineering: siRNA knockdown



Experimental Goals

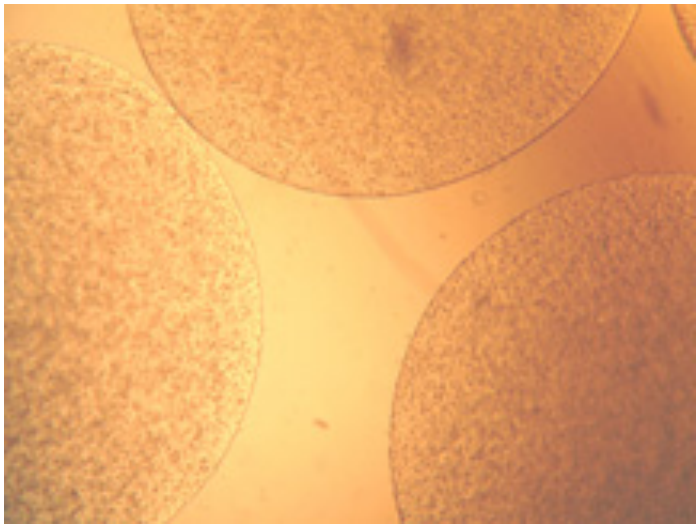
Design: siRNA, comparison

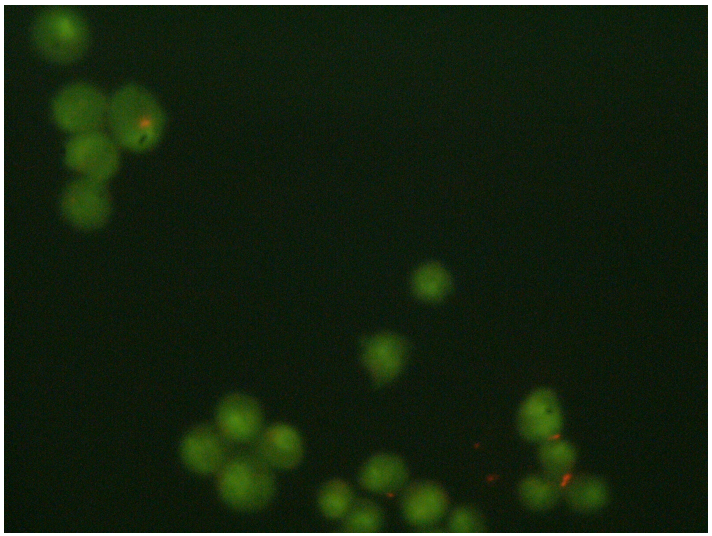
- Transfect cells with DNA + siRNA
- Measure gene knockdown
- Assess genome-wide changes

Lab+Analytical Skills

- Mammalian cell culture
- Reporter plasmids
- Large data sets, statistics
- Intended and unintended effects
- Present primary research article

Cell-Biomaterial Engineering: making cartilage





Experimental Goals

Design: Culture conditions

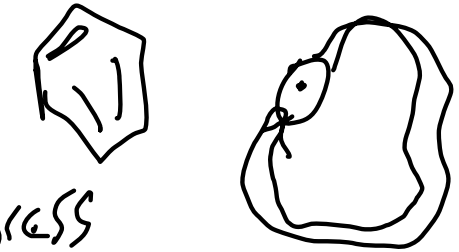
- Study how environment affects cell health, and expression + production of tissue-specific proteins

Lab+Analytical Skills

- 3D cell culture
- Fluorescence microscopy
- Measure specific mRNAs
- Identify protein from mixture
- Present a novel research idea

Scientific writing must tell a story

- Archimedes, Newton, Kekulé
  - Stories help us remember



- You discover the narrative ~~that the~~ + process data tell
- Then convince an audience of your findings
  - Step-by-step explanations
  - Repetition of central ideas
  - Clear visuals

Your data should be true even if your story is wrong

~ Darcy Kelley, Columbia (from *The Canon*, N. Angier)

Communication and Grading

50% Written Work

Module 1: research article

Module 2: condensed report, submission letter

Module 3: data summary

30% Oral Presentations

Module 2: published article

Module 3: original proposal

20% Daily(ish) work

9% Homework

4% Lab Notebooks

5% Quizzes

2% Participation

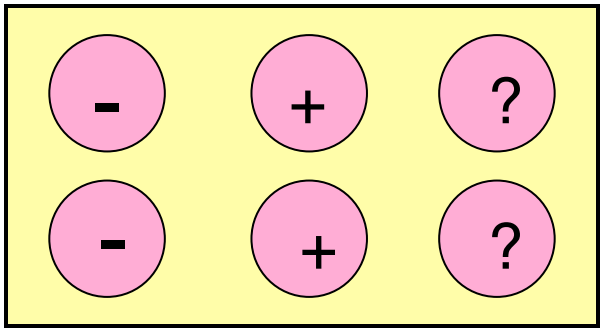
Writing & Oral Communication Faculty

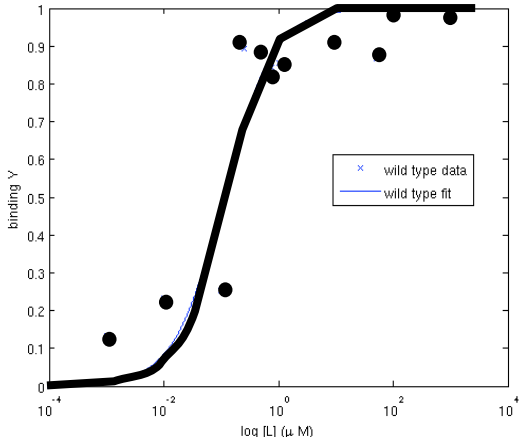
- Neal Lerner
  - Lectures/discussions
  - Written feedback (→ opportunity to revise)

- Atissa Banuazizi
  - Lectures/discussions
  - One-on-one review of videotaped talk

After 20.109, you should be able to…

- Organize a lab notebook
- Implement laboratory protocols
- Design novel experiments with appropriate controls
- Interpret qualitative data
- Analyze quantitative data
- Recognize utility of models
- Examine the scientific literature
- Communicate in multiple modes
- Present salient points of your own and others' ideas





Course Logistics

Lecture Tuesdays and Thursdays 11-12, 4-237

Lab Tuesdays and Thursdays 1-5, 56-322

Wednesdays and Fridays 1-5, 56-322

There are no "make-up" labs

Collaboration with integrity is encouraged: assignments can be worked on together but must be submitted individually. You will perform experiments in pairs.