Welcome to 20.109

Laboratory Fundamentals of Biological Engineering

Orientation Lecture
Spring 2011
Introducing 20.109

• Why you’re here
  – course mission
  – on learning and 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
A cliché: my life has CHANGED!

What drives his learning?
Observations on how babies learn

• Driven by wanting to *do* specific things
  – not external rewards
• Intuitively does experiments
  – gravity testing!
• Wants to communicate
  – gazing, kicking, babbling
• Needs to fail repeatedly
  – and be scaffolded along the way
• Likes bright, shiny objects
Mimicking a baby’s learning in 20.109

• Driven by wanting to *do*  
  – grade desire only gets you so far
• Intuitively does experiments  
  – include your ideas/designs/input
• Wants to communicate  
  – big reports taxing but rewarding
• Needs to fail repeatedly  
  – not judged on experiment’s success, but on *interpretation*  
  – many opportunities to revise writing
• Likes bright, shiny objects  
  – fun equipment to play with
Scientific investigation: a look at recommendations for solid food

- WHO recommends 6 months of breast milk only
  - one reason is gut immaturity → allergy concerns
- Some researchers challenge the guideline (or basis)
- Solid foods and allergies: literature says
  - too early is bad
  - too late is bad
  - depends on the food
  - depends on the baby
A closer look at one study: design

• Read abstract of Nwaru, et al. paper
• What sounds good and what bad about the design?
A closer look: data and complications

Sensitization to egg allergen (OR w/95% CI)

Only milk
<1, 1-3, >3 m

Cow’s milk

Egg

P = 0.01; ns

11 foods
2 models

Nwaru, B.I. et al.
More 20.109 lessons echoed as parent

• Reading critically is a useful life skill…
• … and the devil is in the details
  – experimental design
  – raw vs. processed data
  – statistical analysis
  – sample size
  – research scope and limitations
  – is the question of most interest being asked?
• Note: not all authors will so scrupulously emphasize their *specific* findings and limits
And some things science cannot even hope to determine…

Is he laughing?

Uncomfortable?

Both?

Neither?
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Engineering Principles + Modern Biology

Manipulate and Make

Measure \rightleftharpoons Model


Myriad length scales, systems, and applications
Module 1  RNA Engineering (J. Niles)
Module 2  System Engineering (R. Weiss)
Module 3  Cell/Biomaterial Engineering (A. Stachowiak)
RNA Engineering: aptamer enrichment

Experimental Goals

*Design: Column conditions*
- Prepare RNA aptamers
- Run heme affinity column
- Assess enrichment of binder

Lab+Analytical Skills
- Manipulate DNA and RNA
- Use computational tools
- Perform spectroscopic analysis
- Discuss/present scientific literature
System Engineering: improve edge detector

Experimental Goals

*Design: DNA modification*
- Sub-clone new DNA
- Express in bacteria
- Characterize new system

Lab+Analytical Skills
- Culture bacteria
- Make and analyze DNA
- Measure enzyme levels
- Model/make predictions
- Explore modular composition
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

- Culture mammalian cells
- 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 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: laboratory report; computational analysis
Module 2: research article
Module 3: data summary

30% Oral Presentations
Module 1: published article
Module 3: original proposal

20% Daily(ish) work
7% Homework
5% Lab Notebooks
5% Quizzes
3% Participation
Writing & Oral Communication Faculty

- Neal Lerner and Linda Sutliff
  - Lectures/discussions/exercises in class
  - One-on-one consultations

- Atissa Banuazizzi
  - Lectures/discussions in class
  - 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.