Welcome to 20.109

Laboratory Fundamentals of Biological Engineering

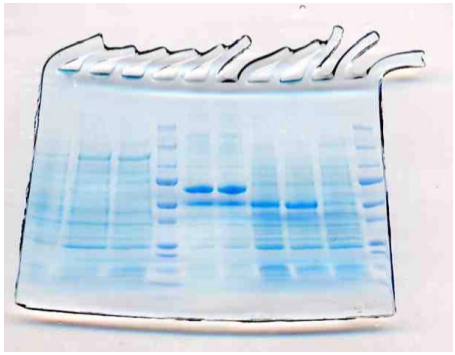
Orientation Lecture

Spring 2011

Introducing 20.109

- Why you're here
  - course mission
  - on learning and investigation

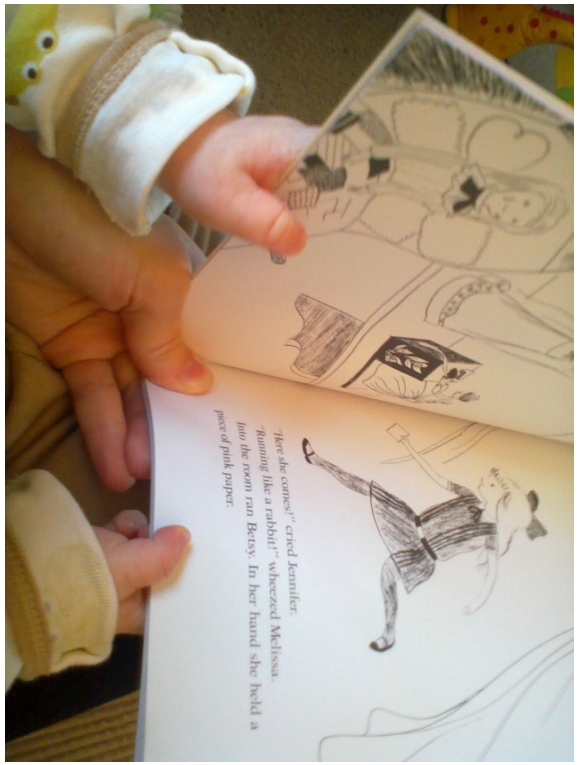
- What you'll do
  - three experimental modules
  - assessments/communication
  - course logistics



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



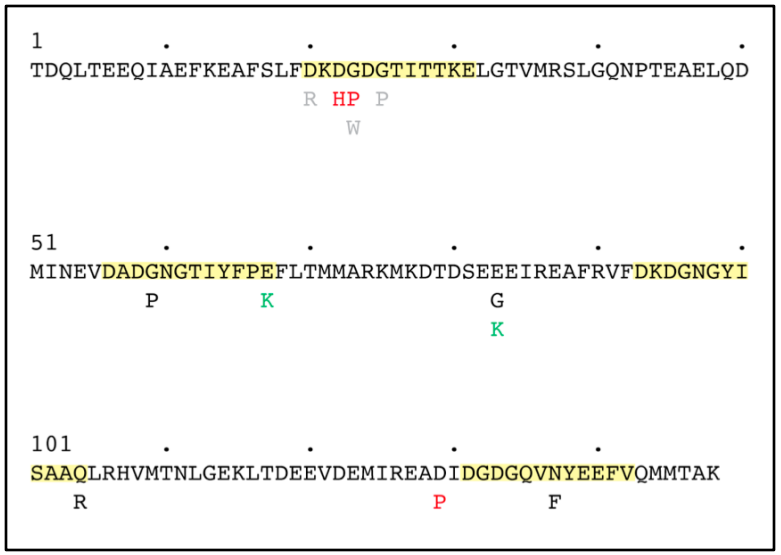
What drives his learning?

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

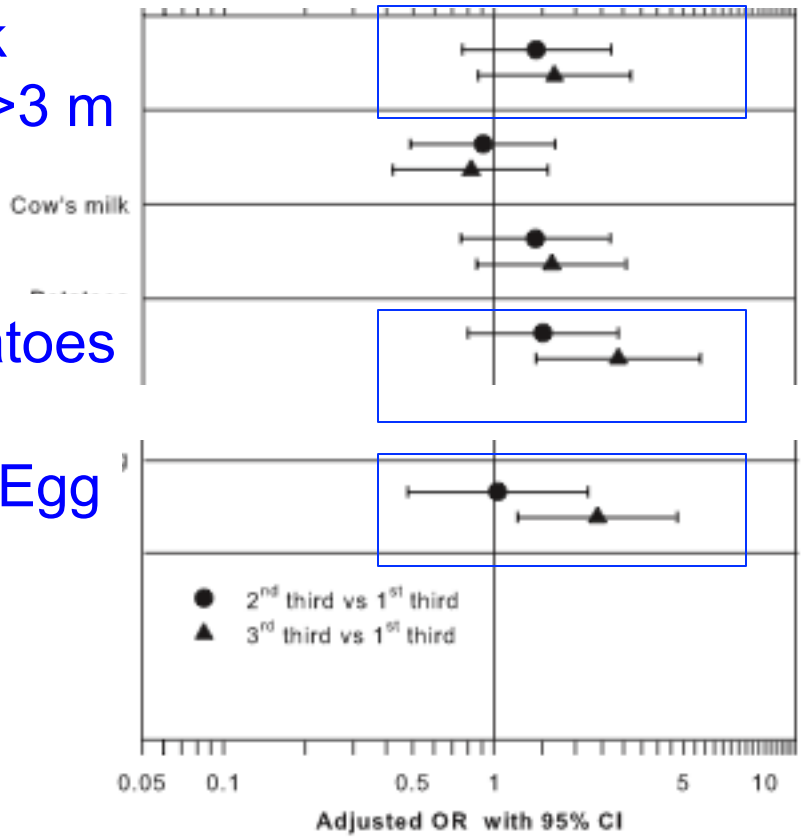
A closer look at one study: design

- 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



(p=0.296)

11 foods
2 models

Potatoes

(p=0.01; ns)

Egg

(p=0.004; 0.017)

Nwaru, B.I. et al.
Pediatrics **125**:50 (2010).

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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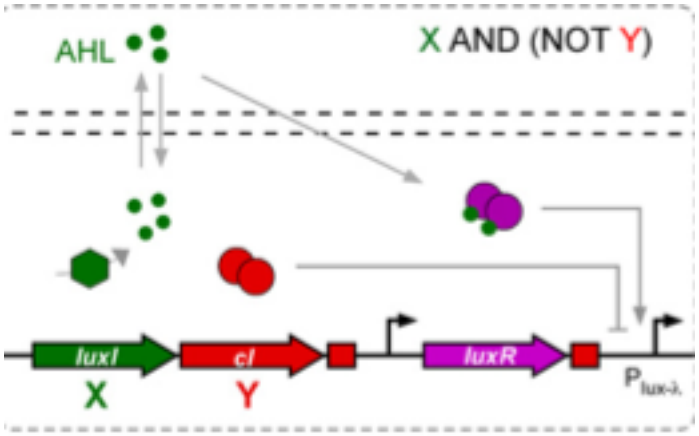
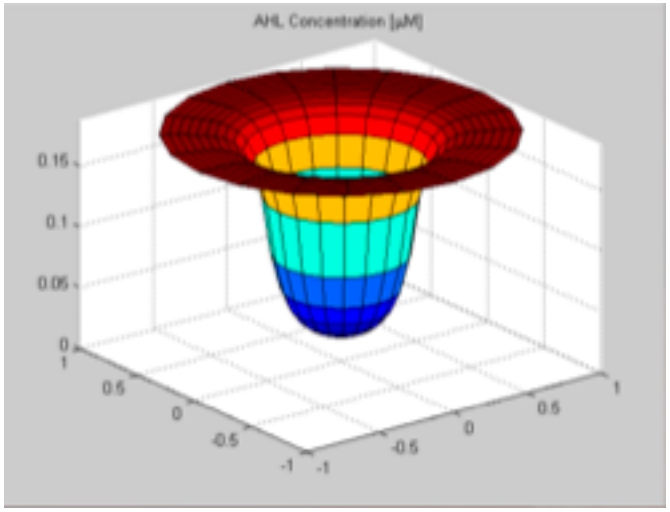
Engineering Principles + Modern Biology

Manipulate and Make



Tabor, J.J. et al. *Cell* **137**:1272 (2009).

Measure ⟷ Model



Myriad length scales, systems, and applications

openwetware.org/wiki/20.109(S11)

Module 1 RNA Engineering (J. Niles)

Module 2 System Engineering (R. Weiss)

Module 3 Cell/Biomaterial Engineering (A. Stachowiak)

RNA Engineering: aptamer enrichment

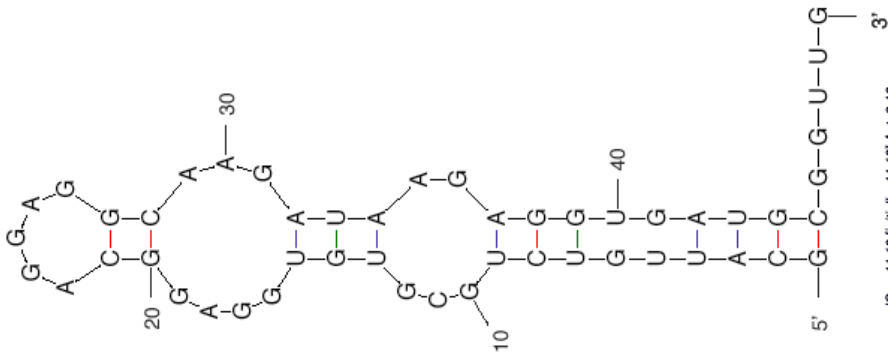
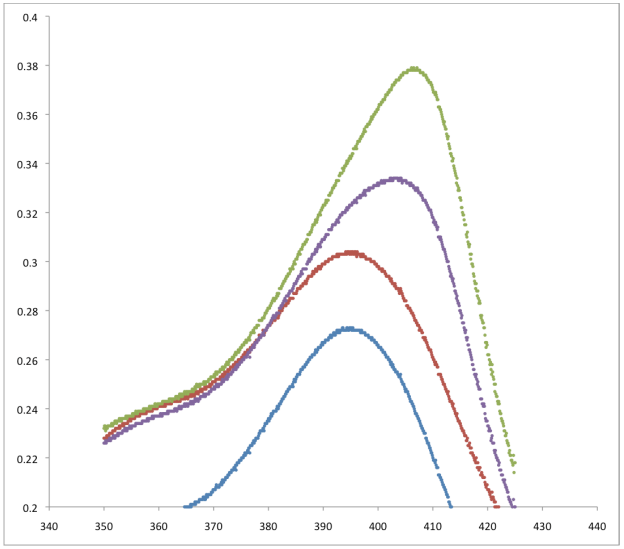


Image prepared using *RNA folding* at http://mfold.bioinfo.rpi.edu/



Experimental Goals

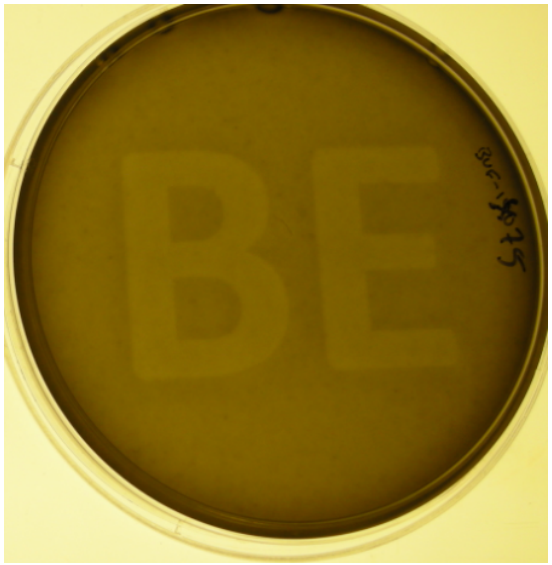
Design: Column conditions

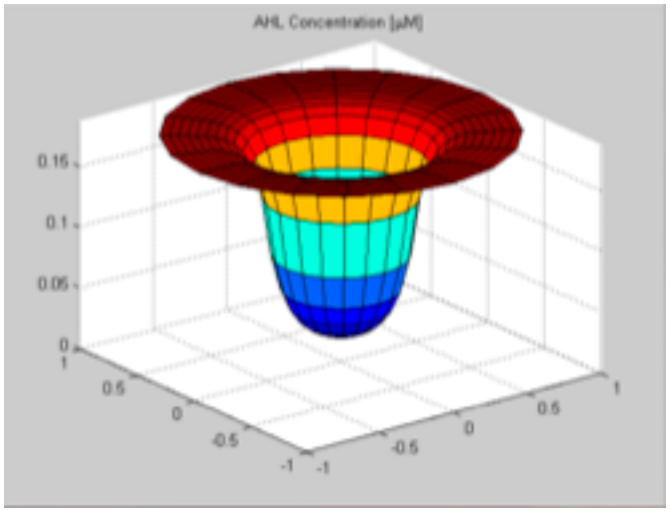
- Prepare RNA aptamers
- Run heme affinity column
- Assess enrichment of binder

Lab+Analytical Skills

- Manipulate DNA and RNA
- Use computational tools
- Perform spectroscopic analysis
- Discuss/present scientific literature

System Engineering: improve edge detector





Experimental Goals

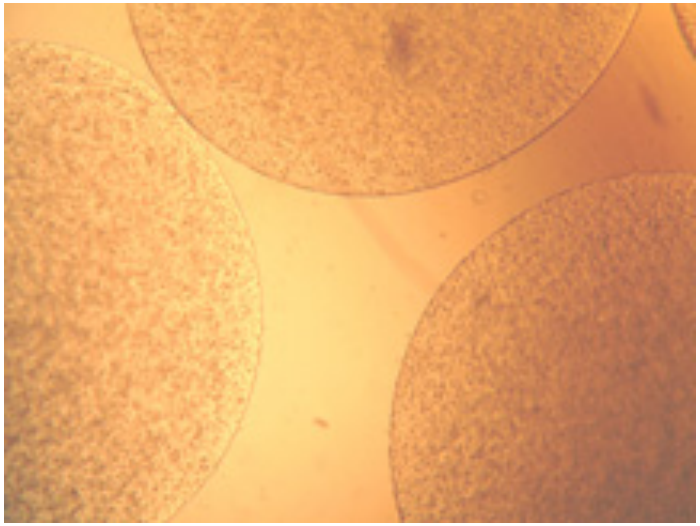
Design: DNA modification

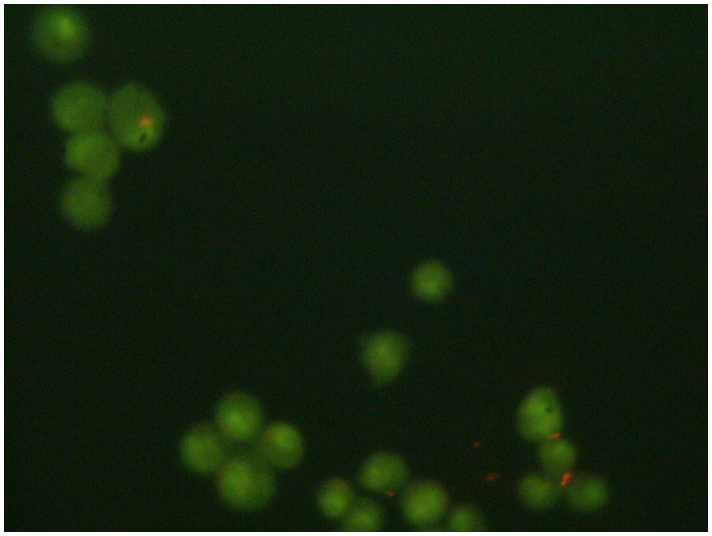
- Sub-clone new DNA
- Express in bacteria
- Characterize new system

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% Quizzes

5% Lab Notebooks

3% Participation

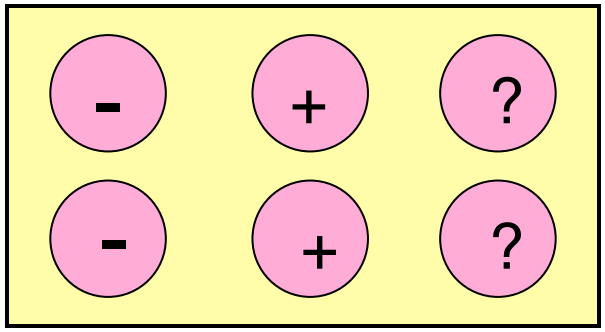
Writing & Oral Communication Faculty

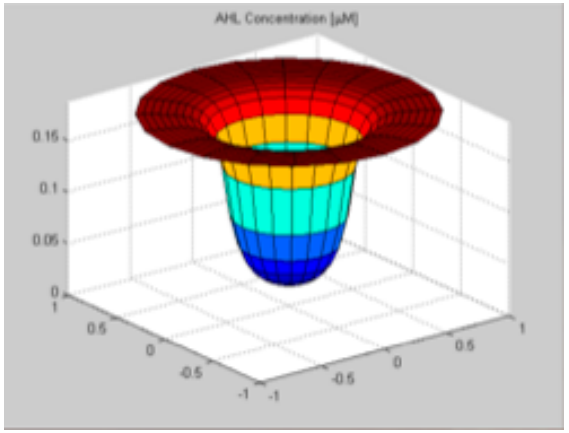
- Neal Lerner and Linda Sutliff
  - Lectures/discussions/exercises in class
  - One-on-one consultations

- Atissa Banuazizi
  - 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.