

Welcome to 20.109

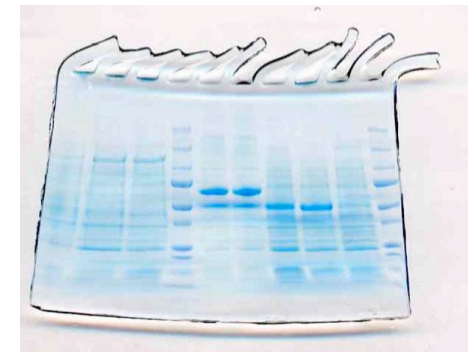
Laboratory Fundamentals of
Biological Engineering

Orientation Lecture

Spring 2010

Introducing 20.109

- Why you're here
 - course mission
 - principles of investigation
- What you'll do
 - three experimental modules
 - assessments/communication
 - course logistics

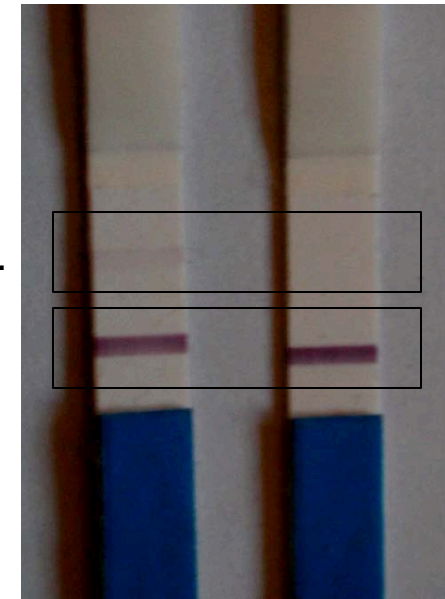


Course Mission for 20.109

- 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

Pregnancy tests: reliability and controls

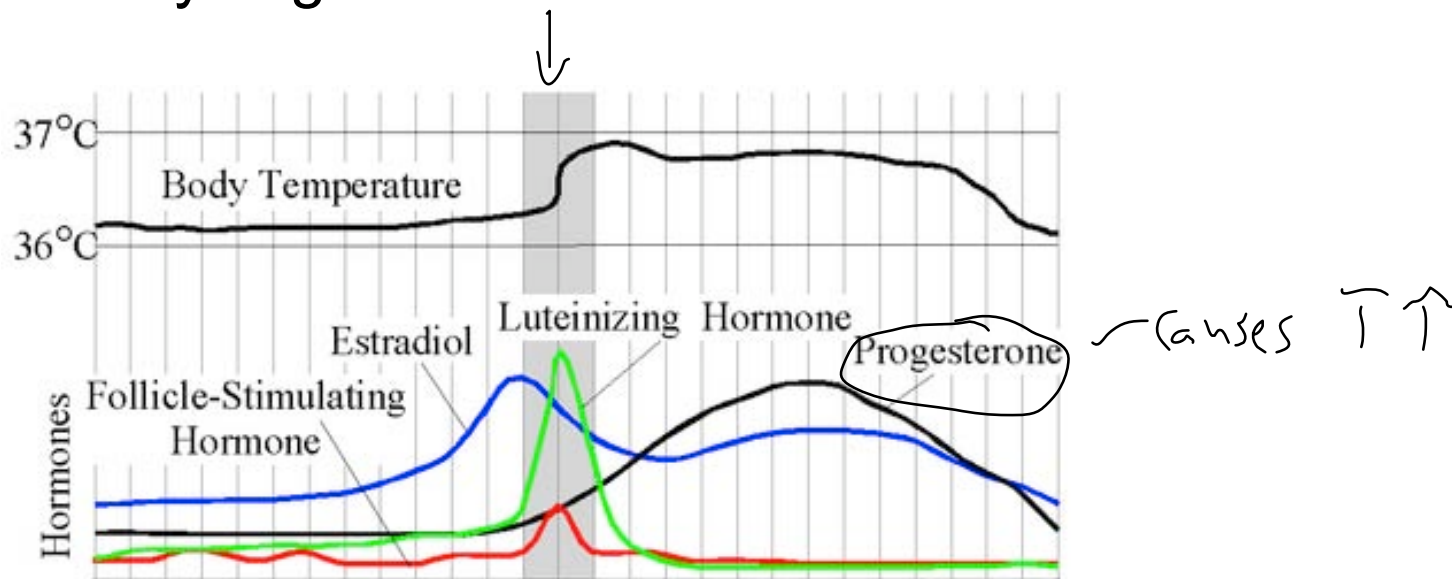
- Mechanism: measure level of hCG
- False positives nearly impossible
- False negatives below the detection limit
- Internal control } did the test work?
- Negative control }
- Positive control }



exp. (-) cont
female male

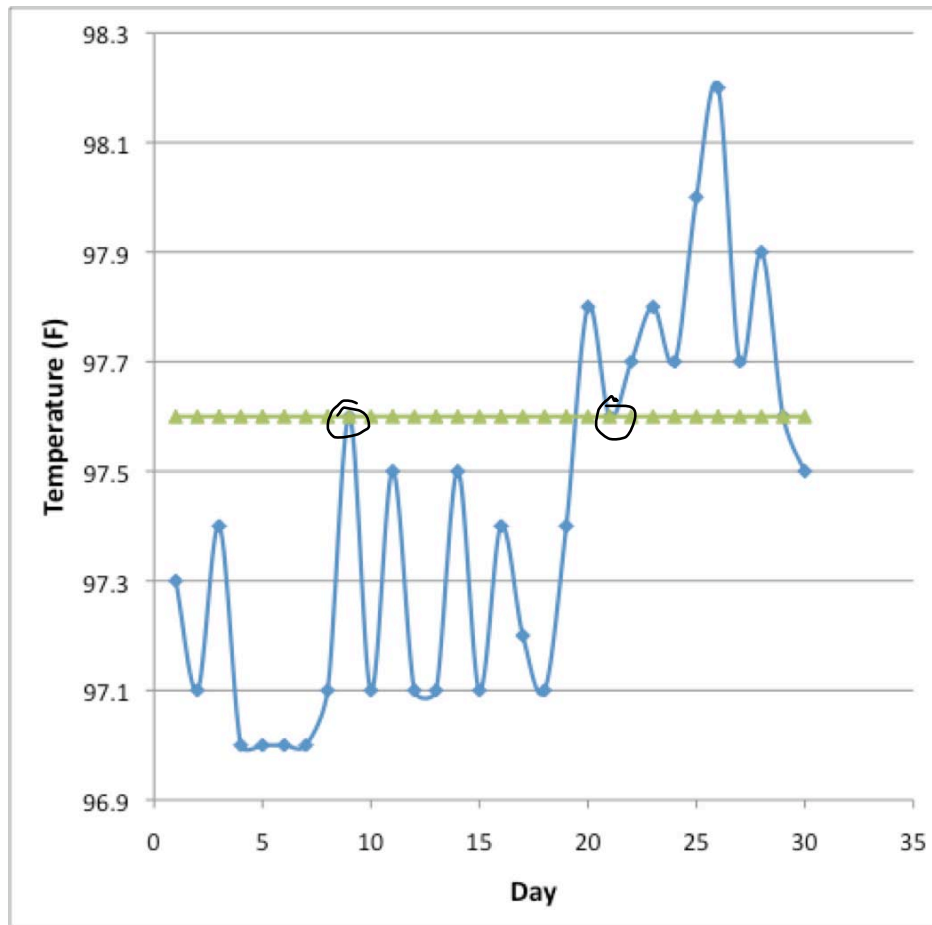
Timing conception: hypothesis-formation

- About a day after ovulation, waking temperature rises
- Why might this be?



Waking temperature: data interpretation

- How might we rigorously determine ovulation day?



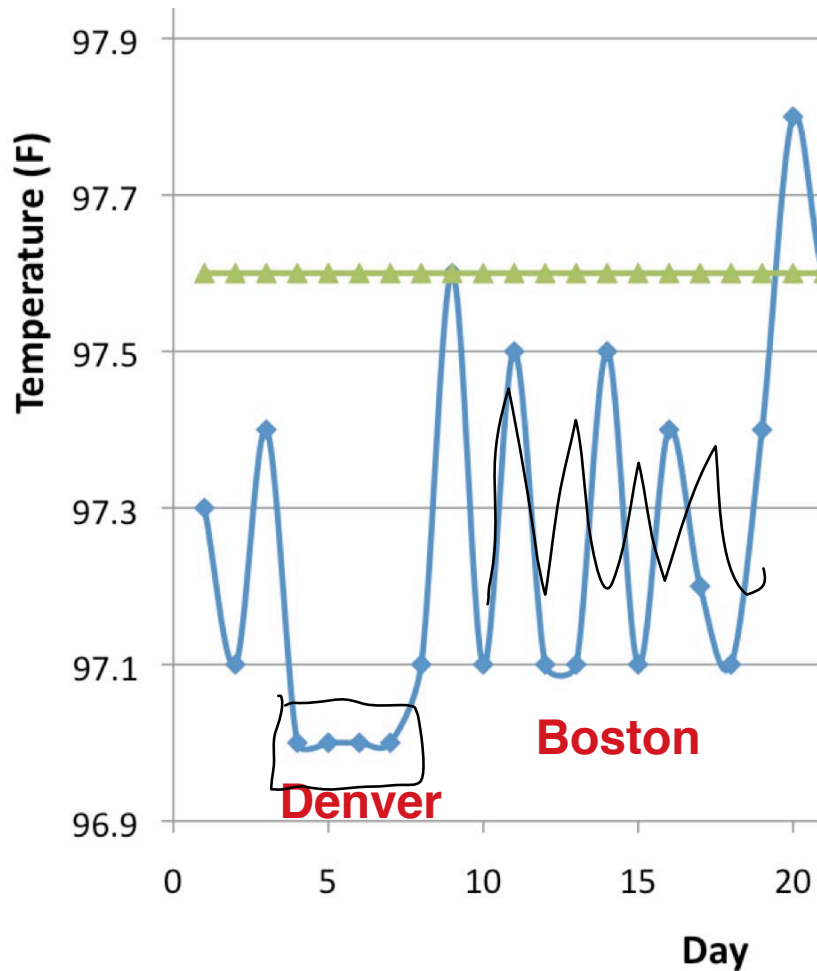
~~threshold~~

moving average
threshold

↓ noise

... complex models

Observations can inspire new research



- Experimental design

groups $\left\{ \begin{array}{l} \text{Denver} \\ \text{Boston} \end{array} \right.$ 10's or 100's

control time-of-day
independent test of over (hormones)

- Analysis

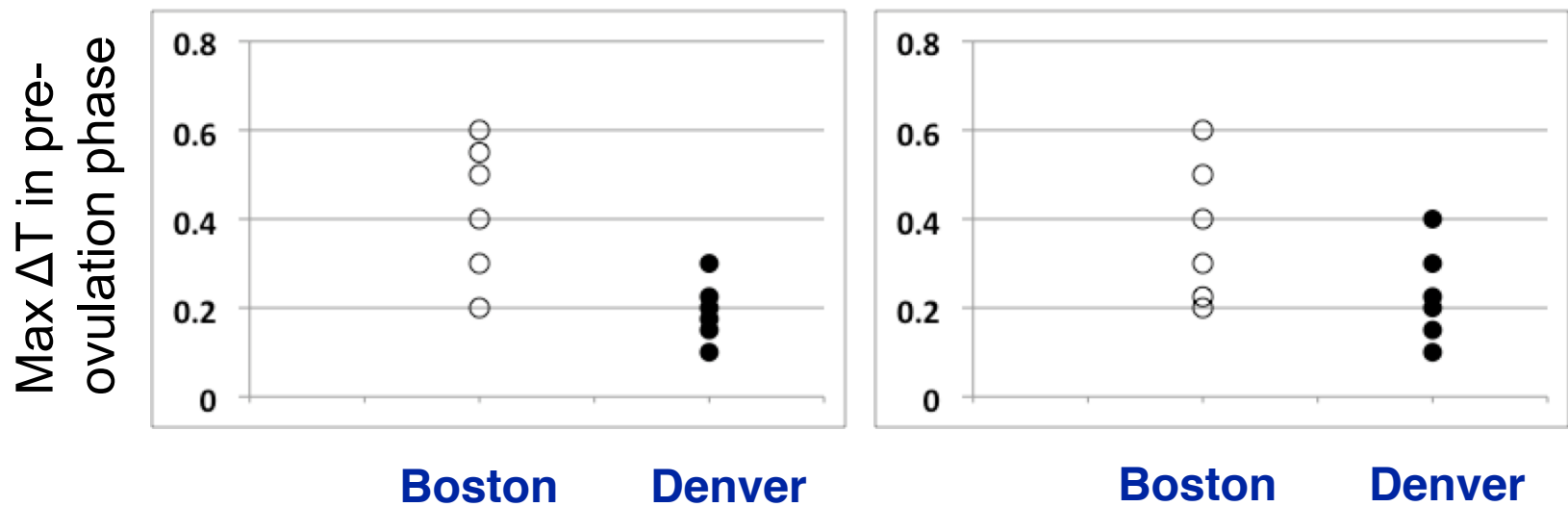
std. dev. per person

max, or ave. AT (absolute, $\frac{70}{10}$)

in pre-ov phase

Geographical temperature-tracking experiment: quantification

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



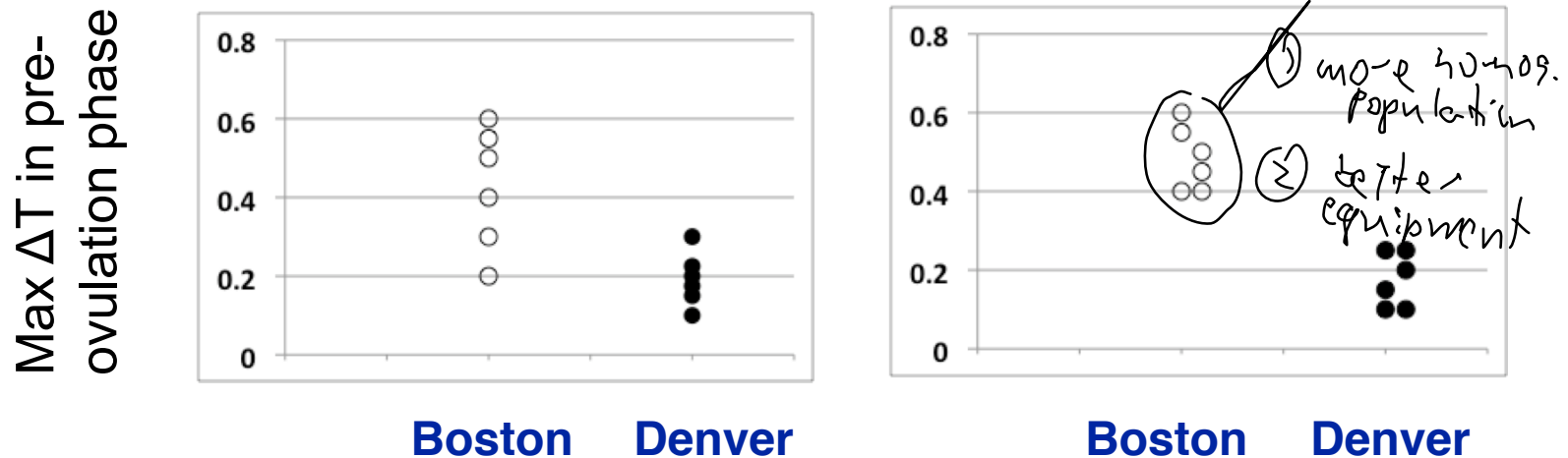
< 1% chance of random occurrence

> 10% chance that random

Apply statistical test

Temperature experiment: community

- What if two researchers got very different results?



- Ultimately, data means little without a *mechanism* and novel predictive ability (that's trivial)

param: humidity, altitude
 mech: ↓ affect equip? ↓ affect sleep cycles? } Bos, Pen, Phoenix

Conception and pregnancy: what does all this have to do with 20.109?

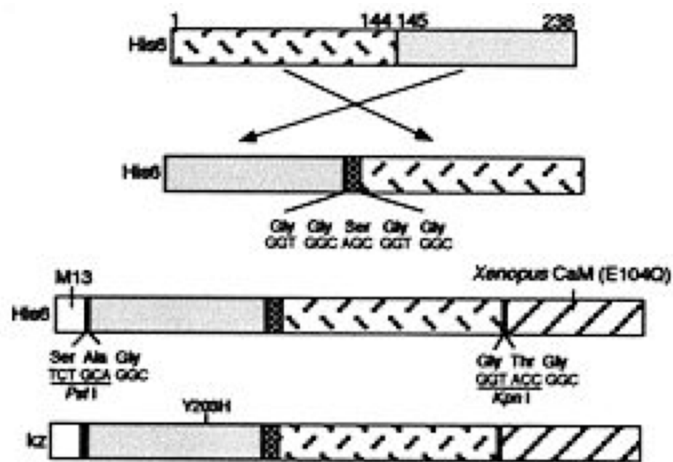
- Posing a good question:
 - Seek out prior knowledge
 - Consider interest and impact
 - Develop good controls
- Interpretation of data:
 - Understand each collection step
 - Perform quantitative analysis
 - Be aware of biases and assumptions
 - Peer review

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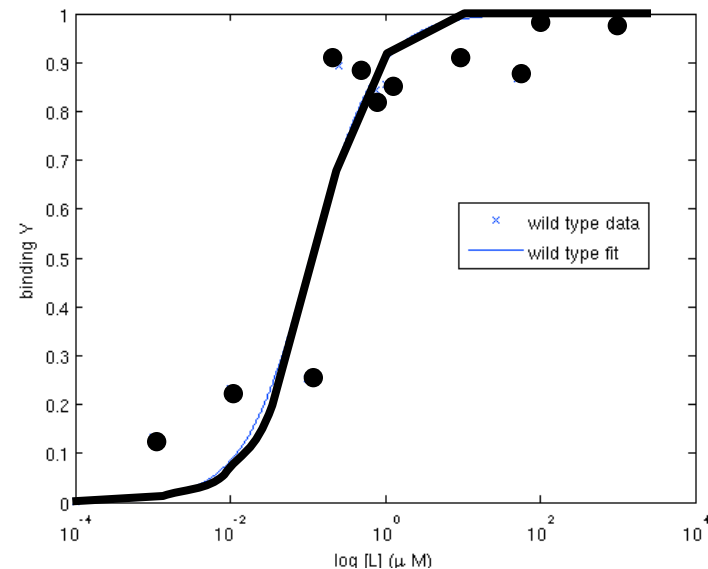
Engineering Principles + Modern Biology

Manipulate and Make



Nagai *et al.*

Measure ↔ **Model**




Courtesy of National Academy of Sciences, U. S. A. Used with permission.

Source: Nagai, T., et al. "Circularly Permuted Green Fluorescent Proteins Engineered to Sense Ca²⁺." *PNAS* 98, no. 6 (March 6, 2001): 3197-3202. Copyright (c) 2001 National Academy of Sciences, U.S.A.

Myriad length scales, systems, and applications

openwetware.org/wiki/20.109(S10)

20.109(S10): Laboratory Fundamentals of Biological Engineering



Home People Schedule Spring 2010 Assignments Lab Basics OWW Basics
RNA Engineering Protein Engineering Cell-Biomaterial Engineering

Module 1

RNA Engineering (J. Niles)

Module 2

Protein Engineering (A. Jasanoff)

Module 3

Cell-Biomaterial Engineering (A. Stachowiak)

RNA Engineering: aptamer enrichment

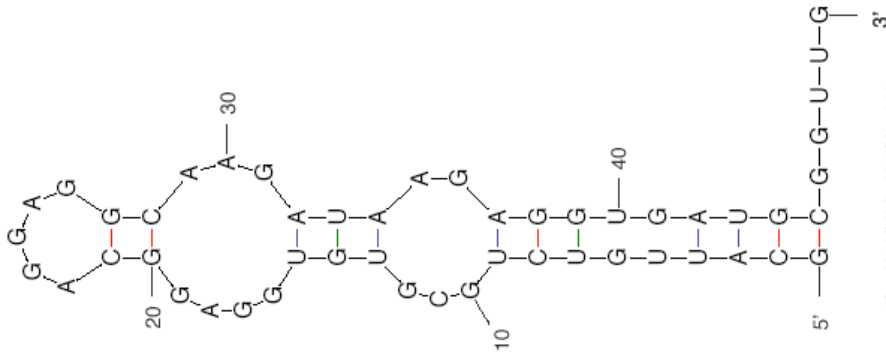
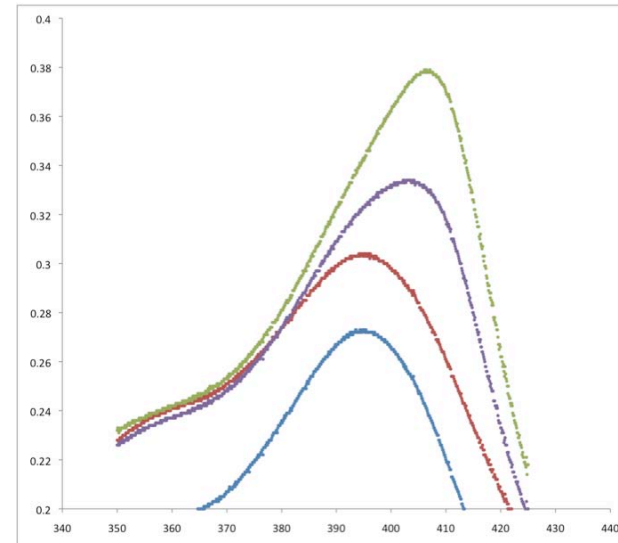


Image prepared using *RNA folding* at <http://mfold.bioinfo.rpi.edu/>

Courtesy of Michael Zuker. Used with permission.



Experimental Goals

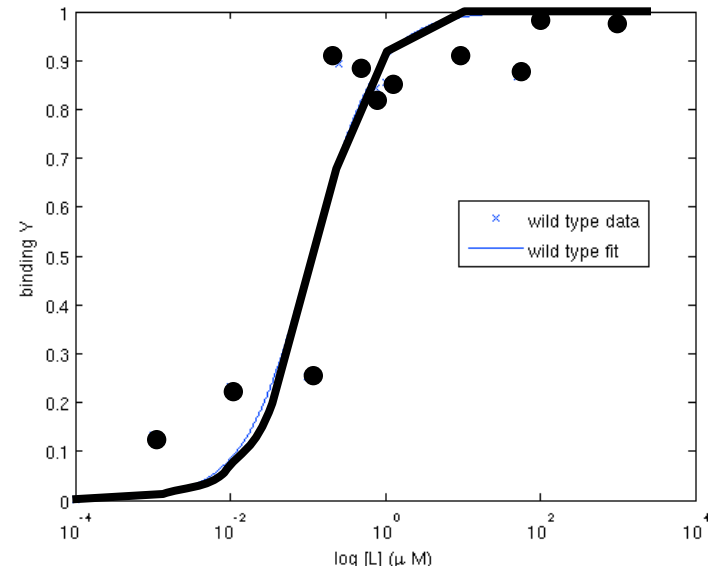
Design: column conditions

- 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

Protein Engineering: calcium sensor redesign



Experimental Goals

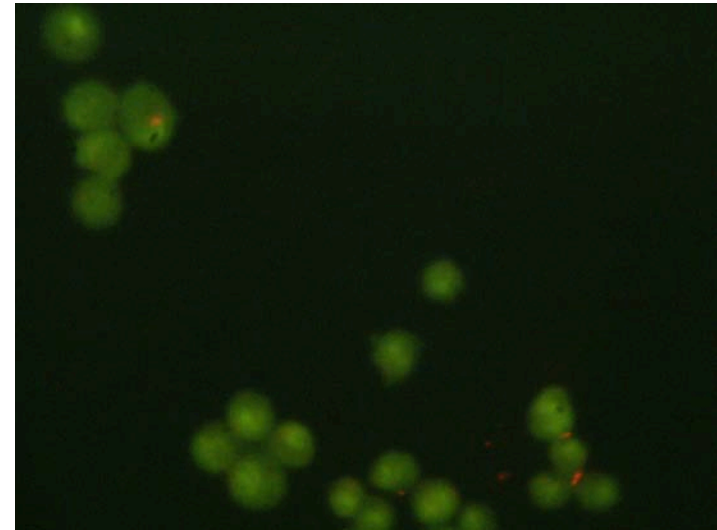
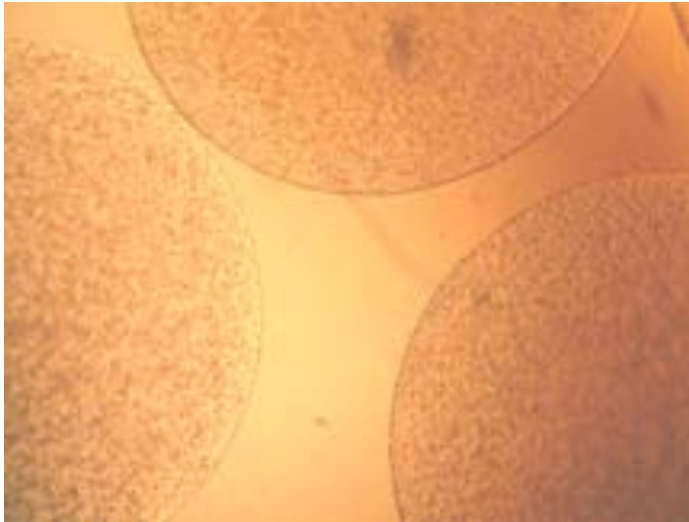
Design: Modify DNA + protein

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

Lab+Analytical Skills

- Culture bacteria
- Manipulate and analyze DNA
- Prepare and characterize protein
- Use MATLAB for modeling

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

- Mammalian 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 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

8% Homework

5% Quizzes

5% Lab Notebooks

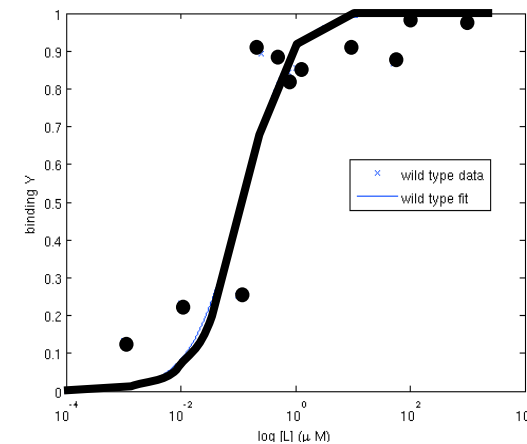
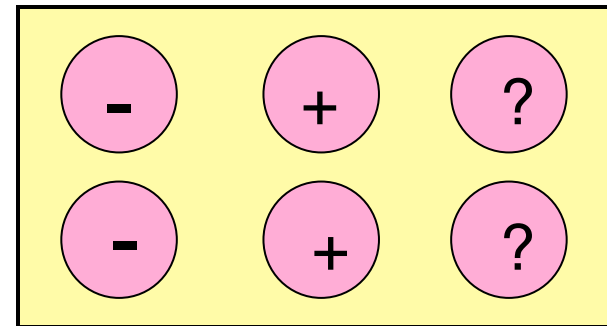
2% Participation

Writing & Oral Communication Faculty

- Neal Lerner and Linda Sutliff
 - Lectures/discussions/exercises in class
 - Written feedback (→ opportunity to revise)
- 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

Lab Tuesdays and Thursdays 1-5

 Wednesdays and Fridays 1-5

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.

MIT OpenCourseWare
<http://ocw.mit.edu>

20.109 Laboratory Fundamentals in Biological Engineering
Spring 2010

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