

Welcome to 20.109

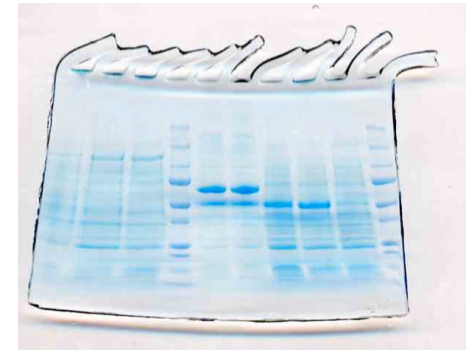
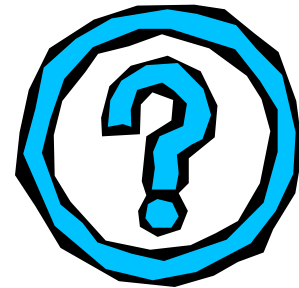
Laboratory Fundamentals of  
Biological Engineering

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

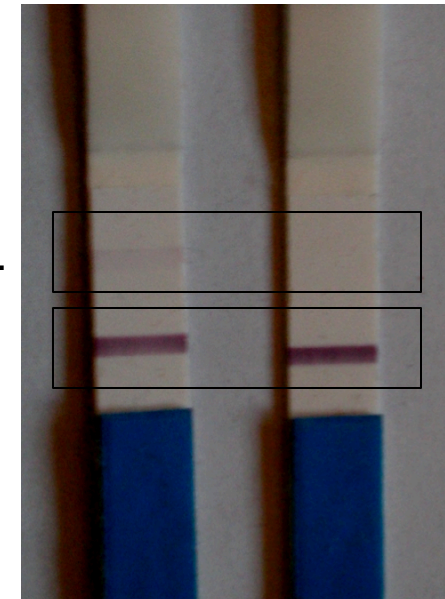


## Course Mission for 20.109

- 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

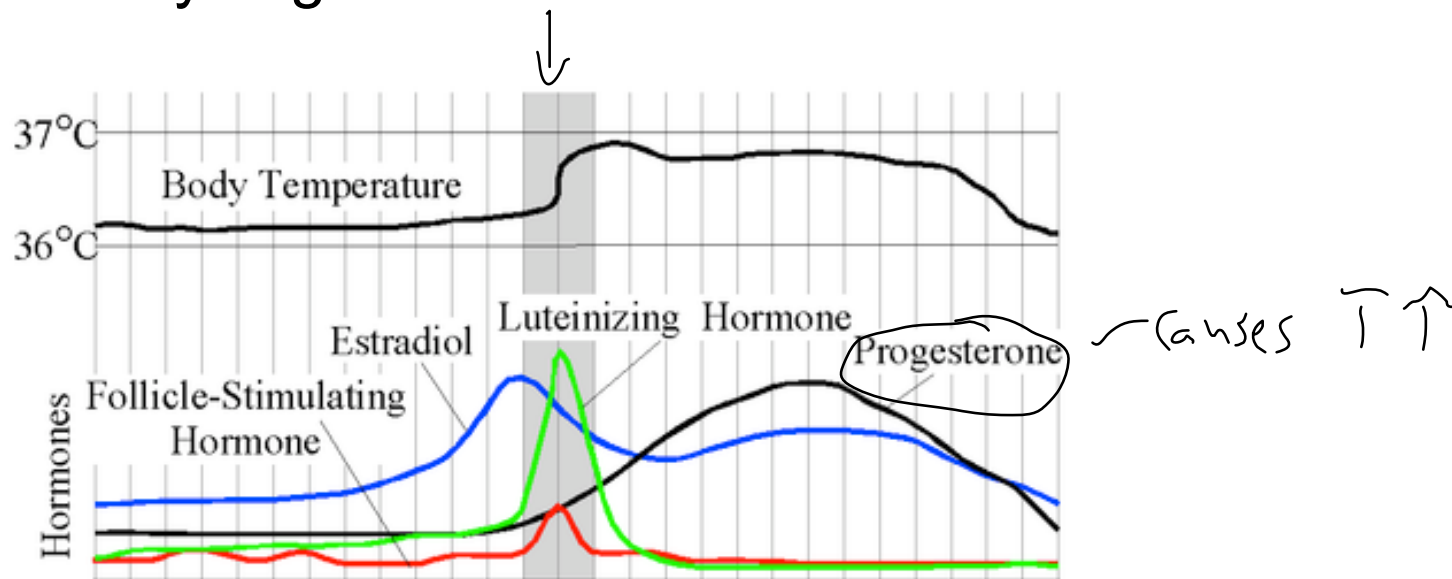
- Mechanism: measure level of hCG
- False positives nearly impossible
- False negatives below the detection limit
- Internal control } did the test work?
- Negative control }
- Positive control }



exp. (-) cont  
female male

# Timing conception: hypothesis-formation

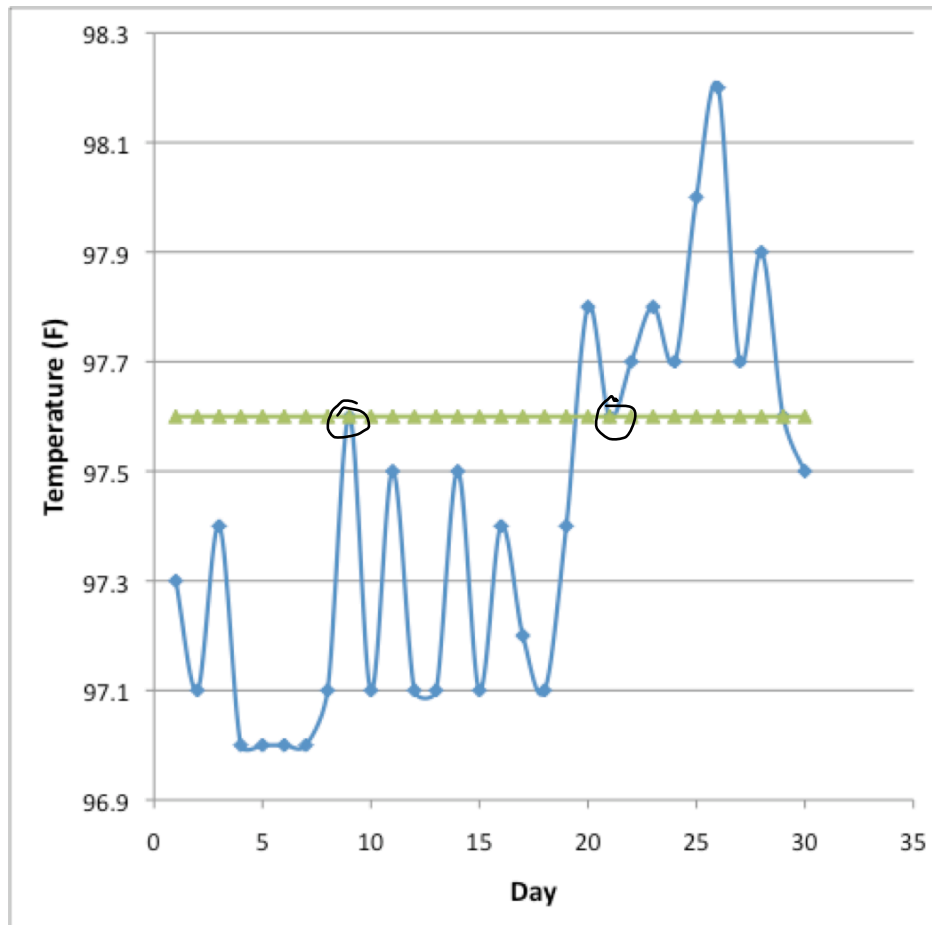
- About a day after ovulation, waking temperature rises
- Why might this be?



This Wikipedia and Wikimedia Commons image is from user Chris 83 and is freely available at <http://commons.wikimedia.org/wiki/File:MenstrualCycle.png> under the creative commons cc-by-sa 2.5 license.

# Waking temperature: data interpretation

- How might we rigorously determine ovulation day?



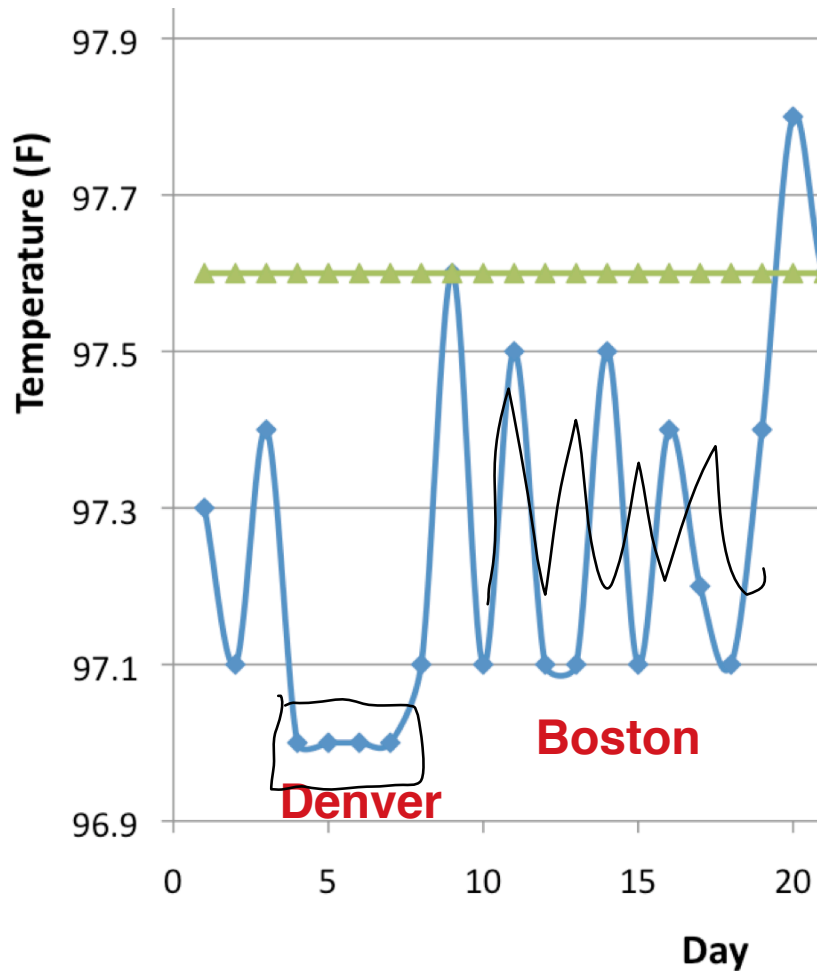
~~threshold~~

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

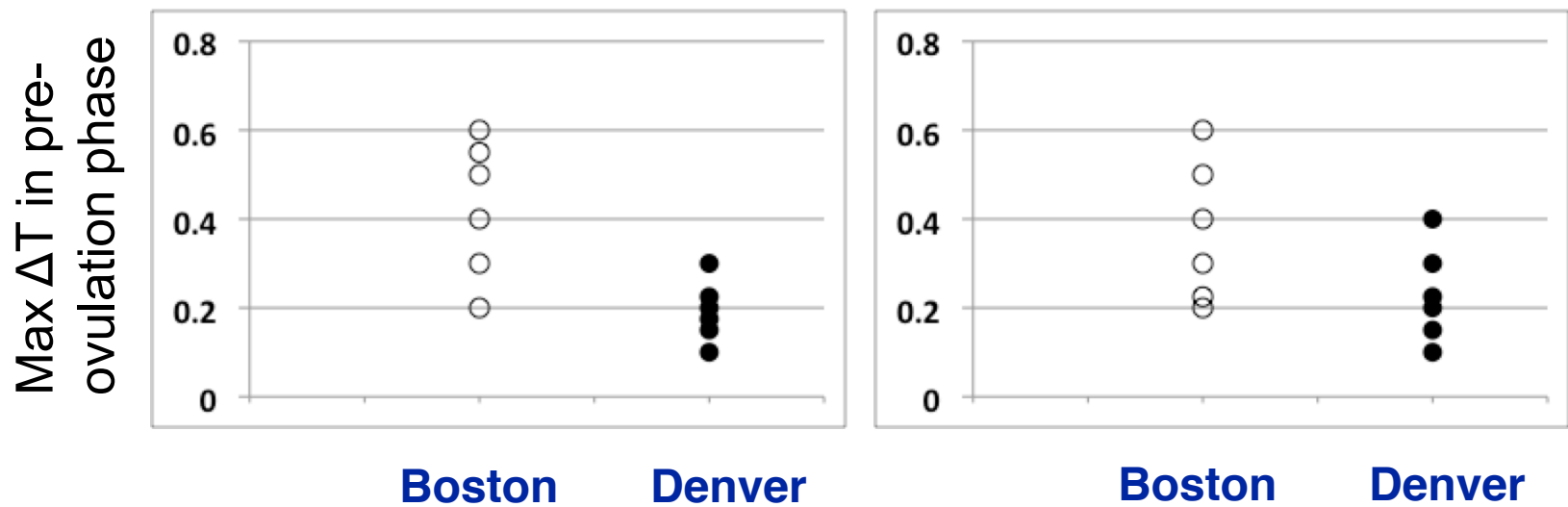
std. dev. per person

max, or ave. AT (absolute,  $\frac{70}{100}$ )

in pre-ov phase

# Geographical temperature-tracking experiment: quantification

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



**Boston** **Denver**  
< 1% chance of random occurrence

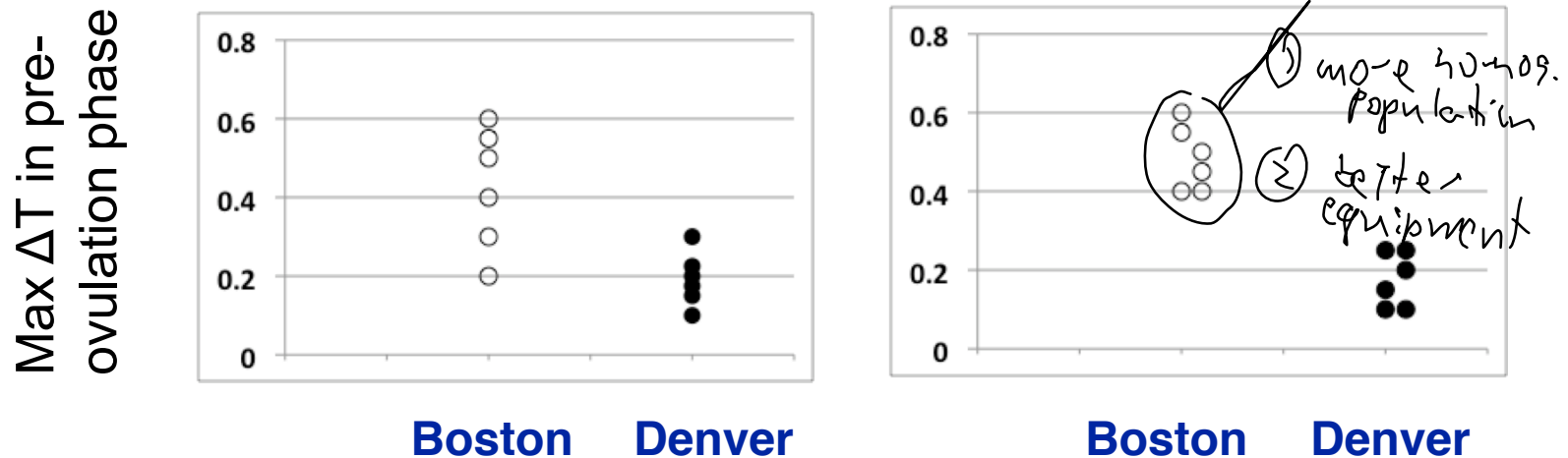
**Boston** **Denver**  
> 10% chance that random

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?

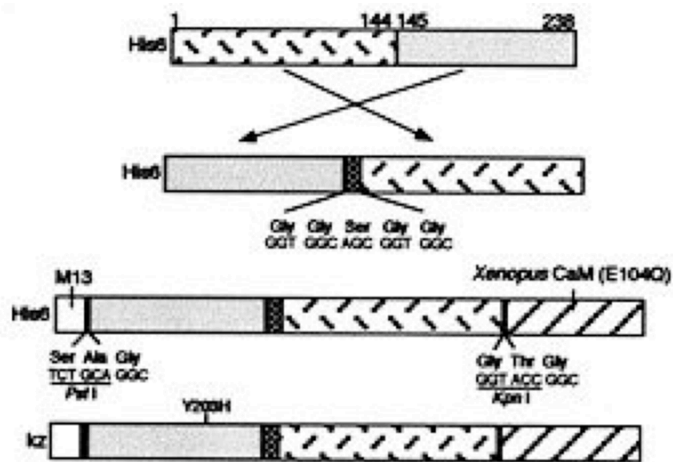
- Posing a good question:
  - Seek out prior knowledge
  - Consider interest and impact
  - Develop good controls
- Interpretation of data:
  - Understand each collection step
  - Perform quantitative analysis
  - Be aware of biases and assumptions
  - Peer review

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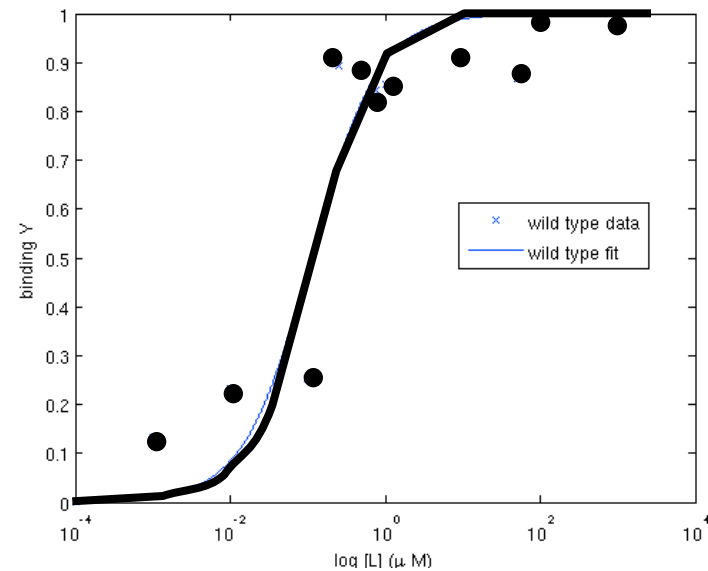
# Engineering Principles + Modern Biology

**Manipulate and Make**



Nagai *et al.*


**Measure** ↔ **Model**



**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

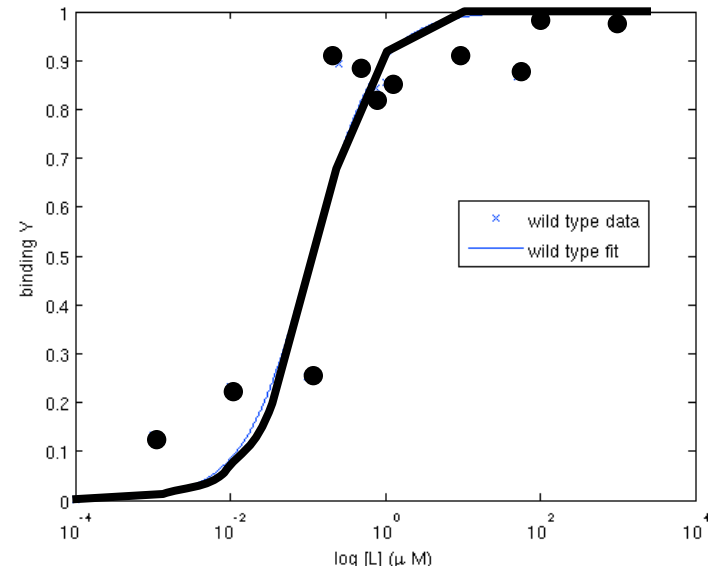
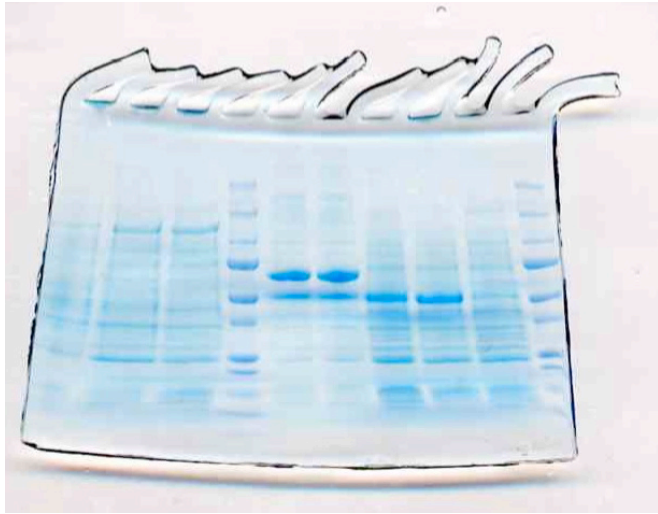
Protein Engineering (A. Jasanoff)

Module 3

Cell-Biomaterial Engineering (A. Stachowiak)



# Protein Engineering: calcium sensor redesign



## Experimental Goals

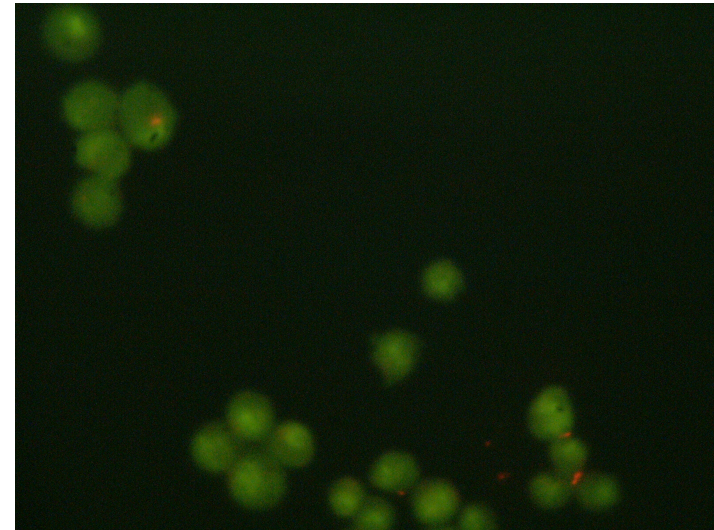
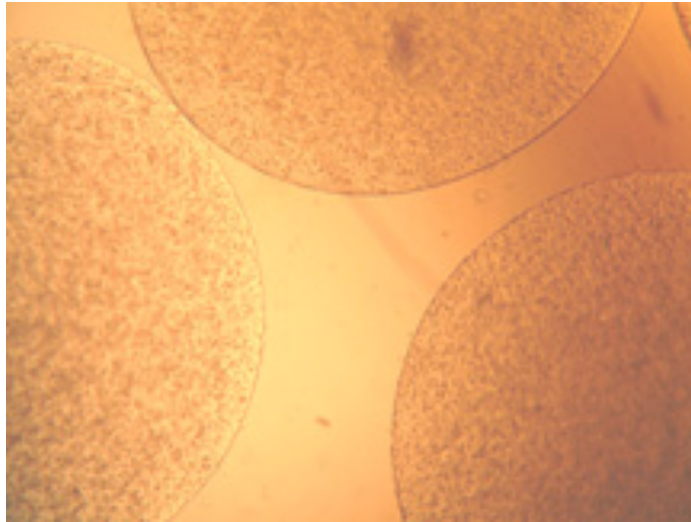
*Design: Modify DNA + protein*

- 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

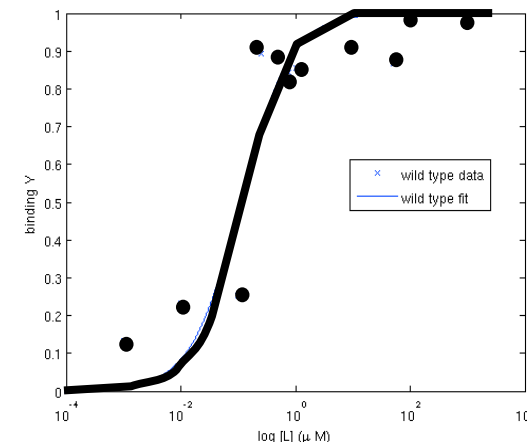
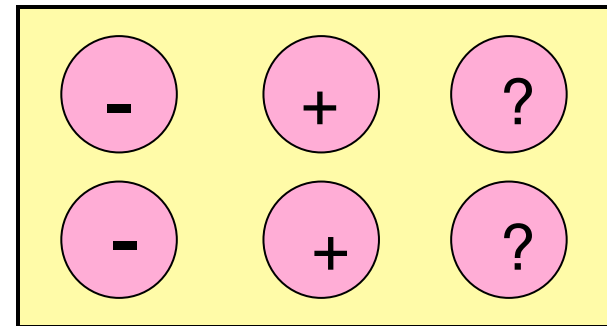
2% Participation

# 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, 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.