# Welcome to 20.109

# Laboratory Fundamentals of Biological Engineering

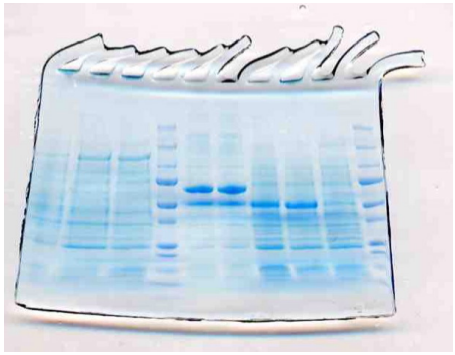
Orientation Lecture

Spring 2012

# 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

# Last year: babies' learning best practices

| **Baby** | **109er** |
|---|---|
| Driven by wanting to *do* | Limits to grade desire |
| Intuitive experimenter | Your ideas/designs/input |
| Wants to communicate | Taxing but rewarding |
| Needs to fail repeatedly | *Analysis* counts, not lab success; report revision |

# This year: the terrible twos

- Toddlerhood
  - becoming an individual
  - community interactions
  - expressing own desires
  - … sometimes unhealthily
  - still wants guidance/support…
  - … on his own terms
- Sophomores
  - academic self-definition
  - bioengineer, not frosh core
  - still want guidance/support…
  - … but not too much

# On investigation: can we mitigate the two's terribleness?

- Source: *The Happiest Toddler On the Block* (H. Karp)
- Method: mirror emotions, *then* explain/distract/etc.
- *Claim: "Stop over half of your toddler's tantrums in seconds* [and] *prevent 50-90% of outbursts from ever happening."*
- Numbers for real?! How evaluate meaningfulness?
- Data seems to be anecdotal/interview-based
- Can *you* think of a rigorous study design and analysis to address whether the method works?

# Your thoughts on studying toddlers

# My thoughts on studying toddlers

- Population: may be self-selecting, not random
  - compare 2 “treatment plans” for same interested parents
- Experiment: include control
  - one group gets *Happiest Toddler…* strategies
  - one gets a placebo or alternative gold standard
- Measurement
  - what parameters define a tantrum? quantitative (decibel level, tear volume), qualitative (exhibits 2 of 3 behaviors)?
  - does parent or independent observer identify tantrums?
- Analysis
  - how is raw data processed? (threshold, integration?)
  - how is the comparison ultimately made? (statistics)

# Toddler tantrum recap: 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

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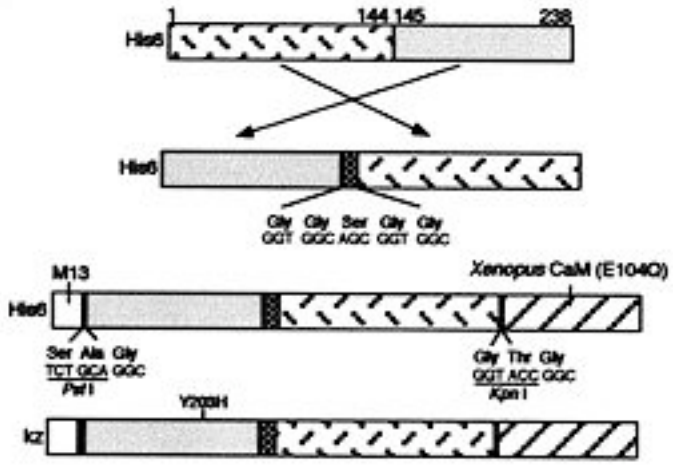
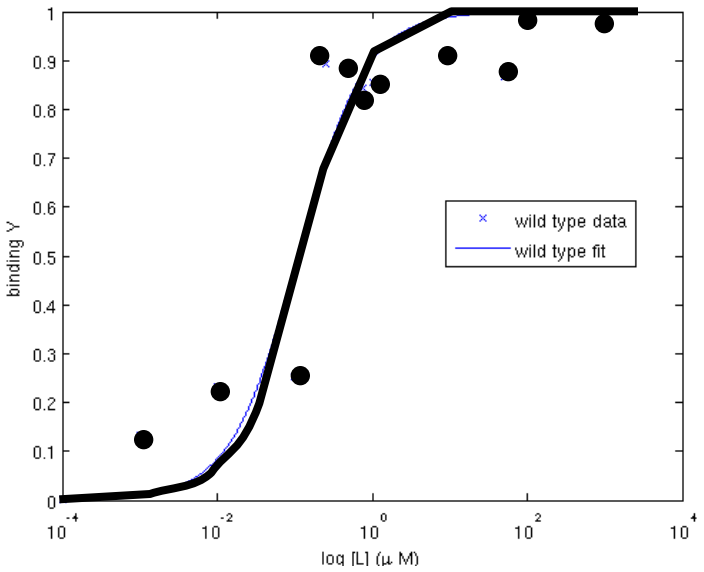
# Engineering principles + modern biology

**Manipulate and Make**



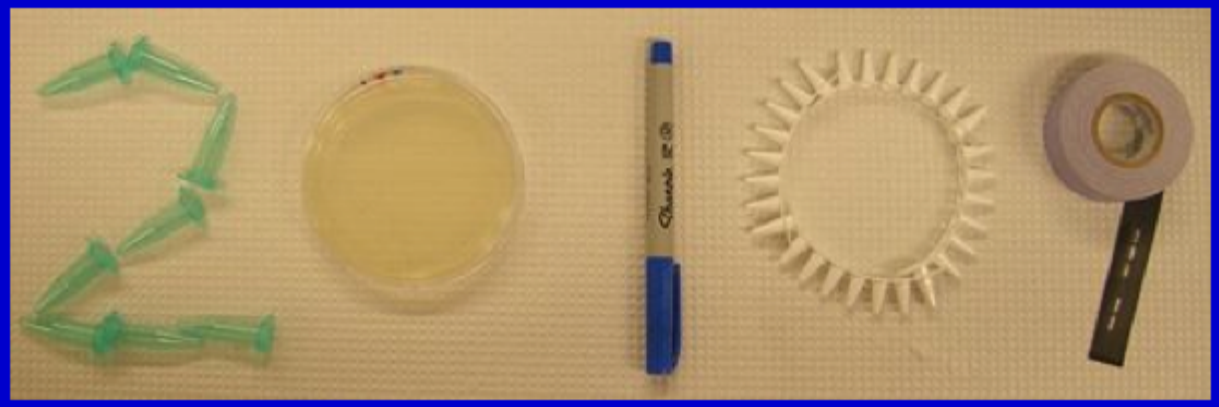

Nagai *et al.*

**Measure ⟷ Model**




**Myriad length scales, systems, and applications**

# 20.109(S12): Laboratory Fundamentals of Biological Engineering



Home Schedule Spring 2012 Assignments
RNA Engineering Protein Engineering Cell Engineering

| | |
|---|---|
| Module 1 | RNA Engineering (J. Niles) |
| Module 2 | Protein Engineering (A. Jasanoff) |
| Module 3 | Cell Engineering (A. Stachowiak) |

openwetware.org/wiki/20.109(S12)

# RNA engineering: aptamer enrichment

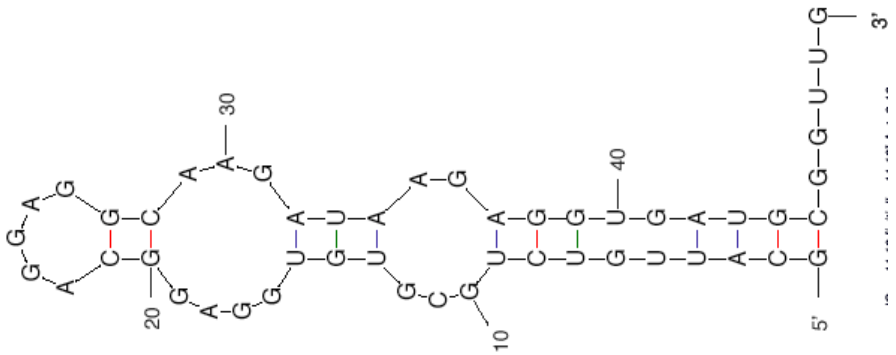
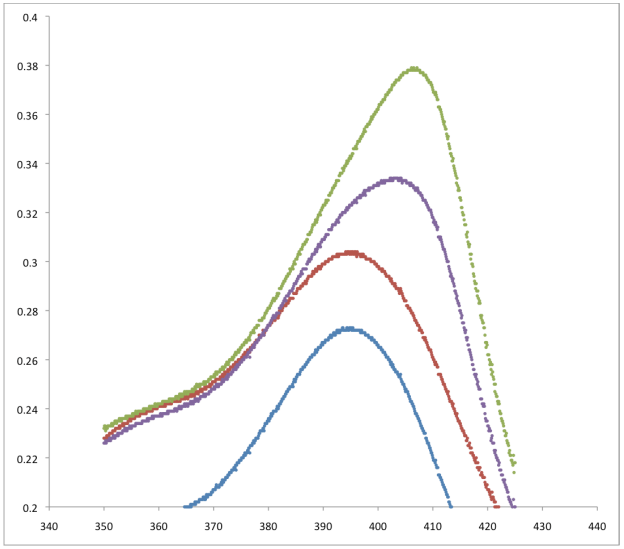


Image prepared using *RNA folding* at http://mfold.bioinfo.rpi.edu/




## Experimental Goals

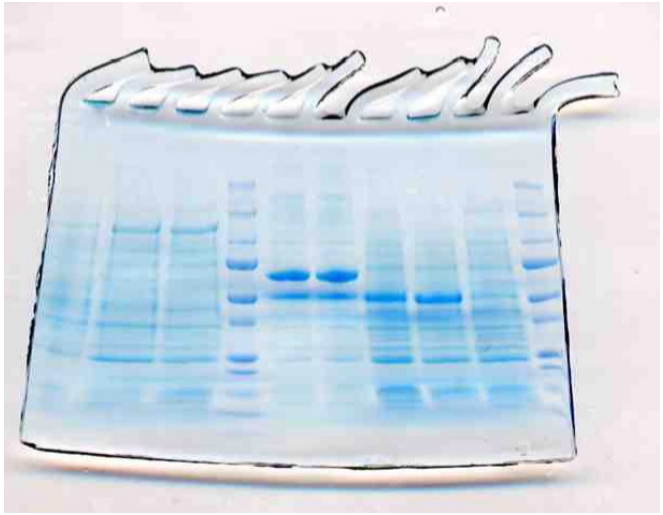
*Design: Column conditions*

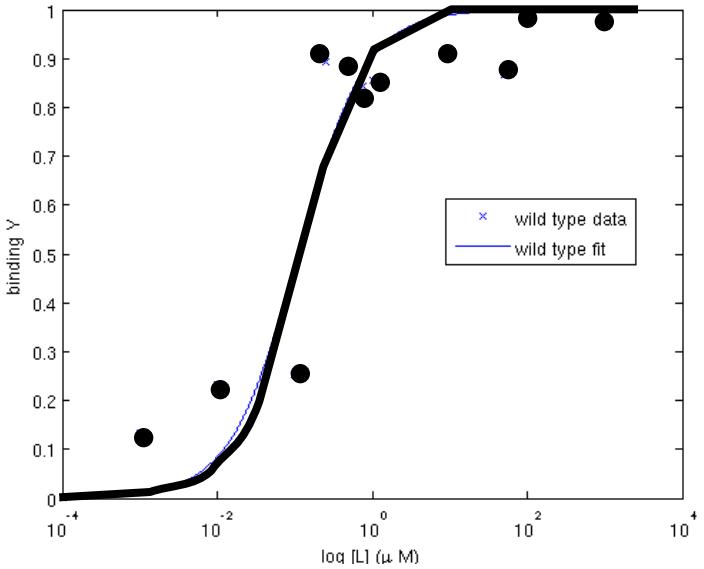
- Prepare RNA aptamers
- Run heme affinity column
- Assess enrichment of binder

## Lab+Analytical Skills

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

# Protein engineering: calcium sensor redesign






## Experimental Goals

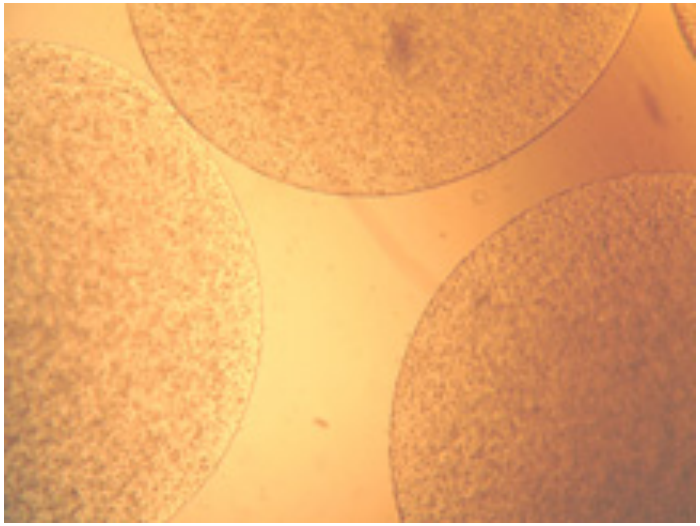
*Design: Modify DNA + protein*

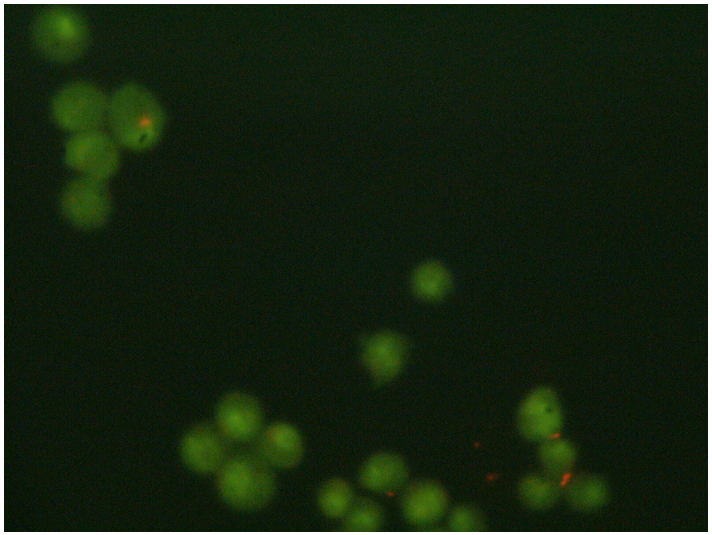
- Mutagenize wild-type plasmid
- Express and purify protein
- Assess effect on protein

## Lab+Analytical Skills

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

# Cell 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

# 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

# Scientific writing must tell a story

- Stories help us remember
  - Archimedes, Newton, Kekulé
- You discover the narrative that the data tell
- Then convince an audience of your findings
  - Step-by-step explanations
  - Repetition of central ideas
  - Clear, effective visuals
  - Ethical choices

***Your data should be true even if your story is wrong***

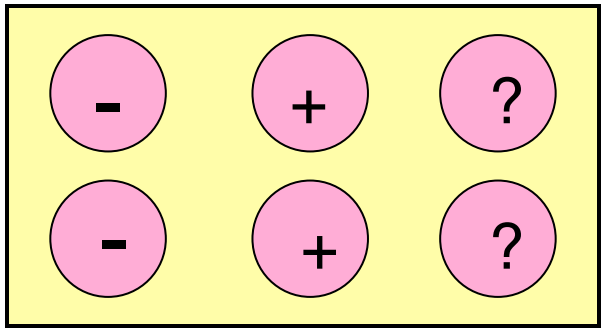
***~ Darcy Kelley, Columbia*** (from *The Canon*, N. Angier)

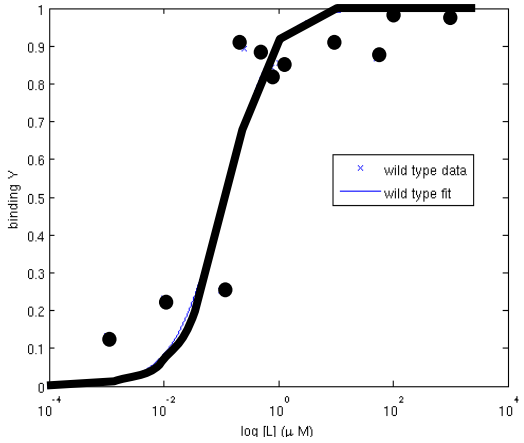
# Writing & oral communication faculty

- Marilee P. Ogren and Leslie Ann Roldan
  - Lectures/discussions/exercises in class
  - Written feedback on draft report sections
  - Office hours by appointment
- Walter Holland
  - Repeated one-on-one consultations
  - Review work from any class
- 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.