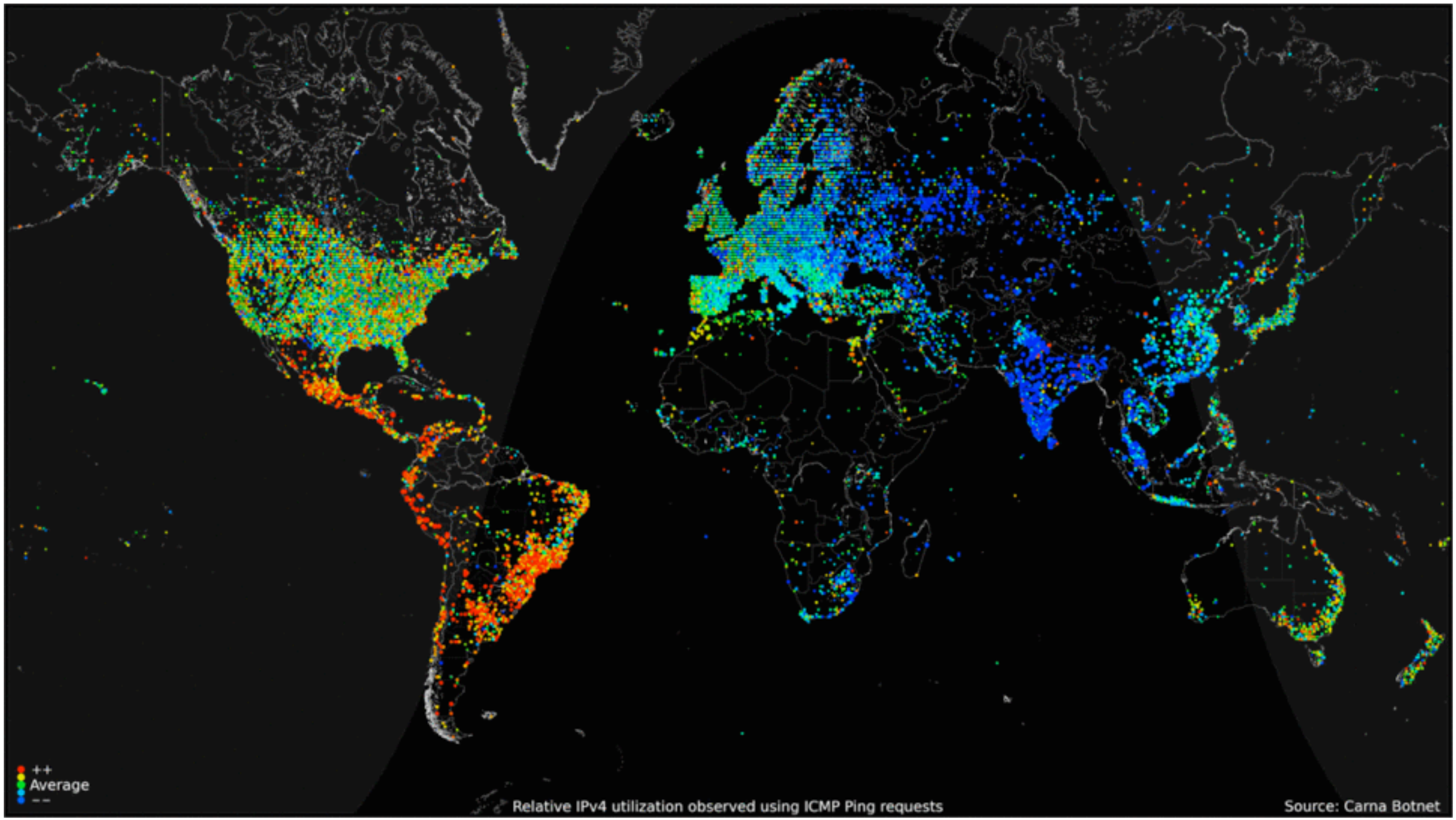
Welcome to 20.109

Laboratory Fundamentals of Biological Engineering

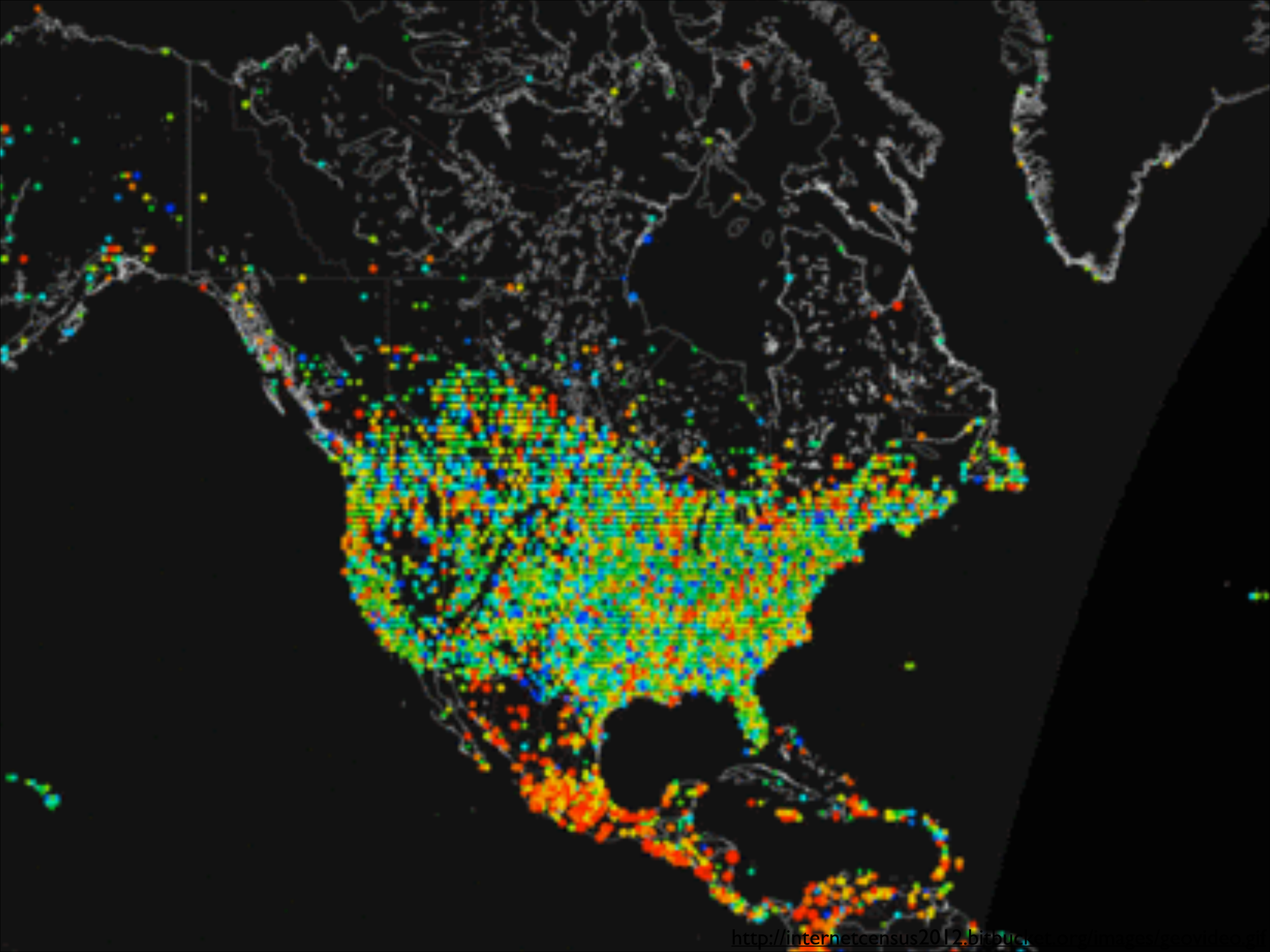
F14 Orientation Lecture, 9/4/14

The start of an MIT semester:



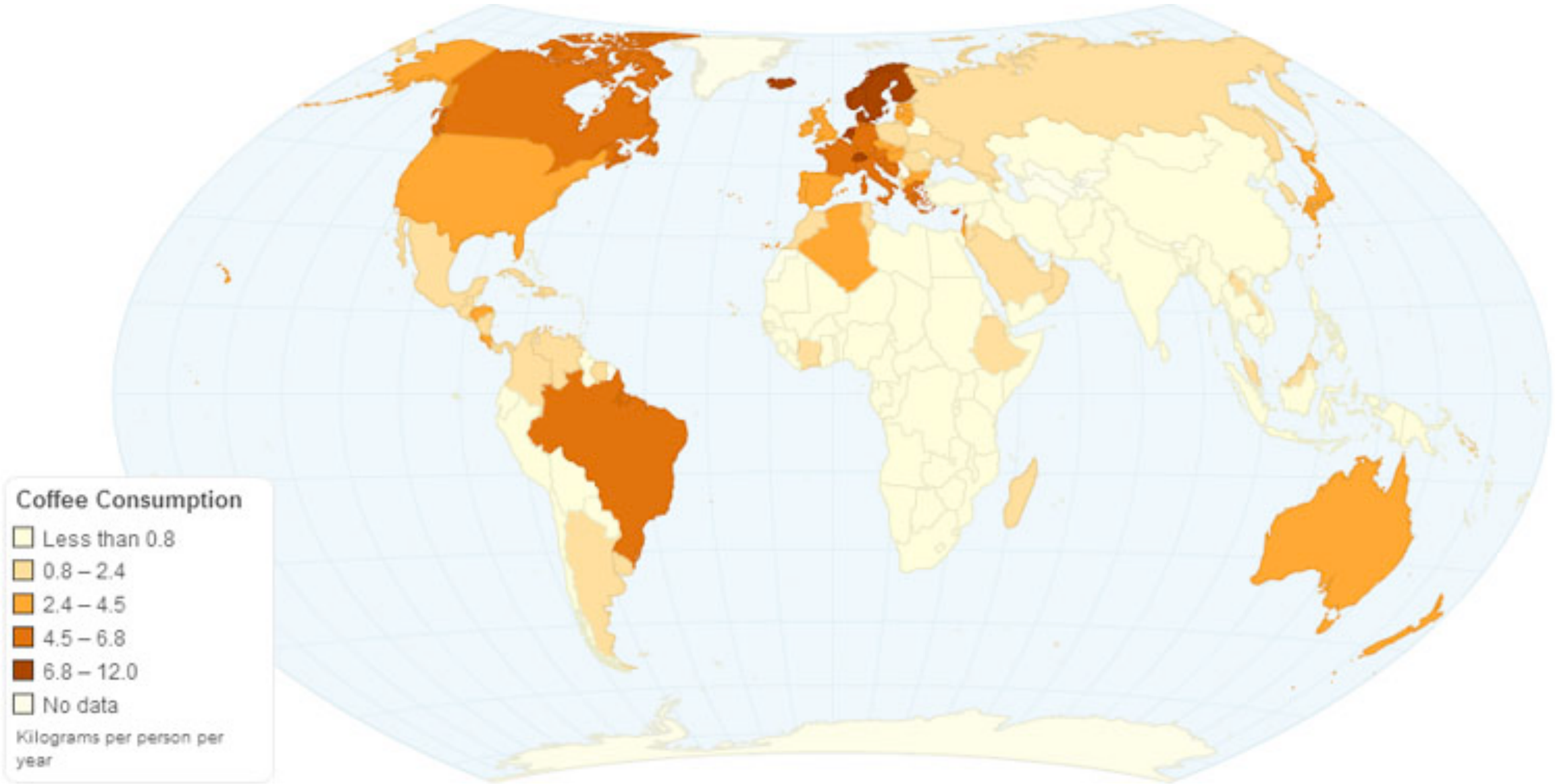
Internet usage over 24 hours

http://internetcensus2012.bitbucket.org/images/geovideo.gif


http://internetcensus2012.bitbucket.org/images/geovideo.gi

How do you do it?

Kilograms of coffee per person per year....



http://chartsbin.com/view/581

How do you do it?

Kilograms of coffee per person per year....

http://chartsbin.com/view/581

Laboratory Fundamentals of Biological Engineering

- Teaching Team
- Core 20.109 Mission

  Building a better bioengineer.
  What's in it for you?

- Modular Structure of Course

  Module 1: DNA Engineering
  Module 2: Systems Engineering
  Module 3: Biomaterials Engineering

- Logistics

  Everything you really want to know -- today

20.109 Instruction Team

Technical

Bevin Engelward (Mod 1)

Natalie Kuldell (Mod 2)

Angie Belcher (Mod 3)

Shannon Hughes (T/R)

Noreen Lyell (T/R)

Agi Stachowiak (W/F)

Communications

Leslie Ann Roldan (Writing)

Jessie Stickgold-Sarah (Writing)

Atissa Banuazizi (Oral Presentations)

Teaching Assistants

Module 1: Isaak Mueller

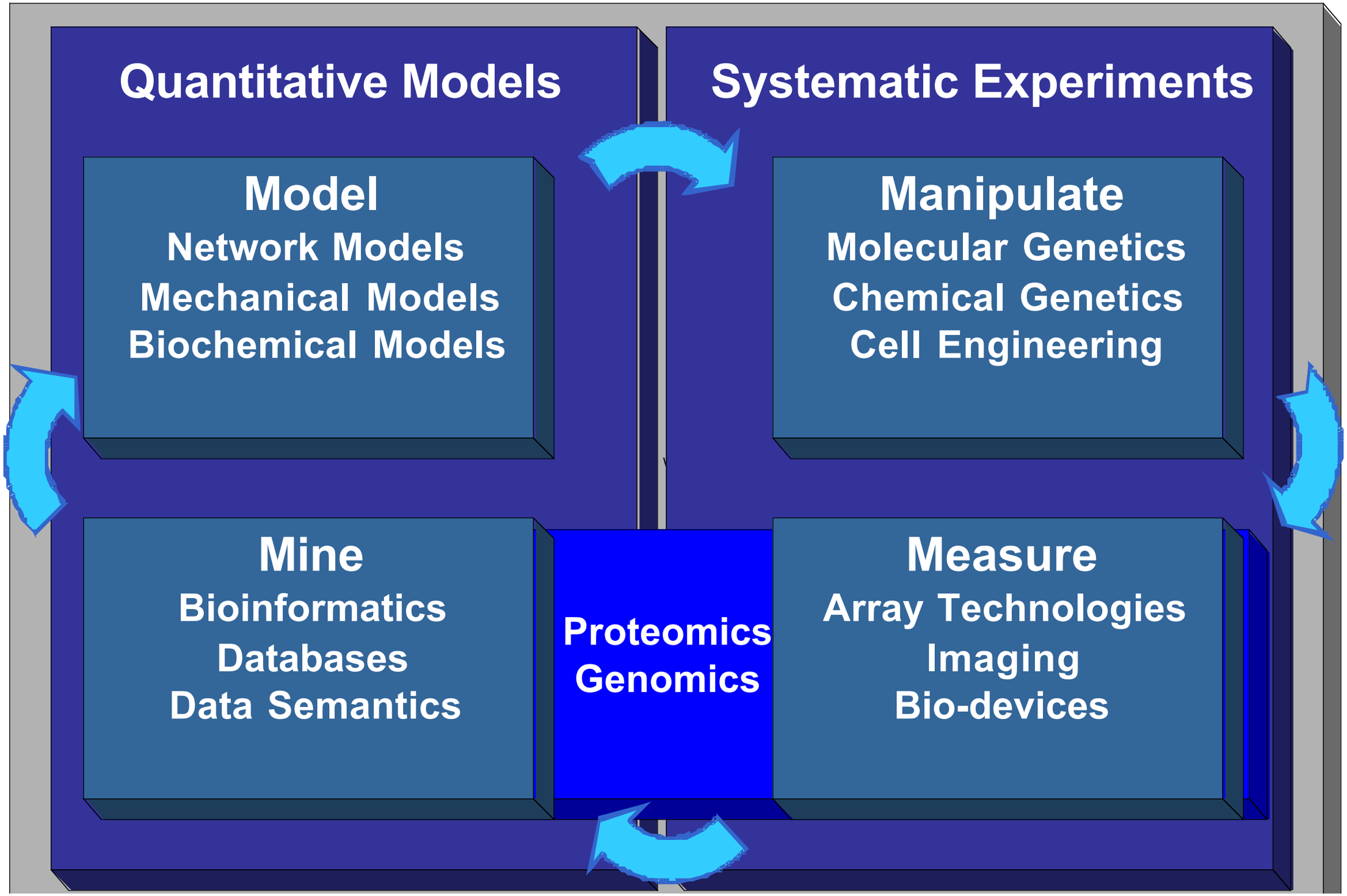
Module 2: Yong Jin Park

Module 3: Tahoura Samad

& Jackie Ohmura

image credit: www.abccollector.com

MIT BE Core Mission



- Definition of biological engineering according to Doug Lauffenburger

20.109 Core Mission

- To prepare students to be the future of Biological Engineering

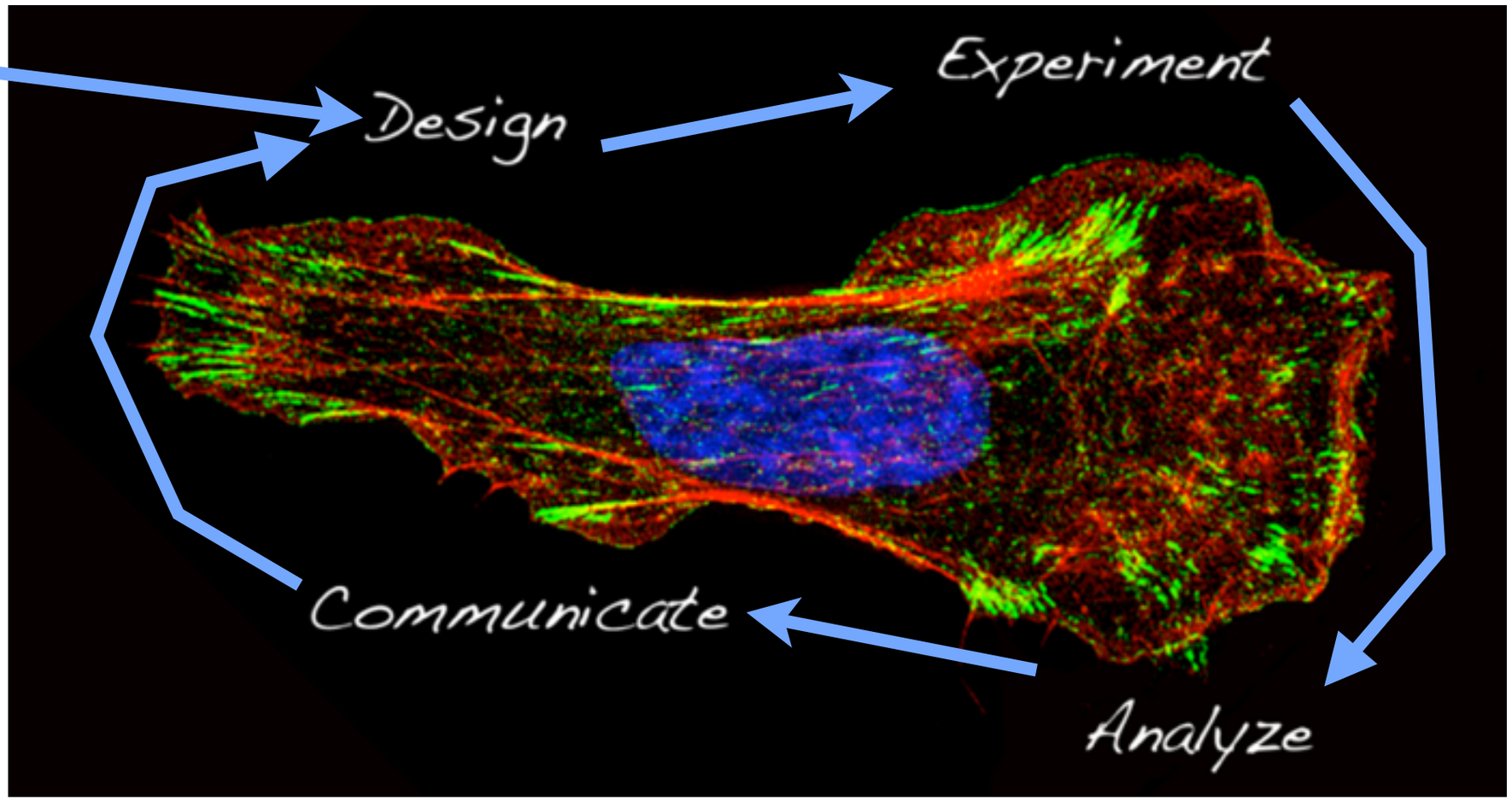
- To teach cutting edge research skill and technology through an authentic research experience

- To inspire rigorous data analysis and its thoughtful communication

20.109's Standard Workflow

We start here

But, you can't design an experiment if you haven't 'analyzed' some data!



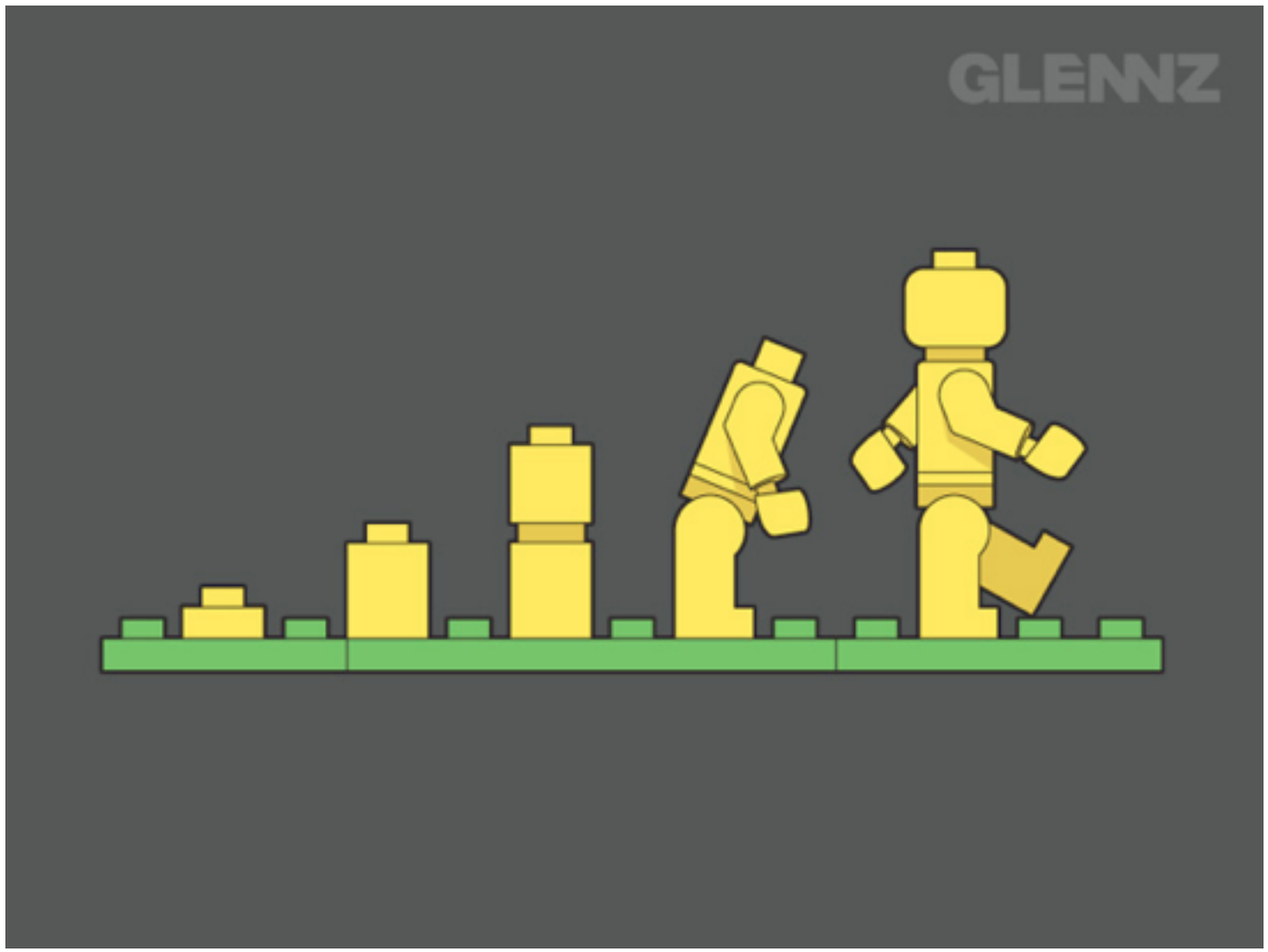
20.109: Design

We aim to prevent "just follow the protocol" syndrome.

Image credit: www.tasss.com

20.109: Experiment

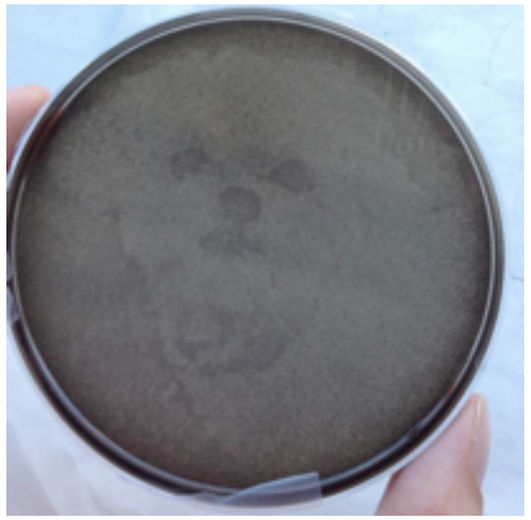
You'll notice a pattern emerge...

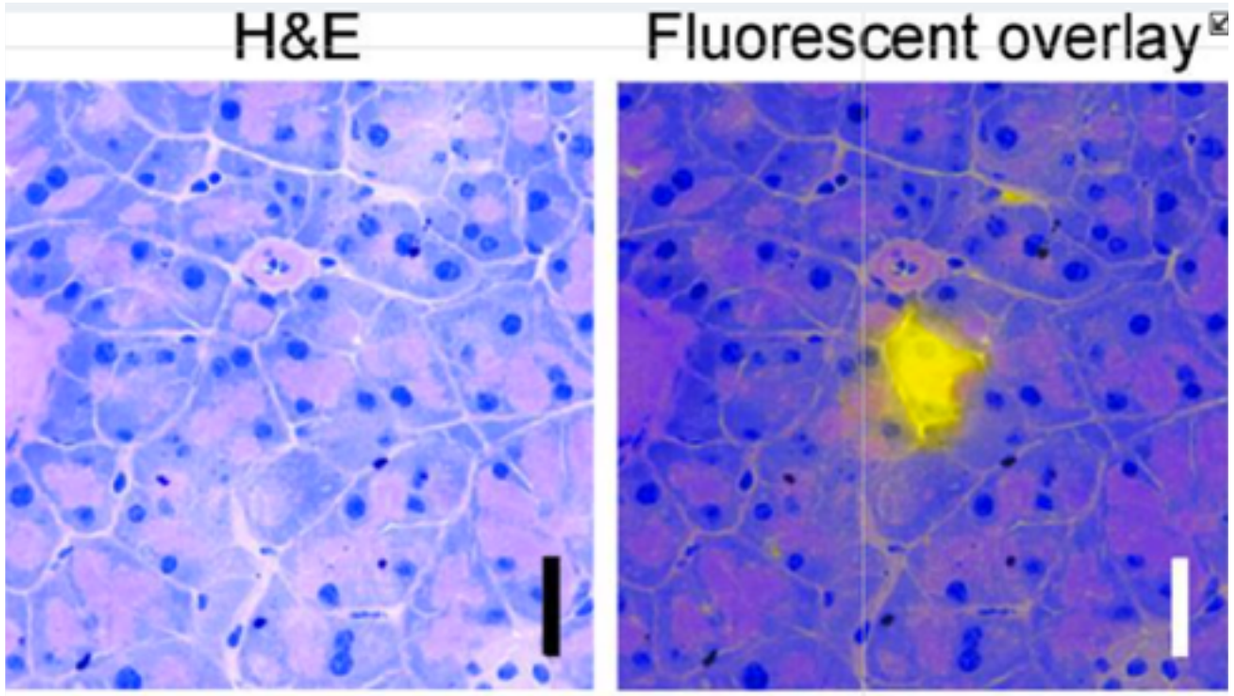


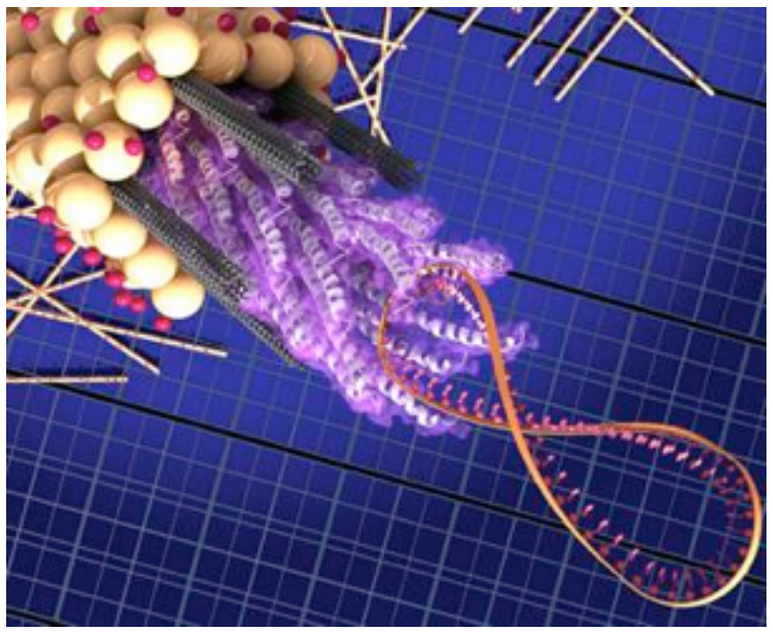
"Supposing is good, but finding out is better."~Mark Twain

Image credit: http://blog.glennz.com/evolution/ Buy the t-shirt!

20.109: Experiment







We will do *relevant and cutting edge* experiments.

Image credits:
http://nfcr.lanl.gov/index.htm
Proc Natl Acad Sci U S A. 2006 August 8; 103(32): 11862–11867.
Hamden, CP. Neuroscience 2006,

20.109: Experiment

We will do *relevant and cutting edge* experiments.

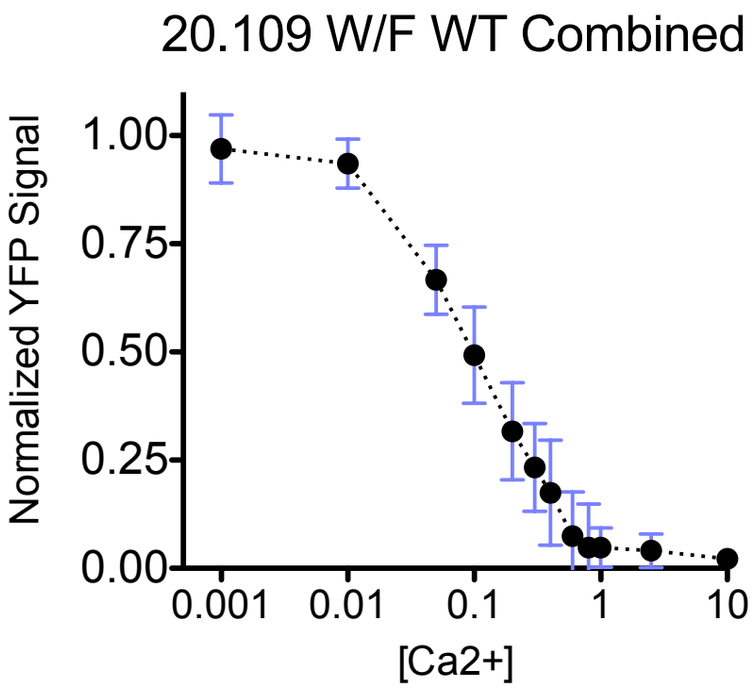
And we do it safely:

http://blogs.discovermagazine.com/bodyhorrors/2013/03/20/mouth_pipetting/#.Uh-277x56TJ

20.109: Analyze

Step one: What are the data?

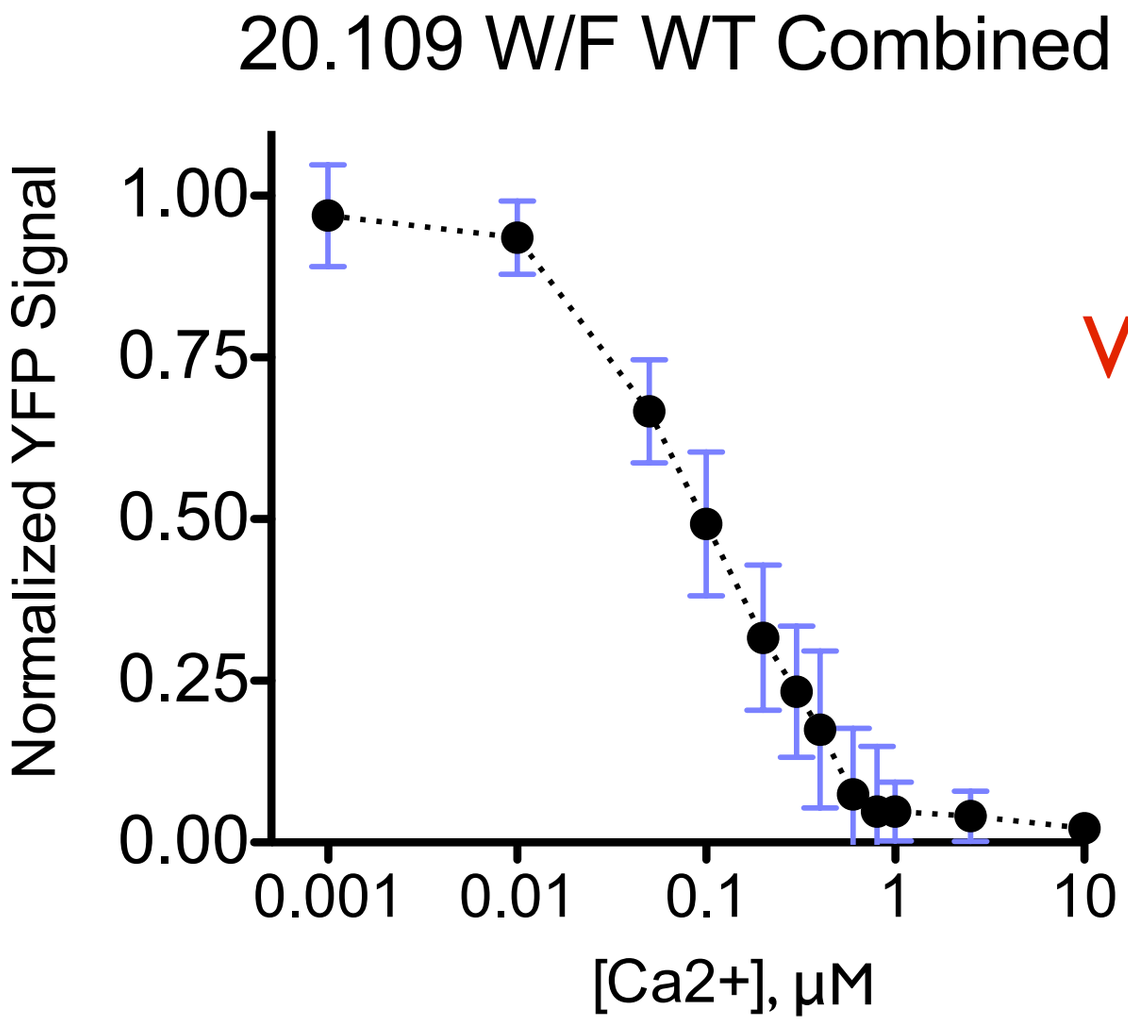
X Title	Data Set-A												
X	A:Y1	A:Y2	A:Y3	A:Y4	A:Y5	A:Y6	A:Y7	A:Y8	A:Y9	A:Y10	A:Y11	A:Y12	A:Y13
0.001	1.000000	1.000000	0.848243	1.000000	0.713133	0.950588	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
0.010	0.806115	0.880406	1.000000	0.973925	1.000000	1.000000	0.894219	0.919256	0.931213	0.921518	0.972005	0.849801	0.918947
0.050	0.548535	0.735558	0.708449	0.779236	0.539573	0.641501	0.596857	0.594858	0.637694	0.598490	0.760630	0.674994	0.655455
0.100	0.502015	0.613624	0.338126	0.648407	0.347801	0.439509	0.364033	0.389130	0.438887	0.410905	0.665287	0.573336	0.425153
0.200	0.257326	0.357331	0.282499	0.605311	0.150865	0.255431	0.196695	0.242768	0.280211	0.259752	0.429967	0.357416	0.222382
0.300	0.152803	0.217029	0.210579	0.518589	0.237044	0.263803	0.123727	0.120837	0.174456	0.179095	0.155648	0.264536	0.194816
0.400	0.177765	0.083181	0.067909	0.459838	0.105253	0.129052	0.078437	0.064896	0.116523	0.113035	0.216040	0.099032	0.122746
0.600	0.071051	0.000753	0.045545	0.422433	0.018956	0.041174	0.030107	0.022286	0.050173	0.064494	0.035743	0.066997	0.055030
0.800	0.024218	0.000000	0.020483	0.411027	0.020630	0.000000	0.016070	0.019293	0.022485	0.000000	0.051325	0.000000	0.046801
1.000	0.026194	0.098671	0.015087	0.000910	0.093265	0.098757	0.000000	0.000000	0.000000	0.013153	0.054582	0.060170	0.077899
2.500	0.004186	0.094503	0.000000	0.000000	0.026212	0.043179	0.047481	0.028909	0.004165	0.009882	0.038296	0.074874	0.066173
10.000	0.000000	0.059246	0.059780	0.012342	0.000000	0.002607	0.040768	0.006809	0.007207	0.016250	0.000000	0.022207	0.000000



Data ≠ Understanding

20.109: Analyze

Step two: What are the data telling you?

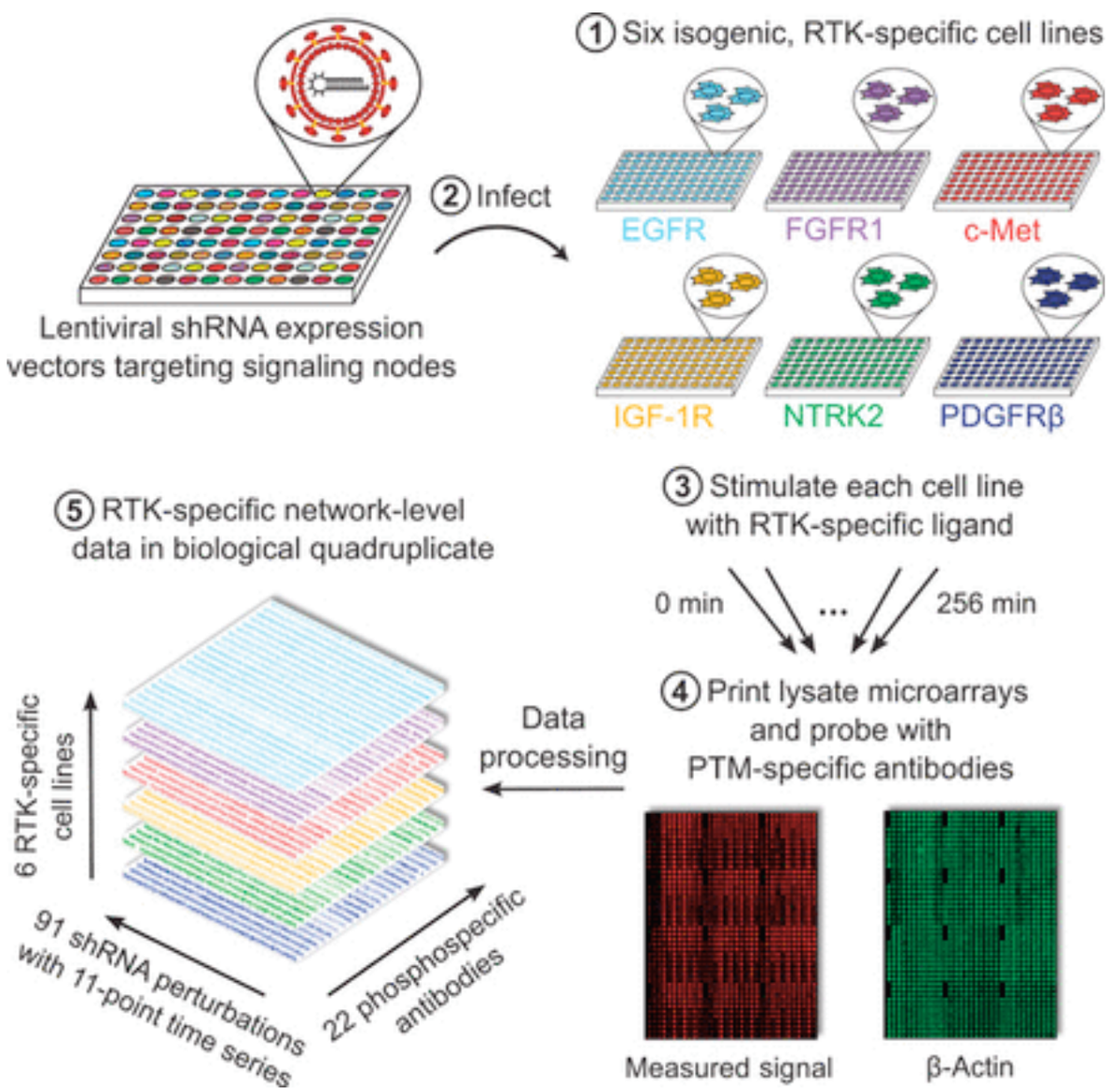


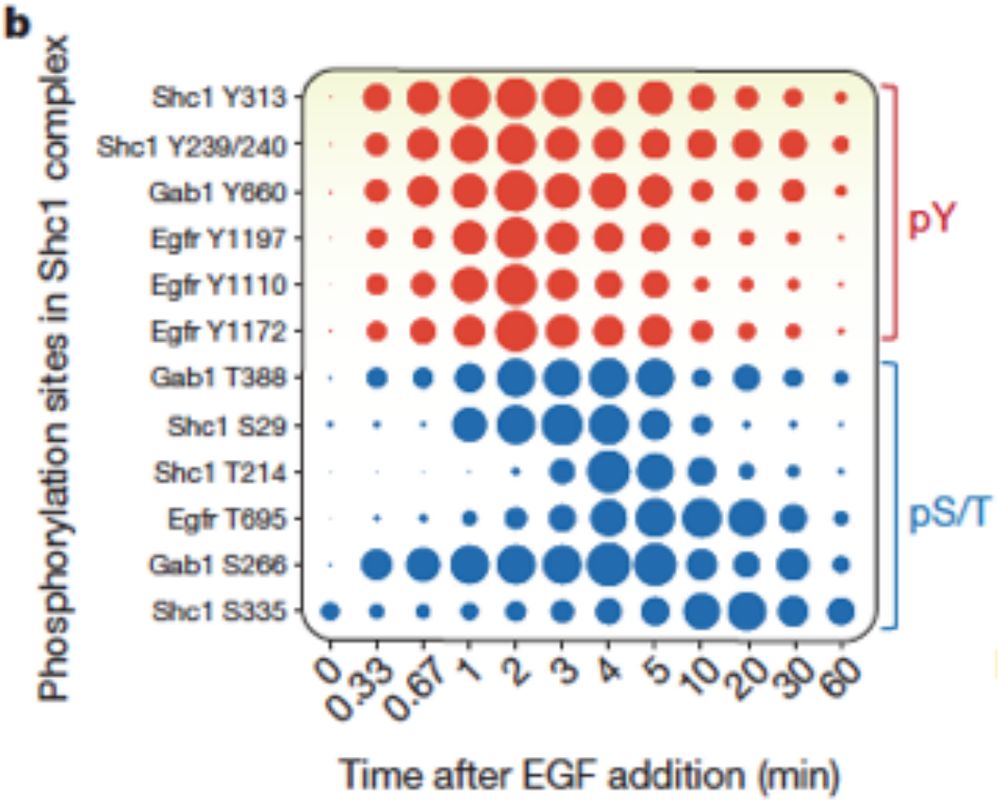
What is the working range of this Ca^{2+} sensor?

Can we detect changes in extracelular [Ca^{2+}]?

http://farm2.static.flickr.com/1159/526560734_3c3ecebb08_o.gif

20.109: Communicate



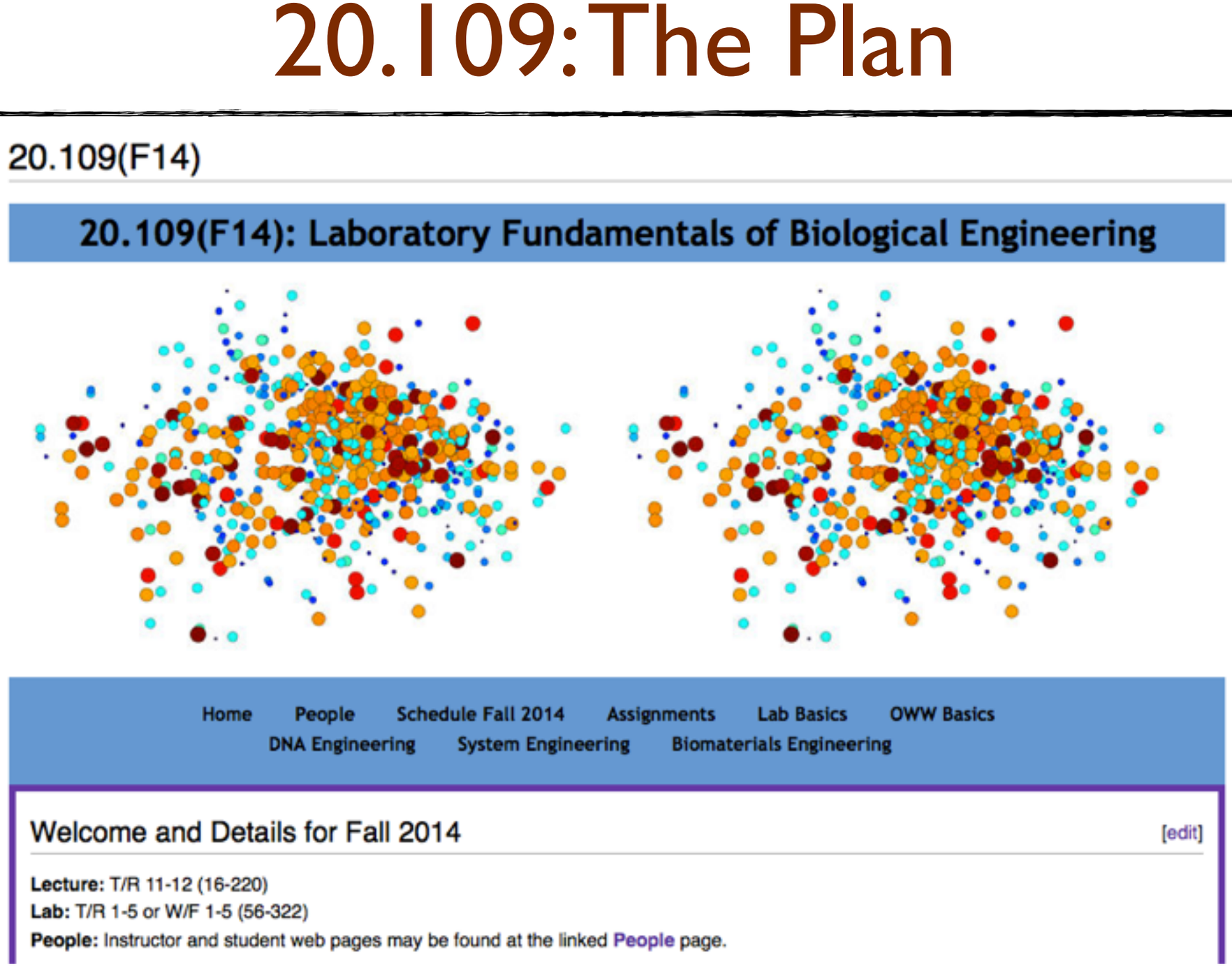


Tell your story!

Wagner et al. *Sci Signaling* July 2013

Zhang et al. *Nature* July 2013

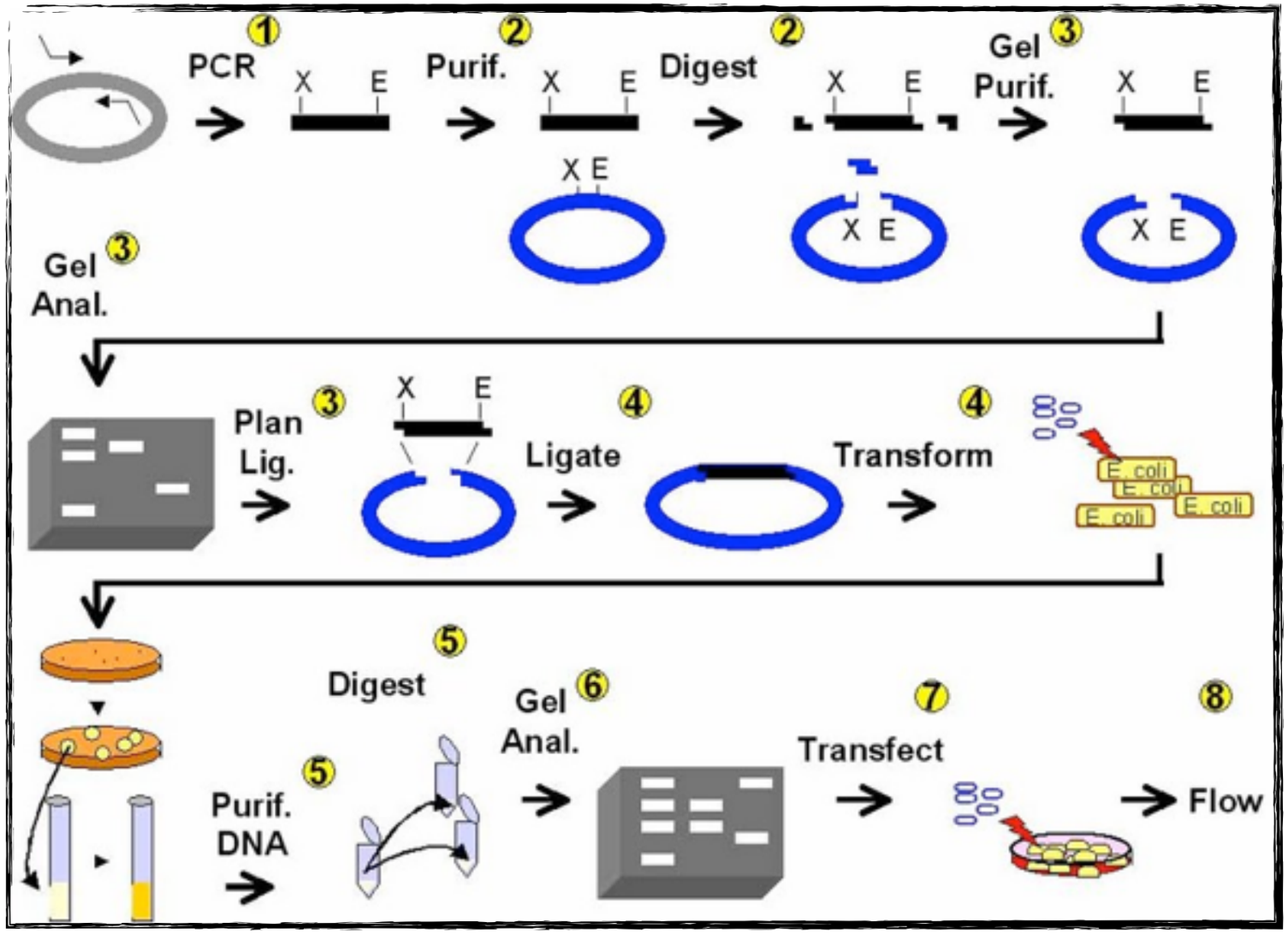
20.109: The Plan



Module 1 DNA Engineering (B. Engelward)
Module 2 System Engineering (N. Kuldell)
Module 3 Biomaterials Engineering (A. Belcher)

openwetware.org/wiki/20.109(F14)

DNA Engineering: Module 1



Experiments:

- Design and create vectors for expressing fluorescent protein in mouse embryonic stem cells.
- Use fluorescence to analyze recombination of damaged DNA substrates.

Lab Skills:

Retrieve and manipulate sequences from databases

Clone PCR-amplified DNA fragments

Transfection of mammalian cells & Flow Cytometry

Systems Engineering: Module 2

Experiments:

- Measure bacterial photography output
- Screen library for mutations that increase dynamic range of system
- Identify amino acid changes and their consequences

Lab Skills:

Optimize a system

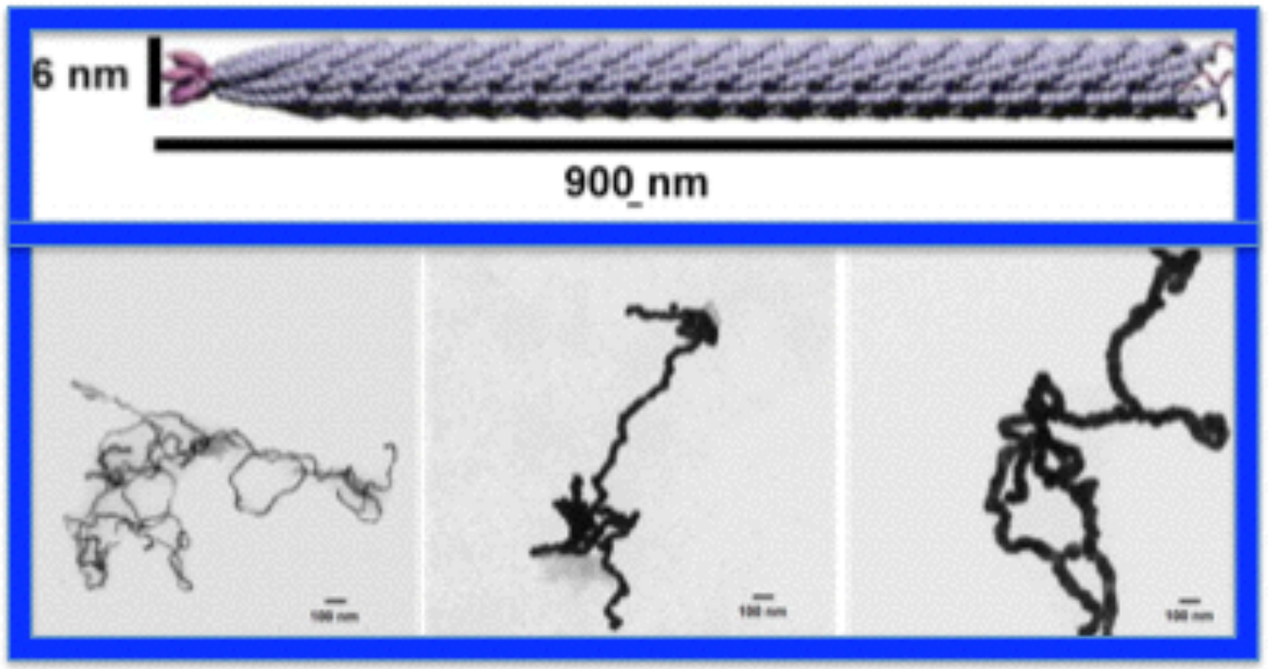
Genetic screen

Western analysis

Sequence analysis

β-gal assay

Biomaterial Engineering: Module 3



M13 nanowires
TEM image of gold nanowires from Youjin Lee

Experiments:

- Mineralize phage surface with gold or SWNT
- TEM to visualize structure
- Assemble and test solar cells

Lab Skills:

Bacteriophage M13 material production

Fabrication of bio-based devices

Parameter variation: effect of SWNT vs. gold at different ratios

Course Logistics

Lectures:

- Tues/Thurs -- 11-12pm in 16-220
- 109 Instructors + Prof. Samson—> Dr. Kuldell --> Prof. Belcher (corresponds to module)

Lab:

- Tues/Thurs -- 1-5pm in 56-322 (Noreen & Shannon)
- Wed/Fri -- 1-5pm in 56-322 (Agi)
- **There are no* make-up labs.**

Important details:

- You will work in pairs in the lab.
- Collaboration with integrity is key.

*some v. limited exceptions

Written and oral scientific communication

Module	Topic	Assignment	% of Final Grade
1	DNA Engineering	Methods section	5
		Data Summary + Abstract	15
2	System Engineering	Research article	25
		Journal club presentation	10
3	Biomaterial Engineering	Research idea presentation	20
		Mini report	5

Remaining 20% comes from daily work and participation.

Written and oral scientific communication

- Stories help us remember
  - Archimedes, Newton, Kekulé
- You discover the narrative that the data tell
- Then convince an audience of your findings
  - logical structure
  - 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)

Slide from Agi Stachowiak

Written and oral scientific communication

Written and oral scientific communication

“One may argue that in an idealized scholarly world, scientists should avoid storytelling. They should instead describe their original hypothesis, detail their experiments in the order conducted and present the data in the rawest form reasonable for interpretation. At the end they should state their conclusions.

But there are many problems with this scenario. Scientists are not automata and, in today's world, operate under substantial time pressures. Even if the scientist's colleagues in this idealized setting had the patience and time to navigate through a long, uninterpreted, purely factual exposition and to sufficiently grasp what was done and its significance, it would still be a cripplingly inefficient process. Furthermore, to borrow from the title of science historian Steven Shapin's recent book of essays, science is conducted by people “situated in time, space, culture and society, and struggling for credibility and authority.” An argument for papers written purely as a factual blow-by-blow account of experiments does not sufficiently take into account this reality.”

Written and oral scientific communication

We are not abandoning you to the unknown...

(1) WRAP instructors:

- Leslie Ann Roldan & Jessie Stickgold-Sarah
  - Lectures/discussions in class
  - Written feedback on drafts
  - Office hours by appointment
- Atissa Banuazizi
  - Lectures/discussions in class
  - One-on-one review of videotaped talk
  - Office hours by appointment

(2) BE Communications Lab:

- Writing fellows available to provide peer coaching

(3) 20.109 instructors:

- Extensive feedback on drafts -- chances to revise major report

Expectations

Some of your expectations of us

- that we will come to class and lab prepared
- that our assignments are clear and reasonable
- that we will treat every 109er with respect
- that we will give everyone equal chance at success

Some of our expectations of you

- that you will come to class and lab prepared
- that you will not interfere with each other's learning
- that you will invest the very best of yourself
- that you will offer honest and frequent feedback

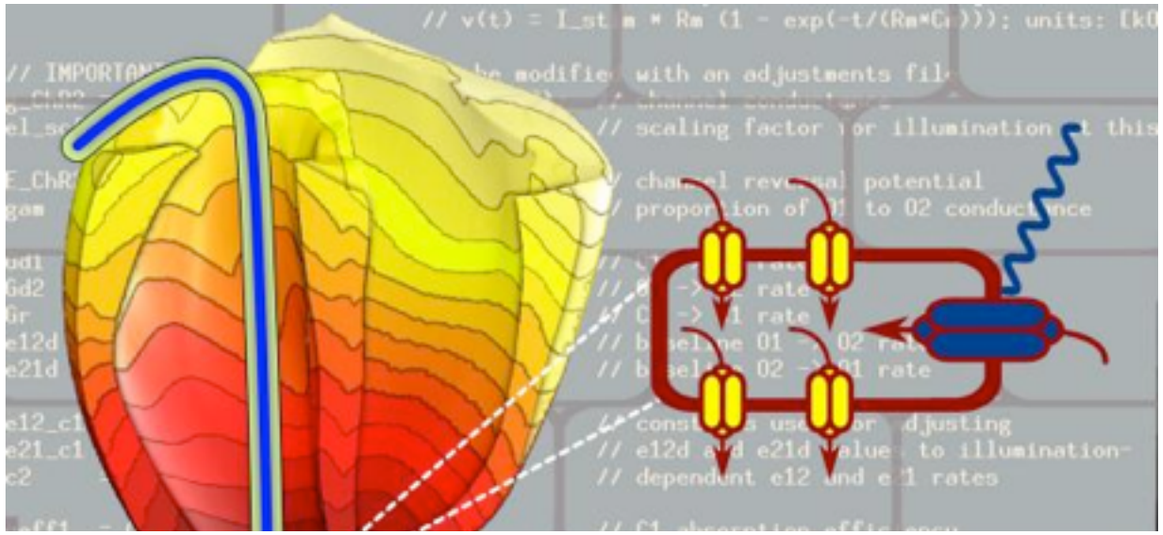
After 20.109, you will be able to:

- Organize a constructive lab notebook
- Implement lab protocols & *troubleshoot*
- Design novel experiments with appropriate controls
- Interpret qualitative data
- Analyze quantitative data
- Recognize the utility of models
- Critically examine the scientific literature
- Communicate your science through writing and oral presentation
- Work as a team and provide constructive and helpful feedback and aid to other engineers/scientists

...The future of biological engineering.

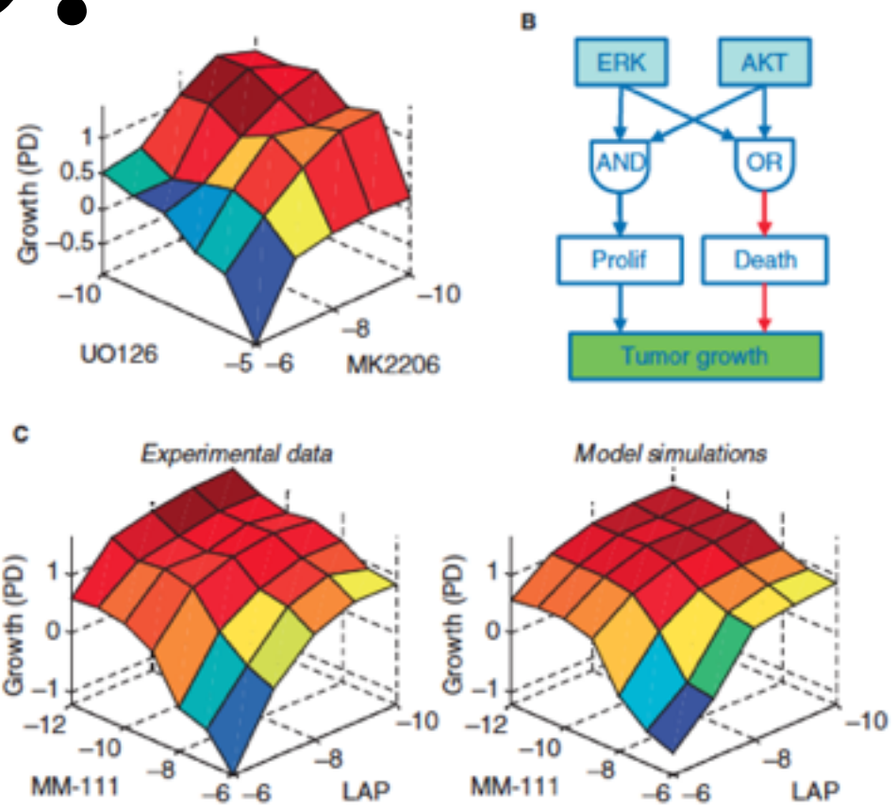
http://technology-regions.blogspot.com/2009/03/color-change-paper-tests-such-as-those.html

YOU!



Future Heart Attack Treatments Will Use Volts, to Keep Your Heart Beating

Friday, Aug. 30, 2013, at 4:44 PM (Slate.com)



Kirouac et al. *Sci Signaling*, Aug 2013