Engineering: From your mind! through your heart(?)

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Some thoughts

- You are coming up on the most exciting time of your life so far.
- "You" will actually be in a position to make decisions on your own
  - some of which will determine your future path!
- Probably, you have had discussions with your friends, and with yourself along the lines...
  - Should I try to make a lot of money?
  - Should I try to "save the world"?

Some quotes falsely attributed to Winston Churchill

- “If you are not a liberal when you are 25 you have no heart. If you are not a conservative when you are 35, you have no brain!”
- “You make a living by what you get; you make a life by what you give!”

- Heart/mind conflict:
  - How does engineering fit in?

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“Review” from yesterday

No conflict here!

Is engineering right for me?

	Study	Create
Physical world	Science	Engineering
Cultural world	Humanities	Arts

How about this?

Key Areas of CBE

- **Energy - getting useful "work" out of stored energy or natural energy fluxes**
- **Examples of energy sources?**
  - Petroleum
  - Natural gas, "shale gas" => "fracking"
  - Coal
  - Biofuels (ethanol from fermentation, biodiesel from plants)
  - Nuclear fission
  - Solar (thermal, photovoltaic)
  - Wind

90% of primary energy. Why? (Petroleum, Natural gas, Coal)

http://chemeprof.com/

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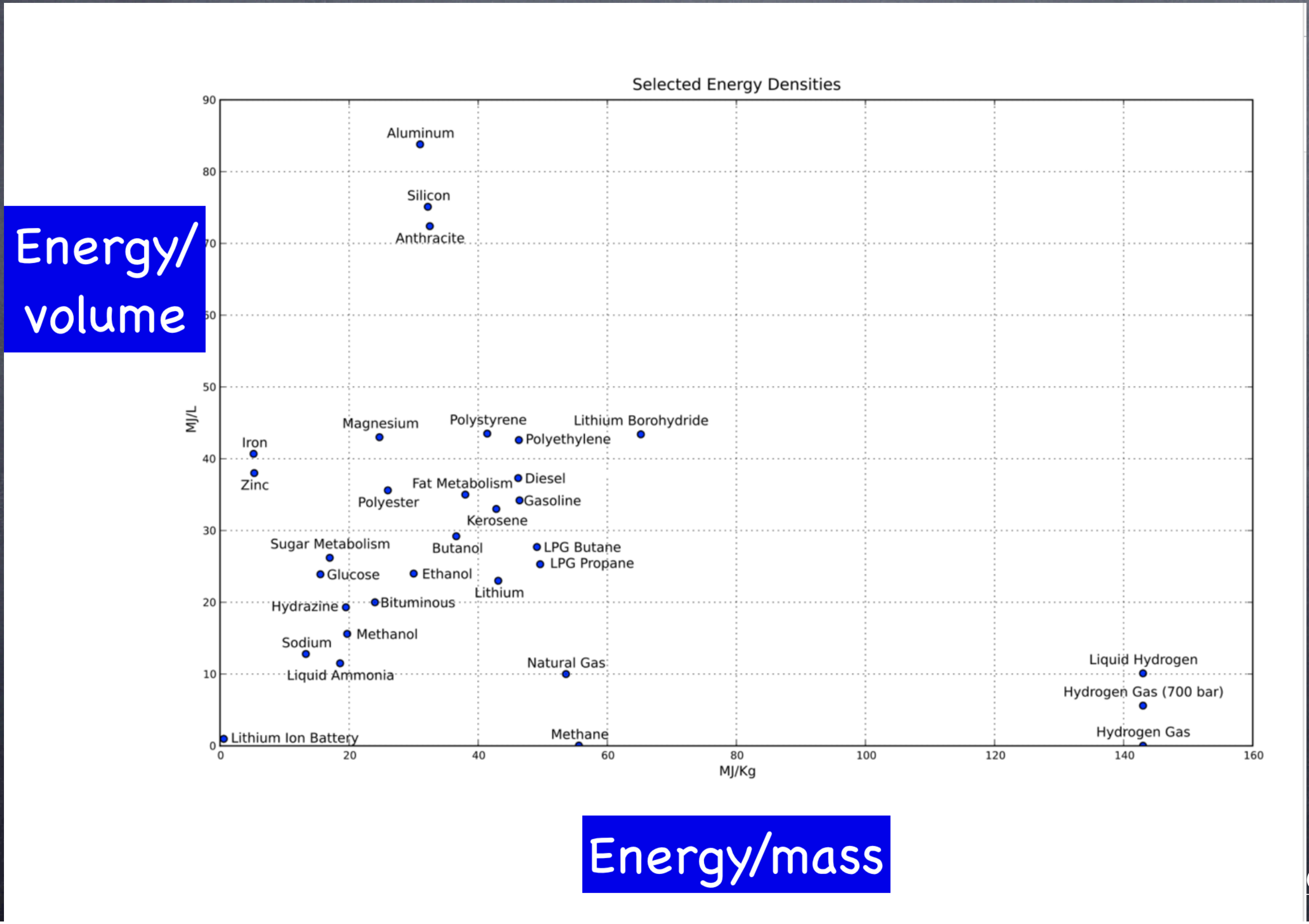
Engineering has to deal with reality!



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More review:

Filling a gas tank

- Gasoline pumped at 4 gallons / minute; what is the rate of power transfer?
- Answer: Equivalent to 8 megawatts of power!
- Engines are 20-25% efficient
- Useful energy transfer rate: 2 MW
    - Electric power of 2000 small homes!

5 MW offshore wind turbine

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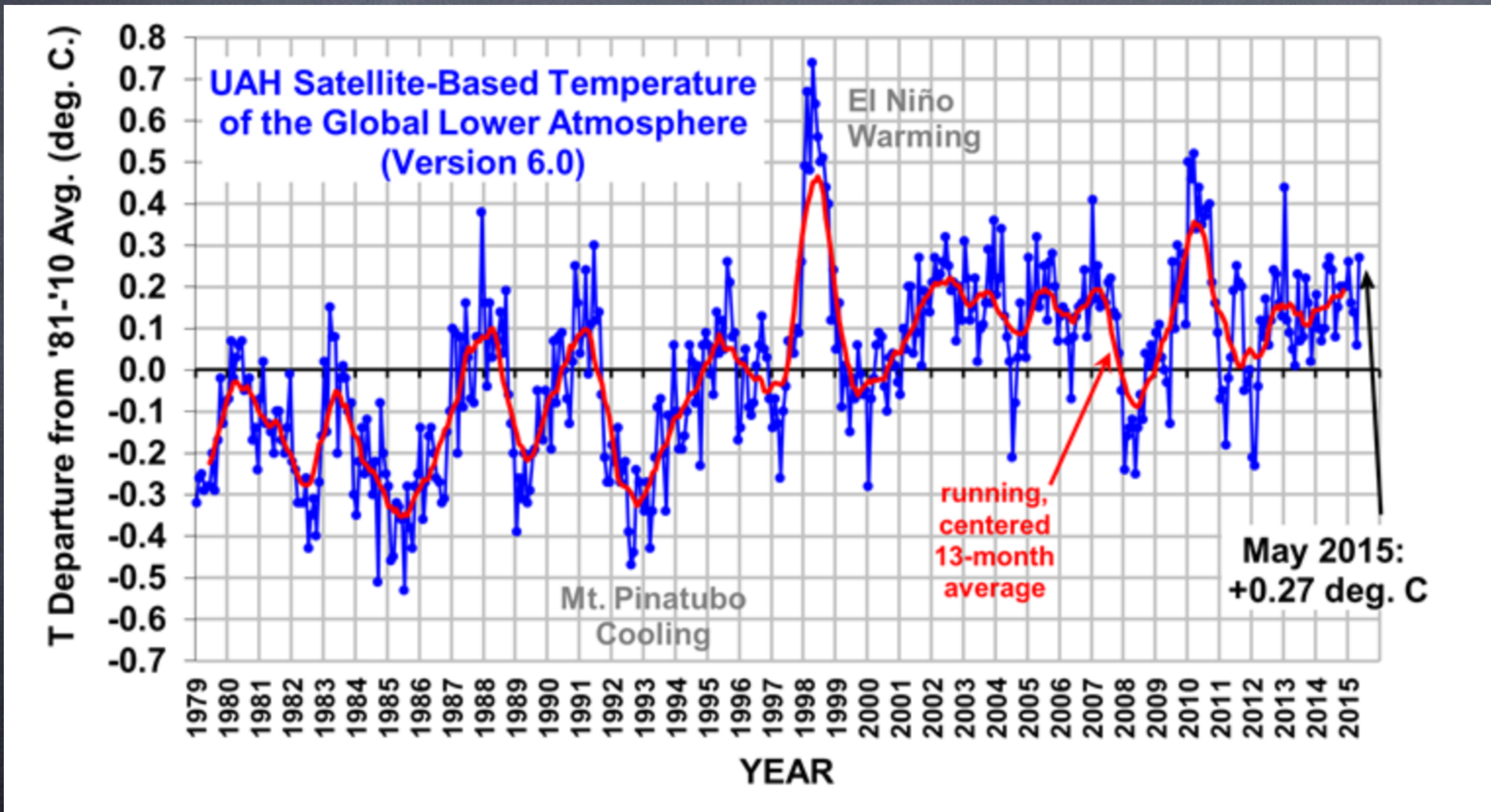
Essence of "Power density"

- On a 100 acre Site:
  - Coal to Electricity: 1000 MW
  - Solar to Electricity: 30 MW
  - Wind to Electricity: 0.4MW
  - Corn to liquid fuel: 0.1 MW
  - 10 oil wells (surface footprint): 10 GW

Don't worry, no crisis yet



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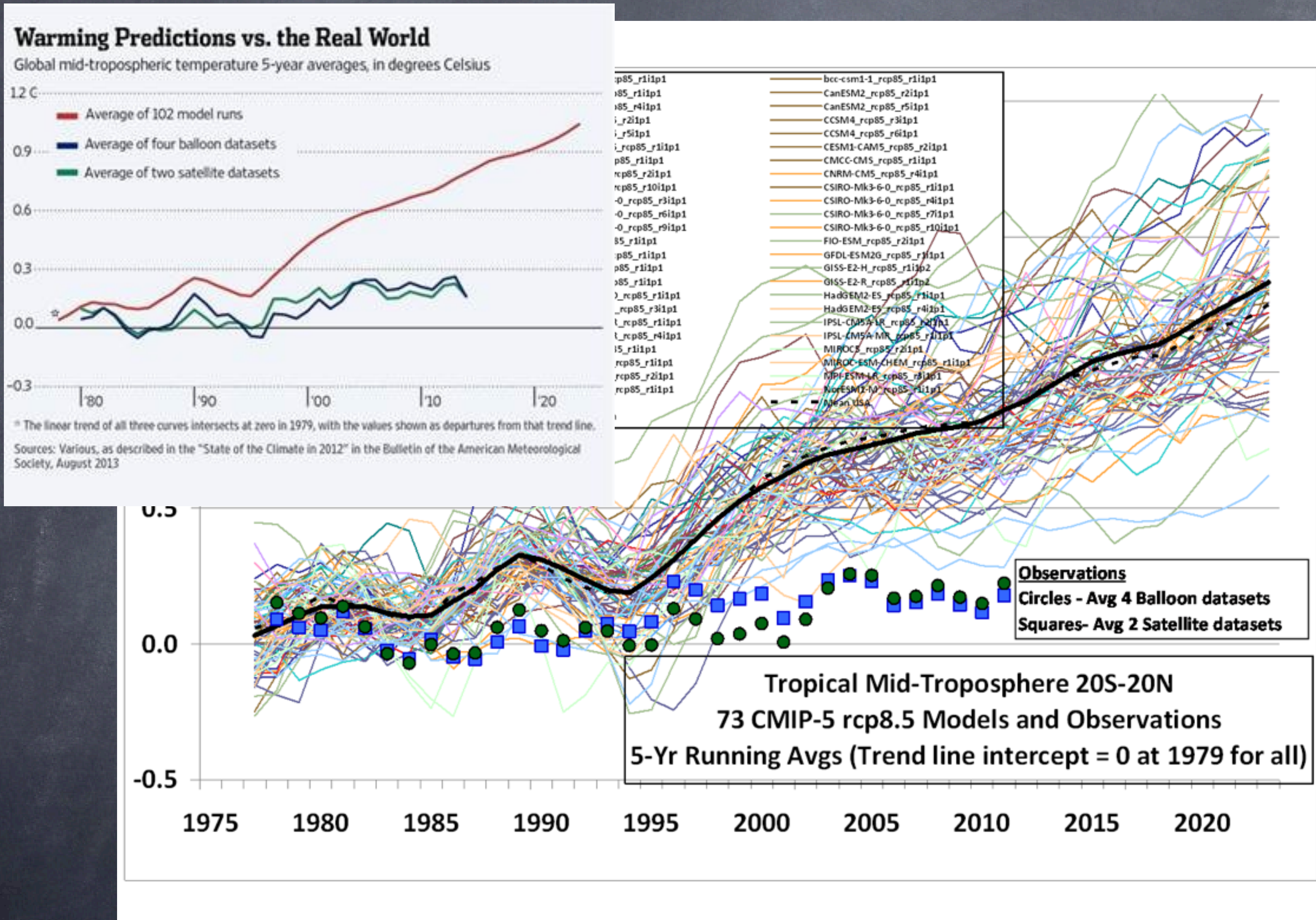
Climate models and data



From Roy Spencer's website

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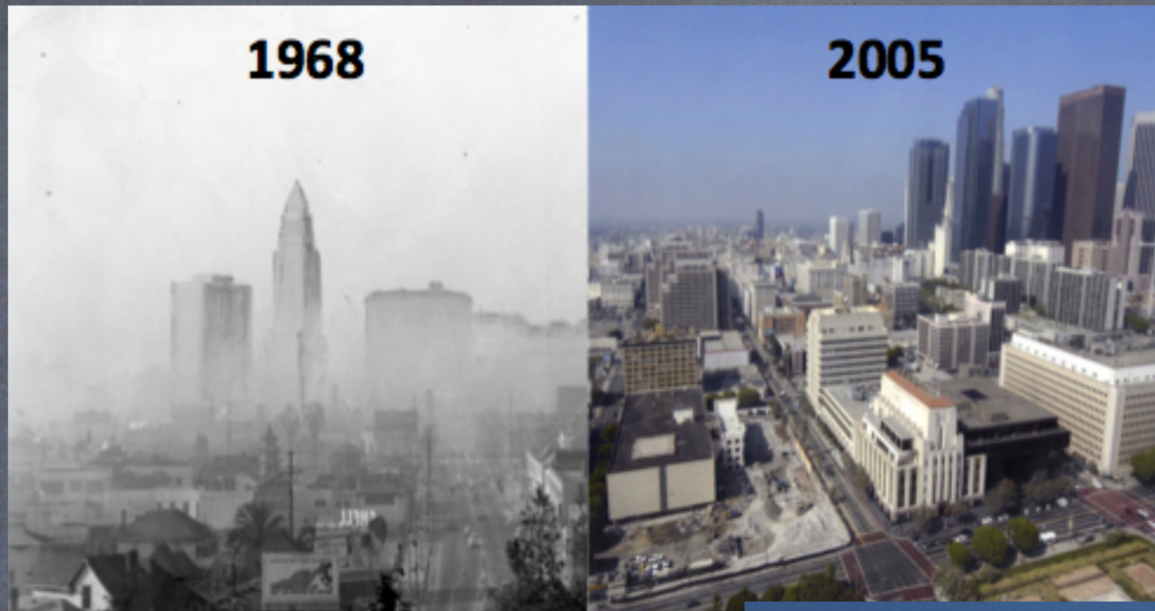
How does engineering fit?

- We have to deal with the realities of nature, but we can produce technologies that not only provide comfort and convenience but (possibly) profound good!
  - "energy" is most certainly good!
  - Within the technology world, you will have a choice how to contribute!

Success to date



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Some famous chemical engineers!

Bob Langer, MIT,
Brain cancer "patch", skin replacement, tissue engineering for heart, liver

Adam Heller, U Texas
Artificial pancreas, technology will generalize to other diseases

Mark Davis, Caltech
Totally synthetic construct for gene delivery and molecular design of catalysts

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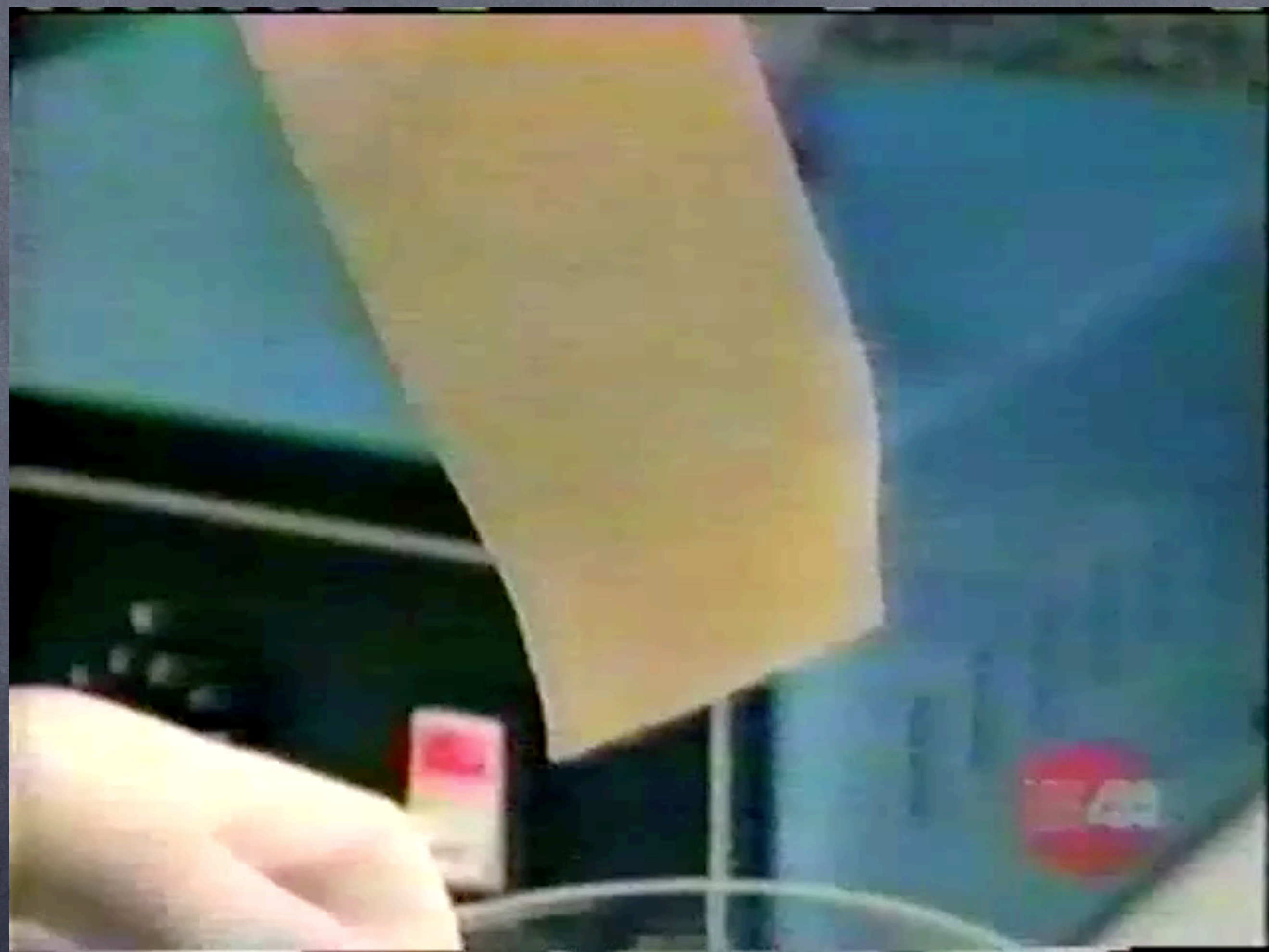
Bob Langer

- A real quote:
- "When I finished graduate school (ScD from MIT) I went to work in a hospital. There I saw many sick people and I wanted to do anything I could to help them!"

Synthesis of replacement parts for people

- Bob Langer, Chemical Enginering Professor at MIT
- Alan Alda, One of Langer's students
- Video from Scientific American Frontiers



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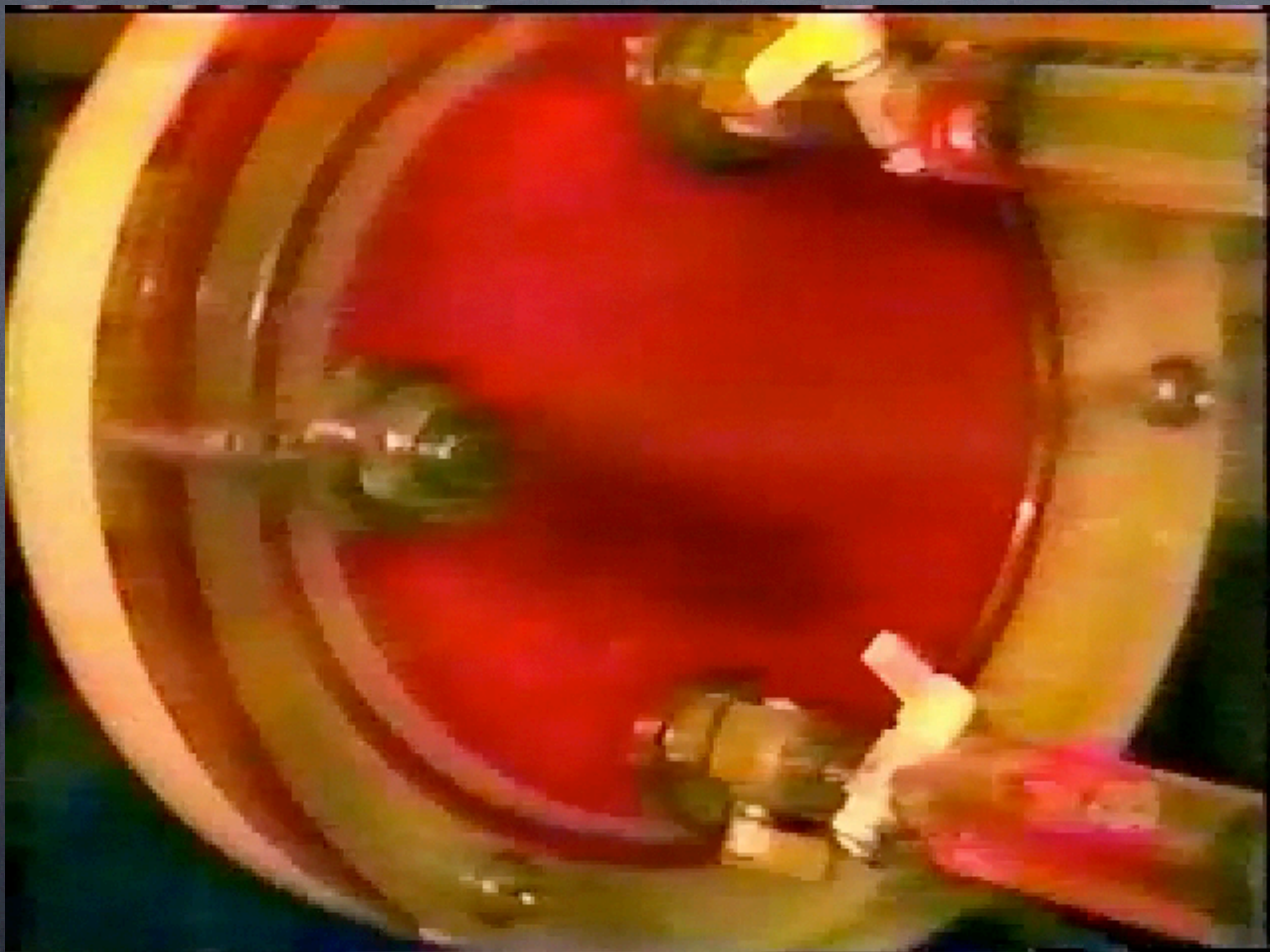
Chemical reactor for growing heart tissue



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Synthetic heart cells

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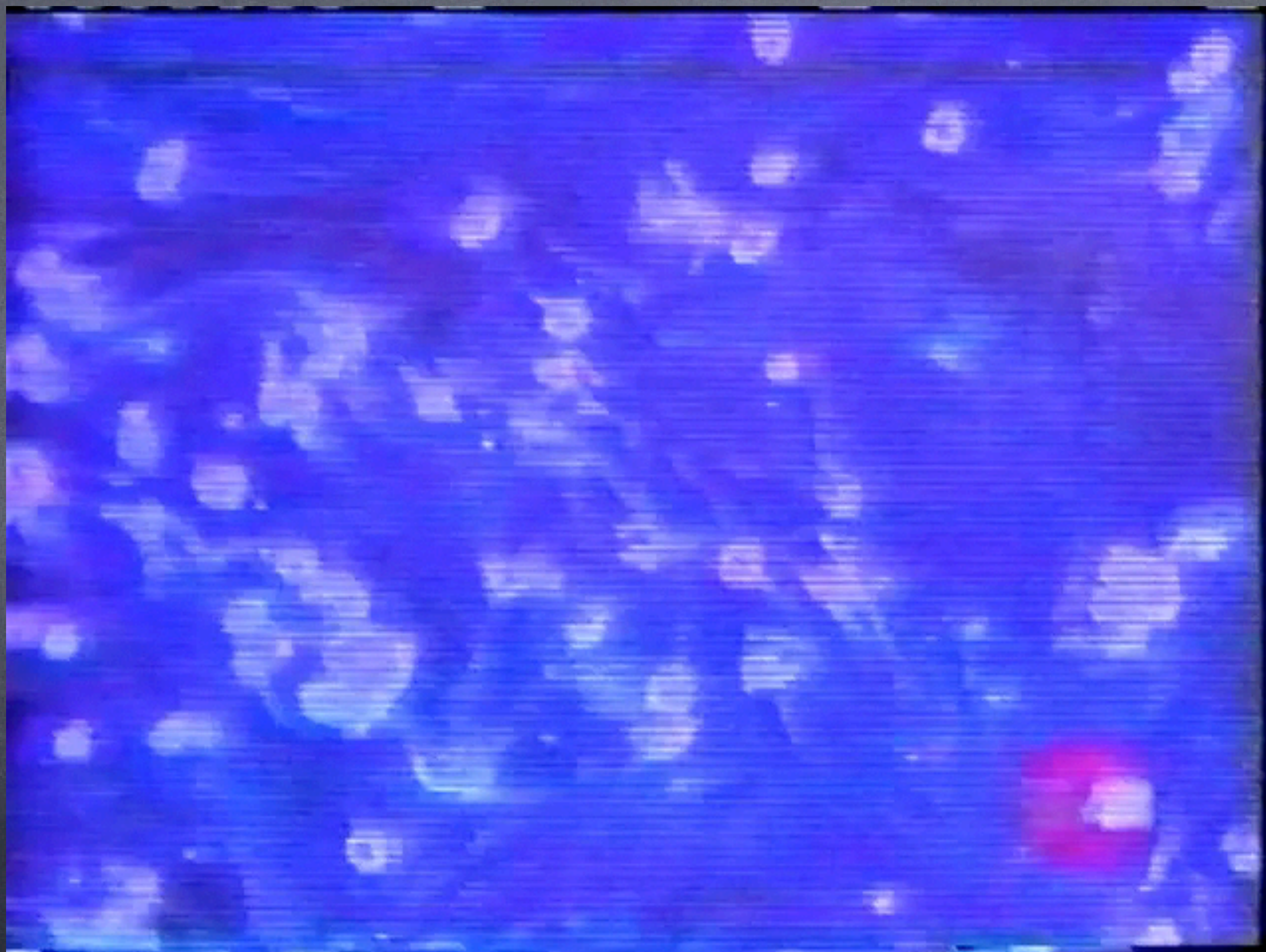
Synthetic heart cells



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“Health” engineering at Notre Dame

- http://newsinfo.nd.edu/news/31468-multifunctional-nanoparticles-promise-to-improve-blood-cancer-treatment/

Outline

- We already talked about:
  - Part of your interest here is to decide if you want to major in engineering in college and...
    - If you want to be an engineer, how do you use your mind to enrich your heart!
- Thoughts about what engineering is
  - A definition and some context
  - Use of mathematical analysis: Ultimate engineering tool
  - How engineers think
    - We practice engineering in society so we need to understand people!

Definitions of engineering

en·gi·neer [en-*juh*-**neer**] Show IPA — *Dictionary.com Unabridged*

noun

1. a person trained and skilled in the design, construction, and use of engines or machines, or in any of various branches of engineering: *a mechanical engineer; a civil engineer.*

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engineering — Use **Engineering** in a sentence — Like

en·gi·neer·ing [en-*juh*-**neer**-ing] Show IPA

noun

1. the art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants.

2. the action, work, or profession of an engineer.

3. skillful or artful contrivance; maneuvering.

Origin:
1710–20; engineer + -ing[1]

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en·gi·neer·ing

/ˌenjəˈni(ə)riNG/

noun

noun: **engineering**

the branch of science and technology concerned with the design, building, and use of engines, machines, and structures.

- the work done by, or the occupation of, an engineer.
- the action of working artfully to bring something about.
  "if not for Keegan's shrewd engineering, the election would have been lost"

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en·gi·neer

/ˌenjəˈni(ə)r/

verb

gerund or present participle: **engineering**

design and build (a machine or structure).
"the men who engineered the tunnel"

- skillfully or artfully arrange for (an event or situation) to occur.
  "she engineered another meeting with him"
  synonyms: bring about, arrange, pull off, bring off, contrive, maneuver, manipulate, negotiate, organize, orchestrate, choreograph, mount, stage, mastermind, originate, manage, stage-manage, coordinate, control, superintend, direct, conduct; More
- modify (an organism) by manipulating its genetic material.
  "genetically engineered plants"

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en·gi·neer·ing *noun* \-ˈnir-iŋ\

: the work of designing and creating large structures (such as roads and bridges) or new products or systems by using scientific methods

: the control or direction of something (such as behavior)

Full Definition of ENGINEERING — Cite! g+1 Like

1 : the activities or function of an engineer

2 a : the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people

b : the design and manufacture of complex products <software *engineering*>

3 : calculated manipulation or direction (as of behavior) <social *engineering*> — compare GENETIC ENGINEERING

See engineering defined for English-language learners »

See engineering defined for kids »

What do engineers do?

- Or, you may have heard it stated that "engineers solve problems..."
- What engineers really do is:
- *Engineers understand how to use techniques of engineering analysis to design (i. e., synthesize) substances, devices and processes even though they have an imperfect understanding of important physical, chemical or biological issues. Furthermore engineers operate under constraints caused by a need to produce a product or service that is timely, competitive, reliable, and consistent with the philosophy and within the financial means of their company.*
- *We need to use all that we know to produce the best answer to a problem!!*

Underlined words

- 1. Engineering analysis

- Engineers use "mathematical models" to describe reality in sufficient detail to produce quantitative results.

- (It is not engineering until we produce some numbers!!)

Underlined words

- 2. Imperfect understanding

- Most significant engineering problems cannot be analyzed and solved exactly.

-

- Thus we need our models or our understanding of phenomena gained by experiment to capture the important features and (usually) ignore a lot of unessential detail.

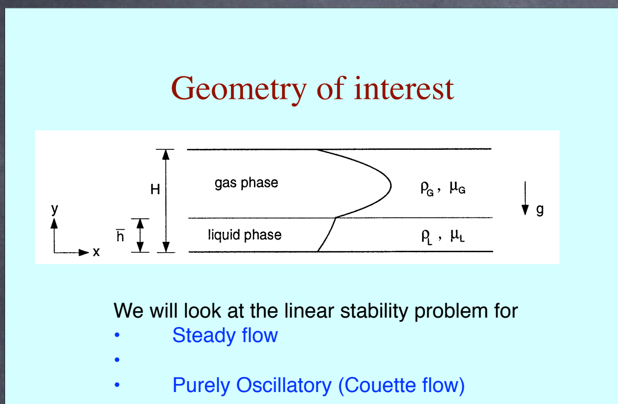
Curveball vs. knuckle ball

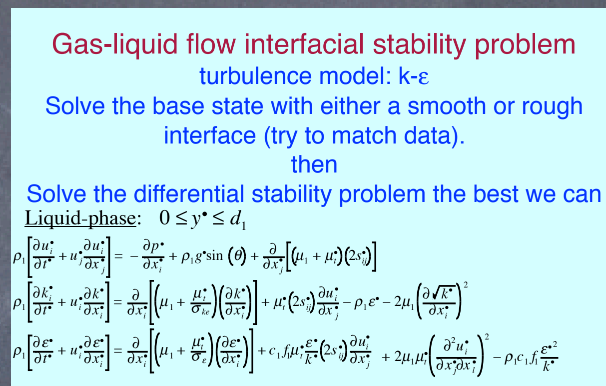
- We tried to make the argument that the imperfectness of a baseball is important to the pitching of a knuckleball, which does not spin and not important in the pitching of a curveball which spins fast. The same effect can either be important or incidental. This is because important issues always as ratios between competing effects. Engineers need to make the decision about what is important!!

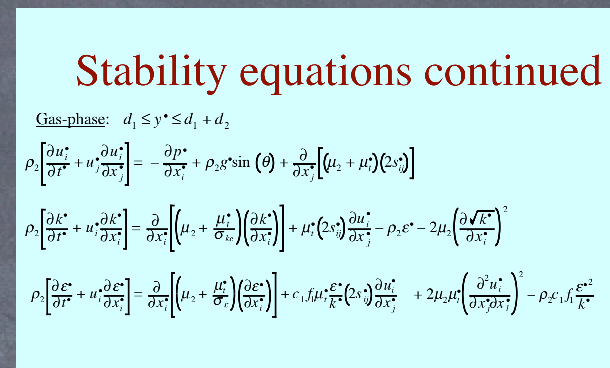
Mathematical Analysis

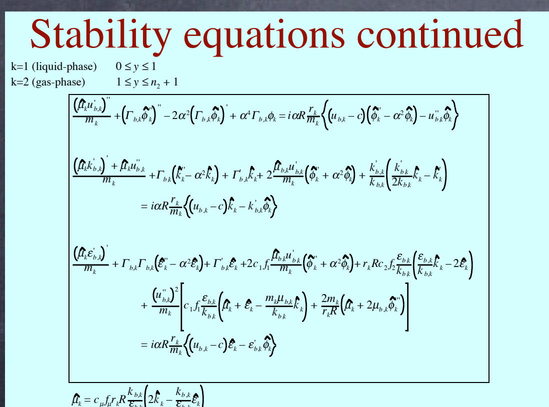
- We would like to know how a device, process or system behaves "before" we build it
  - The only way that this is possible is with accurate mathematical "models" (collections of mathematical equations, that could be based on physical laws or verified observations that represent **reality** sufficiently well)

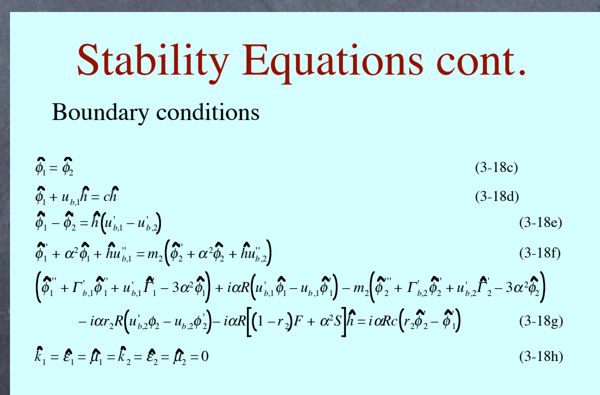
Mathematical modeling can be complex

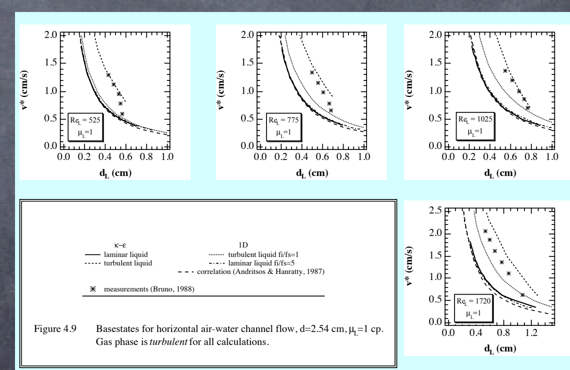










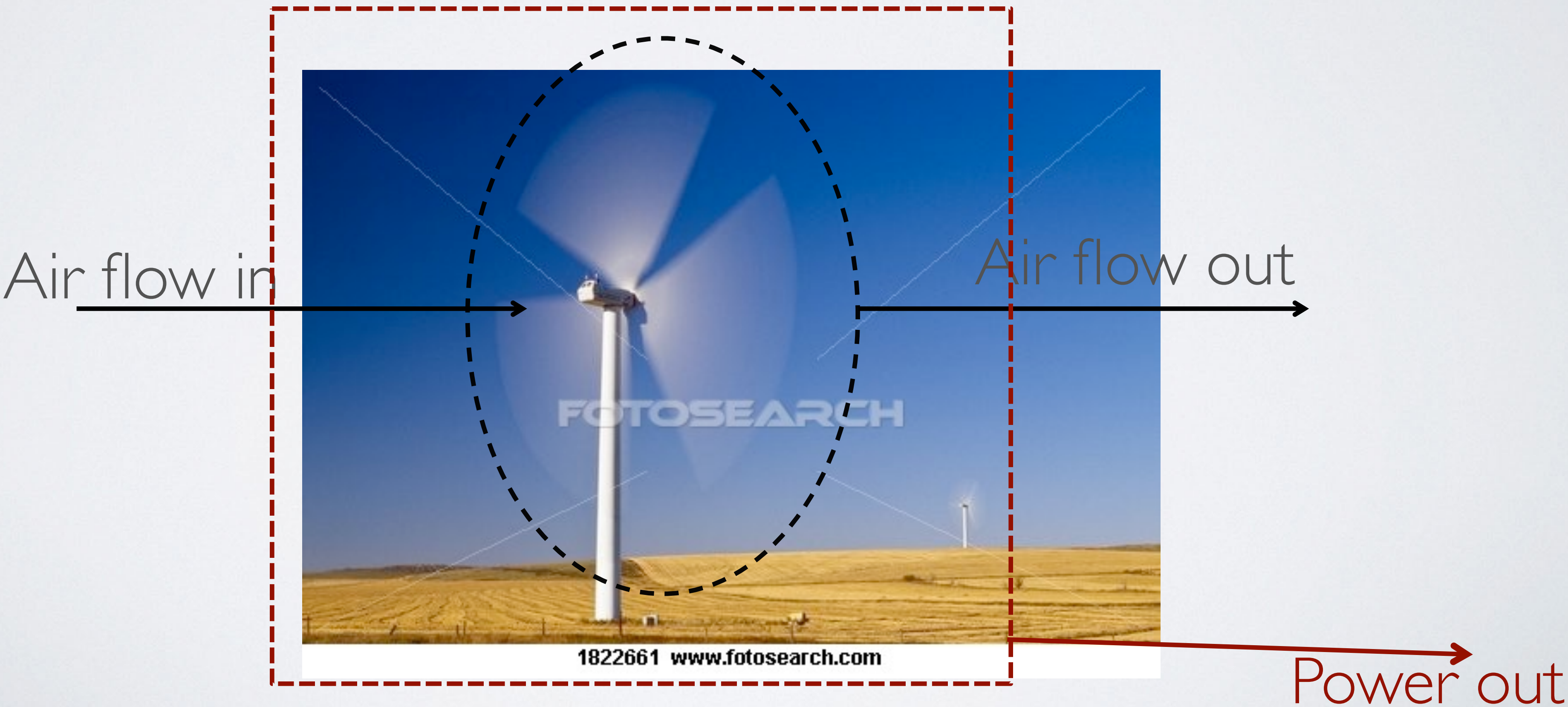


Mathematical analysis

- Could be pretty simple:
- What if we read the Wall Street Journal
  - Wind power
  - http://online.wsj.com/article/SB10001424127887324310104578507242336481504.html?KEYWORDS=wind+energy

POWER AND WIND SPEED?

- How does the power generated by the windmill change with wind speed?
  - How is power being generated?
    - Wind flows through area swept by blades
    - Windmill converts this kinetic energy to electric power



POWER AND WIND SPEED?

- How does the power generated by the windmill change with wind speed?
  - Let's see if we can figure this out based on dimensional reasoning
    - Power is work/time which is force * distance/time which is mass* acceleration *distance/time
    - Thus we could write

$$power = m\ l / t^2 l / t = \frac{ml^2}{t^3}$$

    - What variables could be used?

EQUATION FOR POWER FROM WIND

- Windspeed, blade diameter, air density
  - v [=] l/t
  - d, r [=] l
  - Density of air ρ [=] m/l^3
  - Arrange these variables to get dimensions of power:

$$power \sim \rho v^3 d^2 [=] \frac{ml^2}{t^3}$$

  - If the wind speed doubles, the power increases by a factor of 8!

Why does an egg-roll stay so hot?

- Good insulation, outside sealed, no cooling from water evaporation

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What do CBE graduates do?

- Examples of career paths of Notre Dame CBE grads

Tom Degnan ‘73

- Manager, Breakthrough Technology ExxonMobil
- Joined ND Faculty this year!
- MBA, University of Minnesota, 1979
- PhD University of Delaware, 1976
- Awarded “Hero of Chemistry” prize, American Chemical Society
- Member, National Academy of Engineering

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Shawn O'Grady, '86

- VP Consumer Food Sales, General Mills
- Air Products (2 years)
- Harvard MBA (1990)
- Manages ~ 250 people in division with $2 billion in revenue

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Melanie Sanchez-Jones '89

- Manager, Global Employee Benefits, Air Products and Chemicals
- 18 years at APCI: product manager, university relations, new product commercialization, product marketing
- MBA, Lehigh (1998)
- Currently in Shanghai

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Brian Fitzpatrick '97

- Professor of Law, Vanderbilt University
  - Harvard Law (#1 in class)
  - Clerk for Supreme Court Justice Anthony Scalia
  - Formerly worked for a private firm in D.C.
  - Special Counsel for Supreme Court nominations for a US senator

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Jennifer Ehren '99

- Scientist at Salk Institute working on therapeutics for Alzheimer's disease and diabetes
- ND valedictorian
- Two years in ACE program, then two years are Merck
- PhD Stanford Chemical Engineering

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Pamela Jefson '06

- ND crew team
- Global Operations Leadership Development (GOLD) program, Johnson & Johnson
  - Manufacturing engineering (Ortho Clinical Diagnostics, Rochester, NY)
  - Quality engineer, Ethicon Endo-Surgery (Juarez, Mexico)
  - Source buyer (J&J headquarters, New York)
  - Manager, Ethicon Endo-Surgery (Cincinnati)

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Chris Hensler '13

- Rotational Engineering program, Lummus Technology, Houston, TX
    - First assignment: Randall Gas business
- CBE graduation speaker; active in Tau Beta Pi, AIChE, Joint Engineering Council…
- Process Engineering Intern, Carnegie Strategic Design Engineers, LLC (Pittsburgh)
- Study Abroad, Universidad Politecnica da Valencia, Spain

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Rise of oxygen (why we breath air!)

Two classes of reactions that use glucose

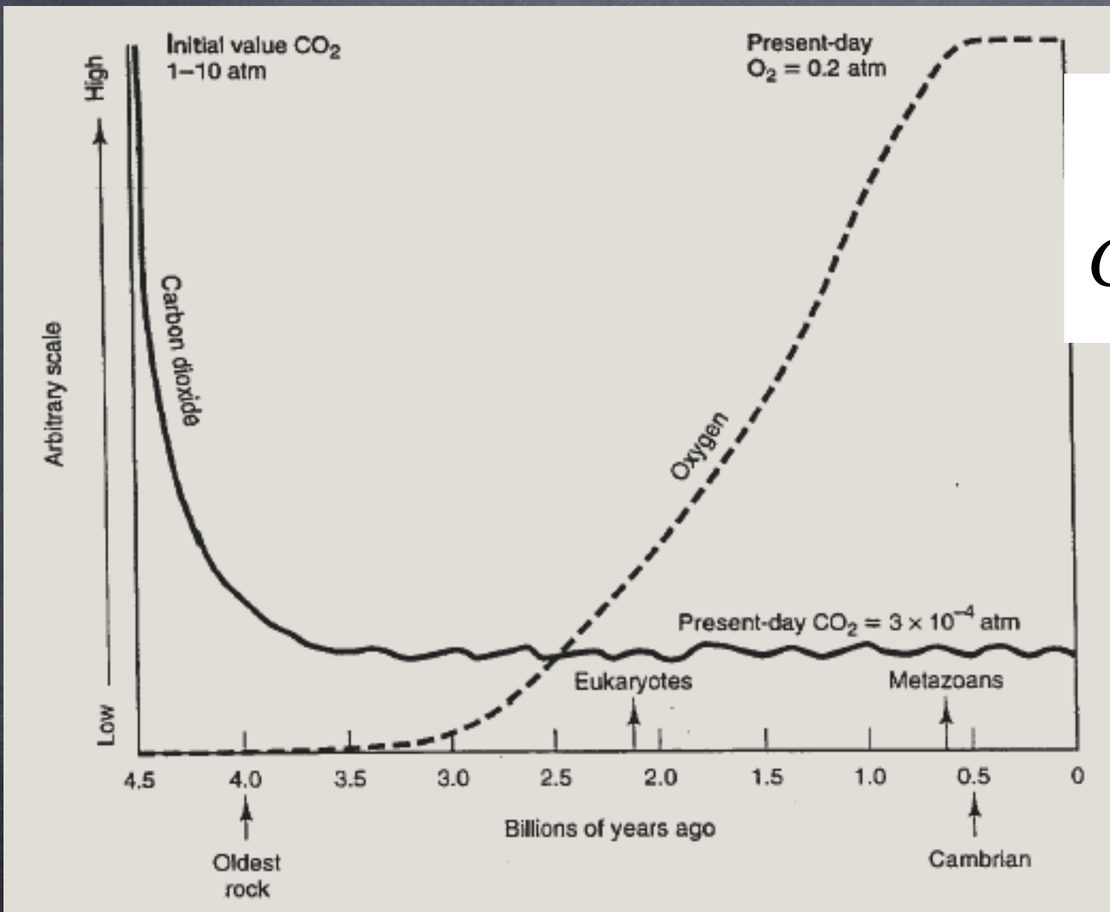

FIGURE 3–10 The history of oxygen and carbon dioxide in the atmosphere during Earth history.

$$C_6H_{12}O_6 \longrightarrow 3CO_2 + 3CH_4$$

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

Aerobic digestion is 17 times more energetic than anaerobic digestion

All of this oxygen comes from various kinds of plant growth

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Recap

- Engineers use understanding of the situation and mathematical analysis to get quantitative answers that tell how to design and build all of the technologies of the world!
- It is within your choice to find a role that provides the personal fulfillment you desire!