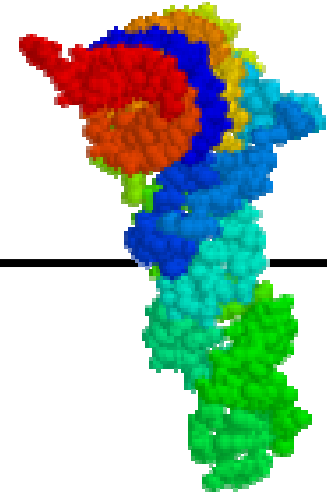


# Genomics, Computing, Economics & Society



10 AM Tue 20-Sep 2005

[MIT-OCW Health Sciences & Technology 508/510](#)

[Harvard Biophysics 101](#)

Economics, Public Policy, Business, Health Policy

# Genomics, Computing, Economics & Society Course plan

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reasons.

Each student will participate in a class-wide project to provide decision-making tools for global/local technology development and deployment. Each will have a web page or wiki describing and updating their part of project going by the second class.

Grades will be based on

25% participation(round robin), 25% personal wiki page (weekly)  
25% contribution to group project/ article, 25% peer evaluations

No prerequisites. It is assumed that each of you brings some expertise to be integrated with the goals and talents of other team members. Each student should make this clear at the start of the project and update it as the course proceeds.

# Genomics, Computing, Economics & Society Course plan

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reasons.

This course will focus on understanding aspects of modern technology displaying exponential growth curves and the impact on global quality of life through a weekly updated class project integrating knowledge and providing practical tools for political and business decision-making concerning new aspects of bioengineering, personalized medicine, genetically modified organisms, and stem cells. Interplays of economic, ethical, ecological, and biophysical modeling will be explored through multi-disciplinary teams of students, and individual brief reports.

Specific (standard) skills to be developed: statistics, modeling, datamining, systems biology, technology development.

# **101: '99-'03 Simple to Complex**

## **'05 Complex to Simple**

**'03 5 problem sets & project**

**'05 Project starts on day 1**

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**'03 one 2 hr ppt lecture + 1.5 hr section per week**

**'05 two 1.5 hr discussion (may include 30' ppt)**

**'03 Project teams or 1 or two students**

**'05 Project team of all students & TFs**

**'03 Choice of two campuses & streaming video**

**'05 Less choice**

**'03 Tools: Perl & Mathematica**

**'05 Wiki (& anything else)**

# Previous class projects

**André Catic**, Cal Collins, George Church, Hidde Ploegh, HL (2004) Preferred in vivo ubiquitination sites. *Bioinformatics* 20: 3302-7.

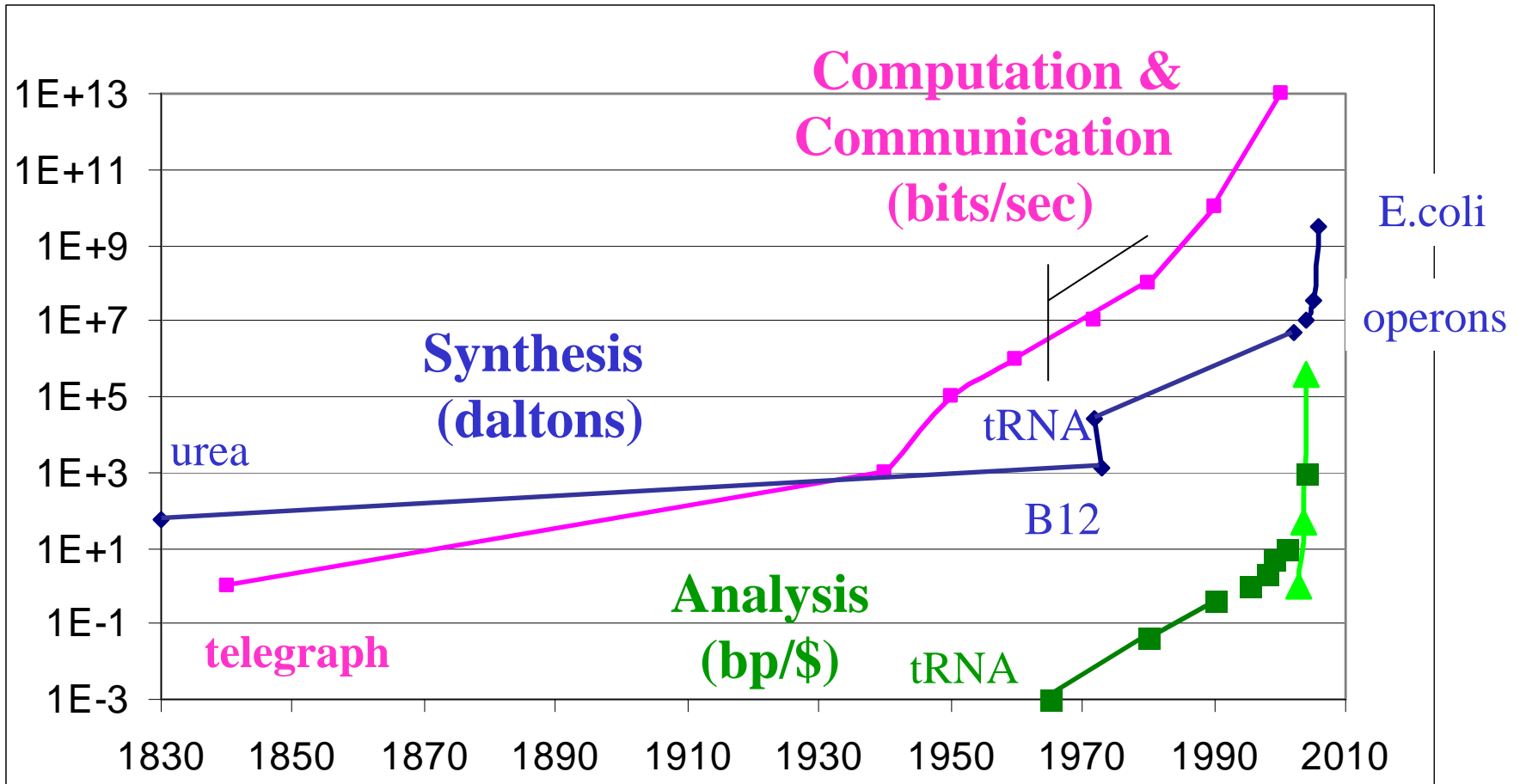
**Andrew Tolonen**, **Dinu Albeanu**, **Julia Corbett**, **Heather Handley**, **Charlotte Henson & Pratap Malik** (2002) Optimized in situ construction of oligomers on an array surface. *Nucleic Acids Research*, 30: e107

**Hui Ge**, George Church, Marc Vidal (2001) Correlation between transcriptome and interactome data obtained from *S. cerevisiae*. *Nature Genetics*, 29:482-6.

John Aach, Martha Bulyk, George Church, **Jason Comander**, **Adnan Derti**, **Jay Shendure** (2001)  
Computational comparison of two draft sequences of the human genome. *Nature* 409, 856-859.

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reasons.

# 3 Exponential technologies (synergistic)



Shendure J, Mitra R, Varma C, Church GM, 2004 Nature Reviews of Genetics.  
Carlson 2003 ; Kurzweil 2002; Moore 1965

# **101: '99-'03 Simple to Complex**

## **'05 Complex to Simple**

**Common ground for conservative, liberal, religious & atheist?**

- **What is life? Should we construct from scratch?**
- **Did life evolve using intelligent design?**
- **When does human life begin?**
- **Stem cells & therapeutic cloning?**

**Can we compare Apples & oranges?**

- **Should we buy iron-lungs or polio-vaccine research?**
- **Do we invest in anti-terrorism or anti-malaria?**

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# Hot buttons

Evolution

Stem Cells

Life extension

Eugenics, race

Privacy

Security, Terrorism

Genetically modified organisms - GMOs

Intelligent machines

Replicating machines

Withholding experimental drugs (e.g. HIV & Cancer)

Gender

Do no harm, abortion

Substance abuse

Vioxx

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# Initial Reading

- **Limits to Growth, The 30-Year Update by Donella H. Meadows, Jorgen Randers & Dennis L. Meadows 2004**
- **Freakonomics by Levitt & Dubner 2005**
- **As the Future Catches You by Juan Enriquez 2000**
- **Genetic Programming IV: Routine Human-Competitive Machine Intelligence by John R. Koza et al. 2003**
- **Consilience by E.O. Wilson 1998**
- **Redesigning Humans by Gregory Stock 2002**
- **Scientific Conquest of Death 2004**
- **Collapse by Jared Diamond 2005**
- **The Tipping Point by Malcolm Gladwell 2000**
- **The Wisdom of Crowds by James Surowiecki 2004**
- **The Climate Of Man by Elizabeth Kolbert 2005**
- **[Widescale Biodiesel Production from Algae](#) by Michael Briggs,**
- **Synthetic Life by WW Gibbs 2004**
- **[Personalized medicine](#) by Francis S. Collins 2005**

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reasons.

# It seemed like a good idea at the time.

Crops  
River life  
Grain trade  
Livestock  
Hygeine  
Insecticides  
Fertilizer  
Nuclear Power  
Tankers  
Pets

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Malaria  
Cholera  
Yersinia  
Flu & HIV  
Polio  
Silent Spring  
Anoxic fish  
TMI, Chernobyl  
Mussels & sea snakes  
Australian herbicide

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# Human subject experimentation (not a test) 5 seconds each

1. Write your name, email, school & year.
2. Estimate  $8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$
3. From a group "of 70 engineers and 30 lawyers: Dick is a 30 year old man. He is married with no children. A man of high motivation, he promises to be quite successful in his field. He is well liked by his colleagues." What is the probability that Dick is an engineer?
4. Write down a string of 10 random H & T characters.
5. From 10 people, how many different committees of 2 members?  
and of 8 members?
6. One individual has drawn 4 red balls and 1 white. Another 12 red and 8 white. What odds should each individual give that the source is  $2/3$  red (rather than  $2/3$  white)?
7. Estimate  $1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$

# Economics Nobel 2002

"Economics has been regarded as a non-experimental science, where researchers – as in astronomy or meteorology – have had to rely exclusively on field data, .. however, these views have undergone a transformation. Controlled laboratory experiments have emerged as a vital component .. & have shown that basic postulates in economic theory should be modified. .. cognitive psychologists who have studied human judgment and decision-making, and experimental economists who have tested economic models in the laboratory. .. **Daniel Kahneman and Vernon Smith.**"

(see also: Judgement under Uncertainty 1974 Science 185:1124)

Cognitive bias .. includes "very basic statistical and memory errors that are common to all human beings and drastically skew the reliability of anecdotal and legal evidence & significantly affect the scientific method."

# High-level decisions

Leon Kass, chairs the US President's Council on Bioethics, opposed IVF '78 & stem cell research '05 via 'the wisdom of repugnance'

<http://groups.msn.com/DebateCriticalThinkingandPhilosophy/killingimmortality.msnw>

[http://www.orionsarm.com/books/Wisdom\\_of\\_Repugnance.html](http://www.orionsarm.com/books/Wisdom_of_Repugnance.html)

<http://www.seti.org/site/apps/nl/content2.asp?c=ktJ2J9MMIsE&b=194993&ct=1324903>

## **The Wisdom of Crowds by James Surowiecki 2004**

Interracial-marriage:

Perez v. Sharp, CA 1948,

Loving v. Virginia,

U.S. Supreme Court 1967

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reasons.

# Economics & Global Ecology

"much of the current enthusiasm for market based regulation stems from the results of a pilot program launched in th US in 1990. Congress amended the clean air act that year to set up a market for the permits that power plants must have to release SO<sub>2</sub>.. Supply & demand.. Market overseers need the power, analogous to the Federal Reserve's.." --W Gibbs, Sci Am 2005

Quantifying the "unquantifiable"  
Interconversions in modeling

# Vaccines for the 21st Century

<http://books.nap.edu/html/vacc21/>

Level I Most favorable: saves money & Quality-Adjusted Life Years(QALY)

Level II < \$10,000 < Level III < \$100K per QALY saved < Level IV

Level I candidate vaccines:

- Viral: CMV vaccine for 12 year olds, Flu vaccine for 20% of the US per year.
- Therapeutic vaccines: IDDM diabetes, MS, Rheumatoid arthritis
- Bacterial: Streptococcus B & pneumoniae vaccine for infants & 65 year olds.
- [HIV vaccines prominent already within NIH.]

“A **quantitative model** that could be used by decision makers to prioritize the development of vaccines against a number of disparate diseases” 1985 & 1999.

# Biomedical Priorities

"The complete conquest of cancer or heart disease would each lead to an increase of a mere 3% in mean life span in humans, i.e. about a tenth of what can be accomplished, today, in laboratory animals of delayed aging. " -- Miller, R.A. (2005) J.Am. Geriatrics Soc. 53:S284.



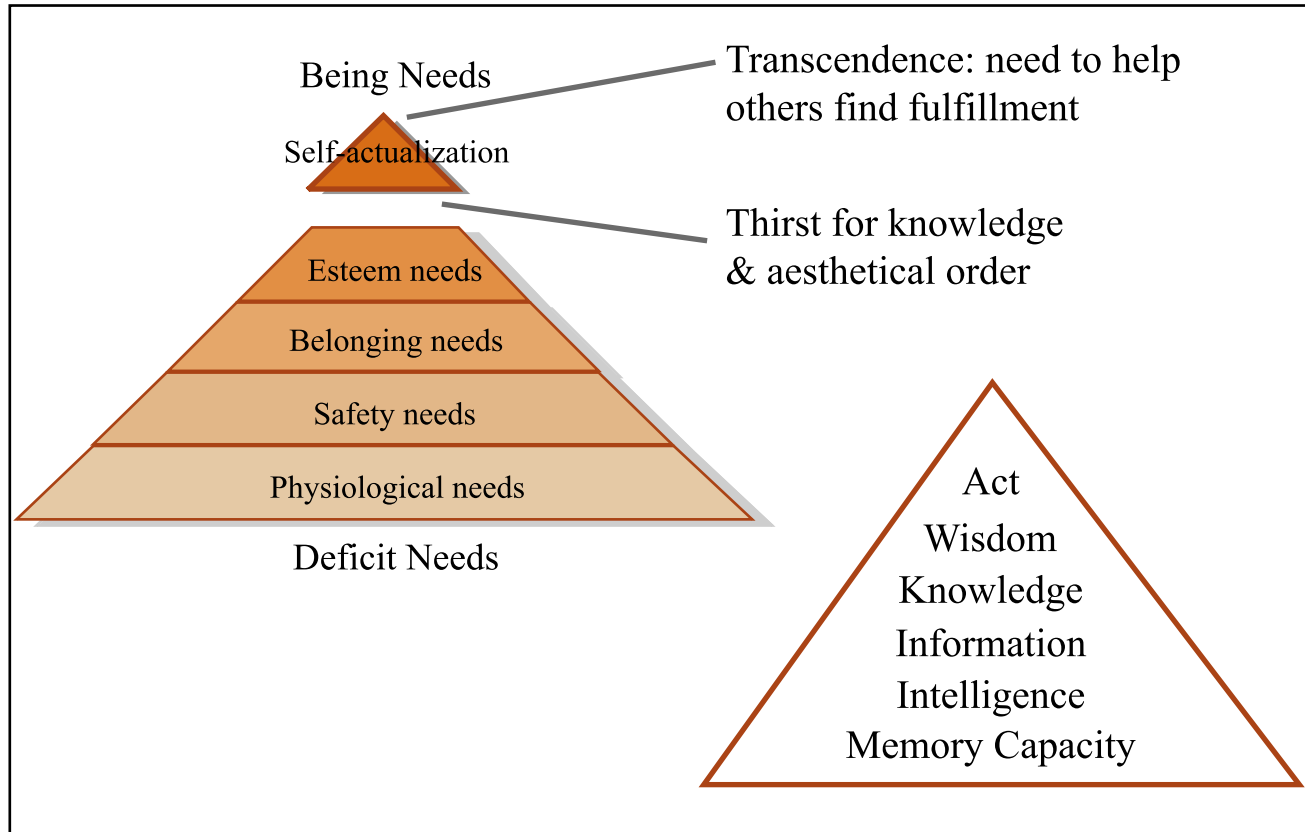
# **CAUSES OF DEATH - USA - 1999 (Thousands)**

- 1. 725 Heart Disease**
  - 2. 549 Malignant Neoplasms**
  - 3. 167 Cerebrovascular Diseases**
  - 4. 124 Chronic Pulmonary Disease**
  - 5. 98 Accidents**
  - 6. 68 Diabetes Mellitus**
  - 7. 64 Influenza & Pneumonia**
  - 8. 45 Alzheimer's Disease**
  - 9. 36 Nephritis, Nephrosis**
  - 10. 31 Septicemia**
  - 11. 29 Self-inflicted Injuries**
  - 12. 26 Liver Cirrhosis**
  - 13. 17 Primary Hypertension (Renal)**
  - 14. 17 Homicide**
  - 15. 16 Aortic Aneurysm**
  - 16. 379 All Other Causes\***
- 2,391 Total**

# CAUSES OF DEATH - WORLDWIDE - 1990 (millions)

1. **6.3 Ischemic Heart Disease**
2. **4.4 Strokes**
3. **4.3 Lower respiratory tract Infections**
4. **2.9 Diarrheal Disease**
5. **2.4 Perinatal Disorders**
6. **2.2 Chronic Pulmonary Disease**
7. **2.0 Tuberculosis (Non-AIDS)**
8. **1.1 Measles**
9. **0.99 Traffic Accidents**
10. **0.95 Lung Cancers**
11. **0.86 Malaria**
12. **0.79 Self-inflicted Injuries**
13. **0.78 Liver Cirrhosis**
14. **0.75 Stomach Cancer**
15. **0.59 Birth Defects (Rubella & CMV)**
16. **0.57 Diabetes Mellitus**
17. **0.56 Violence (Non-war)**
18. **0.54 Tetanus**
19. **0.54 Nephritis**
20. **0.50 Drowning**
21. **0.50 War**
22. **0.50 Liver Cancer (Hepatitis B Virus)**
30. **0.31 AIDS HIV-1**
- 50.40 Total Deaths**

# The Maslow pyramid, 1943



Figures by MIT OCW.

# Depolarization

## How do we make decisions? How do we bridge?

Not "right vs wrong", nor "moral relativistic flip-flopping"

- What is the maximum discrepancies between societal benefit vs actual strategies? And how do we find them convincingly?
- What are the reasons for such? Do "special interests" represent lags in the knowledgebase of the decision makers.
- To what extent and by what means do we avoid oscillation?

# Framework draft outline

Working title: **Prove, Predict, prioritize, practice**  
**Breaking barriers & building bridges**

**Prove, predict:** Connect problems, technologies, modeling options

**Example:** Evolution - replicating &/or intelligent machines  
stem cells, abortion

**Model:** Quantitatively define life.

**Prioritize, practice:** Metabolic networks

**Example:** Carbon & Energy

**Model:** Multilevel from molecular to global.

**Prioritize:** Privacy vs openness

**Example:** Personal genomics

**Model:** Evolutionary conservation, etc.

# Framework Draft continued

**Prioritize, practice:** Synthetic Biology & chemistry

**Examples:** biosecurity, bioterrorism

Genetically modified organisms - GMOs

Withholding experimental drugs (e.g. HIV & Cancer)

Substance abuse, Vioxx

**Models:** Risk & benefit, systems models.