Genomics, Computing, Economics & Society
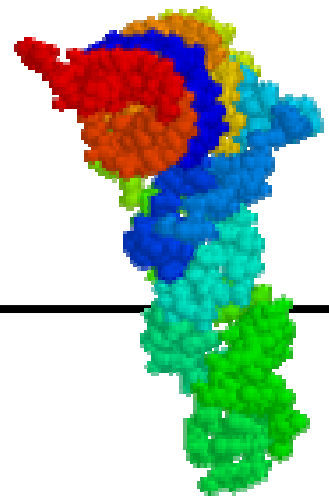
10 AM Tue 4-Oct 2005

MIT-OCW Health Sciences & Technology 508/510

Harvard Biophysics 101

Economics, Public Policy, Business, Health Policy

Class outline

(1) **Topic priorities for homework since last class**

(2) Quantitative exercise: **bits**

(3) Project level presentation & discussion
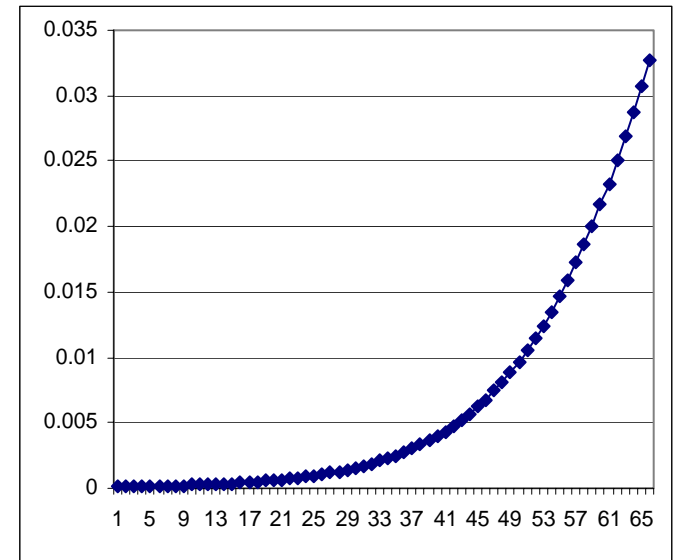
(4) Sub-project reports & discussion:

Personalized Medicine & Energy Metabolism

(5) Discuss communication/presentation tools

(6) Topic priorities for homework for next class

Exponent.xls

A3 =MAX(r*A2*(1-A2),0)

```
try r=  0.9,  1.01, 1.1,  1.5, 3, 3.67859, 4, 4.03
try y(i) =r*y(i-1)    (i.e. A3=r*A2  etc.)
```
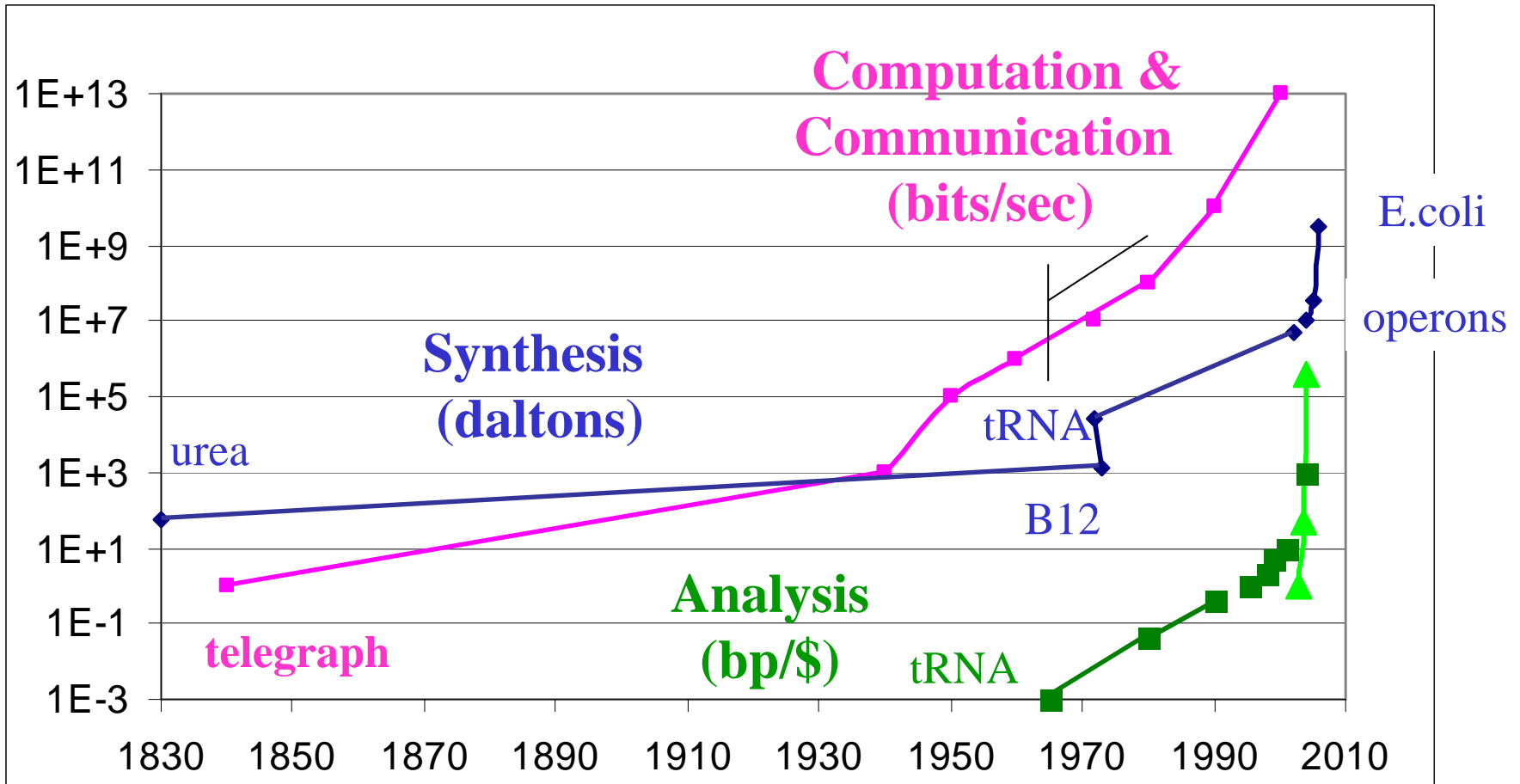
Why the (1-A2) term?
Why the MAX function?
What happens when r is larger than 3? (What assumptions?)

3 Exponential technologies
(synergistic)

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

Vertebrate brain size evolution

Figure removed due to copyright reasons.

Human-chimp 1.2%
Human-human 0.1%
Genome: 2x 3Gbp

Ongoing Adaptive Evolution of *ASPM*, a Brain Size Determinant in *Homo sapiens* Science 2005
Bond et al 2002 ASPM is a major determinant of cerebral cortical size. Nat Genet. 32(2):316-20.
Jerison, Paleoneurology & the Evolution of Mind, Scientific Amer. 1976

Bits & complexity

How many bits to represent your genome (from your mother)?
How many additional bits for paternal DNA?
How many bits to define the ribosome structure below?

Figure removed due
to copyright reasons.

Brain complexity

"The retina's 10 million detections per second [.02 g] ... extrapolation ... 10^{14} instructions per second to emulate the 1,500 gram human brain. ... thirty more years .." (Morovec99)

Figure removed due to copyright reasons.

Edge & motion detection (examples)

Discovering the Capacity of Human Memory Wang 2003
N=10^{11} neurons, m=1000 connections: n!/[m!(n-m)!] = 10^8432 bits.
How Many Bytes in Human Memory? Merkle 1988
Landauer 2 bits/sec (<10^8 bits per lifetime)

Inheritance is not just DNA

Photos removed due
to copyright reasons.

Inheritance is not just DNA

	Past	Current
Locomotion	50	26720 km/h
Ocean depth	75m	10,912 m
Visible λ	.4-.7 μ	pm-Mm
Temperature	275-370	3-1900°K
Memory years	20	5000
Memory bits	10^9	10^{17}
Cell therapy	0	most tissues

http://www.techworld.com/opsys/features/index.cfm?fuseaction=displayfeatures&featureid=467&page=1&pagepos=5

http://www.merkle.com/humanMemory.html

THE FUTURE OF HUMAN NATURE

The Singularity Is Near : When Humans Transcend Biology
The Law of Accelerating Returns   by Ray Kurzweil

An analysis of the history of technology shows that technological change is exponential, contrary to the common-sense "intuitive linear" view. So we won't experience 100 years of progress in the 21st century -- it will be more like 20,000 years of progress (at today's rate). .. ultra-high levels of intelligence that expand outward in the universe at the speed of light.

http://www.kurzweilai.net/articles/art0134.html?printable=1

Bill Joy Wired 8.04 | Apr 2000
Our most powerful 21st-century technologies - robotics, genetic engineering, and nanotech - are threatening to make humans an endangered species.

Personalized Medicine/Genetics

•Haplotype Diversity across 100 Candidate Genes for Inflammation, Lipid Metabolism, and Blood Pressure Regulation in Two Populations. Crawford, et al.

•A common haplotype in the complement regulatory gene factor H (*HF1/CFH*) predisposes individuals to age-related macular degeneration Hageman, et al. 2005

Common Disease – Common Variant Theory. How common?

ApoE allele ε4 : Alzheimer's dementia, & hypercholesterolemia
20% in humans,   >97% in chimps

HbS 17% & G6PD 40% in a Saudi sample

CCR5Δ32 : resistance to HIV
9% in caucasians

SNPs & Covariance in proteins

e4 20%   **ApoE**   **e3   80%**

Figure removed due
to copyright reasons.

Ancestral = Arg 112 Thr 61

Energy & CO$_2$ Sequestration

Humans consume 2kW per person = 10^{10} kW.
Sunlight hits the earth at 40,000 times that rate (70% ocean).

CO$_2$/yr: Fossil fuel use releases 5 Gton.
Ocean & terrestrial productivity = ~100 Gton each.

Autotrophs: 10^{26} *Prochlorococcus* cells globally (10^8 per liter)

Lab:100X

Sequestration v. respiration v. use: heterotrophs (*Pelagibacter*),
phages, predators (*Maxillopoda, Malacostraca, herring*)

0.1 μ

0.1 mm

6 cm

Photos removed due
to copyright reasons.

http://www.gsfc.nasa.gov/gsfc/service/gallery/fact_sheets/earthsci/terra/earths_energy_balance.htm
http://clear.eawag.ch/models/optionenE.html   http://en.wikipedia.org/wiki/Copepod
Morris et al. Nature 2002 Dec 19-26;420(6917):806-10.

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