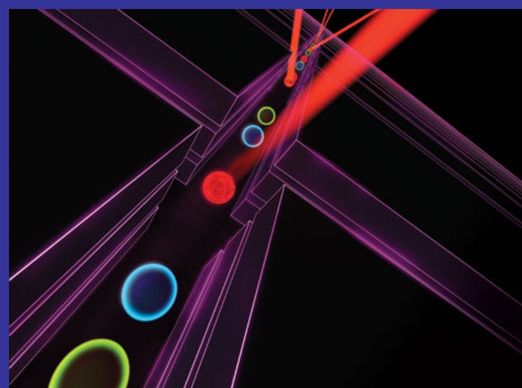
The Future of Technology



Technology And Society Committee
November 11, 2008

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Slides: http://www.slideshare.net/lablogga/slideshows

Summary

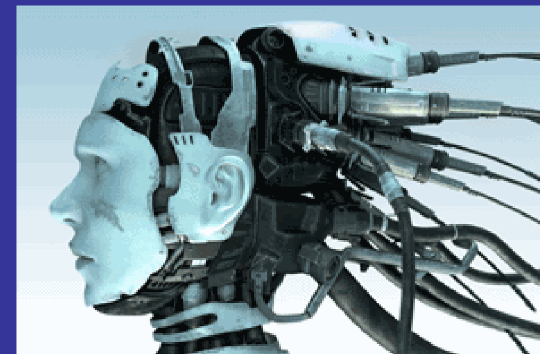


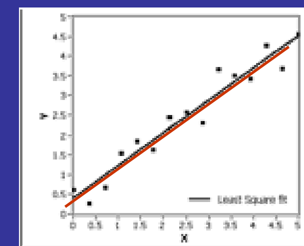
Image: Fausto de Martini

- General framework for understanding and assessing science and technology change is needed
- Growth paradigms are not just linear and exponential, most importantly they are discontinuous
- The realm of technology is no longer discrete, technology is immersing other areas in exponential and discontinuous change
- Next fifty years: linear and exponential growth and possibly a discontinuous change with greater impact than the Internet

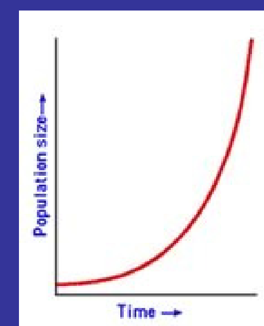
Paradigms of growth and change

- Linear
  - Economic, demographic, life span phenomena
  - Tivo wedge: sustainable new category
- Exponential
  - Technology: processors, memory, storage, communications, iPhone applications
- Discontinuous
  - Plane, car, radio, wars, radar, nuclear weapons, satellites, computers, Internet, globalization
  - Impossible to predict
    - Rapid transition time and doubling capability
    - Adjacent technology advances

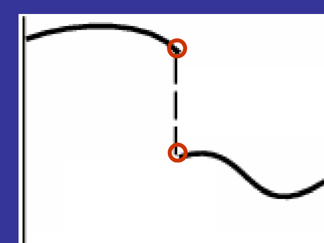
Linear



Exponential

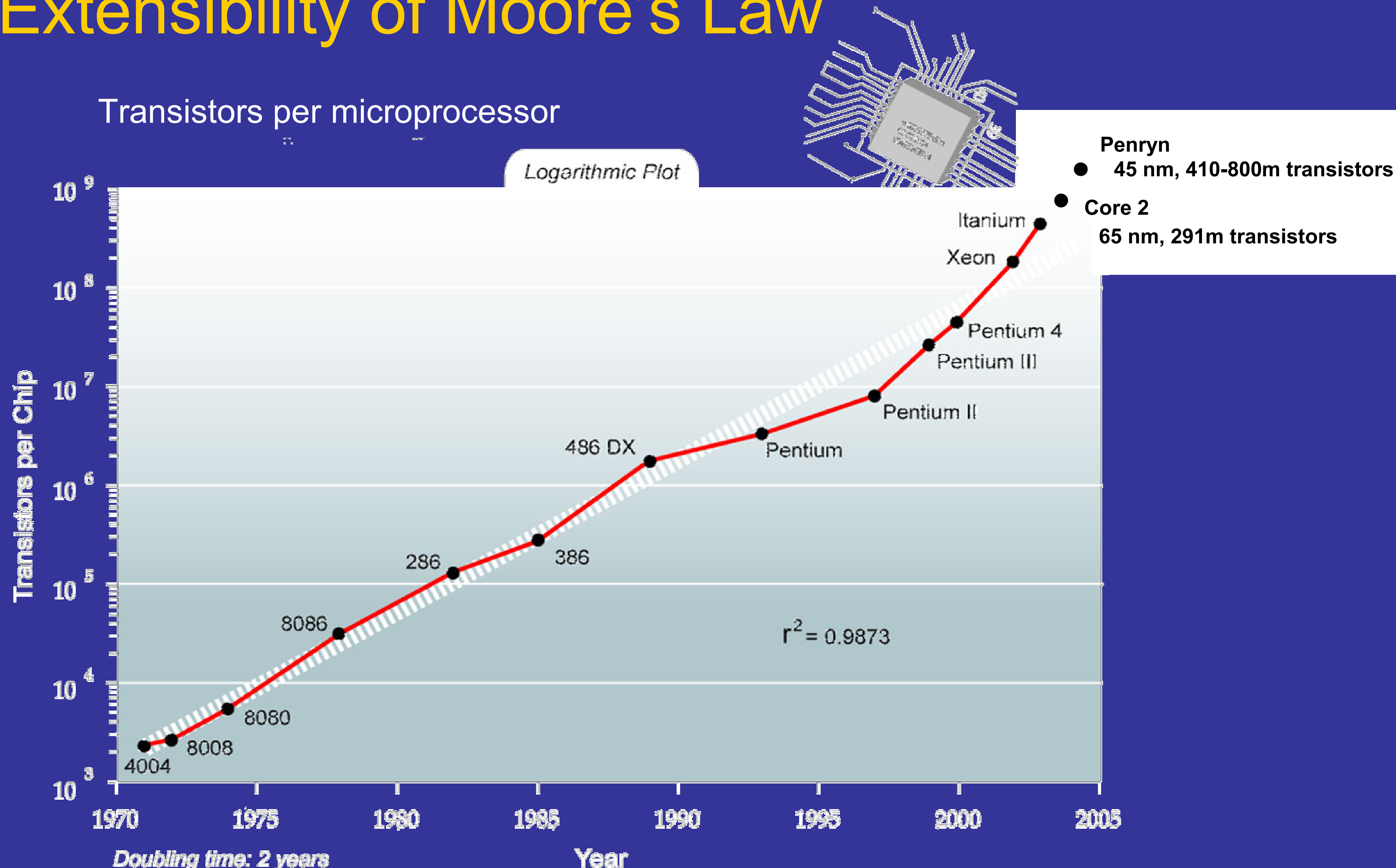


Discontinuous



Extensibility of Moore's Law

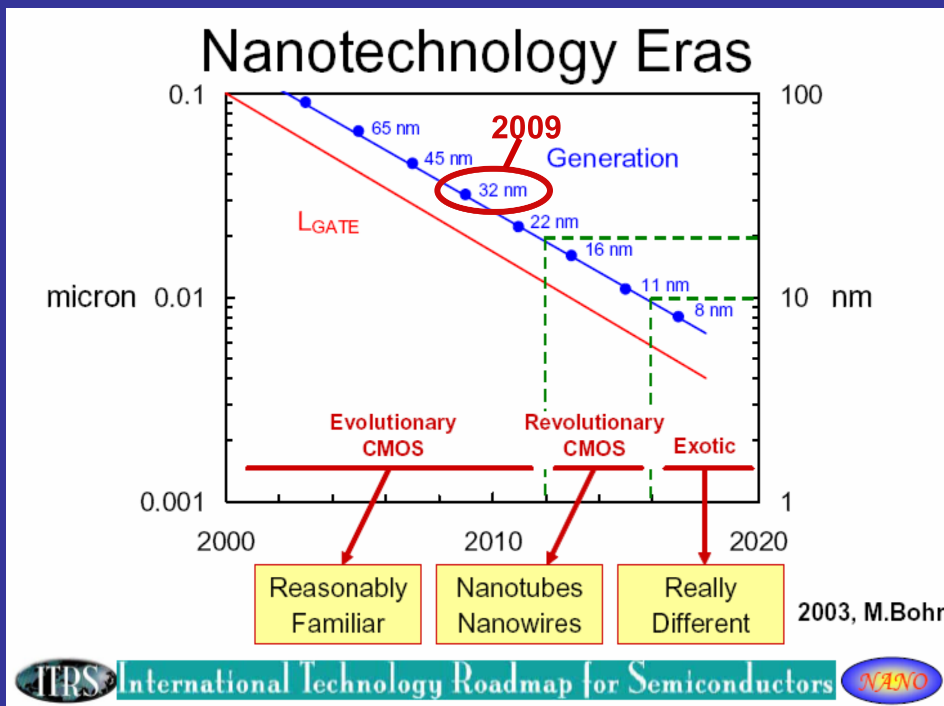
Transistors per microprocessor

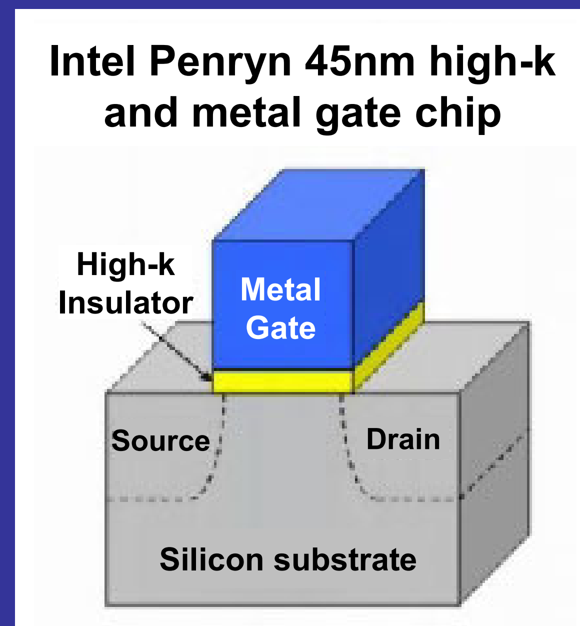


Source: Ray Kurzweil, http://www.KurzweilAI.net/pps/ACC2005/

Evolution of computing

- 32 nm 2009, 22 nm 2011, molecular manufacturing needed for 10 nm





Sources: ITRS Semiconductor Roadmap, http://download.intel.com/technology/silicon/Paolo_Semicon_West_071904.pdf, http://www.intel.com/technology/architecture-silicon/32nm/index.htm, http://www.siliconvalleysleuth.com/2007/01/a_look_inside_i.html

Future of computing

Traditional model

- Linear, von Neumann

Novel models

- Parallel
- Cloud, grid, distributed
- Quantum
- Optical computing
- Cell broadband engine
- Liquid computer

Current model extensibility

- New materials
- 3D chip stacking
- Molecular electronics
- Solar transistors

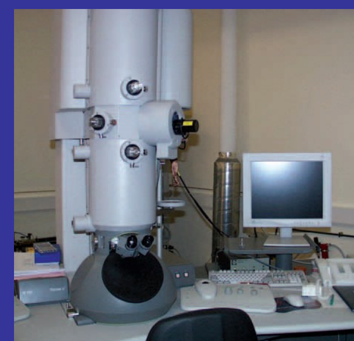
Biological models

- DNA computing
- Biosensors
- Cellular colonies
- Bacterial intelligence
- New paradigm discovery

Tool complexity growing

- Contemporary lab tools increasingly dependent on software
- Analytic layer for modeling, simulation, statistics, informatics

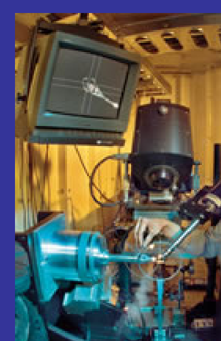
Software: analytics
Software: operating
Hardware


Scanning tunneling electron microscope


Mass spectrometer


Allen array telescope


Gas chromatograph


Protein crystallographer


Flow cytometer

What might be the next Internet?

Mobile applications

Alternative energy

Affordable space launch

Synthetic biology

Virtual environments

Personalized medicine

New computing models

Anti-aging therapies

Brain-computer interfaces

3D printing, fabbing

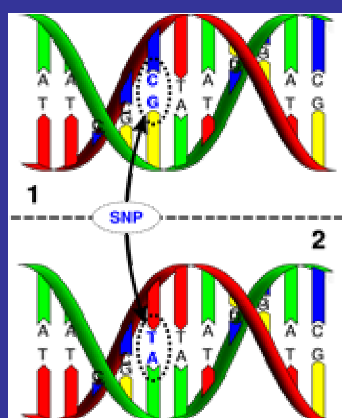
Molecular nanotechnology

Artificial intelligence

Robotics

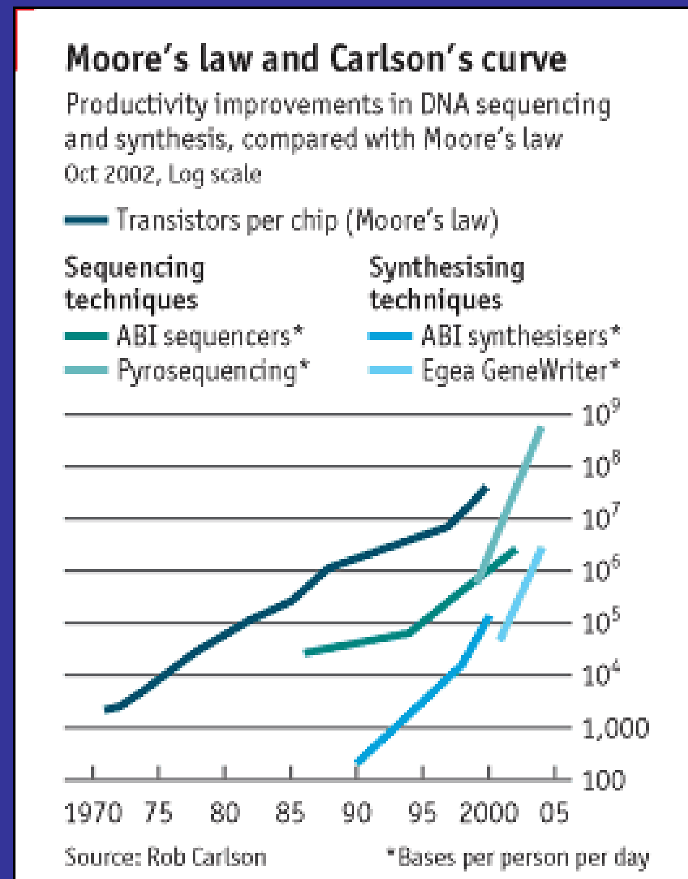
Biology evolves from art to information science to engineering problem

- Genomics
  - DNA Sequencing
  - DNA Synthesizing
  - Variation: SNPs
- Proteomics, other “-omics”



Variation: SNP

DNA Synthesizer

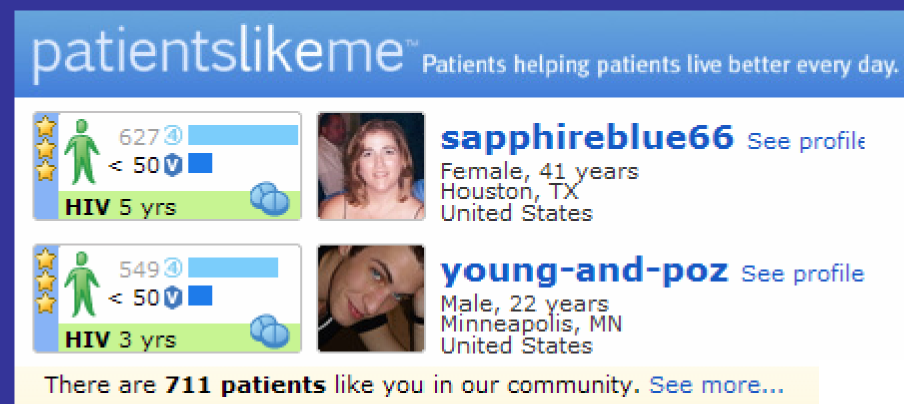


Sources: http://www.economist.com/background/displaystory.cfm?story_id=7854314, http://www.molsci.org/%7Ercarlson/Carlson_Pace_and_Prolif.pdf

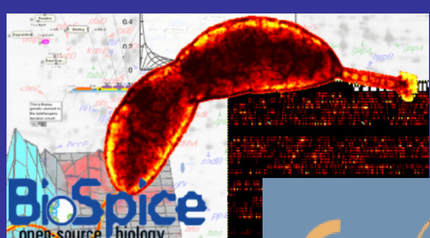
Life sciences advances

- Personalized medicine
- Direct-to-consumer patient empowerment
  - Genomic testing
  - Health social networks
  - Niche physicians
- Synthetic biology
  - Model, simulate and build

Personalized medicine

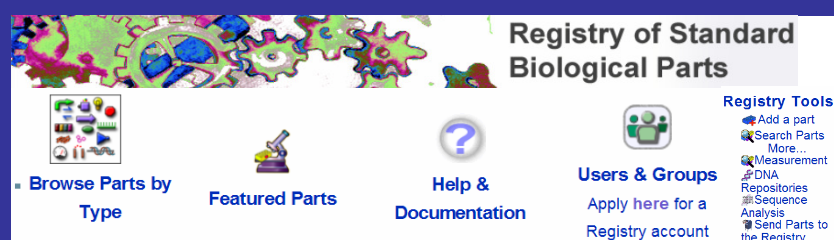


Health social networks



BioSpice.org

SimTK.org



PartsRegistry.org

iGEM competition

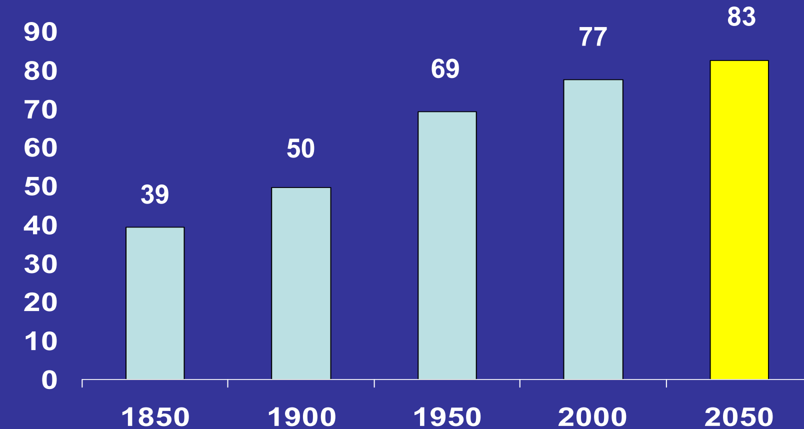
Extending lifespan and healthspan

- Aging is a multidisciplinary pathology
- Aubrey de Grey: Strategies for Engineered Negligible Senescence (SENS)
  - Nucleic and mitochondrial mutations
  - Intracellular and extracellular junk
  - Cell loss and senescence
  - Extracellular crosslinks
- Solutions and escape velocity
  - Mutation anti-suppressors
  - Bioremediation
  - Cell strengthening
- Real age estimation tests

The Methuselah Foundation

Research to repair and reverse the damage of aging

U.S. Life Expectancy, 1850 – 2050e

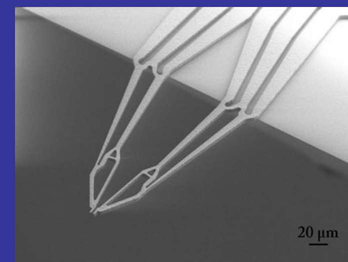


Source: http://www.infoplease.com/ipa/A0005140.html
Source: http://earthtrends.wri.org/text/population-health/variable-379.html

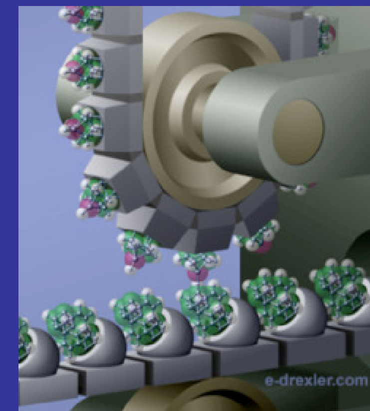
http://www.realage.com
http://gosset.wharton.upenn.edu/mortality/perl/CalcForm.html

Molecular nanotechnology

- 3D atomically precise placement
- Scale
  - Human hair: 80,000 nm
  - Limit of human vision: 10,000 nm
  - Virus: 50 nm, DNA: 2 nm
  - Atom 0.1 nm
- Energy applications
- Tools, mechanosynthesis validation needed
  - Mills, motors
  - Microscopy



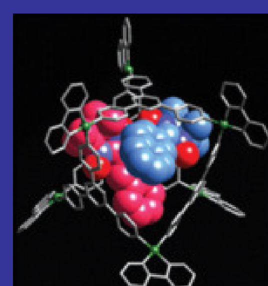
Microgripper

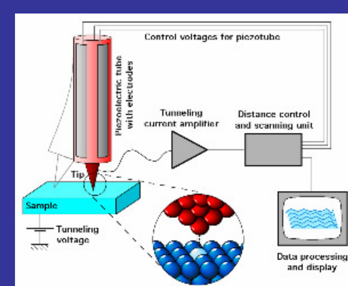


Molecular mill


MEMS ratchet


Molecular motor


Molecular scaffold

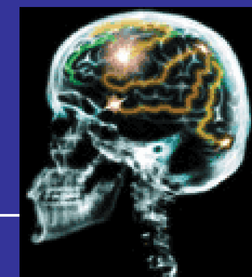


Scanning tunneling electron microscope


Molecular synthesizer

Images: http://www.imm.org, http://www.rfreitas.com, http://www.foresight.org, http://www.e-drexler.org

Arms race for the future of intelligence



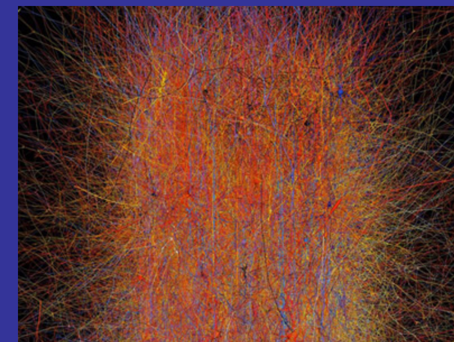
Machine	Human
▪ IBM Roadrunner 1 petaflop/s (>1,000 trillion IPS) and 80 TB memory[1] ▪ Unlimited operational/build knowledge ▪ Quick upgrade cycles: performance capability doubling every 18 months ▪ Linear, von Neumann architecture ▪ Understands rigid language ▪ Special purpose problem solving (Deep Blue, Chinook, ATMs, fraud detection) ▪ Metal chassis, easy to backup	▪ An estimated 20,000 trillion IPS and 1,000 TB memory[2] ▪ Limited operational/build knowledge ▪ Slow upgrade cycles: 10,000 year evolutionary adaptations ▪ Massively parallel architecture ▪ Understands flexible, fuzzy language ▪ General purpose problem solving, works well in new situations ▪ Nucleotide chassis, no backup possible

[1] *Source: Top 500, June 2008, http://www.top500.org/lists/2008/06, http://www.top500.org/system/8968, http://www.crn.com/hardware/208403186*

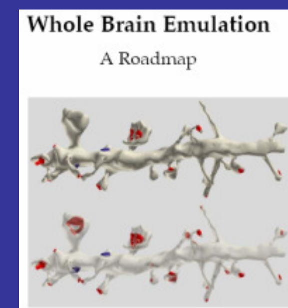
[2] *Source: http://paula.univ.gda.pl/~dokgrk/bre01.html*

Status of intelligence research

- Whole brain emulation (IBM, Oxford)
- Neuroimaging tissue volumes
- Brain-computer interfaces
- Robotics
- Artificial intelligence
  - (Narrow) DARPA, corporate
  - (Strong) startups



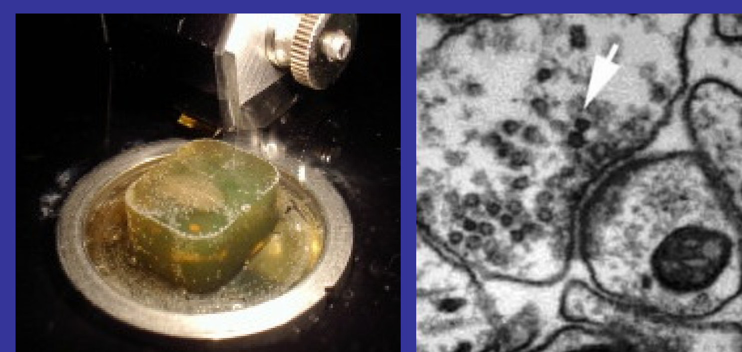
IBM Rat Cortical Column



Brain Emulation Roadmap

Leonardo

Emotiv brain computer interface gaming helmet



Mouse brain block and cortex slice

Virtual environments

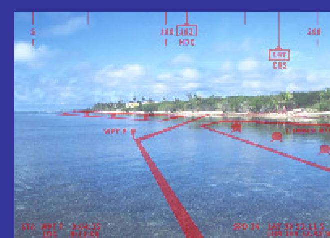
- Data visualization, simulation and 3D data display
- Reality capture
- Virtual worlds
  - “Serious” platform
  - Teleconferencing
  - Green data centers
  - AI training

Google Earth

GPS

Life-logging rig

Heads-up Display

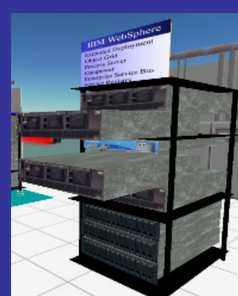


Data Overlay

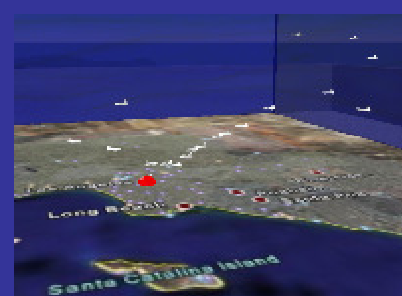
Blended Reality Conference

Wild Divine

NTT’s Aromatic Display



IBM’s Virtual NOC

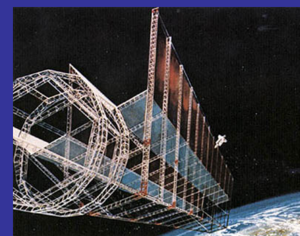


LAX Air Traffic Data

3D Stock Charts

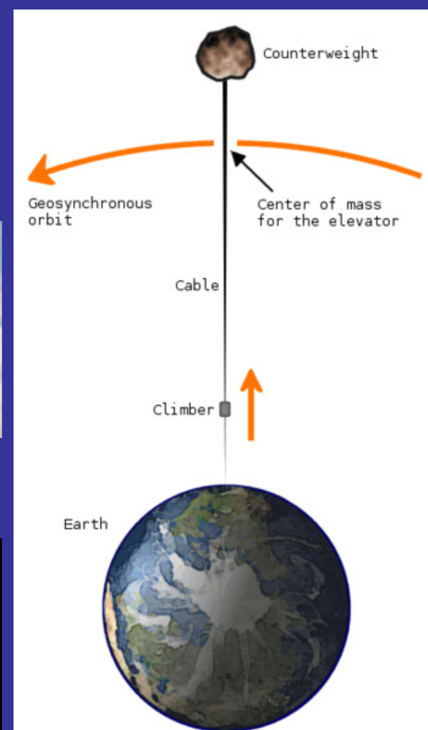
Physics and space

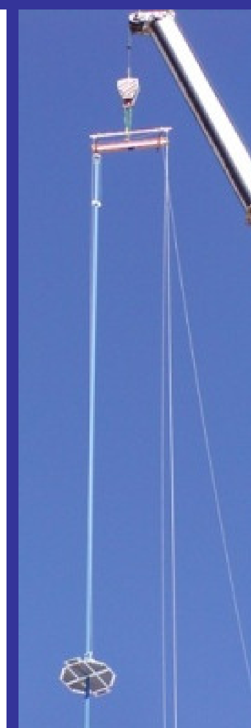
- Physics
- Space commercialization
  - SpaceX
  - Armadillo Aerospace
  - Google Lunar X Prize
  - Virgin Galactic
  - Space elevator

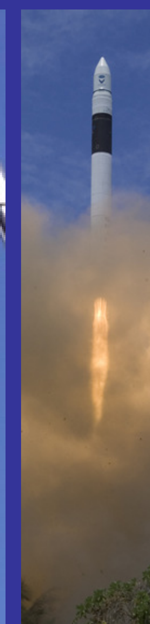

Space-based Power


Chang'e-1


Spaceport America, NM



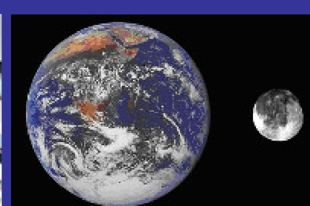

Space Elevator and Climber Competition


SpaceX


Armadillo Aerospace



Virgin Galactic


Google Lunar X Prize

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Affordable space launch

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Virtual environments

Personalized medicine

New computing models

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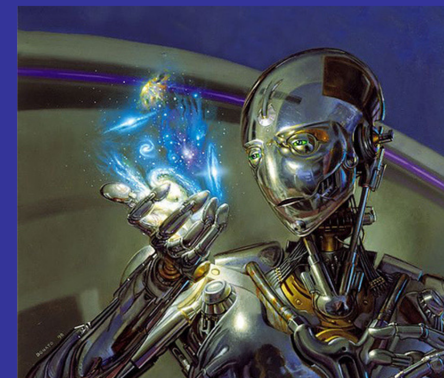
Molecular nanotechnology

Artificial intelligence

Robotics

Summary



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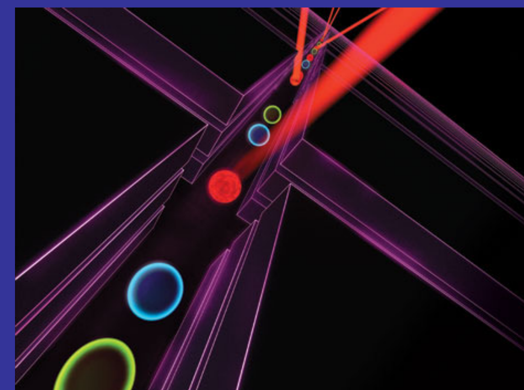
Thank you



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