

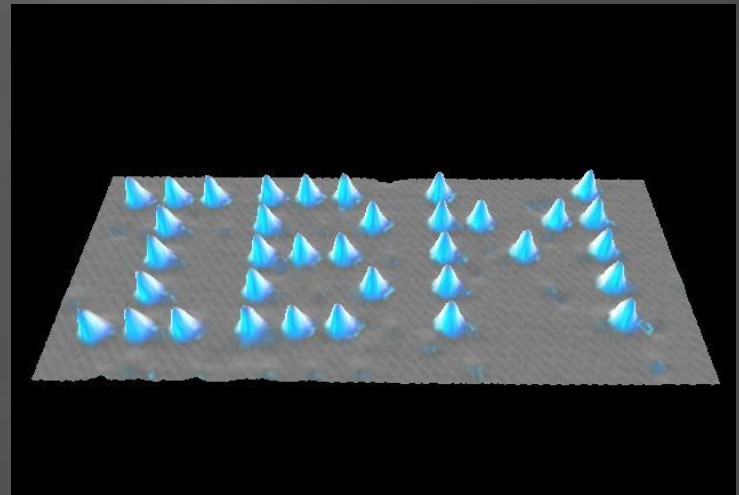
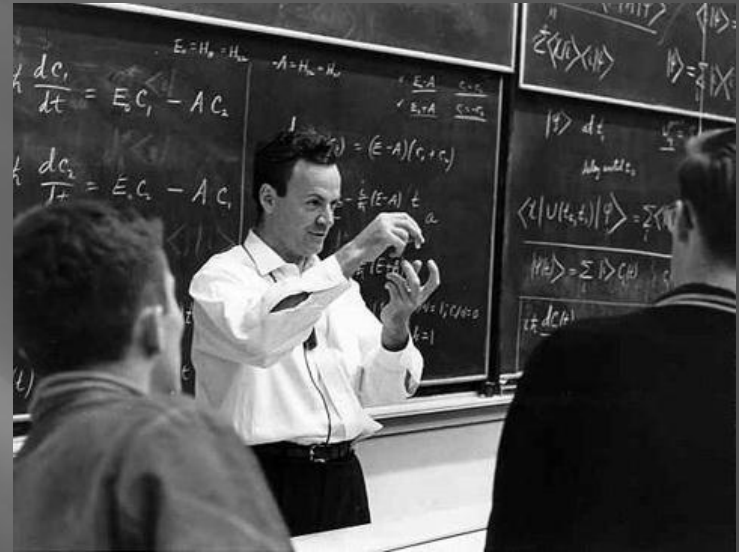
Bear Robotics

Understanding Moore's Law ©

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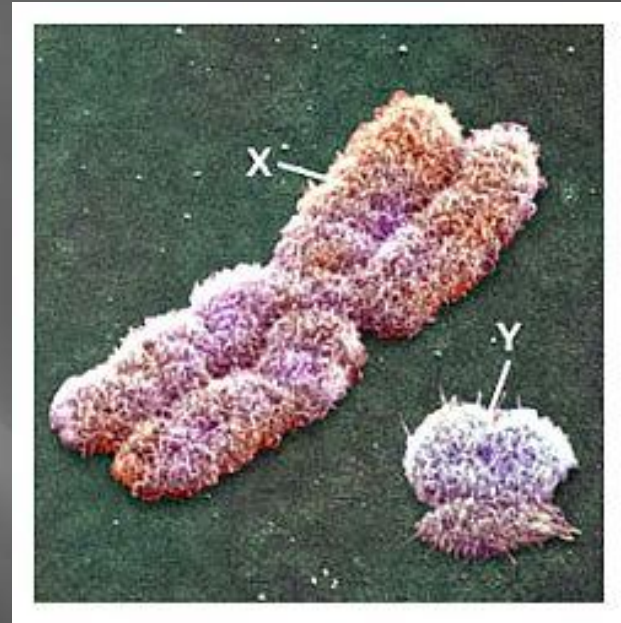
“There’s Plenty of Room at the Bottom”

- ▣ Richard P. Feynman, visionary physicist, Nobel Prize winner
- ▣ Publication of his talk inspired field of Nanotechnology
- ▣ To see “IBM” requires a very powerful microscope (scanning tunneling microscope)



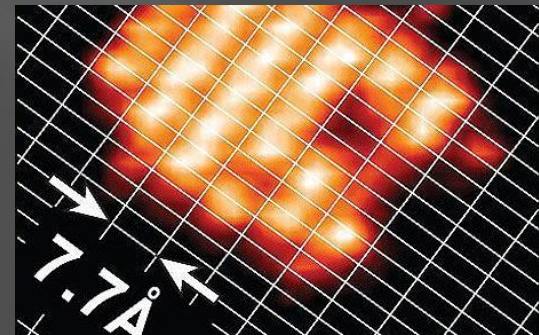
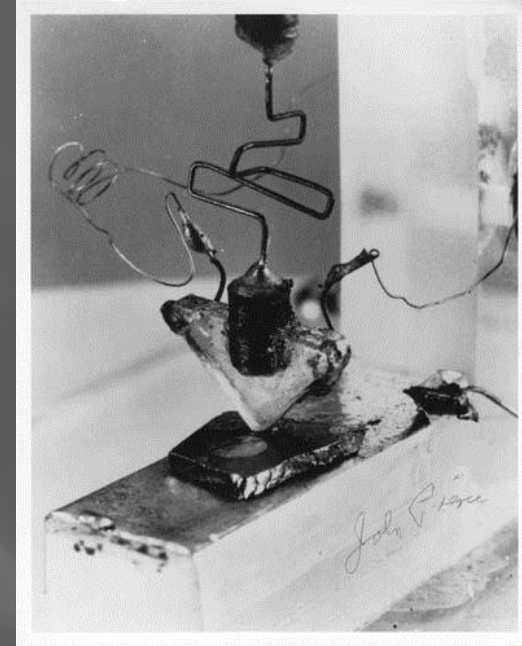
What if someday less than 50-100 atoms were needed for transacting 1 bit of information?

- ▣ Comparable to human DNA:
 - 250 Million base pairs in about 10 feet
 - All your DNA fits in one trillionth of your thumb's volume
- ▣ A thumb-size memory cube would equal the capacity of 5 Billion iPhones



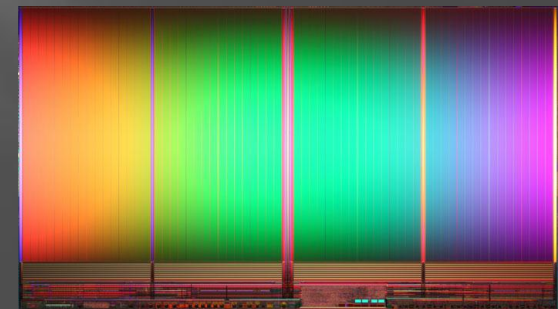
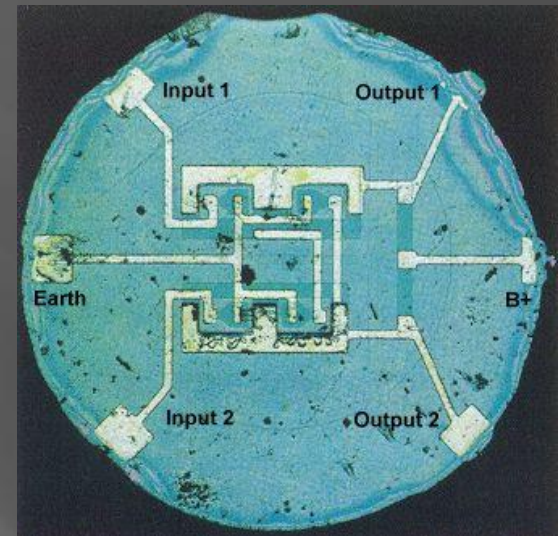
The Rapidly Shrinking Transistor

- ▣ The world's first transistor:
 - Invented at Bell Laboratories, December 16, 1947
 - William Shockley, John Bardeen, and Walter Brattain shared the Nobel Prize in Physics in 1956
- ▣ The world's smallest transistor in 2010 (U of New South Wales):
 - Made of seven atoms
 - About 1 Million times shorter than the first transistor



Explosive Growth of Semiconductor Memory Density

- ▣ First Monolithic Silicon IC Chip, invented by Robert Noyce, of Fairchild Corporation, in 1961
- ▣ Intel announces world's densest NAND FLASH memory in 2011
- ▣ About 10 Billion increase in memory density since first semiconductor memory



Moore's Law

- ▣ Explains the explosive increase in computer performance from rapid increases in semiconductor density (and decreasing transistor cost)
- ▣ Density of semiconductors has doubled in less than 18 months for more than 40 years
- ▣ What does an increase of 1 Billion in chip performance allow?
 - An iPhone has more than 100 times the memory capacity of the main computer of Carnegie Mellon's Physics Department during the early 1980's.
 - Some toys have more compute power than super computers in the 1970's.

A Software Revolution

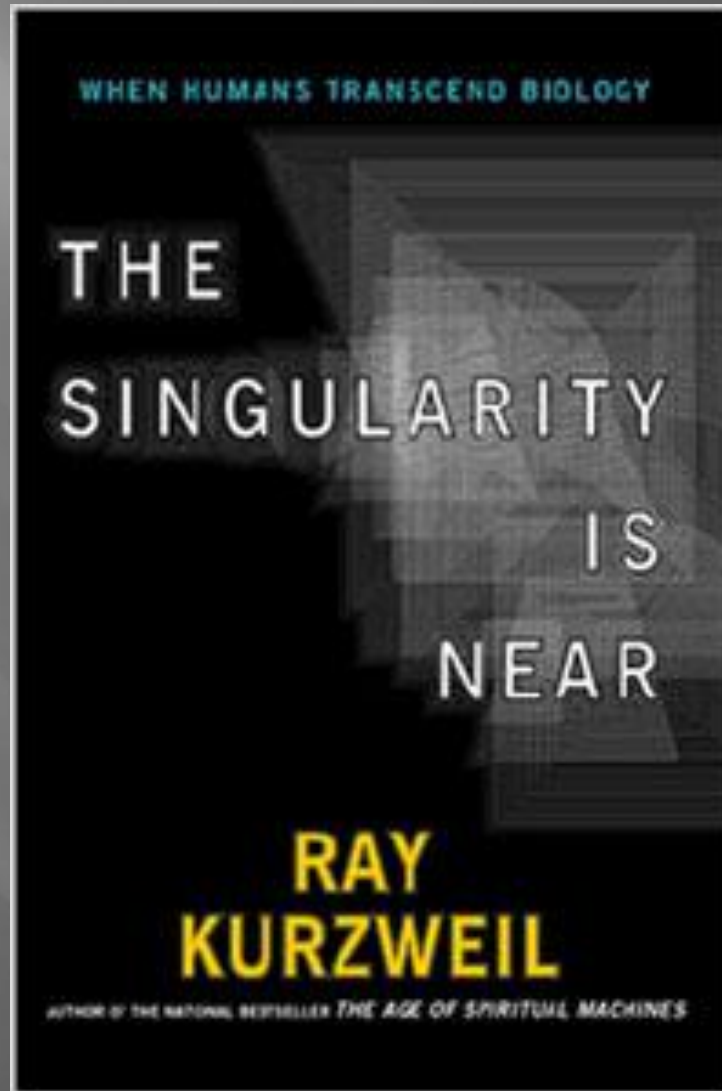
- ▣ Source codes have grown from 10's of instructions to 10's of millions of instructions
- ▣ Software applications have grown from 100's to countless millions
- ▣ Navigational maps of the Earth can be stored and used by cell phones
- ▣ Search engines allow access more than 1 Million books and allowed me to write this talk in hours not days
- ▣ Email allows nearly instant communications with more than 1 Billion people world-wide

Artificial Intelligence is Emerging

- ▣ Hans Moravec with the Stanford Cart in 1977
- ▣ iRobot's Roomba vacuum cleaner in 2011
- ▣ World Chess Champion, IBM's Deep Blue in 1997
- ▣ IBM's Watson wins at Jeopardy in 2011



The Singularity is Near



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Thank You for Listening



References & Links

- ▣ “There’s Plenty of Room at the Bottom,” R. P. Feynman, Caltech Engineering and Science, Volume 23:5, February 1960, pp 22-36.
- ▣ http://www.nobelprize.org/nobel_prizes/physics/laureates/1956/
- ▣ <http://www.science.unsw.edu.au/news/quantum-leap-world-smallest-transistor-built-with-just-7-atoms/>
- ▣ http://www.chiphistory.org/legends/fairchild_ic.htm
- ▣ <http://www.technewsworld.com/story/chips/69240.html>
- ▣ <http://www.frc.ri.cmu.edu/~hpm/>
- ▣ www.singularity.com