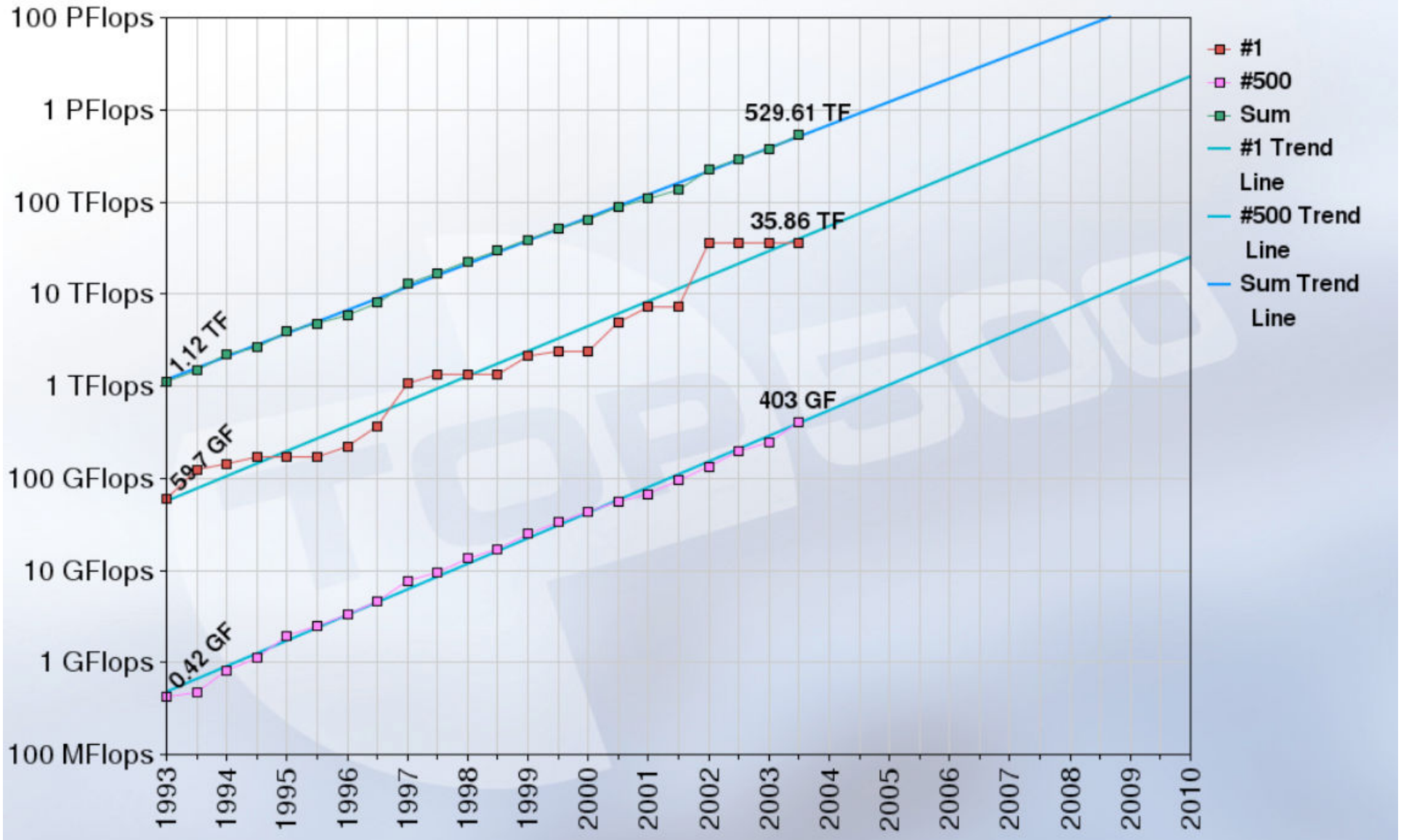
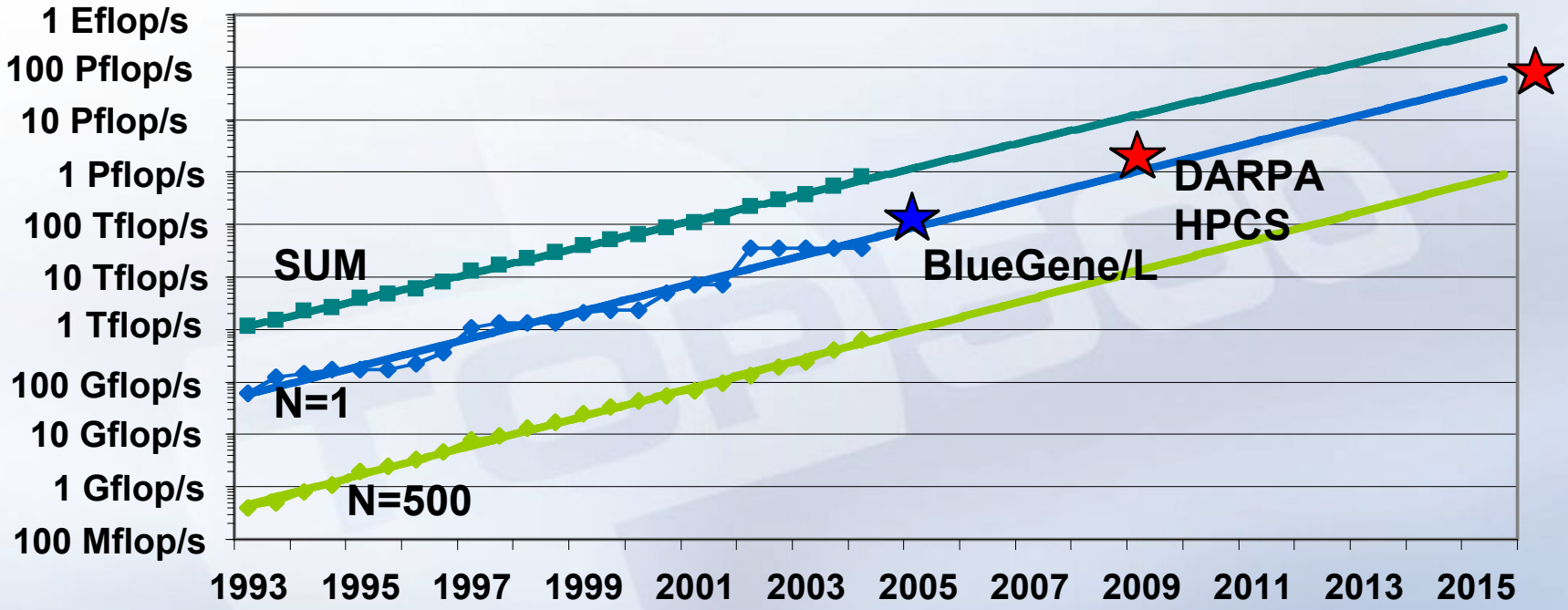
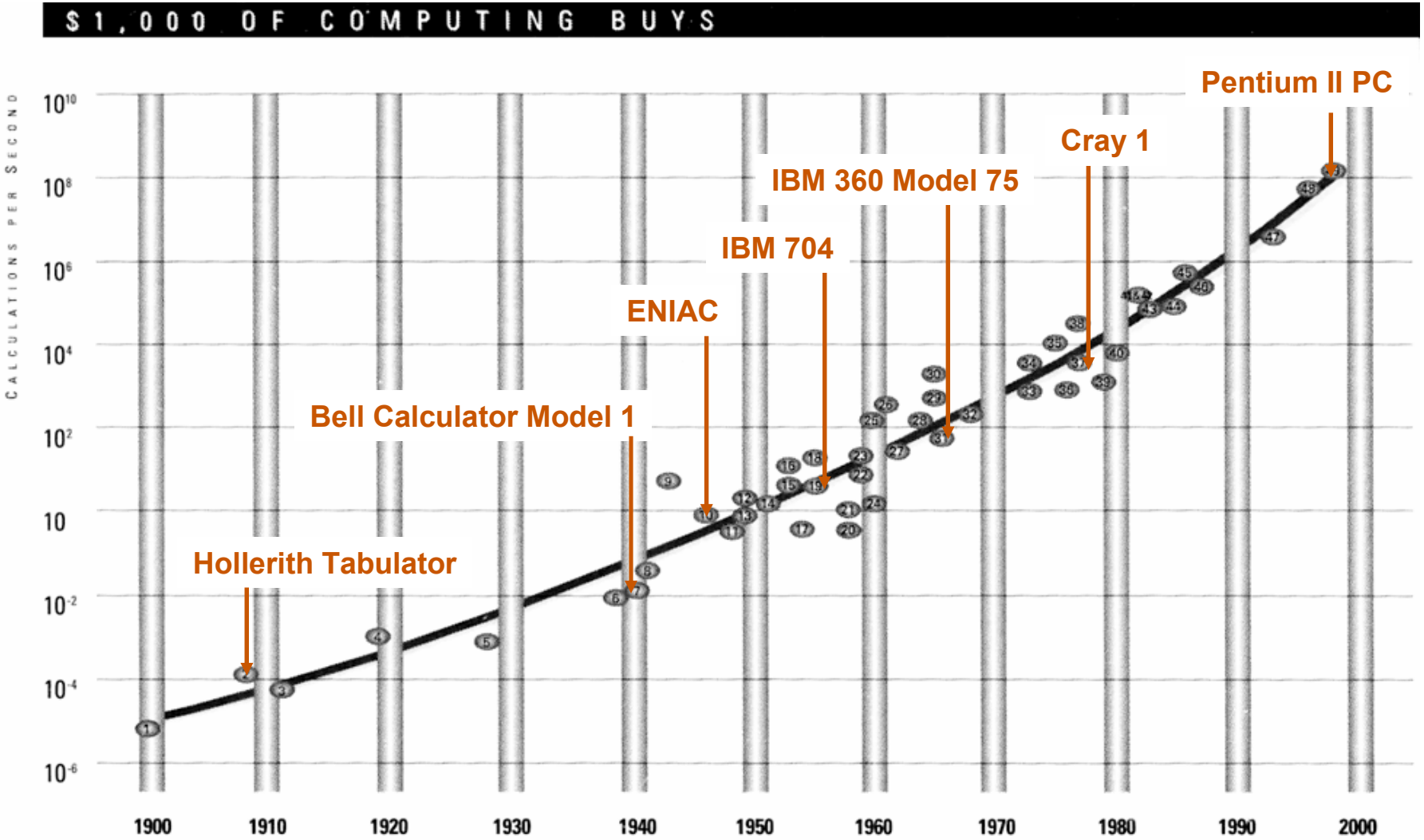
Projected Performance Development



TOP 500 Performance Projection

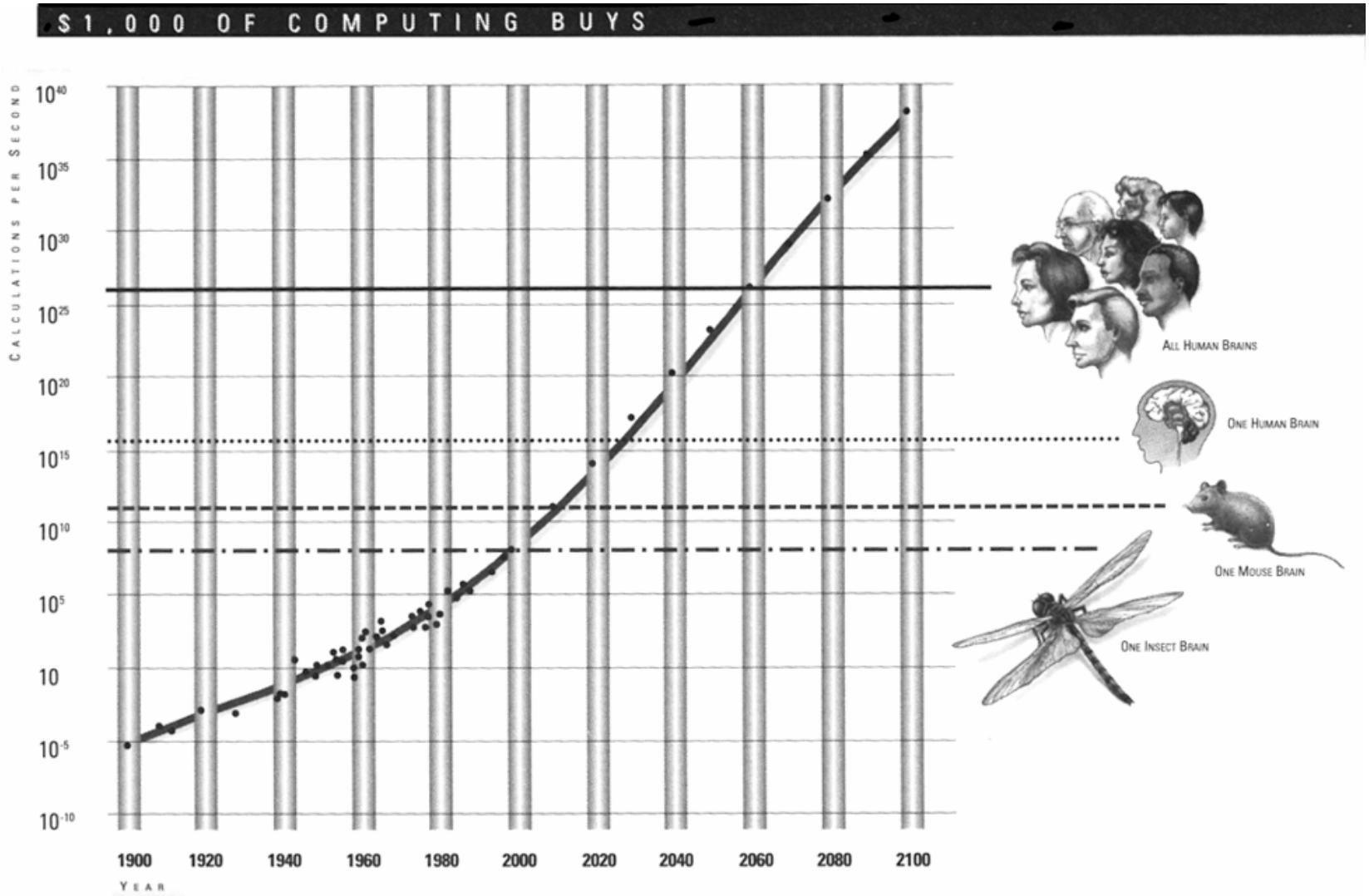


The Exponential Growth of Computing, 1900-1998



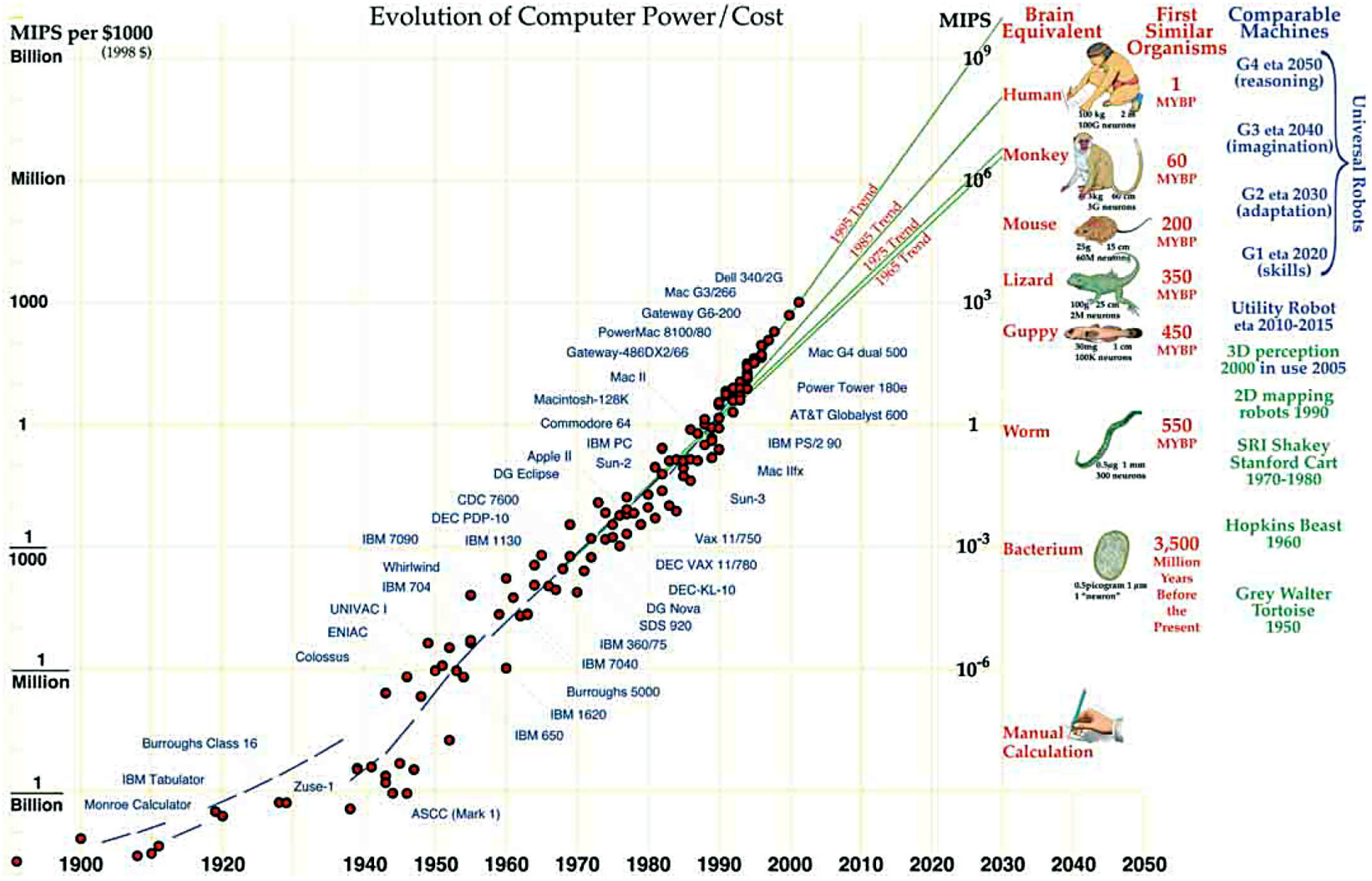
Adapted from Kurzweil, *The Age of Spiritual Machines*

The Exponential Growth of Computing, 1900-2100



Adapted from Kurzweil, *The Age of Spiritual Machines*

Growth of Computing Power and "Mental Power"



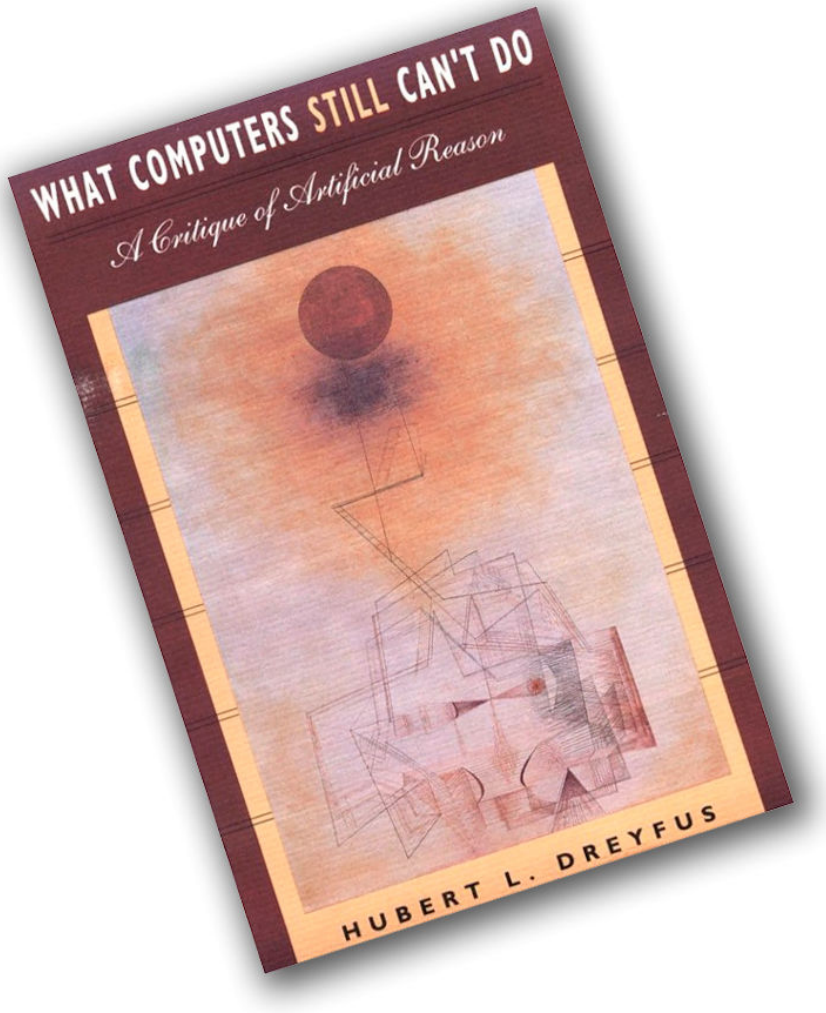
Hans Moravec, *CACM* 10, 2003, pp 90-97

Why this simplistic view is wrong

- Unsuitability of Current Architectures
  - Teraflop systems are focused on excelling in computing; only one of the six (or eight) dimensions of human intelligence
- Fundamental lack of mathematical models for cognitive processes
  - That's why we are not using the most powerful computers today for cognitive tasks
- Complexity limits
  - We don't even know yet how to model turbulence, how then do we model thought?

"The computer model turns out not to be helpful in explaining what people actually do when they think and perceive"
Hubert Dreyfus, pg.189

Example: one of the biggest success stories of machine intelligence, the chess computer "Deep Blue", did not teach us anything about how a chess grandmaster thinks.

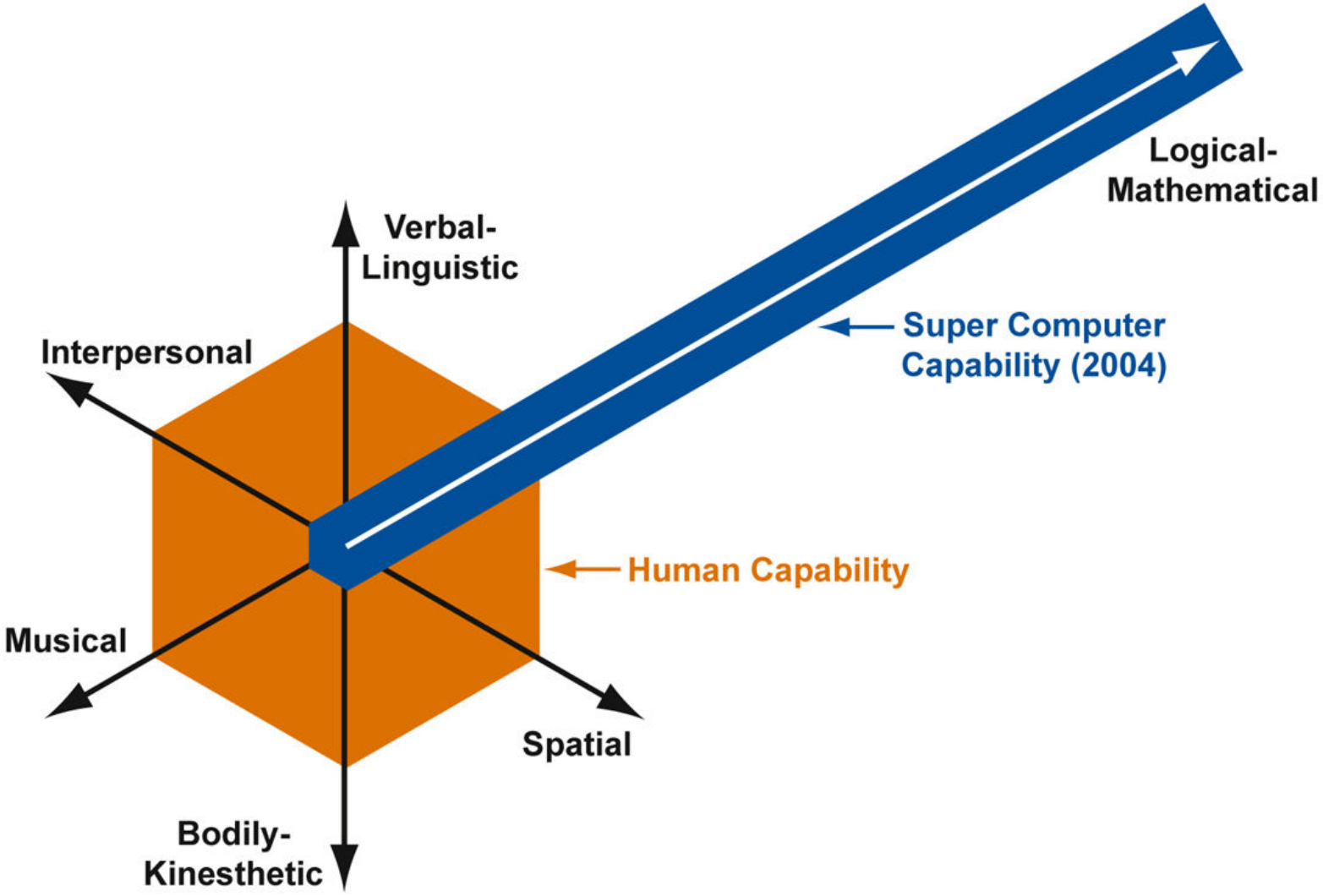


Six Dimensions of Intelligence

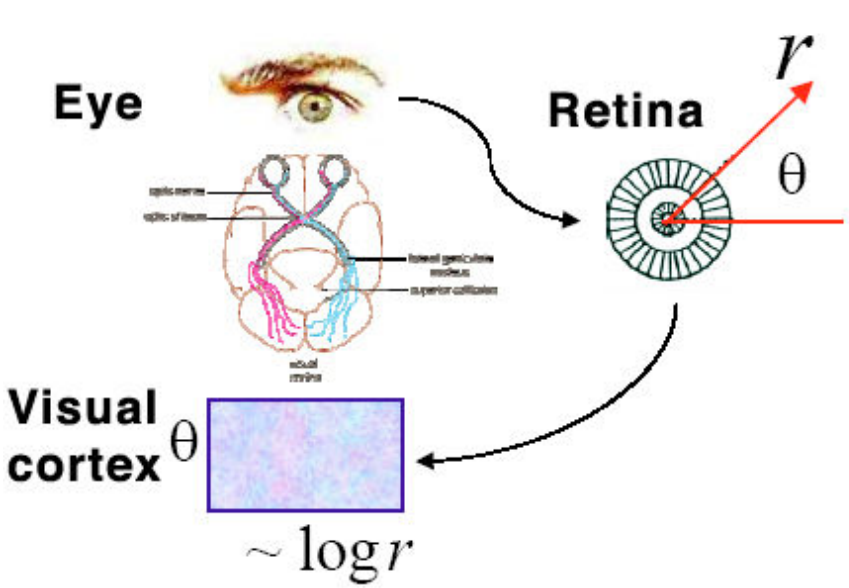
1. **Verbal-Linguistic**
   ability to think in words and to use language to express and appreciate complex concepts
2. **Logical-Mathematical**
   makes it possible to calculate, quantify, consider propositions and hypotheses, and carry out complex mathematical operations
3. **Spatial**
   capacity to think and orientate in physical three-dimensional environment
4. **Bodily-Kinesthetic**
   ability to manipulate objects and fine-tune physical skills
5. **Musical**
   sensitivity to pitch, melody, rhythm, and tone
6. **Interpersonal**
   capacity to understand and interact effectively with others

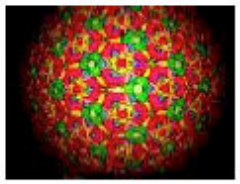
Howard Gardner. *Frames of Mind: The Theory of Multiple Intelligences*. New York: Basic Books, 1983, 1993.

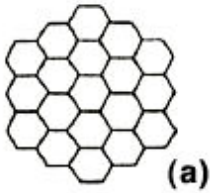
Current State of Supercomputers

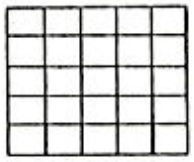


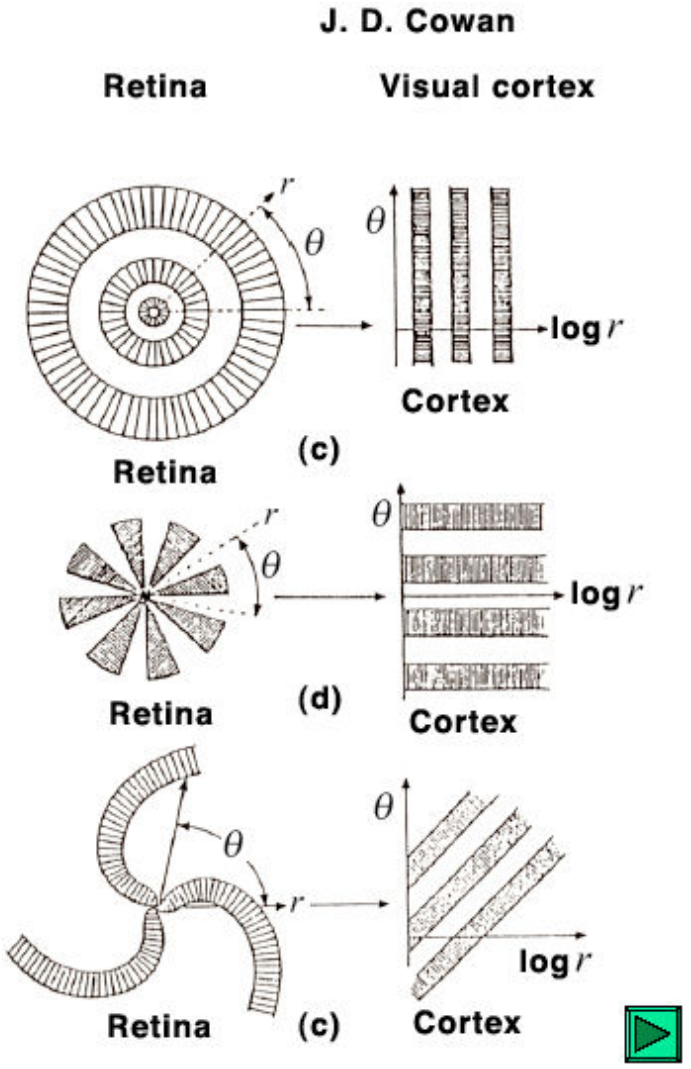
Retina to Visual Cortex Mapping











Building New Models

- About 1/3 of human brain is probably dedicated towards processing of visual information
- We have only very rudimentary knowledge of the principles for human vision computing
- Research project by Don Glaser at UC Berkeley investigates mapping from retina to visual cortex
- Attempt to model “optical illusions” and simple movement of objects in the visual cortex
- Current models limited to about 10**5 neurons
- Supercomputer project at NERSC in 2005

Fourth Observation about CSE

4. There are vast areas of science and engineering where CSE has not even begun to make an impact
   - current list of CSE applications is almost the same as 15 years ago
   - current set of architectures is capturing only a small subset of human cognitive abilities
   - in many scientific areas there is still an almost complete absence of computational models

See also: Y. Deng, J. Glimm, and D. H. Sharp, Perspectives on Parallel Computing, Daedalus Vol 12 (1992) 31-52.

Major Application Areas of CSE

- Science
  - Global climate modeling
  - Astrophysical modeling
  - Biology: genomics, protein folding, drug design
  - Computational chemistry
  - Computational material sciences and nanosciences
- Engineering
  - Crash simulation
  - Semiconductor design
  - Earthquake and structural modeling
  - Computational fluid dynamics
  - Combustion
- Business
  - Financial and economic modeling
  - Transaction processing, web services, and search engines
- Defense
  - Nuclear weapons—test by simulations
  - Cryptography

This list from 2004 is identical to a list from 1992!

Your vote counts

A Zettaflops computer will have emergent intelligent behavior.

The first sustained Petaflops application will use MPI.

The first sustained Exaflops application will use MPI.