

How the exponential growth of knowledge  
is both creating a singularity and  
may at the same time provide some way  
to avoid or manage the singularity crisis

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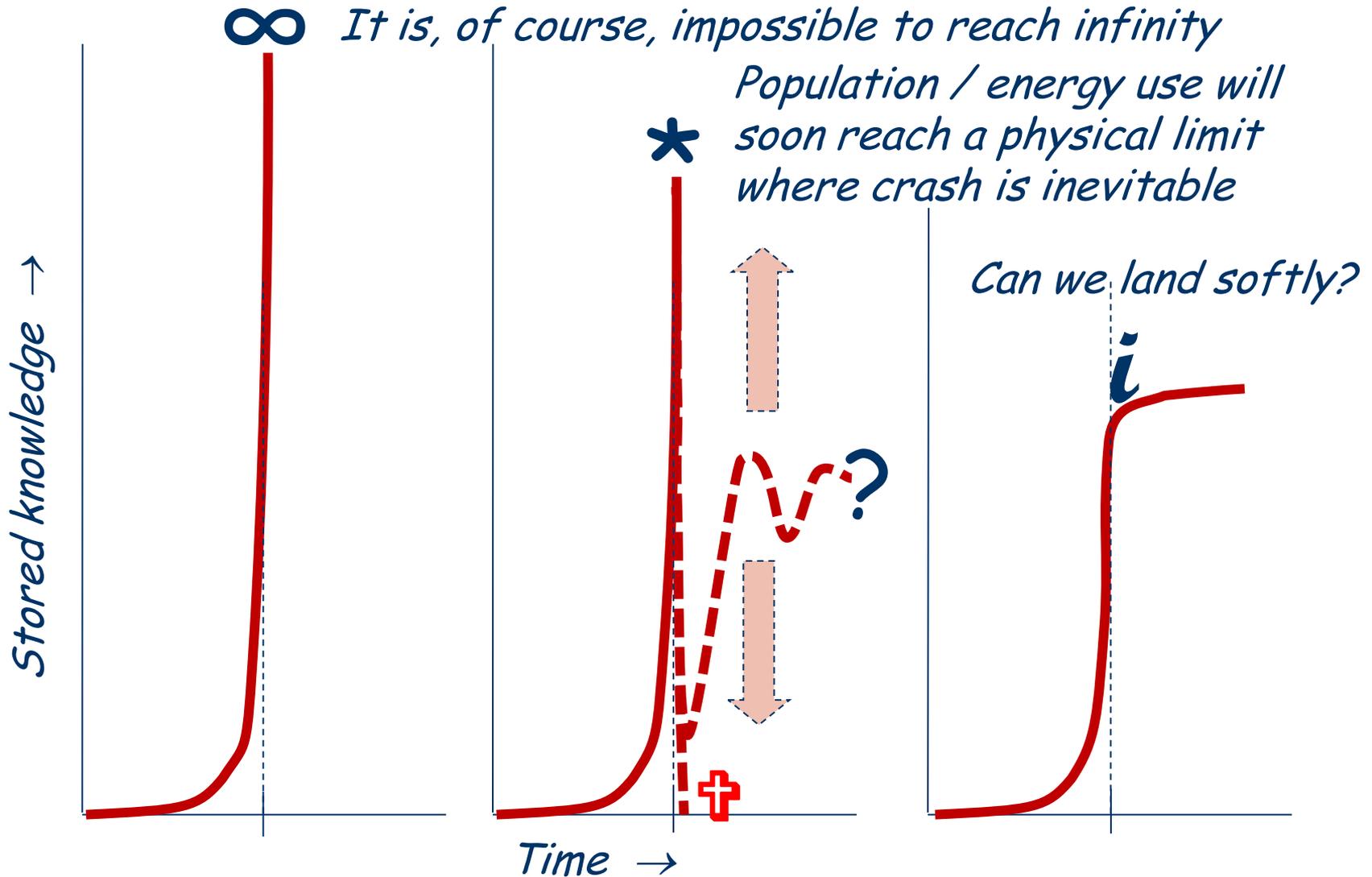
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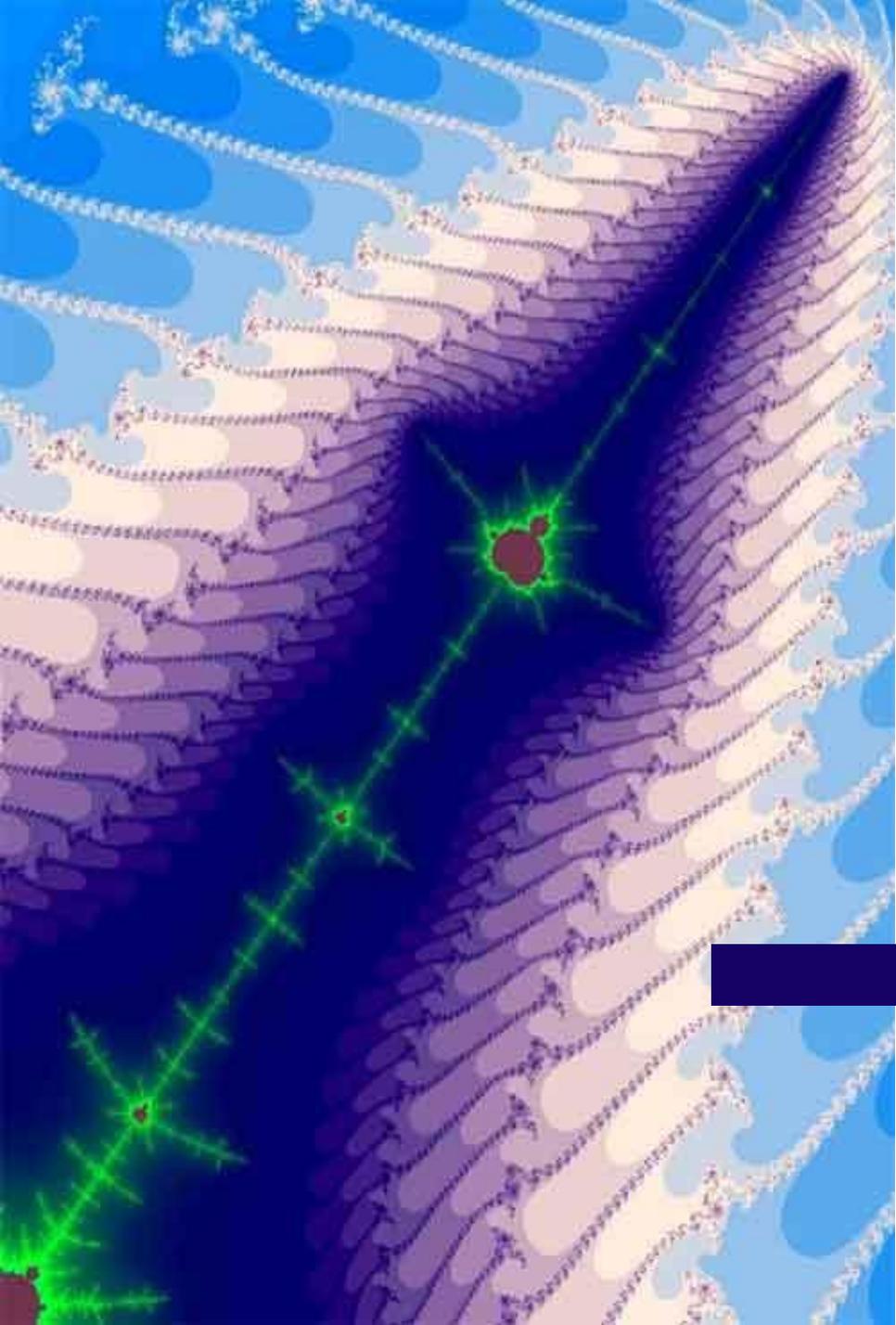
Unitarian Philosophy Forum  
3 May 2015

# Today

- Some thoughts leading towards the concluding Coda section of my hypertext book nearing completion
- Application Holy Wars or a New Reformation - A Fugue on the Theory of Knowledge
  - Explores the co-evolution of human cognition and our increasingly cognitive technologies over the last 5 million years
    - Social accumulation of knowledge causes exponential growth in knowledge
    - Increasing knowledge causes exponential growth in technological prowess
    - Technological revolutions discontinuously increase rate of knowledge growth
- Coda — key concepts
  - Exponential growth and the concept of singularity
  - One world with finite resources
  - Tragedy of the commons
  - Global footprint
  - The stark choices
  - Can we achieve sustainability through knowledge

# Will exponential knowledge growth end in a singularity, spike or inflected S curve?



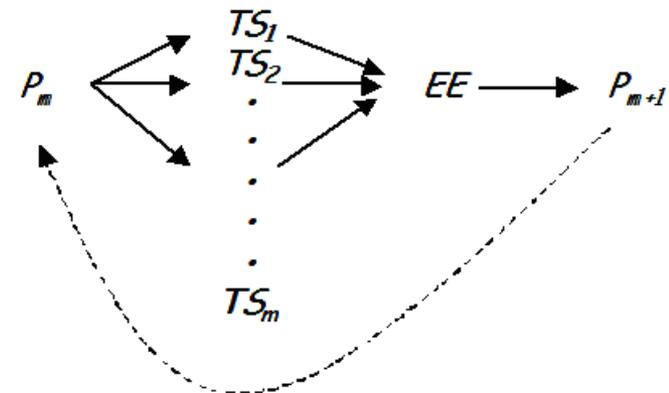


# Co-evolution of knowledge and technologies

# Natural selection, knowledge and power over resources for existence

- Knowledge is solutions to problems of life
- Successful solutions represent power to control the environmental circumstances

- Karl Popper's (1972) general theory of evolution



- Knowledge grows as a consequence of natural selection
  - Genetic knowledge grows by the elimination of failed mutants
  - Individual knowledge grows by the elimination of failed ideas
  - Cultural knowledge grows by sharing successful solutions

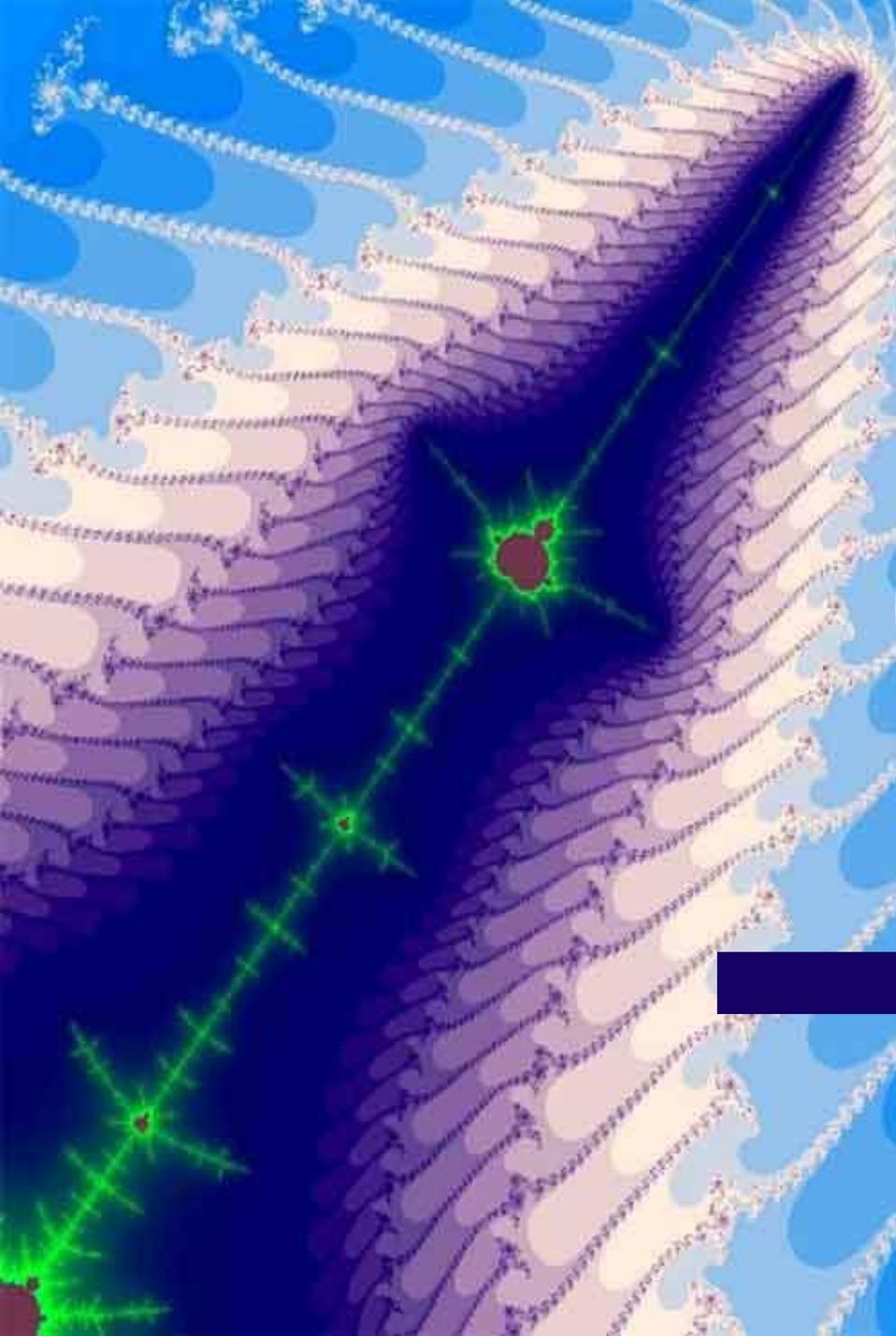
## Time-line for the most fundamental **revolutions** in knowledge storage, processing power and bandwidth

### Physics begets life

- Memory and cognition in living things- **4.5 billion years ago**
- Genetic memory at the molecular level - **4 bn years ago**
  - Add RNA & DNA
- Multicellular memory - **2-1.5 bn years ago**
  - Add dynamic structure in cellular neurons → neural nets → brains
- Group cultural memory - **5 million years ago**
  - Add tacit then linguistic creation, communication & sharing of knowledge
- Codification, storage & transfer of knowledge in and via tangible artefacts, e.g., writing & communication- **5 thousand years ago**
- Virtual memory, communication, cognition at light speed - **50 years ago**
- *Global brain* - **now!**

## Knowledge-based revolutions in material technology cause grade shifts in the ecological nature of the human species

- Accelerating change in our material technologies:
  - > 5,000,000 *years ago* - **Tool Making**: sticks and stone tools plus fire (~ 1 mya) extend human reach, diet and digestion
  - ~ 11,000 *years ago* - **Agricultural Revolution**: Ropes, digging implements and specialized knowledge controls and manages non-human organic metabolism
  - ~ 560 *years ago* **Printing** enables the Reformation & unlimited accumulation of knowledge for the Scientific Revolution
  - ~ 250 *ya* - **Industrial Revolution**: extends/replaces human and animal muscle power with inorganic mechanical power
  - ~ 50 *years ago* - **Microelectronics Revolution**: extends human cognitive capabilities with computers
  - ~ 5 *years ago* - **Cyborg Revolution**: convergence of human and machine cognition with smartphones (today) and neural prosthetics (tomorrow)



**5 million years of  
human history  
concatenates many  
cognitive  
revolutions**



# Where we started: socially foraging, tool-using forest apes in East African Garden of Eden > 5 mya

(click pictures below to view videos)

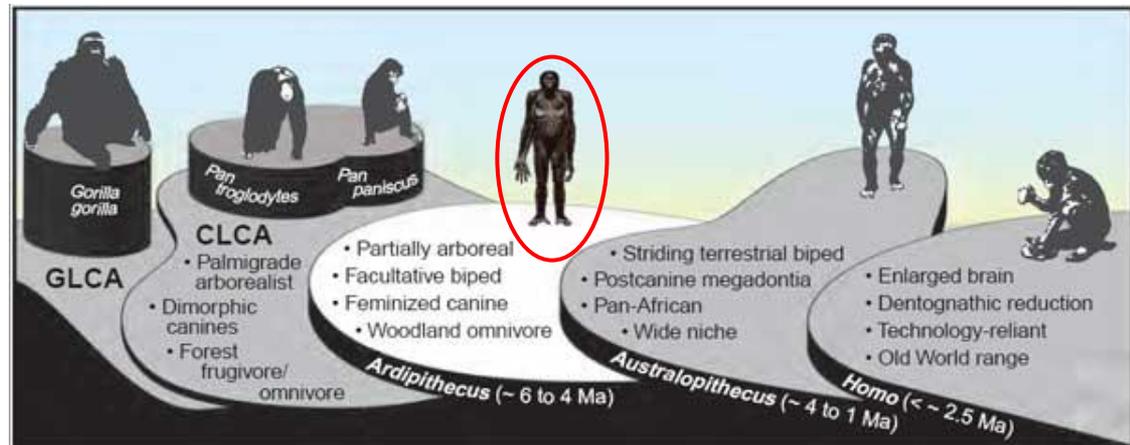


Chimps use probes to collect ants. Probe is inserted almost to full length into earth.



Child watching mother crack otherwise inedible palm nuts using stone hammer & anvil.

Adaptive plateaus achieved in the Pliocene as our ancestors became more bipedal and better adapted to open and arid environments (White et al. 2009)

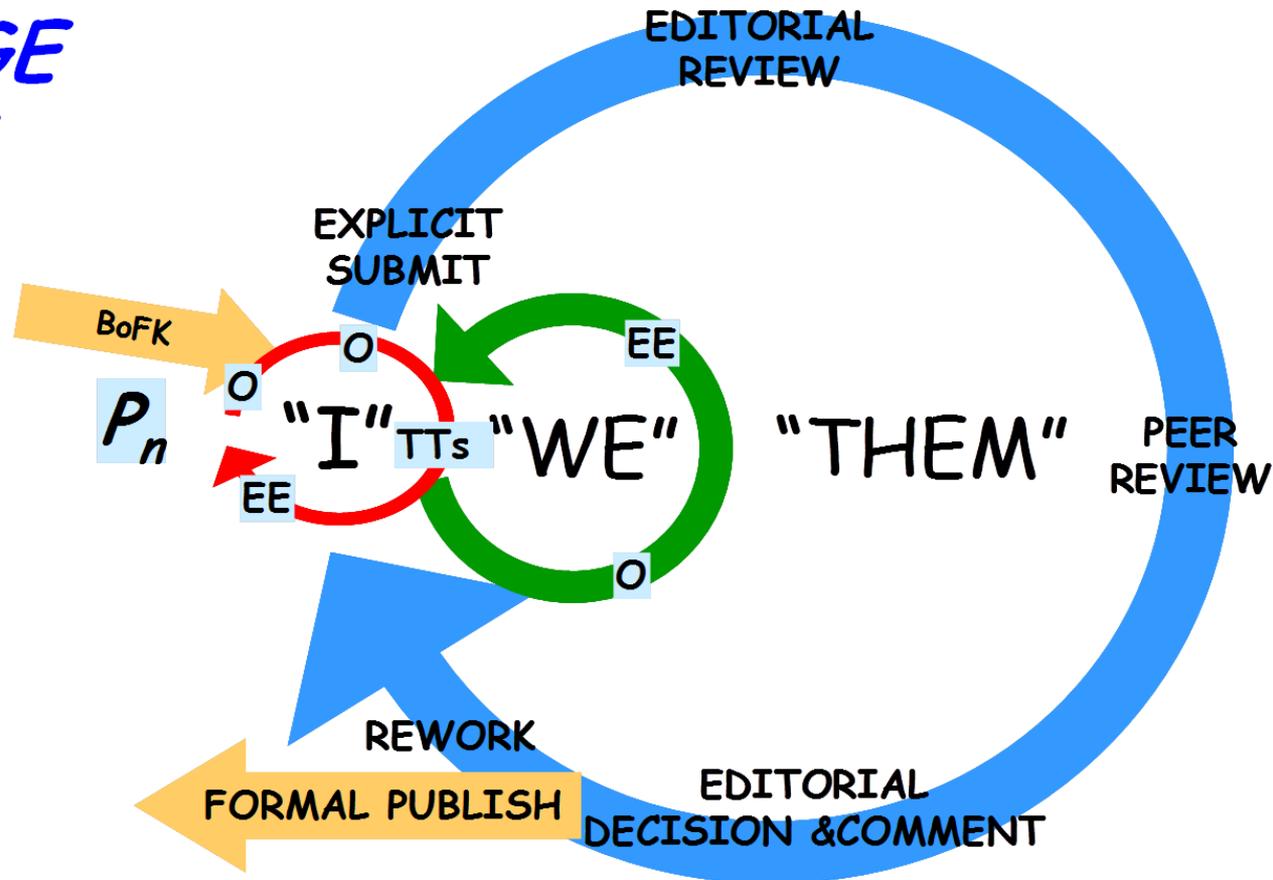


## Grade shifting revolutions in human technologies repeatedly reinvent the nature of & bandwidths for individual cognition

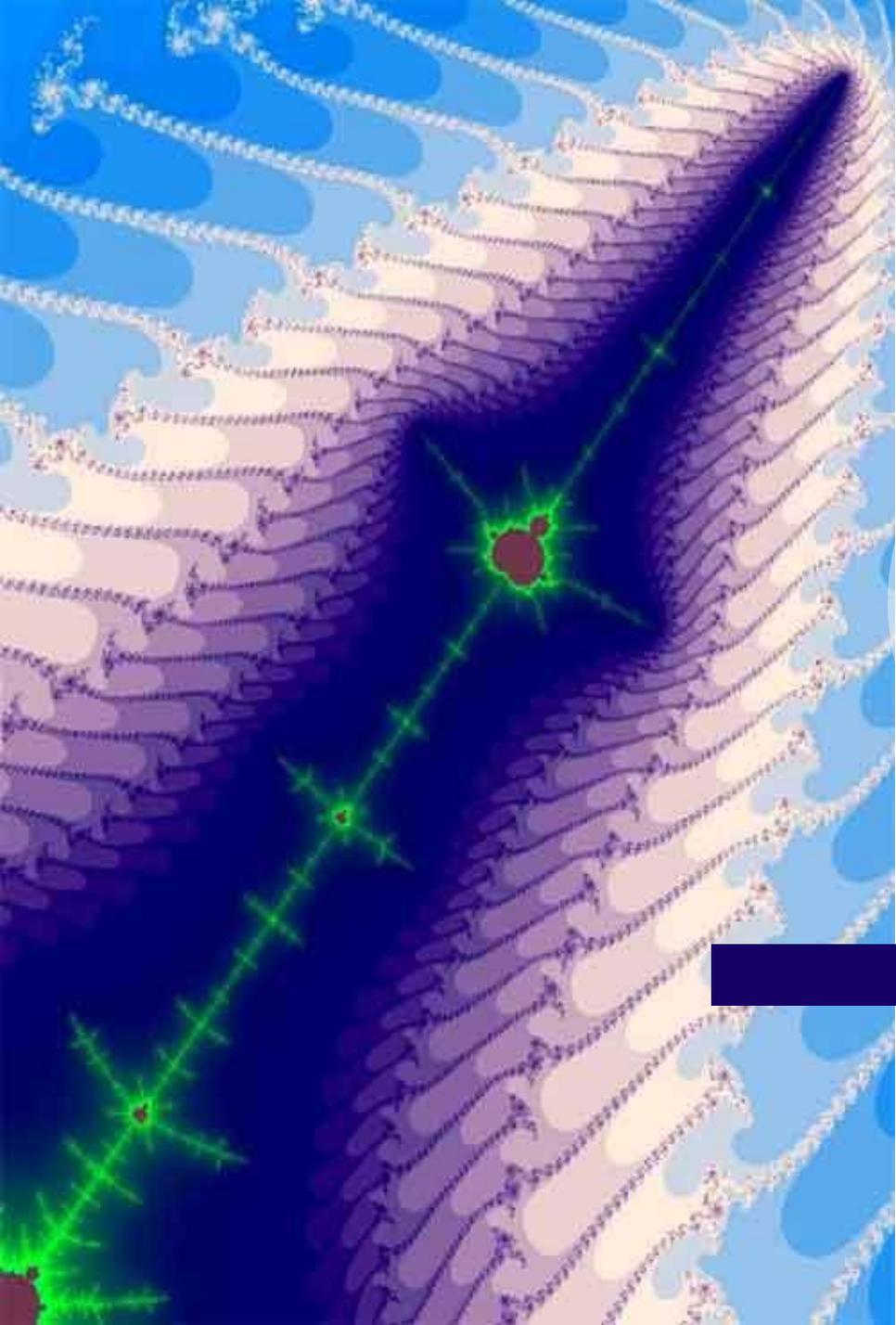
- Accelerating change in extending human cognition
  - > 5,000,000 yrs - Tacit transfer of tool-using/making knowledge adds **cultural inheritance** to genetic inheritance
  - ~ 2,000,000 yrs - Emergence of **speech** speeds direct transfer of cultural knowledge between individuals
  - ~ 11,000 yrs - Invention of **physical counters** (11 K), **writing and reading** (5 K) to record and transmit knowledge external to human memory (technology to store transfer culture)
  - ~ 560 yrs - **printing and universal literacy** transmit knowledge to the masses (cultural use of technology)
  - ~ 65 yrs - **computing** tools actively manage corporate data/knowledge externally to the human brain and personal knowledge (Web browsing - 20 yrs)
  - ~ 10 yrs- **smartphones** merge human and technological cognition (human & technological convergence)
  - ~ Now. Emergence of **human-machine cyborgs** (wearable and implanted technology becoming part of the human body)

# Scientifically constructing formal knowledge to control the world (Hall & Nousala 2010; Vines & Hall 2011)

## KNOWLEDGE SOCIETY



- Formal knowledge is considered "safe to use"

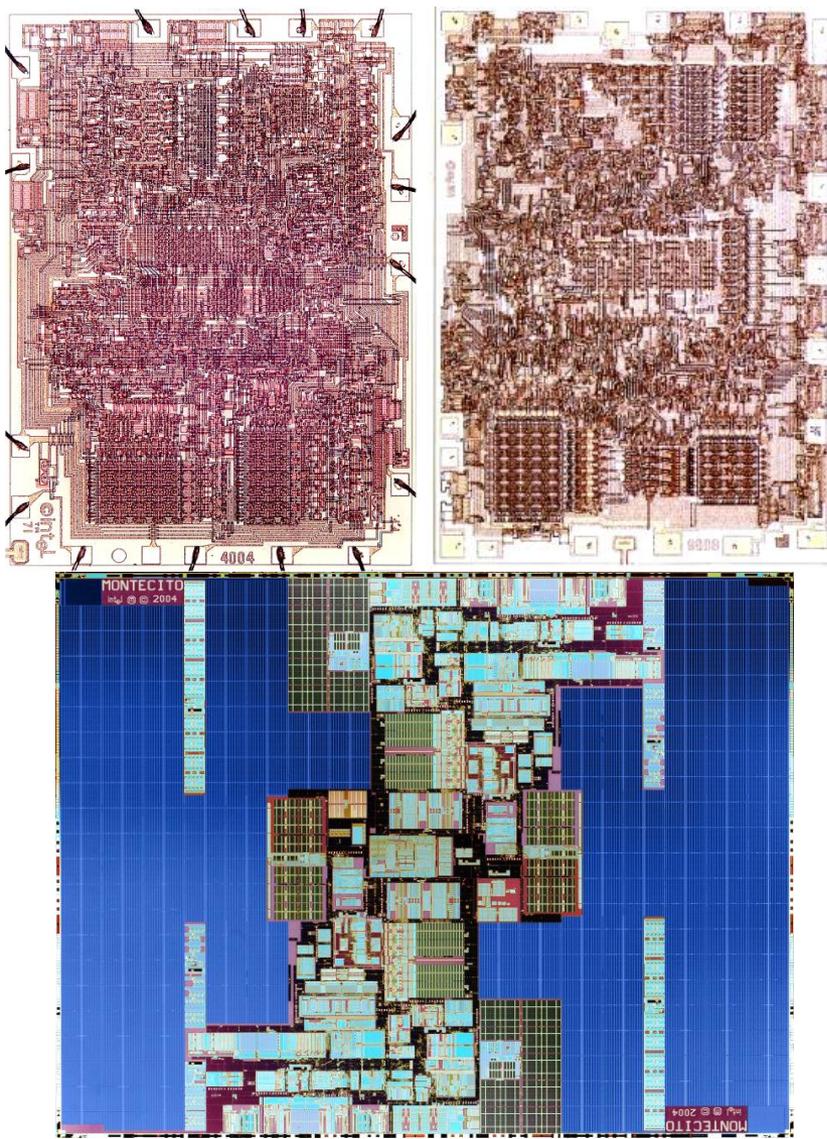


# Exponential growth and Moore's Law

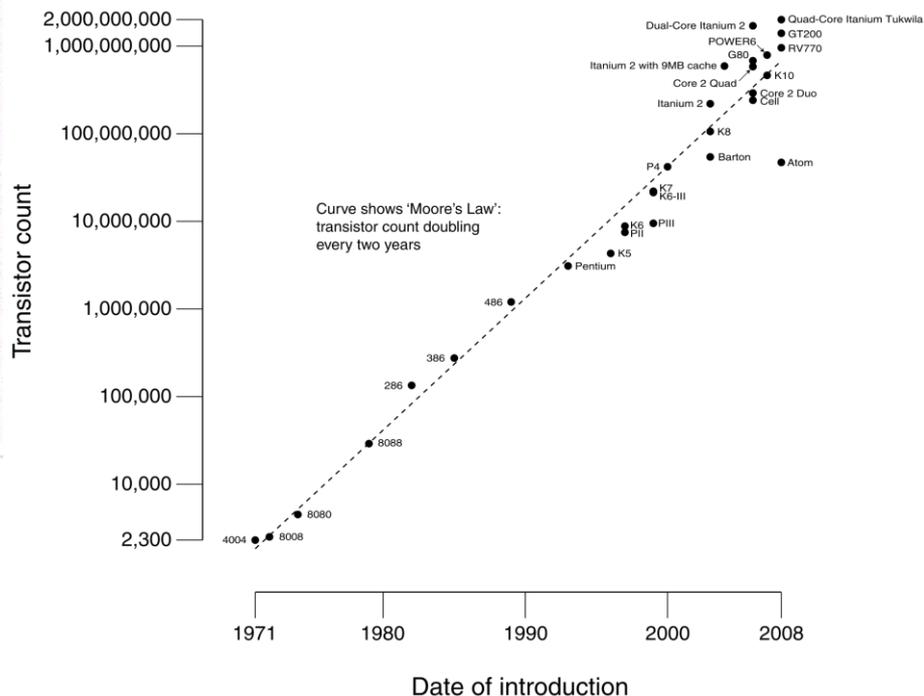
The incredible shrinking of  
time and space



# Large scale integration and Moore's Law

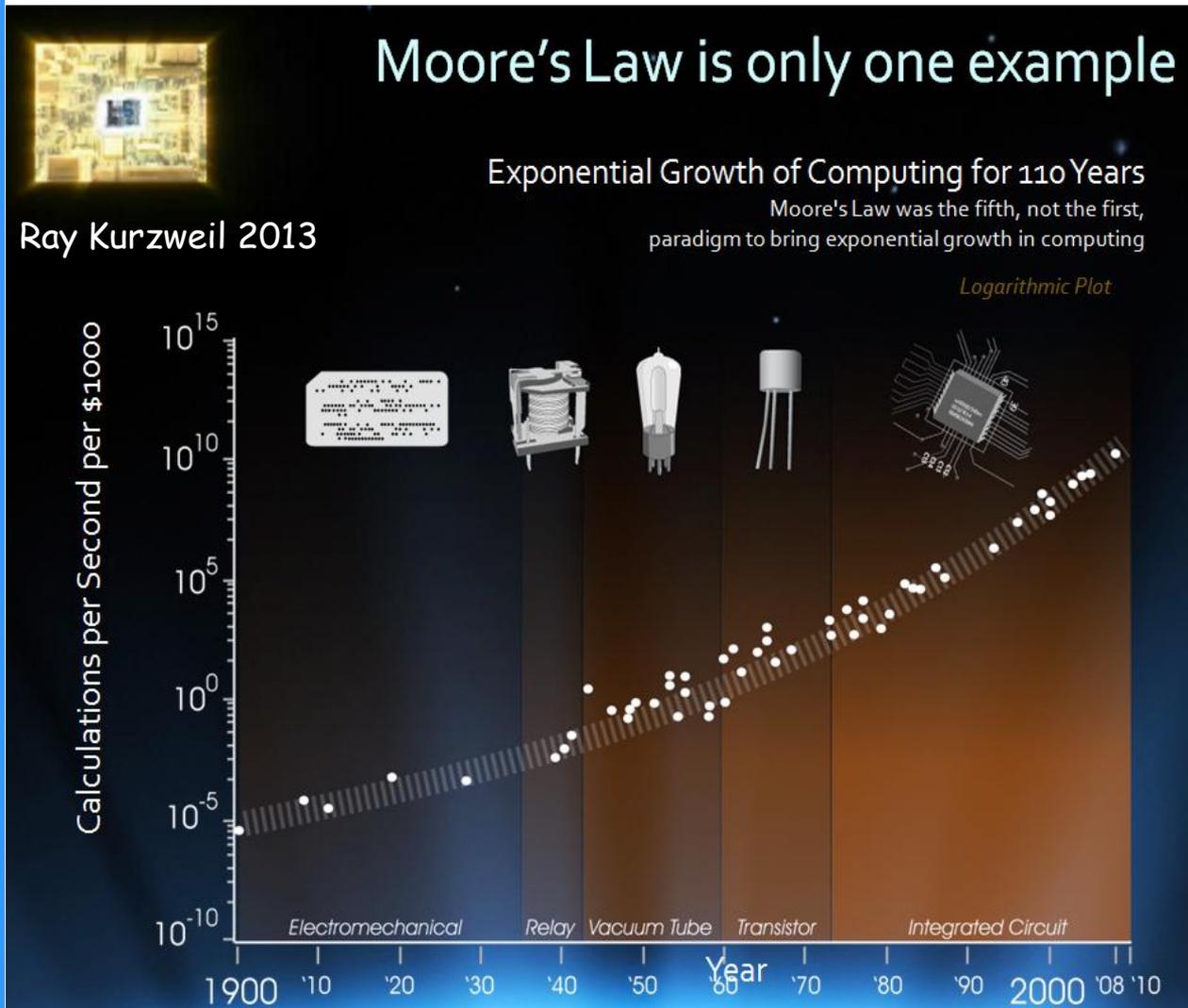


CPU Transistor Counts 1971-2008 & Moore's Law



**Moore's Law as applied to the evolution of microprocessors.** Recent studies show the rate of increase is actually hyper-exponential. Magnetic storage density doubles even faster, as does total processing power. Chips are 4004 (2300 transistors, 1971), 8008 (3500 transistors - 1972), and Dual-Core Intel® Itanium® Processor (1.3 BN transistors - 2006)

# Hyperexponential growth in computing technology



- Beyond flat IC's
  - 3D IC's
    - Heat management
  - Biomolecular (e.g., DNA)
    - Speed
    - Transduction
    - Interface
  - Quantum
    - Heat management

# The Microelectronics Revolution and the increasing externalization and convergence of individual and social cognition

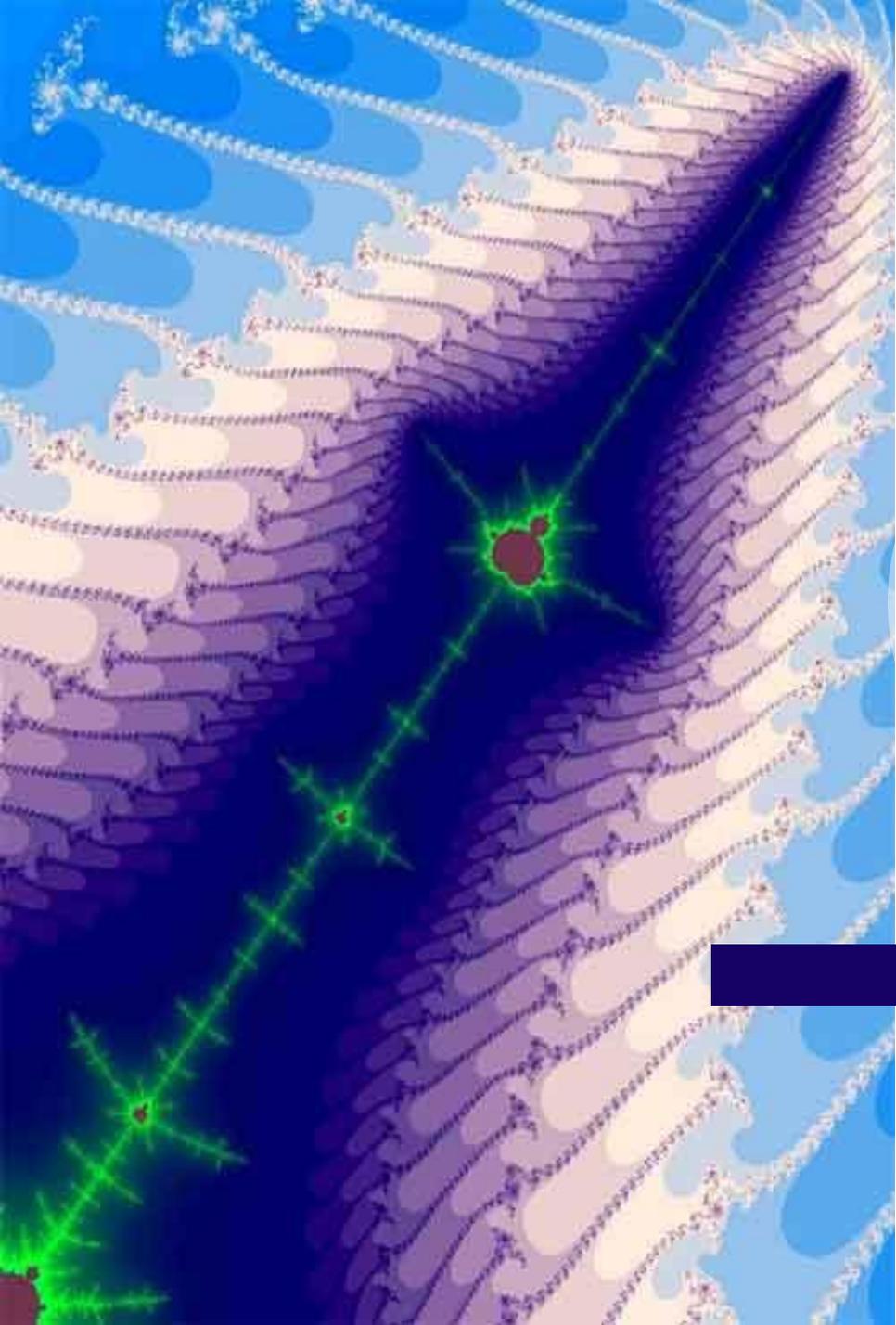
## ----- Externalizing cognition -----

- ~ 150 Y mechanical and electro/mechanical technologies for corporate/scientific number crunching & data processing
- ~ 65 Y birth of electronic digital processing
- ~ 44 Y invention of integrated circuit microprocessors and automatic fabrication
  - **Moore's Law & the still continuing hyperexponential growth of processing power**
  - Extending and replacing more and more human cognition
- ~ 36 Y automated processing, storage, distribution and retrieval of personal and corporate knowledge. (Wordstar 1979)
- ~ 23 Y networking knowledge with the World Wide Web (Tim Berners-Lee 1992)

## ----- Universal access to the world knowledge base -----

- ~ 21 Y Mosaic Netscape Navigator 1994
- ~ 17 Y free open-source browsers Mozilla Firefox 1998
- ~ 15 Y one billion web pages indexed, more than two billion by end of 2000
  - Last decade provides instant web search, access & retrieval of virtually the entire scientific & technical literature via Google Scholar/research library subscriptions
  - Majority of all English language book titles scanned, indexed, and available (if out of copyright), with smaller fractions non-English books processed.

## ----- Networking brains directly - towards a global brain/mind? -----



**Emergence of the  
networked  
post-human cyborg  
still driven by  
natural selection**



# Interconnecting minds and cognitive processes via the cloud “social computing” and convergent technology

## ● Technological convergence - mobile phone becomes a cognitive prosthesis

- **Email:** ARPANET (1971), TCP/IP (1982), SMS text (2002), Gmail (2005)
- **Internet browsing & Search:** MOSAIC/Netscape (1994), Google (1997)
- **Internet telephony:** Voice over IP (1994), Skype (2003)
- **Media:** iTunes (2000), Amazon Kindle (2007), Google Play (2008)
- **Still and video imaging:** Picassa/iPhoto (2002); YouTube (2005);
- **Cloud storage:** Napster (1999), BitTorrent (2001), Amazon S3 (2006), DropBox (2008)
- **Business/Office tools:** Google Docs/Drive (2007)
- **Geospatial:** Google Earth/Maps 2005; Panoramio (**geolocated photos converging with Google Earth/Google Maps** - 2005)
- **Social:** chat rooms (1980); Groups/Listservers (1992), LinkedIn (2003), Facebook (2004), Twitter (2006)
- **Knowledge construction/sharing/broadcasting:** Wikis (1994), Wikipedia (2002), Blogs/Wordpress (2003)



## ● Human-computer interfacing

- Head-mounted displays (1960's)
- Google Project Glass (2013)
- Networked SmartWatches (2014)

## ● Implanted/emodied human-machine interfaces

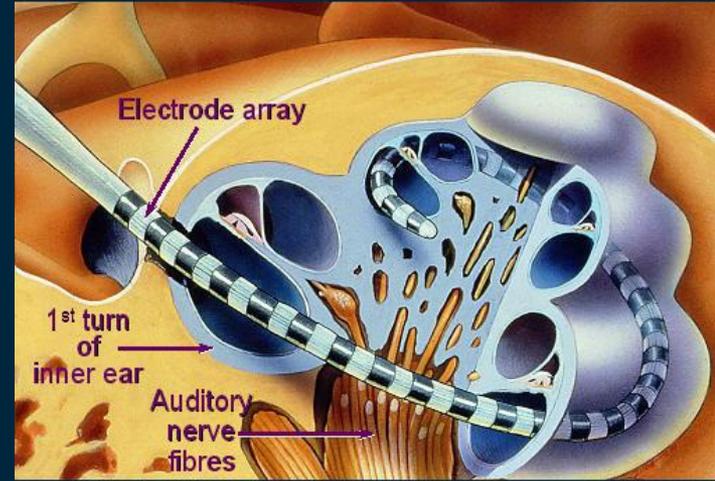
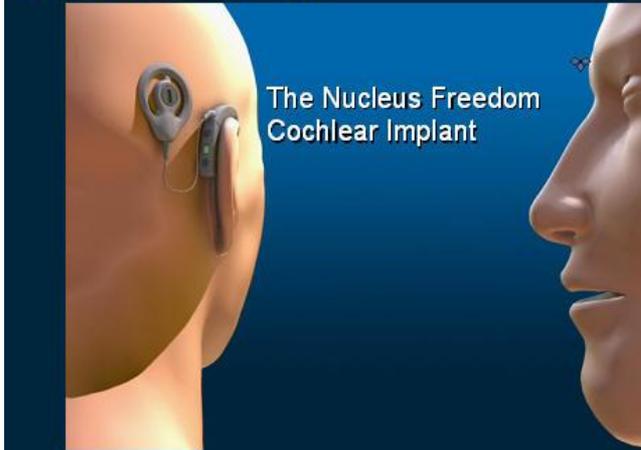
- Cochlear implants/Bionic Ears
- Retinal implants/Bionic Eyes
- Direct brain reading and stimulation



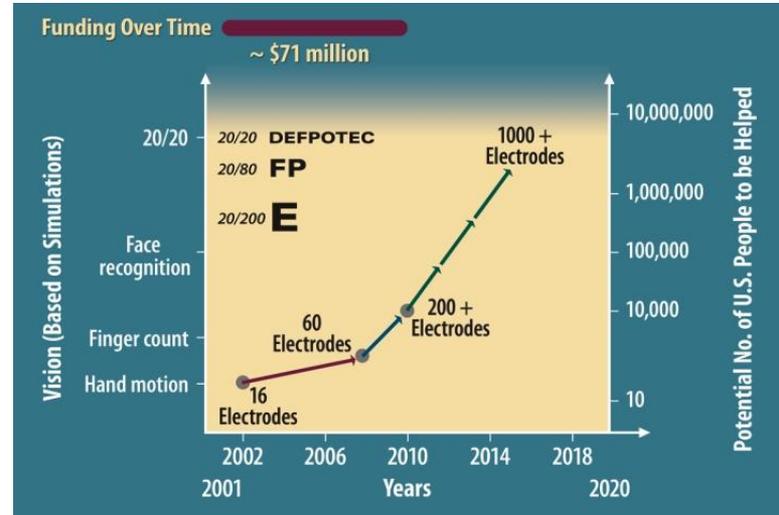
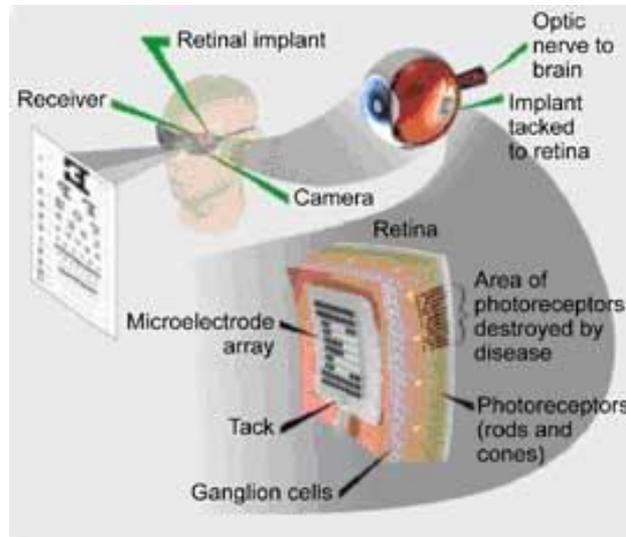
# Sensory integration: Count on Moore's Law to drive the price down

Direct stimulation of the cochlea (Graeme Clark Foundation, How the cochlear implant (bionic ear) functions.)

The Nucleus Cochlear Implant for Children and Adults



Direct stimulation of the retina (Bionic Eye. DOE Artificial Retina Project)

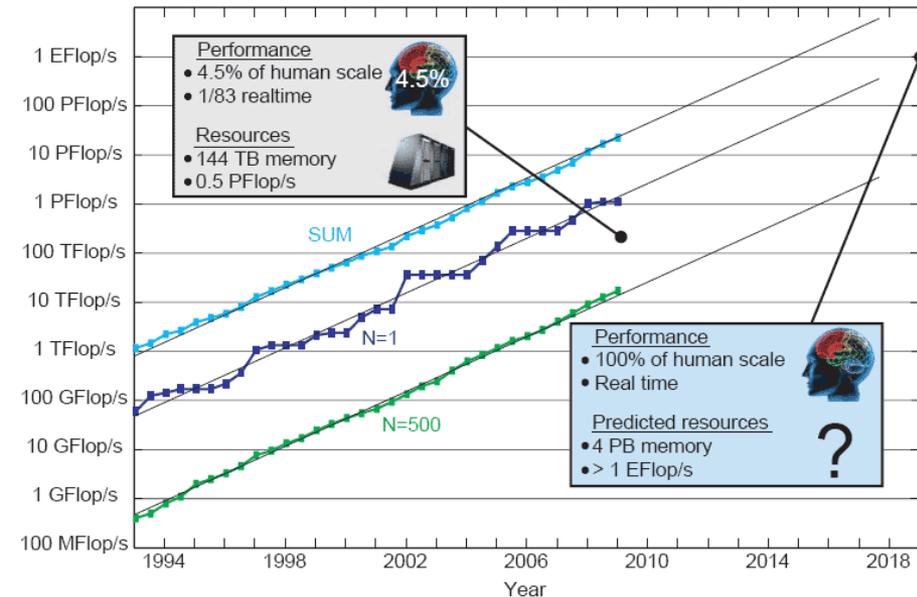


# Brain simulation and emulation

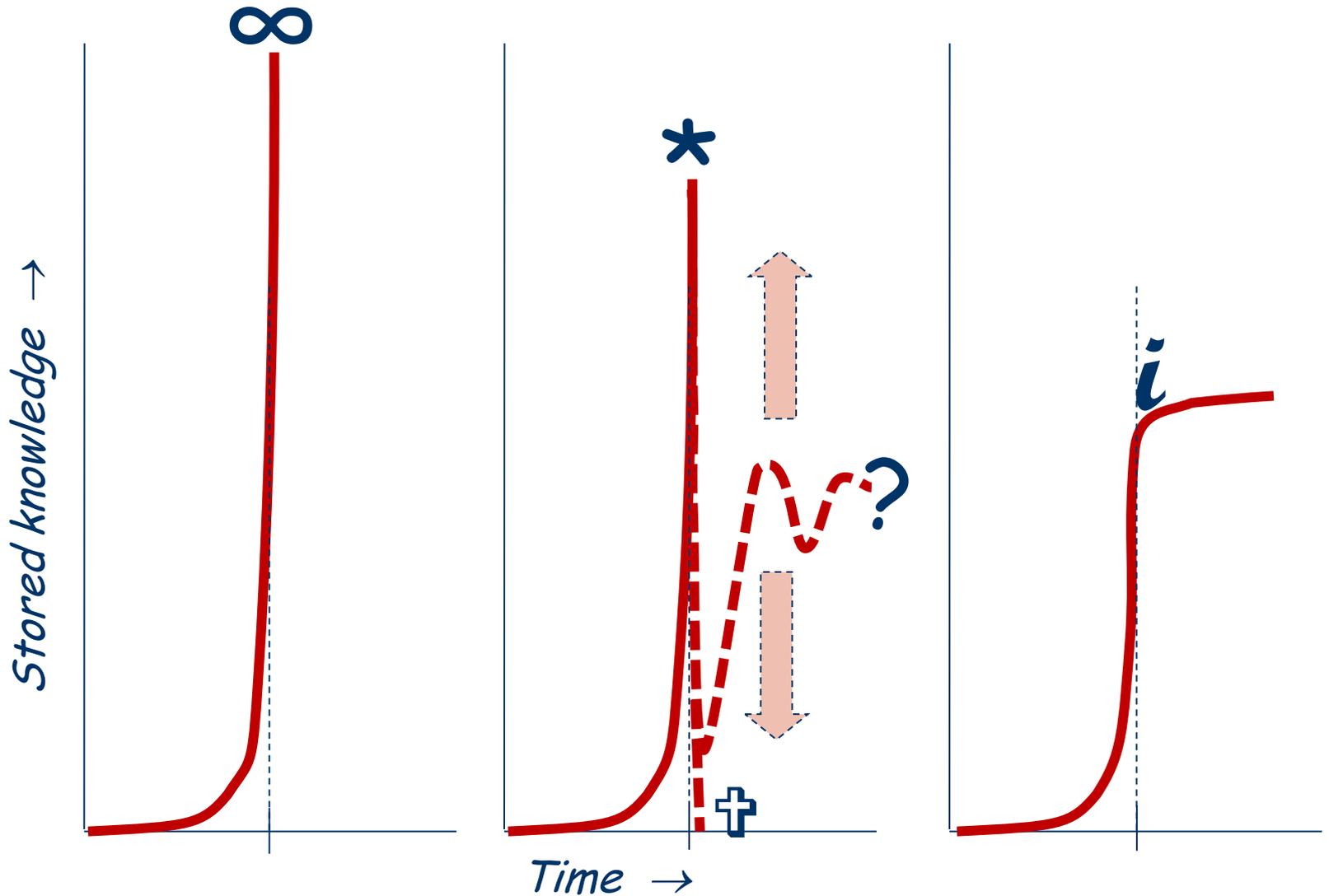
## Blue Brain Project / Human Brain Project

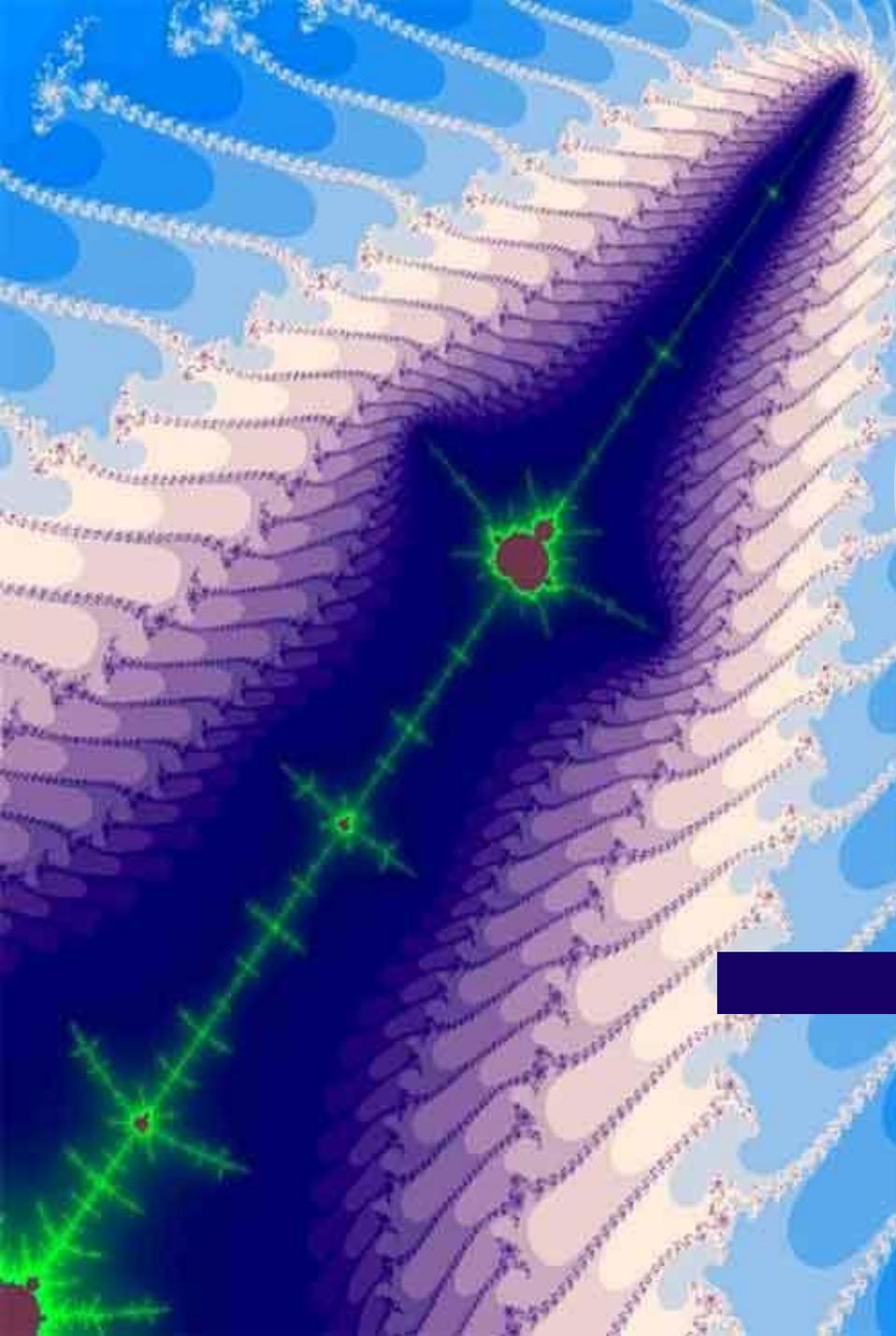


- Human Connectome Project
  - US NIH funded 2010-2015
  - Map of neural connections in the brain
  - Broadly, a connectome includes mapping of all neural connections in an organism's nervous system
- Simulation & emulation
  - Modelling of synapses & neurons
  - Neurons on chips (Moore's Law)
  - EU Blue Brain/Human Brain Projects
    - Single cell: 2005
    - Neocortical column: 2008 - 10,000 cells
    - Mesocircuit: 2011 - 100 columns
    - Rodent brain: ~2014 - 100 mesocircuits
    - Human brain: ~2023 - 1000 x rodent brains



# Will knowledge growth end in a singularity, spike or inflected S curve?





**Physics trumps  
belief  
The physical world  
won't go away  
because we don't like  
it**

Papers elaborating the ideas can be found on  
<http://www.orgs-evolution-knowledge.net>.

For working drafts and extracts see  
[https://www.dropbox.com/sh/odx80z06k1bsb  
b4/AADrCRISdqv8ivBPKPov8oHwa](https://www.dropbox.com/sh/odx80z06k1bsb/b4/AADrCRISdqv8ivBPKPov8oHwa)

# One world with finite resources

- Natural selection favours the evolution of ever more power



# Physics trumps belief

## The physical won't go away because we don't like it

- "The tragedy of the commons"

Garrett Hardin 1968. The tragedy of the commons. *Science* Vol. 162, No 3859, pp. 1243-1248

- Sets out the consequences of an uncompromising economic logic governing the harvesting of valuable but limited resources from a commons

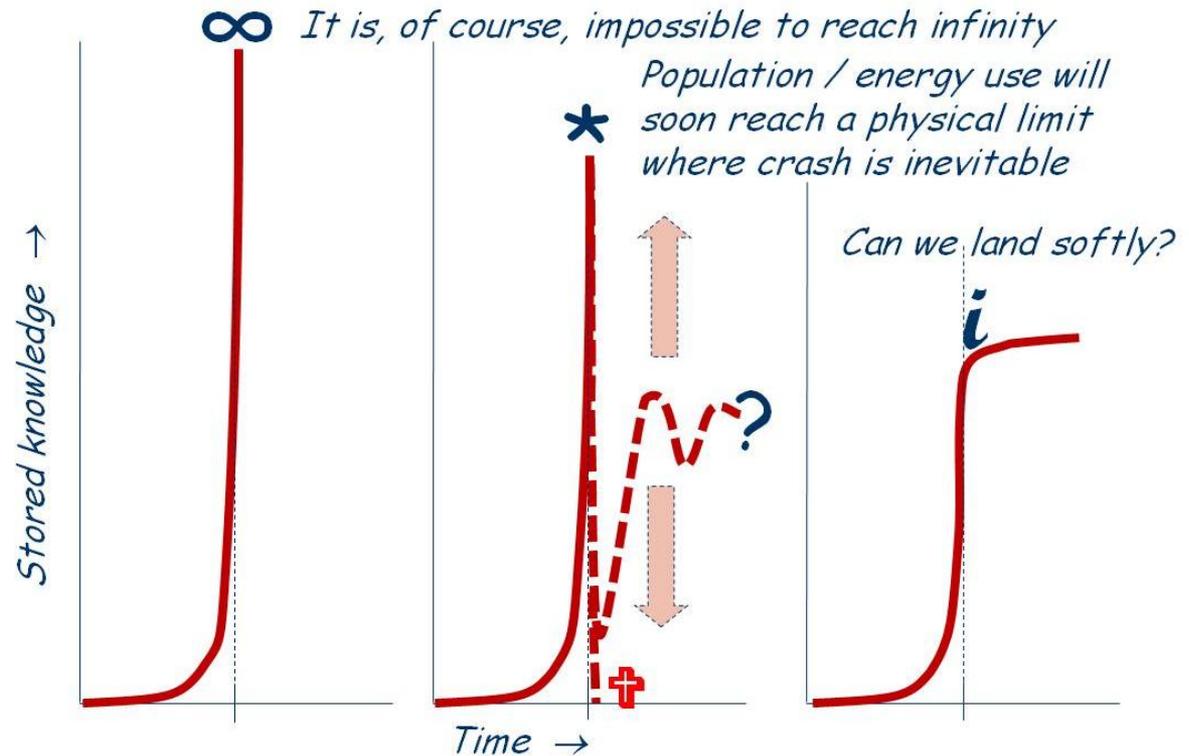
- Unfettered individuals make a net profit of **+1** for every unit of resource they extract/harvest and use
- The future loss due to the removal of that unit is shared with all other individuals extracting the resource for a net loss of **-1/n**
- *It is always to the net economic advantage of every individual to continue extracting the resource until it is totally consumed*
- *Situation grows worse if the resource's unit value rises with scarcity*
- *Any individual refraining from extraction only benefits those who thus have more resource to extract*
- **Only through some form of higher level control or governance (e.g., social or despotic) over the scarce resource can its extraction be limited to some socially beneficial level**

# Global footprint

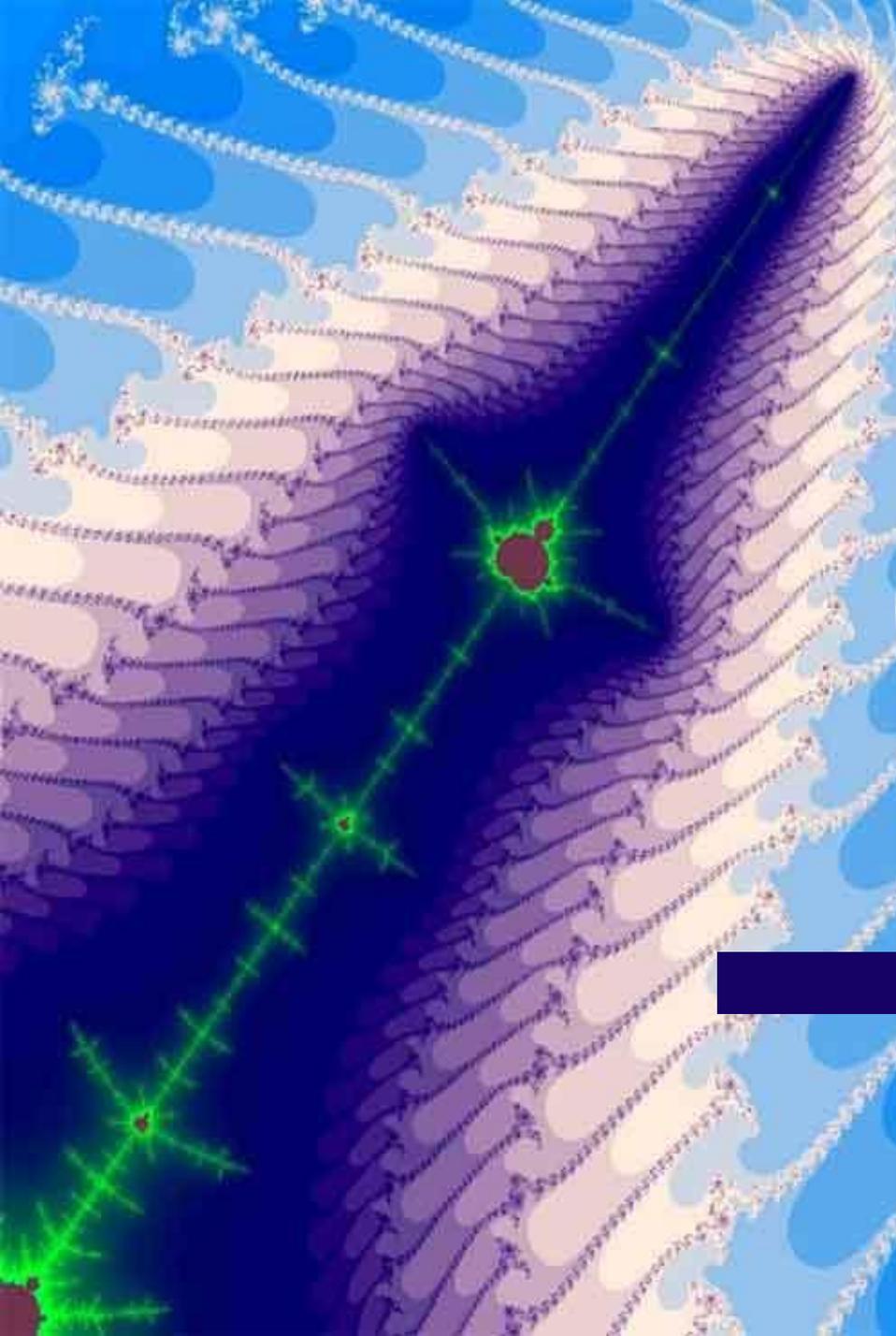
- Humanity's growing population and affluence has already exceeded the "carrying capacity" of our planet.
- In 2007 the Global Footprint Network estimated that "humanity uses the equivalent of 1.5 planets to provide the resources we consume and absorb our waste", or around  $1\frac{1}{2}$  years to replace one year's biological resources we use and absorb our waste.
- This does not include:
  - Depletion of critical non-renewable resources for our technologies such as oil, rare elements, etc.
  - Unsustainable use of fertile soil and fresh water
  - Collapse of world fisheries
  - Human induced global warming and climate change leading to ocean acidification, rising sea levels and inundation of prime agricultural lowlands.
  - the impacts our footprint has on other, potentially keystone, species maintaining ecosystem health
- Rising extinction rates suggests we are teetering on the edge of ecological collapse

# Stark choices

## Physics trumps belief and faith



- Can we become sustainable by substantially reducing our populations and use of resources?
- Can we transfer our cultural heredity to the solidstate and become interstellar



**THE END**

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