Session 23: Coda — The sting in the tail

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Tonight is our last for this series!

- Last time I finished Episode 5 by considering how the printing revolution again fundamentally changed the structure of society.
  - **In my own lifetime** I have lived through three major technological revolutions, i.e., microelectronics, the Internet Revolution, and social networking. These are driving cognitive and cultural revolutions at least as profound as those of formal mnemonics, writing, and printing.
  - Mass printing and near universal literacy removed many controls over access to technical knowledge, enabling the Reformation and the Scientific and Industrial Revolutions.
  - Printing & literacy also set the stage for today's situation of knowledge detonations and hyper-exponential technological change
- In this session will attempt to project the consequences of these detonating changes change into the future to consider its likely consequences over the next few decades and for humanity's evolution.
  - I hope you read Charles Stross's downloadable Sci-Fi book, Accelerando
  - Limits to growth are ecological, thermodynamic, and are very, very real
  - Exponential growth of knowledge and technology cannot continue for long
    - **Singularity** - leading to some form of "sublimation" (Ian M. Banks' Culture Sci-Fi)
    - **Spike** – demographic/ecological catastrophe leading to extreme die-off (J Diamond)
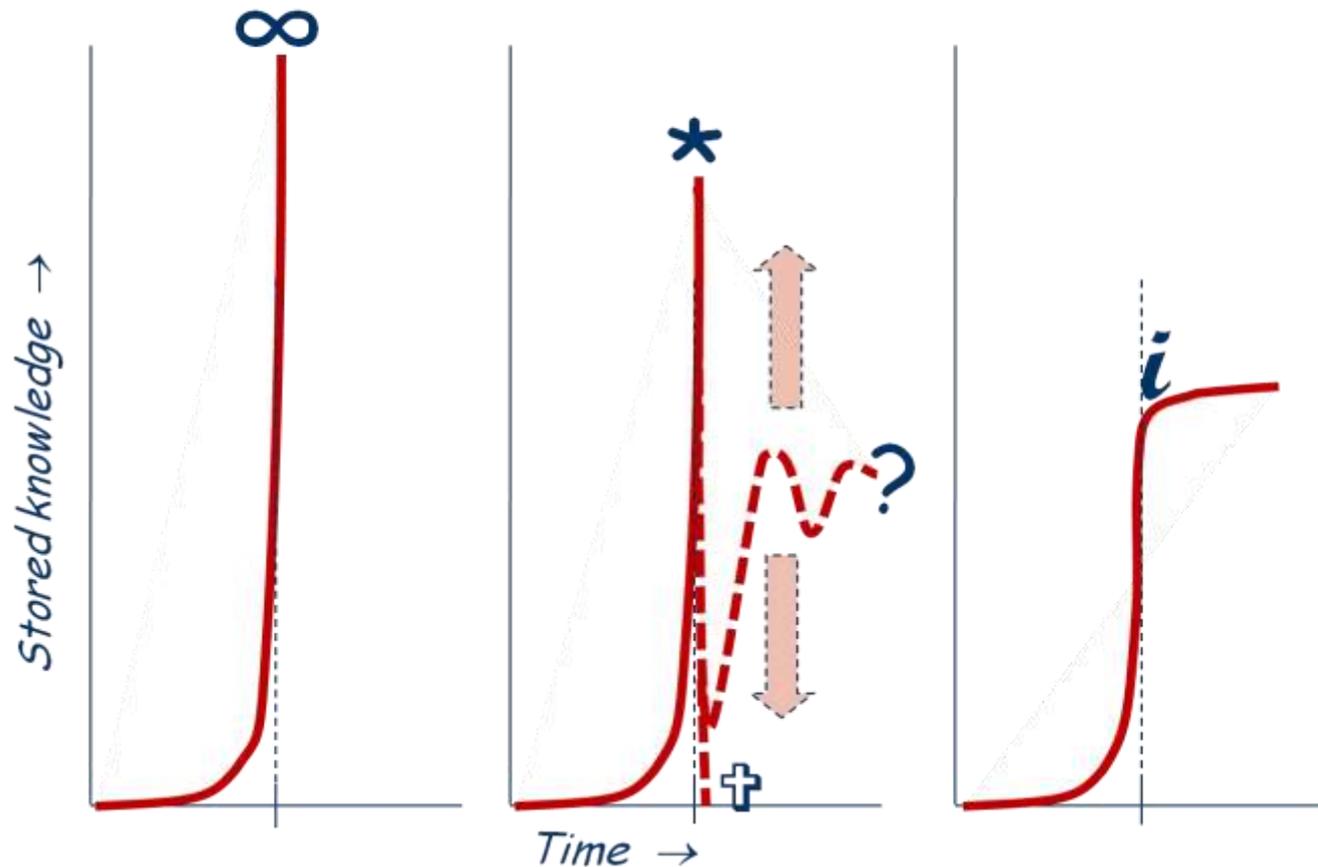   - **Inflection** – decreasing rate of change as humans learn to live sustainably on our one planet (Polyanna?)
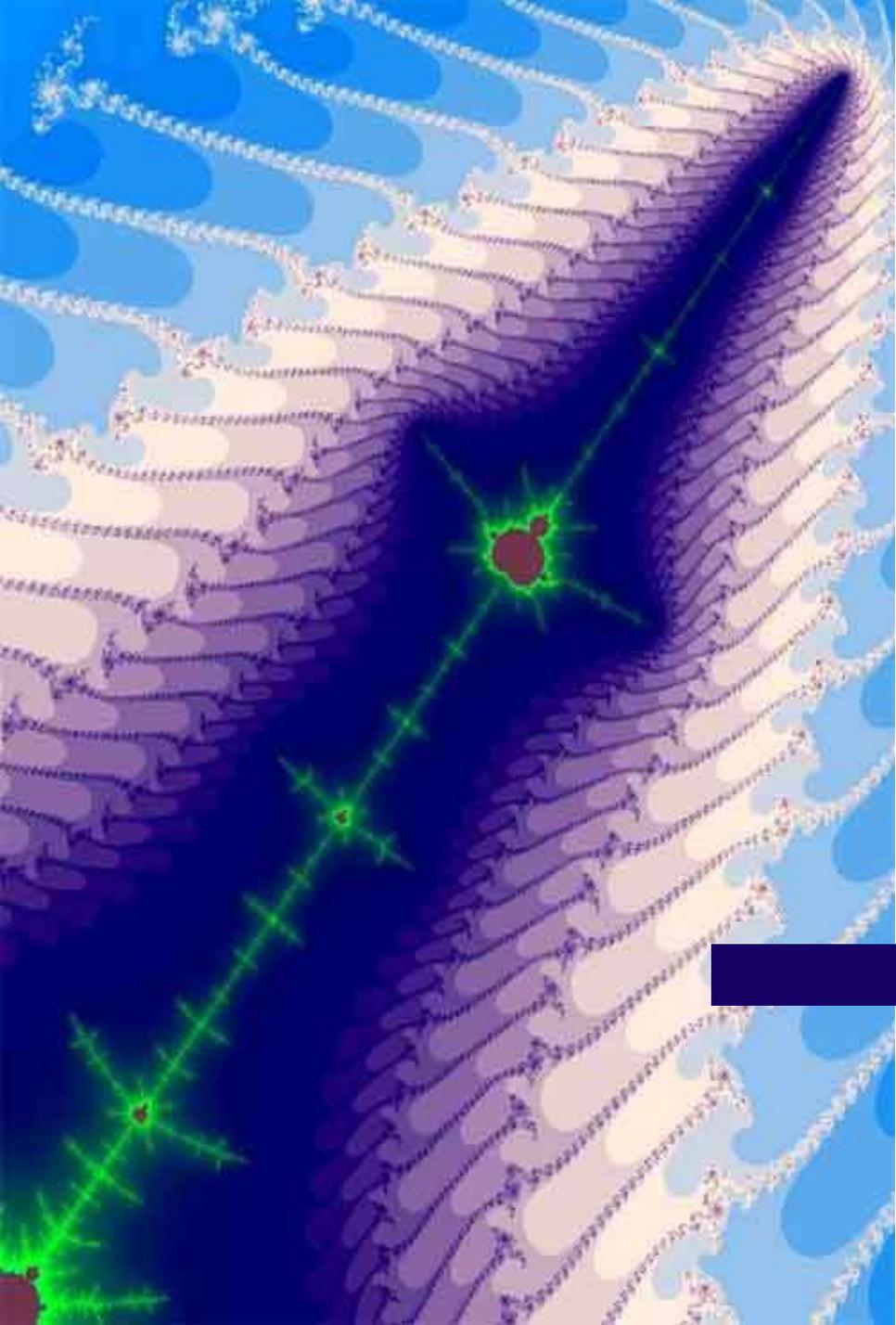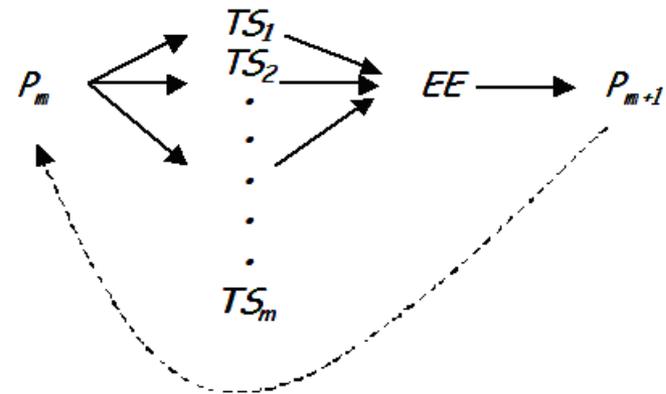
Some key themes

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

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Natural selection, knowledge growth and power over resources for existence

- Knowledge is solutions to problems of life
- Many cultural solutions apply technological developments
- Successful solutions represent power to control environmental circumstances

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

- Knowledge and technological power grow as a consequence of selection working on "heritable" variations to remove failures
  - Genetic knowledge grows by eliminating failed mutants/genes
  - Individual knowledge grows by eliminating failed ideas
  - Cultural knowledge grows by eliminating bad solutions/memes
  - Explicit knowledge can accumulate to grow exponentially

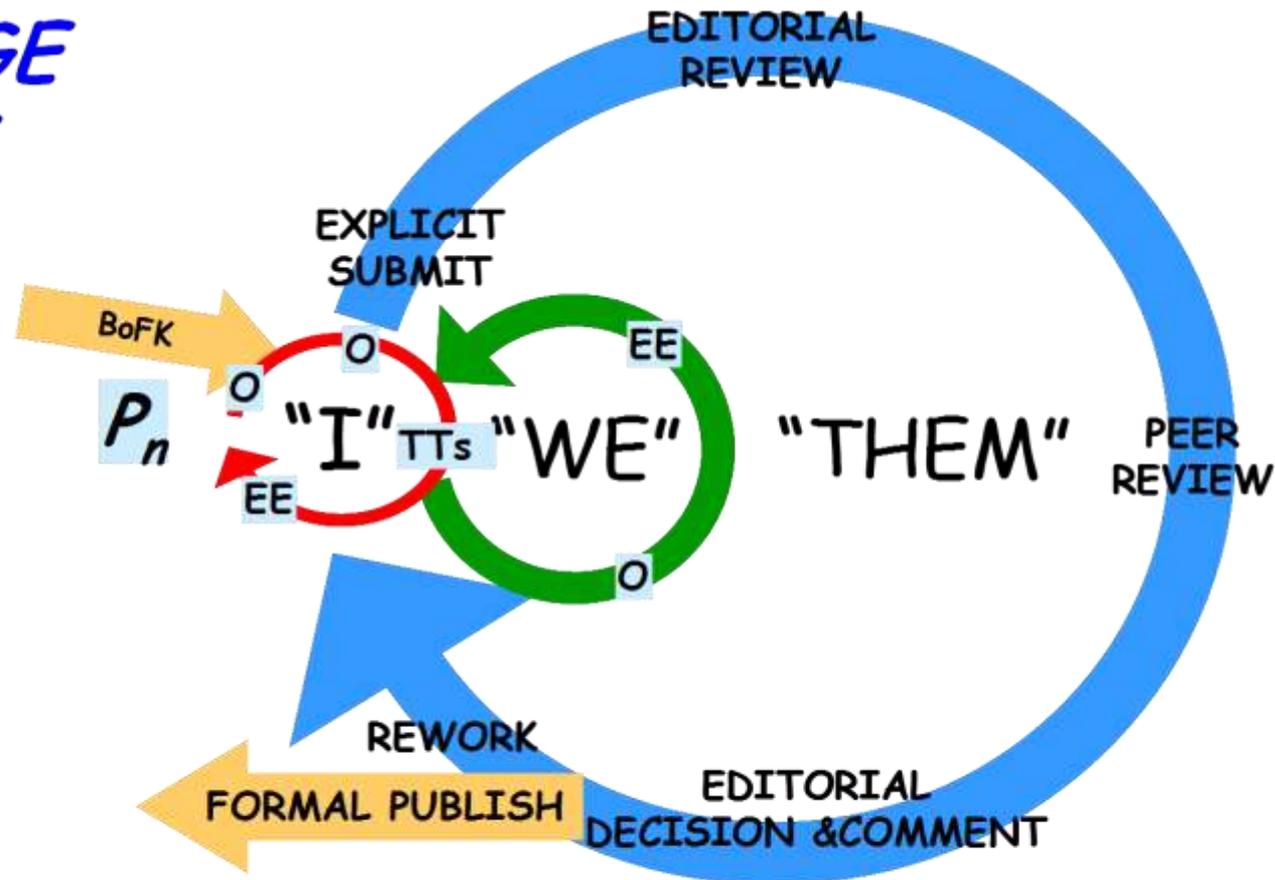# Relations among knowledge storage, technology, and cognition

- Interactions, feedback and co-evolution among fundamental revolutions in knowledge storage, technology and cognition
- **Timeline**
  - **Physics begets life**
    - **Replication**
  - Life begins to build a history of structure – **3.8 billion years ago**
    - **RNA & DNA**
  - Genetic knowledge stored at the molecular level – **3.5 bya**
    - **Dynamic structure in cellular neurons ➔ neural nets ➔ brains**
  - Living knowledge & memory stored in neurons – **2-1.5 bya**
    - **Tacit knowledge transfer ➔ linguistic creation & sharing**
  - Group knowledge stored in living cultural heritage – **5 mya**
    - **Writing & libraries ➔ printing & communication**
  - Codification, storage & transfer of objective knowledge – **5 kya**
    - Electronic processing, storage & transfer
  - Virtual memory, communication, cognition at light speed – **50 ya**
    - **Web & cloud storage**
  - *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 used to control and manage 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
    - ~ 55 years ago - **Microelectronics Revolution**: extends human cognitive capabilities with microelectronic processors
    - ~ 5 *years ago* - **Cyborg Revolution**: convergence of human and machine cognition with smartphones (today) and neural prosthetics (tomorrow)
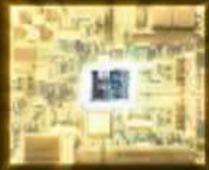
KNOWLEDGE SOCIETY

EDITORIAL REVIEW

EXPLICIT SUBMIT

BoFK

P_n "I" TTs "WE" "THEM"

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PEER REVIEW

REWORK
FORMAL PUBLISH

EDITORIAL DECISION &COMMENT

• Formal knowledge is considered "safe to use"

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Hyperexponential growth in computing technology

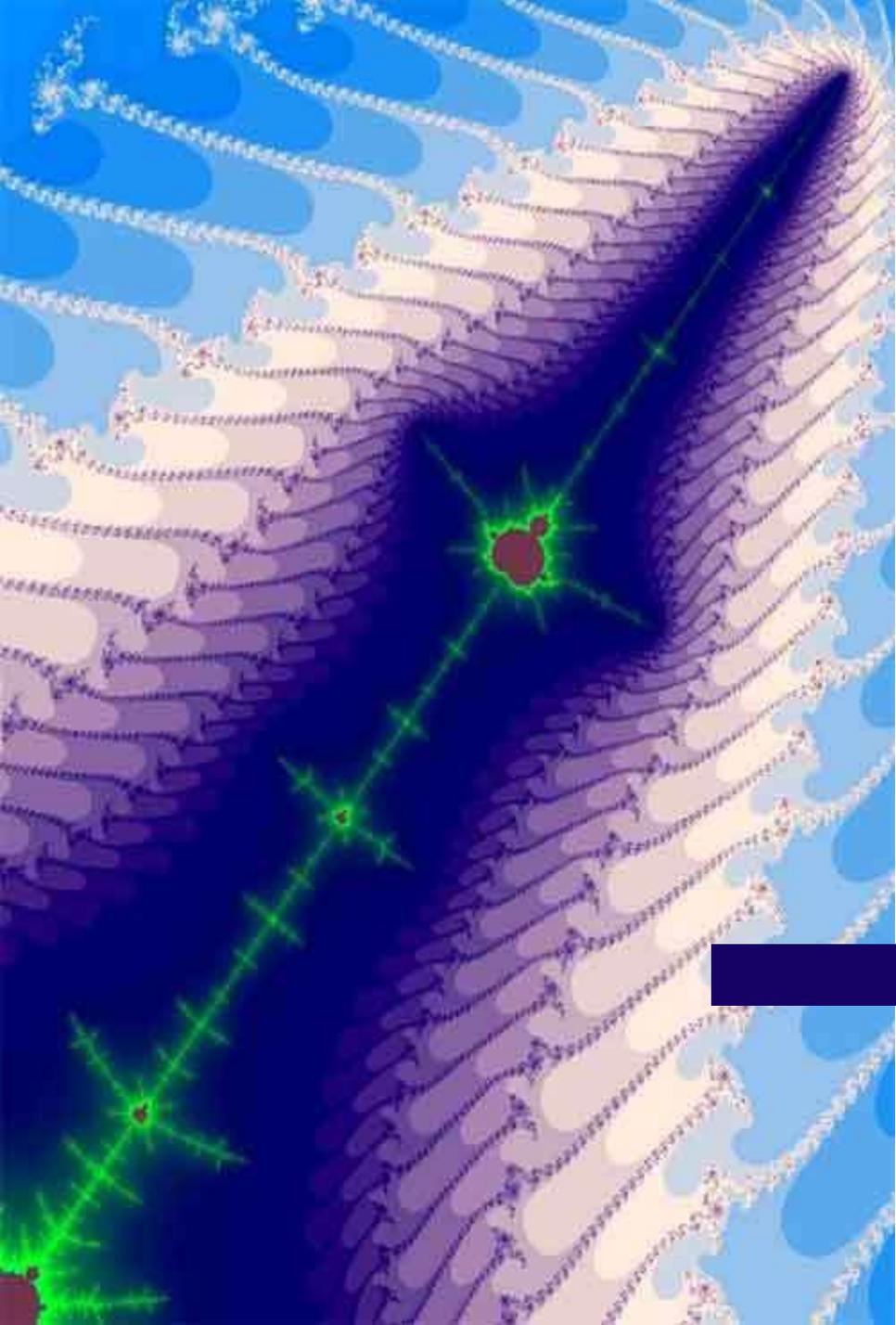

Moore's Law is only one example

Exponential Growth of Computing for 110 Years
Moore's Law was the fifth, not the first,
paradigm to bring exponential growth in computing

Logarithmic Plot

Ray Kurzweil 2013

20 orders of magnitude!
Where is it taking us?

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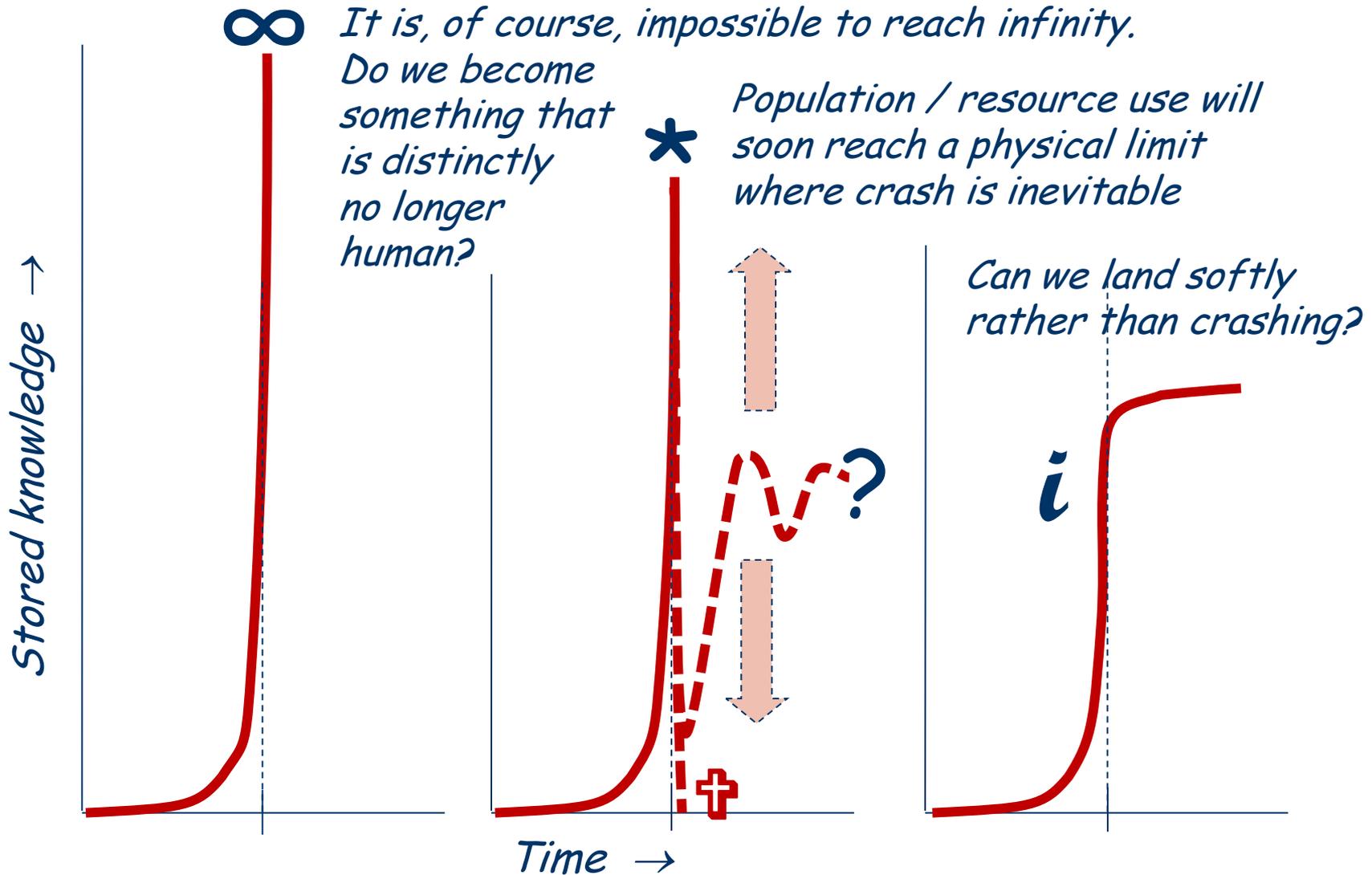   - Heat management

Singularity
—
Concept

Conceivable post-human phase changes

Does Stross explain the Fermi Paradox or why no one is out there?

∞ *It is, of course, impossible to reach infinity.*

Do we become something that is distinctly no longer human?

Population / resource use will soon reach a physical limit where crash is inevitable

*

Can we land softly rather than crashing?

~ ?

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Stored knowledge →

**Time →**

Different kinds of "Singularity"

- **Maths**: a point where a given mathematical object is not defined, e.g. a point where the solution of an equation becomes infinite or is discontinuous
- **Technology**: the hypothetical advent of artificial general intelligence (also known as "strong AI").
  - Such a computer, computer network, or robot would theoretically be capable of recursive self-improvement (redesigning itself), or of designing and building computers or robots better than itself.
  - Repetitions of this cycle would likely result in an exponential runaway effect beyond anything we have seen to date (e.g., an accelerando)
  - Such an AI would be beyond human control
- "**Sublimation**": transformation into/replacement by something no longer recognizably human, e.g., strong AI or "upload"
- "**Spike**": exponential increase in human population overwhelming resource base, followed by a crash or dieoff
- "**Inflection**": a point on a curve at which the curve changes from being concave (concave upward) to convex (concave downward)

Conceivable technological singularities

- Upload into biomechanical sensor/effector systems (i.e., machines) with solid-state cognitive processors
  - No reason to expect the machines would be remotely anthropoid
  - Conceivably much more efficient cognitive processing than messy tangles of neurons, axons, & dendrites (i.e., Accelerando scenario)
  - Would be essentially immortal, thus able to cross interstellar space
  - Not difficult to extrapolate from today's technologies
- Upload into virtual reality
  - E.g., Greg Egan's 1994 Permutation City and 1997 Diaspora
  - The difficulty here is how will disembodied minds maintain the computational substrate for this virtual reality
- Replacement/extermination by runaway AIs with or without preserving and building on human cultural heritage
  - Possibility all too real
- Global/hive mind
  - Networked minds will essentially be telepathic – able to propagate memes at light speed
  - How to manage sensors and effectors?

Transubstantial uploading, the solid state, and interstellar travel

- An easy path, assuming human civilization doesn't collapse first
  - Exponential growth in knowledge and technology
    - The human brain
    - Cognitive processes
    - Nature of life itself
  - Solid state microelectronics: fast, robust, durable, essentially immortal
    - Orders of magnitude faster processing than neurons
    - Neuromorphic processors use minimal energy (compared to diodes)
    - Replication to provide redundancy against radiation damage
    - Capacity for inert storage
    - Can be put into zero energy stasis with no loss of memory
- Immortality offers access to the universe in slow time for anyone achieving the necessary technological grade
  - Capacity for xponential replication & spread
- The Drake Equation and the Fermi Paradox
  - Where is everyone???? – Did Stross provide a powerful explanation?
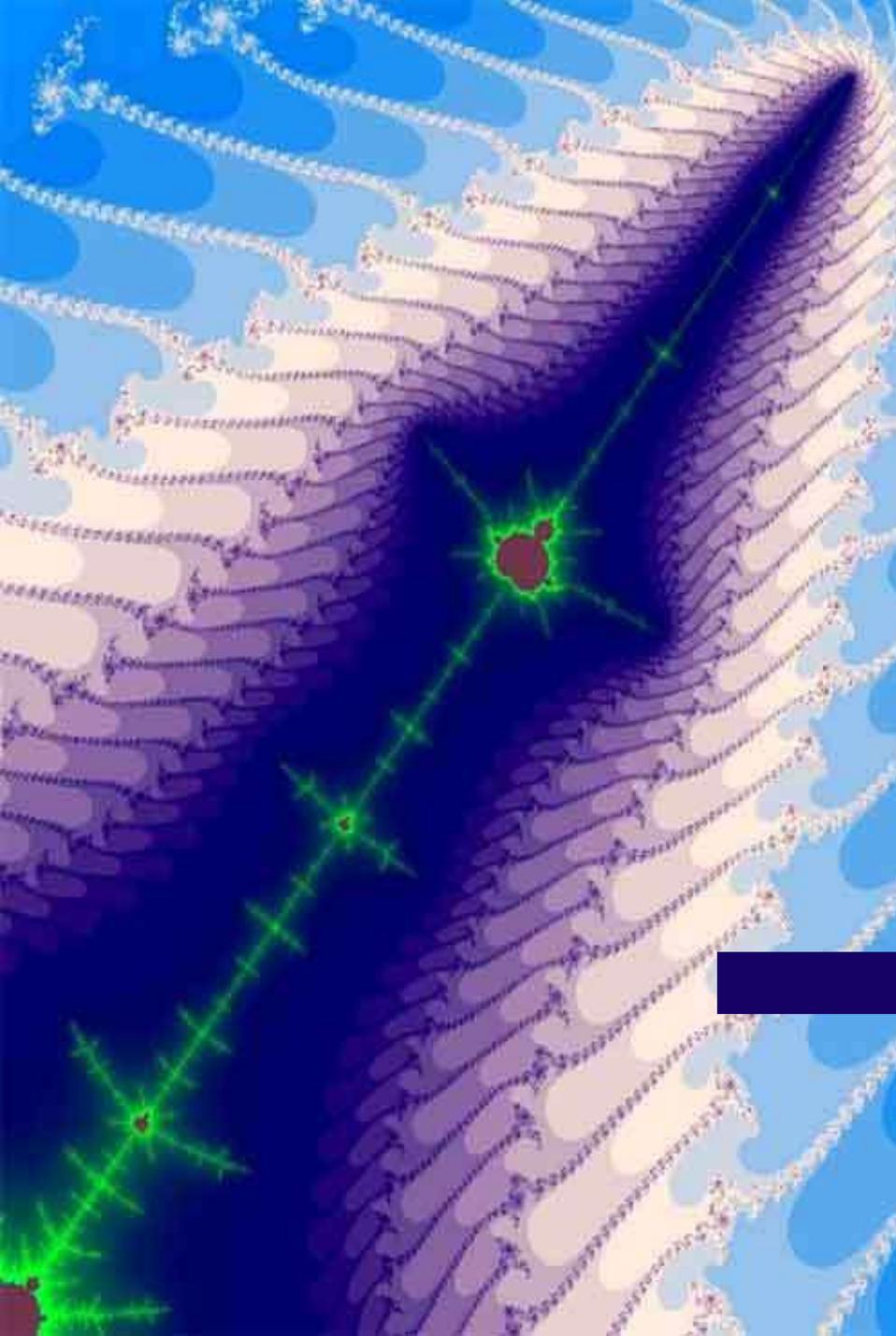
A "spike"

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Singularities
A spike has a sharp end
Global footprint & ecological catastrophe

Singularities and "spikes"

- Damien Broderick used the term in the title of his 1997 book on the impending singularity, "The Spike"
  - Futurist & writer of sci-fi and pop science
  - To him, the spike referred to all kinds of singularities
- To me, the "spike" is an exponential growth curve that has a sharp termination, followed by an equally rapid (or even faster) collapse or die off.
- **We have one world**
  - with finite resources
  - The biosphere is homeostatic to a degree, but
  - Its ecosystems are potentially fragile
- See Malthusian catastrophe
  - People and our tech are the problem

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 1.6 planets to provide the resources we consume and absorb our waste", or around 1½ 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 possible keystone species, critical for maintaining ecosystem health
- Rising extinction rates suggests we are teetering on the edge of ecological collapse

Physics trumps belief
Physical reality 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**

Even if we don't destroy the world ourselves: Increasing existential risks from the next extreme solar zap

- Could our increasingly networked technology and knowledge survive a major zap?
  - Our "devices" depend on regular supplies of electricity
  - An ever increasing proportion of our total knowledge is being transferred into the cloud
  - Manufacturing and distribution are increasingly automated….
  - Our lives increasingly depend on exponentially more complex tech
- Solar flares and coronal mass ejections (CMEs)
  - Periodically blast the Earth with highly energetic particle radiation and geomagnetic storms
    - Geomagnetic storms from largest (X-class) flares/CMEs induce high electrical currents in power transmission lines capable of burning out major power transformers that could take many years to replace
    - Energetic particles + induced electrical currents can fry satellite electronics
  - 1859 Carrington Event affected telegraph lines around the world and burned out telegraph some of them
    - Evidence for flares at least 5 X more powerful than the Carrington Event occurred in pre-industrial times – so they not *that* rare
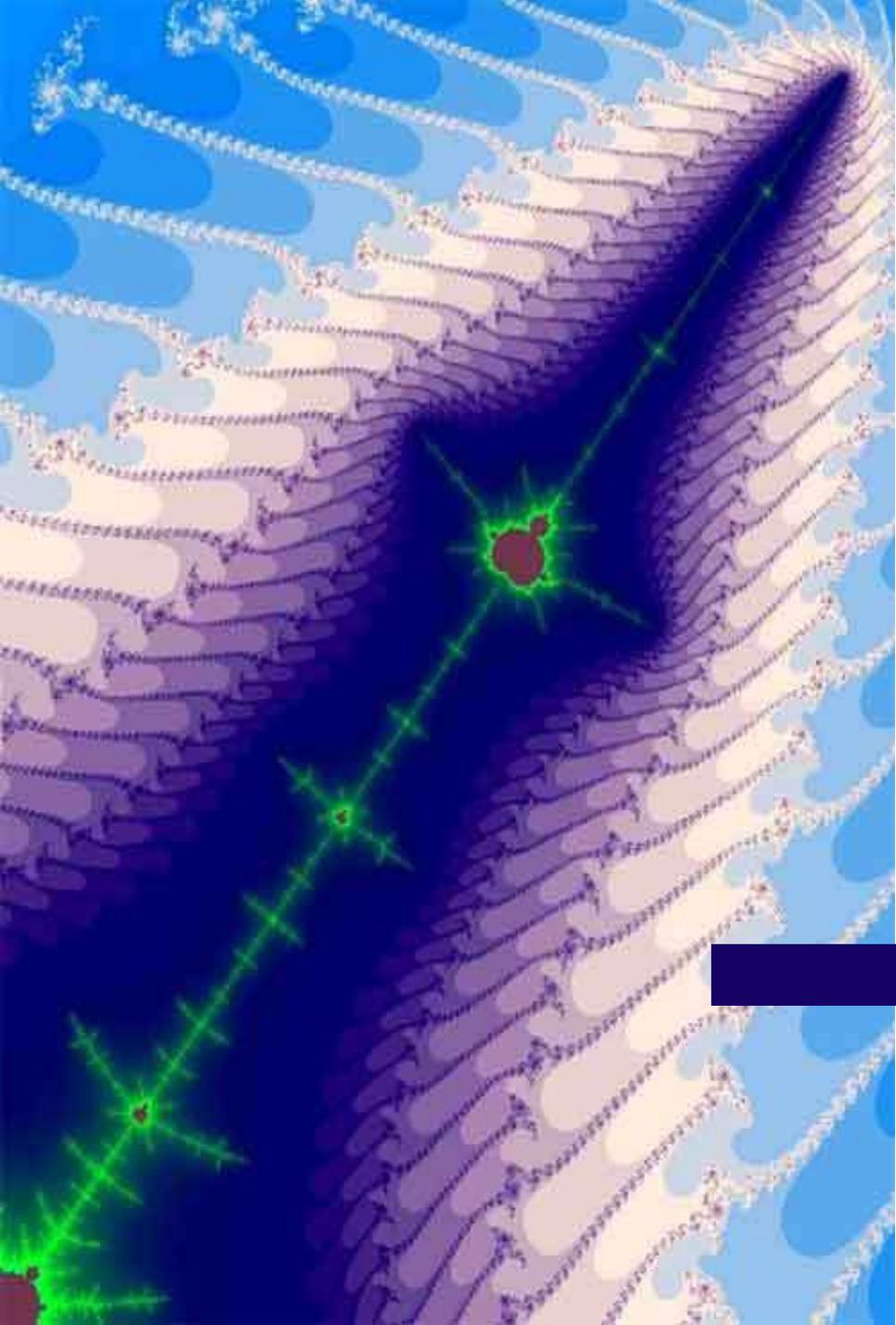
Inflection
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The "S" or logistic growth curve

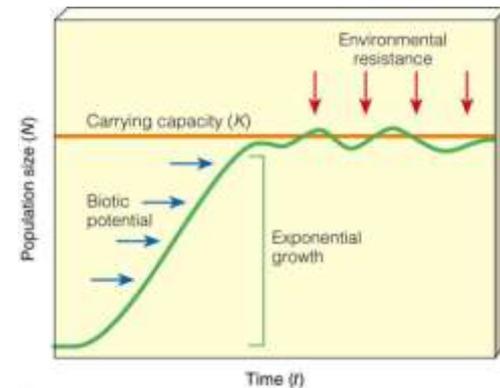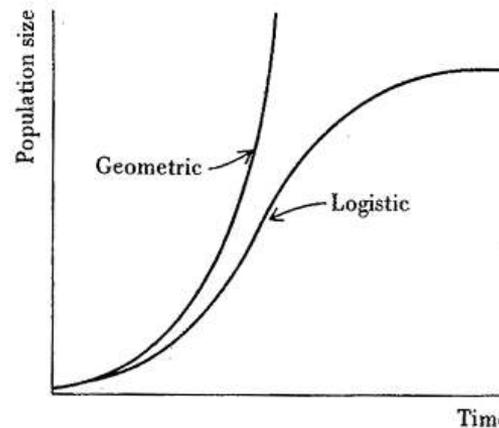There is no such thing as "sustainable growth"

Do we have the will to achieve genuine sustainability?

Logistic growth curves

- Logistic vs geometric/exponential growth
  - Biotic potential = potential rate of production
  - We have the cognitive capacity to control production to stay within carrying capacity
  - But the real world isn't that simple!

- Overshoot and the Malthusian catastrophe
  - Feedback cycles between different species' populations and their environments include delays between real world and adaptive responses to the world ➔ non-linearity ➔ complex, chaotic systems
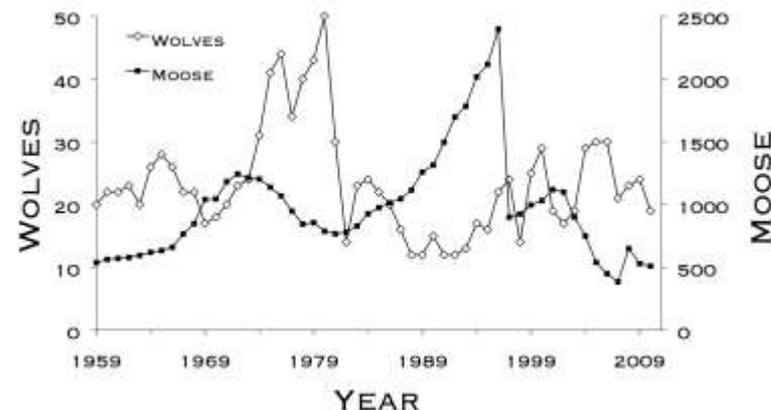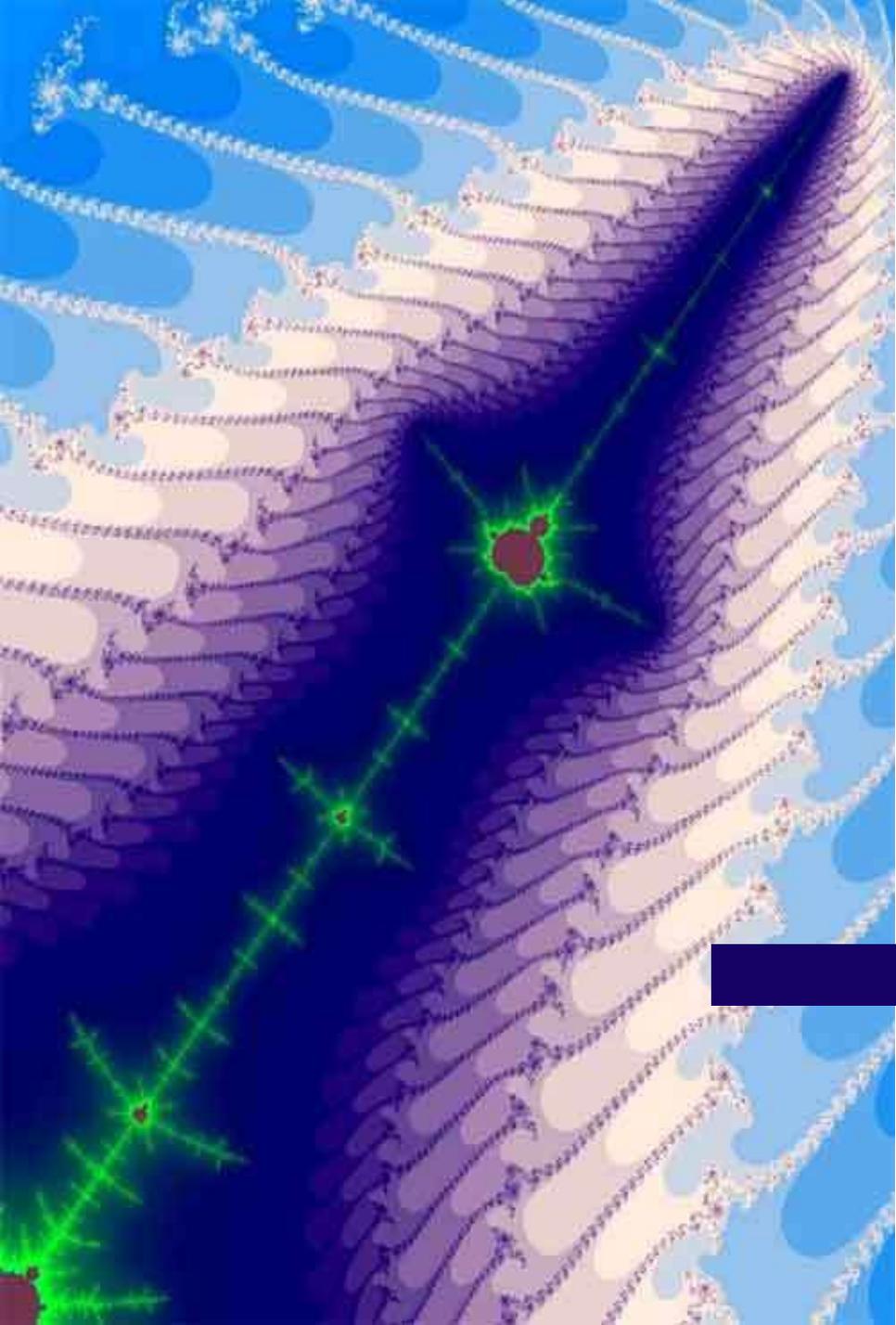
Natural selection got us where we are. But, it isn't the last word.

We have the cognitive capacity and technology to inflect our population and technology growth curves to manage a soft landing.

Will we/can we choose to do so?
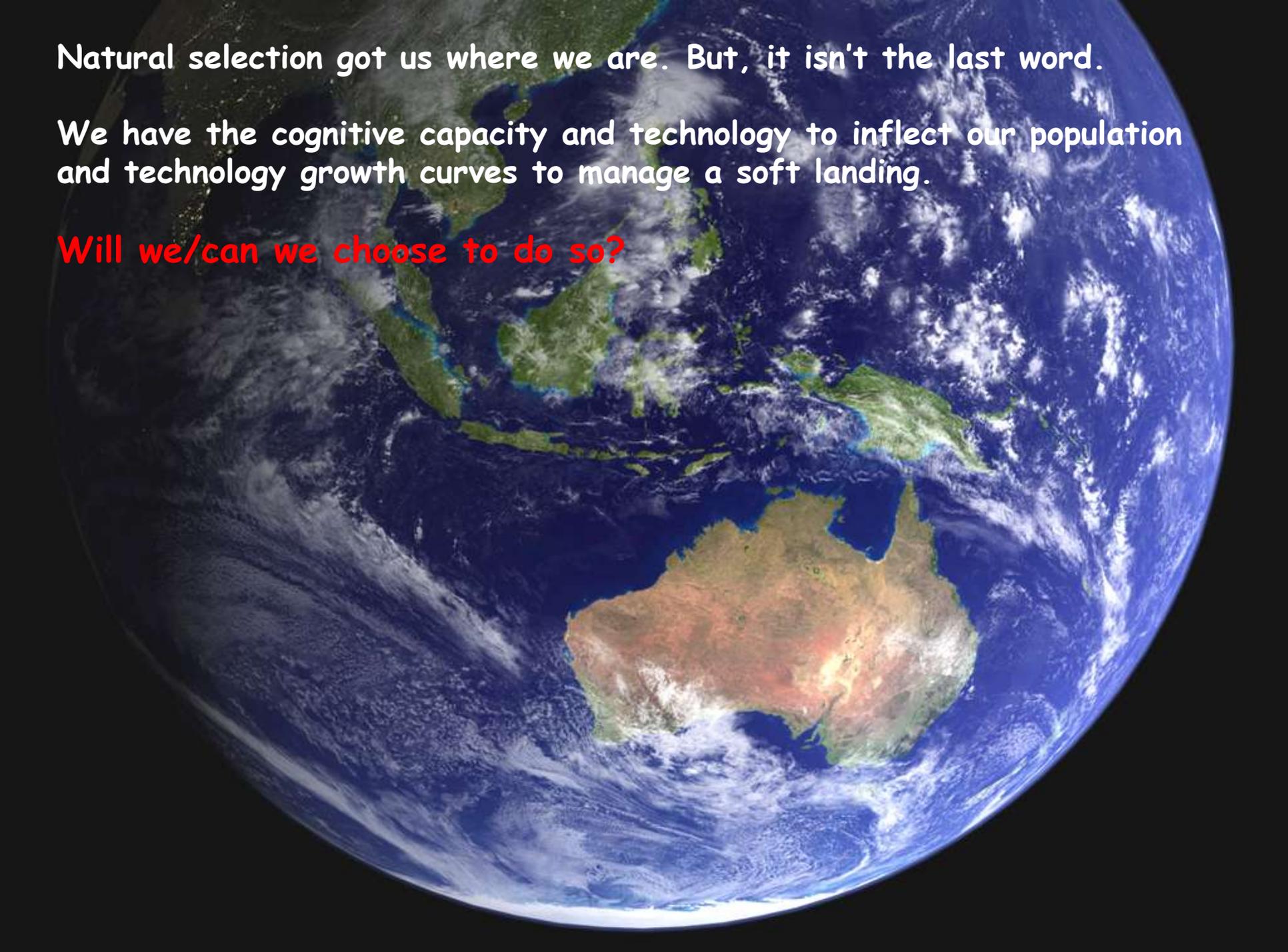
Is this THE END
or,
Do we continue next year with open discussions and presentations from others?

Extending the concept of heritability

The concept of heritability is normally used in the context of genetically determined traits that are passed from one generation to the next. In my usage here, I extend the concept to essentially repeatable states of similar/related systems in instants of time that constrain the possible states of those systems in subsequent instants to subsets of the otherwise physically possible states of those systems in those subsequent instants. In other words, their states through time are constrained by their histories. The fact that one path is followed rather than the other, means that future possibilities physically inherent in that other path cannot be realized.

"Systems" refer to coherently bounded dynamic structures that identifiably persist through time, e.g., living organisms, bounded populations or groups, etc.

"Genes" refer to molecularly encoded components of information involved in developing the phenotype.

"Memes" refer to cognitively encoded components of information involved in organizing or influencing cultural activities