

Session 4: Epistemology, technology and knowledge growth

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Tonight

- Tonight we begin with the real content of the book
- The **Subject** of the book concerns knowledge and its interactions with technology

SUBJECT - Epistemology, Technology and Knowledge Growth

"Holy Wars" Highlight Fundamental Changes in the Creation and Use of Knowledge

Thomas Kuhn's Scientific Revolutions and Karl Popper's Epistemology

Theory of knowledge

Popper's evolutionary theory of knowledge

Karl Popper's three worlds

Knowledge revolutions

Paradigms and incommensurability

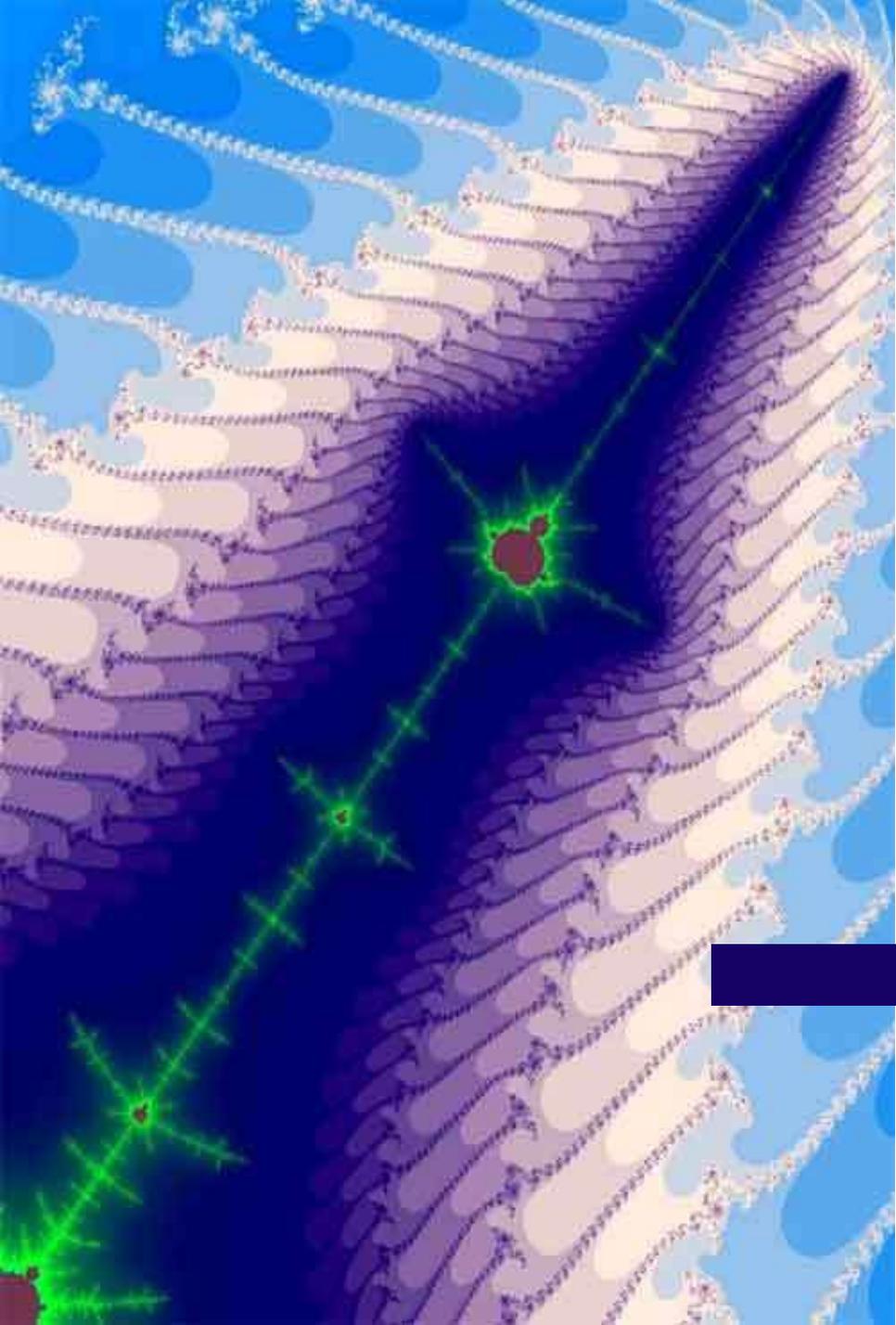
Technological and Conceptual Revolutions in Human Affairs

Biological evolution vs. revolutions

Technological and cognitive revolutions that reinvent the nature of humanity

Technological revolutions

Cognitive revolutions



What is knowledge and why is it important?

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Solutions to problems
Tacit & explicit
Popper's Three Worlds



What is knowledge?

- Knowledge manager's views in organizational frameworks
 - Artisanal approach rather than scientific
 - Differences between "information" and "knowledge"
 - "Tacit" vs "explicit" knowledge
 - Technological vs anthropological approaches
- Biological/anthropological views in ecological and economic systems
 - Charles Darwin (1859) *On the Origin of Species by Means of Natural Selection...*
 - Karl Popper (1972) *Objective Knowledge an Evolutionary Approach*
 - Nelson & Winter (1982) *An Evolutionary Theory of Economic Change*
 - **Knowledge is "solutions to problems of life"**

Introducing Popper's evolutionary epistemology

- Justified true belief vs (radical) constructivism
 - Former relies on assumption that our perceptions give us a true view of the external world
 - Popper argued that the nervous system and cognition construct a fallible mental image of the external world
 - Induction did not lead to reliable knowledge
- General theory of evolution
 - All claims are fallible
 - Seeking confirmation to justify claims is a recipe for disaster
 - Confidence in a claim to knowledge can best be built through robust criticism and the elimination of claims that fail to stand up

Popper's "general theory of evolution"

Natural selection builds knowledge (= solutions to problems)

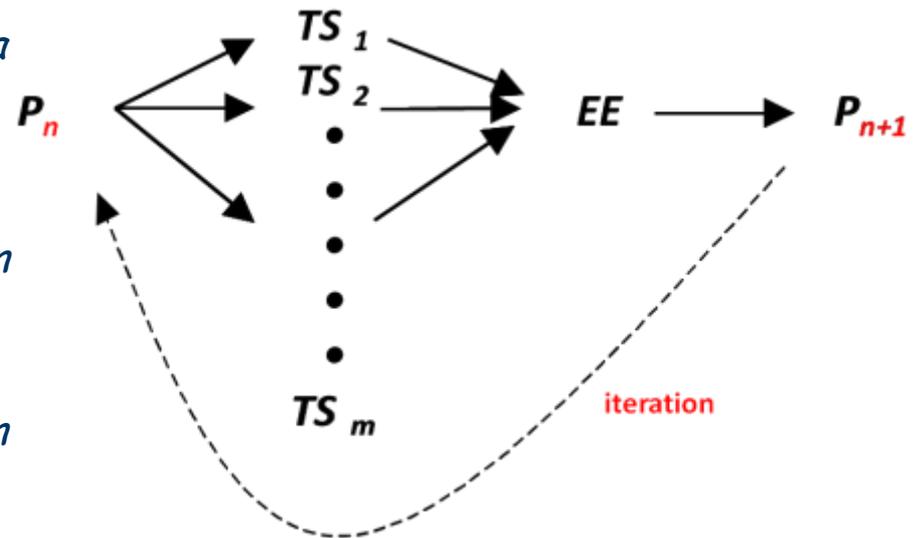
P_n a real-world *problem* faced by a living entity

TS a *tentative solution/theory*.
Tentative solutions are varied through serial/parallel iteration

EE a test or process of *error elimination*

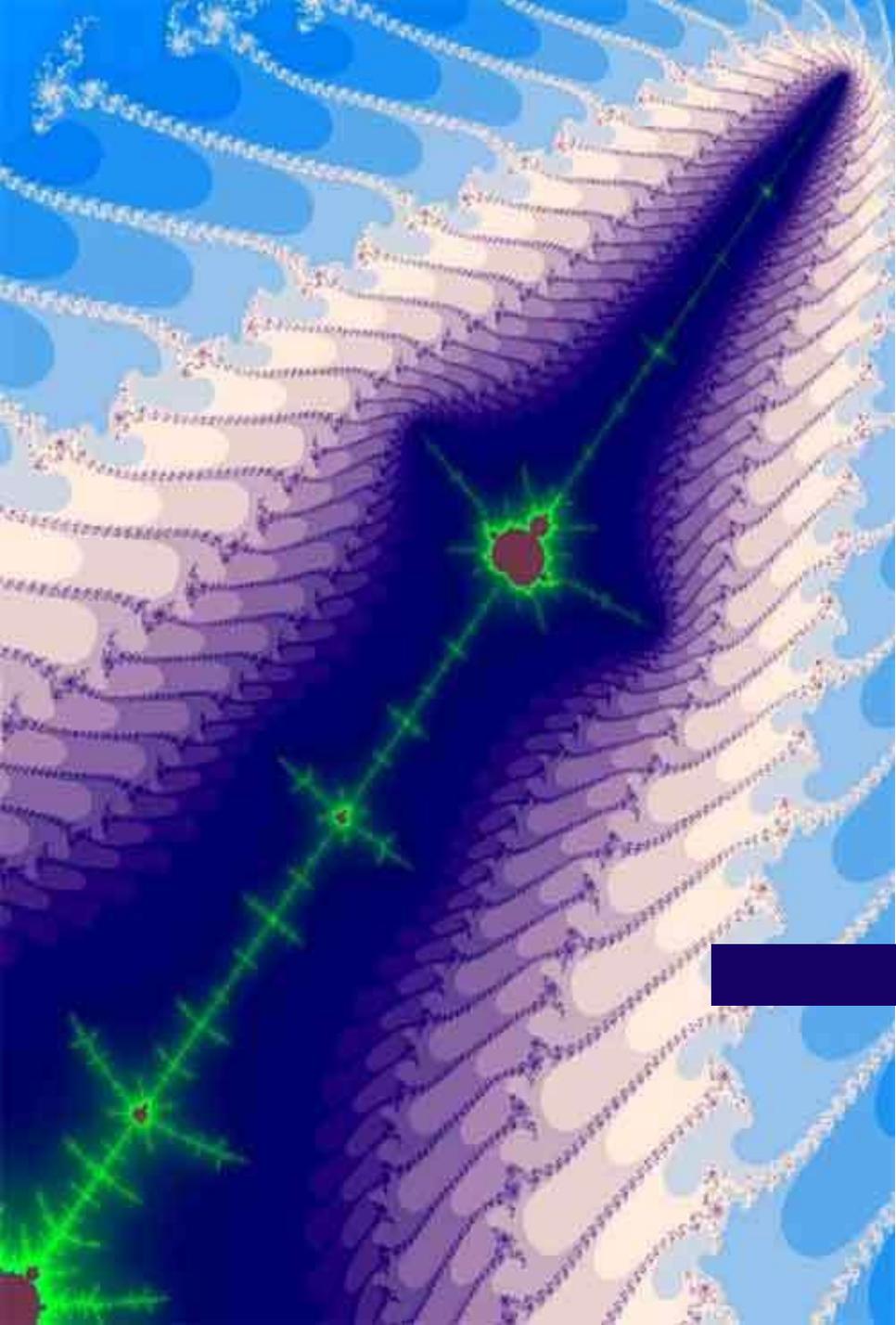
P_{n+1} *changed problem* as faced by an entity incorporating a surviving solution

The whole process is iterated



Karl Popper, *Objective Knowledge - An Evolutionary Approach* (1972), pp. 241-244

- All knowledge claims are constructed, cannot be proven to be true
- **TSs** may be embodied as "structure" in the "knowing" entity, or
- **TSs** may be expressed in words as hypotheses, subject to objective criticism; or as genetic codes in DNA, subject to natural selection
- **Objective expression and criticism lets our theories die in our stead**
- Through cyclic iteration, sources of errors are found and eliminated
- Solutions/theories become more reliable as they survive repetitive testing
- Surviving **TSs** are the source of all knowledge!



How does knowledge grow?

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Karl Popper's Evolutionary
Epistemology
Thomas Kuhn's Scientific
Revolutions



The General Theory of Evolution's working environment

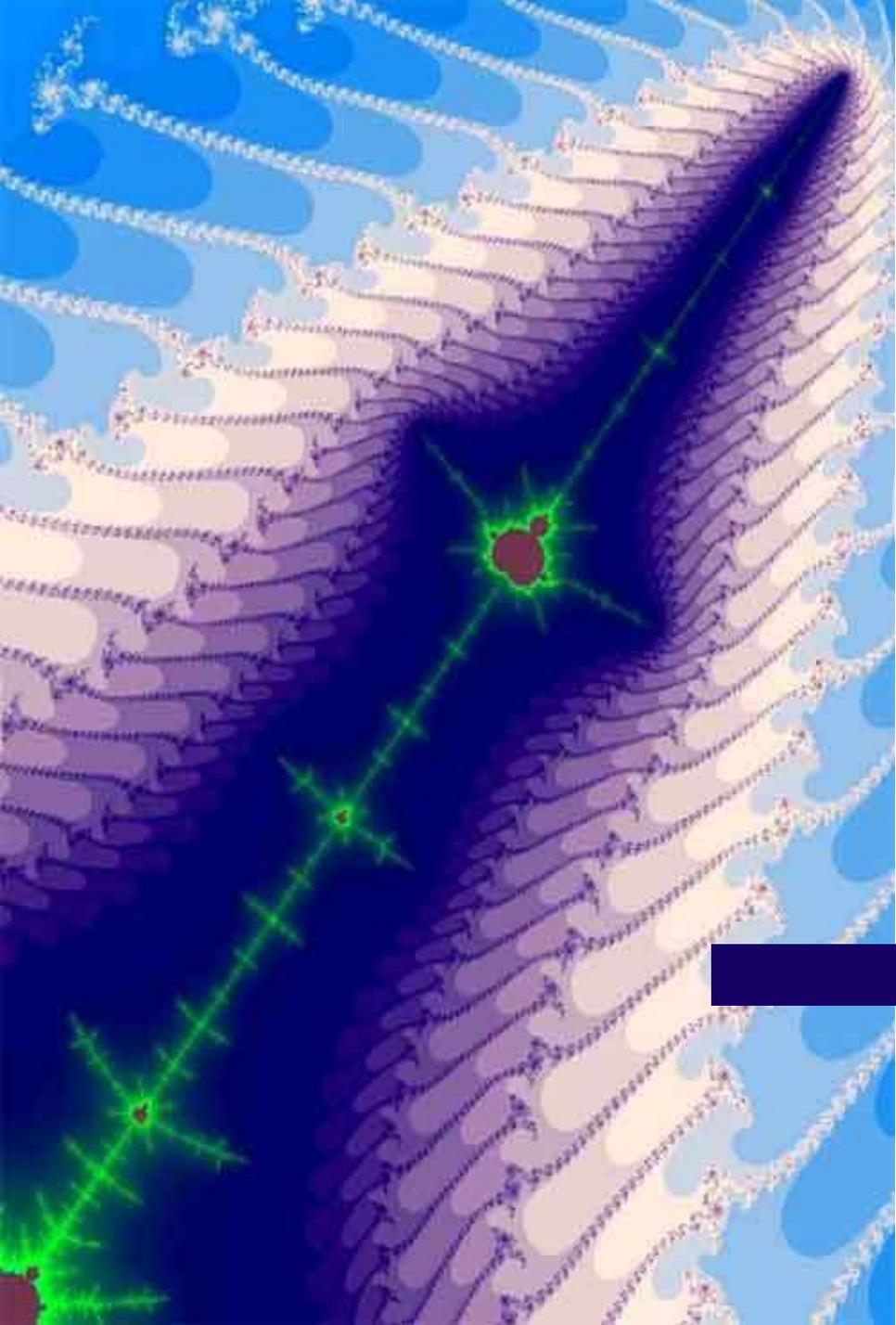
- Three worlds
 - World 1 - ("W1") the physical universe as it actually exists independently of any perceptions, i.e., reality.
 - World 2 - ("W2") the world of our subjective perceptions and experience, i.e., what knowing entities or subjects think about the world, i.e., "living knowledge"
 - World 3 - ("W3") the world of logical contents of books, libraries, computer memories, and suchlike"; and genetic code - i.e., "explicit knowledge"
- Living knowledge can be embodied in
 - the dynamic structure and organization of a living entity
 - the neuronal connections and dynamics of a living brain
- Explicit knowledge is persistently encoded into/onto inert objects that may be decoded by living things

The construction of knowledge

- Popper - knowledge is built by speculating and eliminating the speculations that don't work.
 - Self-criticism to recognize that what doesn't work is probably wrong
 - Without self-criticism errors lead to death of those depending on wrong ideas
 - Campbell, D.T. 1960. Blind variation and selective retention in creative thought as in other knowledge processes. *Psychological Review* 67, 380-400 (not free to the web)
- With iterated cycles of guessing, testing our guesses against the world, and eliminating ideas that our senses tell us didn't work gradually builds an increasingly accurate picture of the world and how it seems to work
- With continued criticism, our understanding/knowledge grow through time.

Cognitive & knowledge revolutions

- Thomas Kuhn 1962, 1970 - The Structure of Scientific Revolutions
- Scientists (and others) work within *paradigms*
 - Worldviews, jargon, disciplinary matrices/exemplars
 - Mostly learned tacitly as students - therefore difficult to surface and discuss explicitly
- Most (i.e., "normal") knowledge growth consists of incremental additions to existing paradigms
- Too many anomalous observations may lead to a "*crisis*"
 - A different worldview/viewpoint may lead to a more comprehensive explanation including previous anomalies (i.e., a revolution)
 - New world view, exemplars, new/redefined jargon, etc. → new paradigm
 - Without surfacing tacit understandings, alternative explanations are incommensurable so respective proponents cannot communicate rationally
 - Persistent misunderstanding for no obvious reason → "*holy wars*"
- Same situation applies to technologies and species ecological niches



**Cognition and
technology interact
to solve the
problems of life**

—



Biological evolution vs “punctuated equilibria”

- Directional selection vs normalizing selection
- Species/population's ecological niche determined by its biological properties as affected by feedback from the external environment (cf. general theory of evol.)
- Genetic/environmental attractor basins/paradigms
- Crossing the threshold of an unoccupied basin provides the opportunity for revolutionary evolution
- Concept of the biological “grade shift” where crossing a threshold allows a step change in a lineage's adaptive possibilities
- Human anatomy/physiology not greatly different from other apes
- **Modern humanity the consequence of coevolutionary feedback between technological and cognitive revolutions**

Evolution vs revolutions

- Thomas Kuhn (1970) - Structure of Scientific Revolutions (= chaotic & discontinuous changes in non-linear systems)
 - **Normal Science** = incremental evolutionary change within an established world view/cognitive structure
 - **Scientific Revolution** = discontinuous change resulting from emergence of a new/disruptive cognitive structure
- Concepts apply more broadly than scientific theory
 - Technology - normal technological development disrupted by new technologies doing same things in new ways
 - Biology - **slow incremental change producing better adaptations to local peaks in the adaptive landscape, may be punctuated by "grade shifts" creating new landscapes opening new realms for adaptive radiations**

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

- Memory and cognition in dynamic structure of the autopoietic system (W2 only) - **4.5 billion years ago** - physics begets life
 - Virtuous cyclical dynamics at the molecular level able to maintain homeostatic control in some circumstances
- Genetic memory at the molecular level (W2 + W3) - **4 bn years ago**
 - Add RNA, DNA and epigenetics
- Multicellular memory (molecular W2 + W3 + cellular W2) - **2-1.5 bn years ago**
 - Add dynamic structure in cellular neurons → neural nets → brains
- Group cultural memory (molecular W2 + W3 + cellular W2 + organizational W2) - **5,000,000 ago**
 - Add tacit then linguistic creation, communication & sharing of knowledge
- Codification, storage & transfer of knowledge in and via tangible artefacts, e.g., writing & communication (molecular W2 + W3 + cellular W2 + organizational W2 + W3) - **5,000 years ago**
- Virtual memory, communication, cognition at light speed - **50 years ago**
- *Global brain* - **now!**

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

- **Accelerating changes extend 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)
 - ~ 32 *yrs* - **computing** tools actively manage corporate data/knowledge externally to the human brain (32 Y) and personal knowledge (World Wide Web - 18 Y)
 - ~ 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)

What are the consequences of exponentially increasing cognitive power?

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

