Knowledge vs Belief, Justification and Truth
What Scientific Knowledge Is and How it Works

An attractor

A unique area in
the state space of the
Mandlebrot set   definition

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Access my research papers from
Google Citations

Introduction to this talk

- For better or worse, science works. It has given humans dominion over the earth
  - It is now within humanity's capacity to either destroy the ecosystems we depend on for our survival or make the world a better place to live
- What is it about the epistemological foundations of science that makes it so much more effective helping us to understand the world than are philosophical systems based on faith and belief?
- This talk introduces the epistemological work of Sir Karl Popper, who I regard as history's greatest epistemologist.
- Caveats
  - I am not a student of philosophy and am not familiar with much of its literature
  - I have extended Popper's ideas in a number of areas as I have explored the biological roles and nature of knowledge in living systems

Questions about knowledge arise from my career in theoretical and applied epistemology

- Physics background, PhD in evolutionary biology (Harvard, 1973)
- University of Melbourne Research Fellow in Genetics 1977-1979
  - Reviewers of my PhD work forced me to ask whether my approach to comparative biology was "scientific"
  - Spent two years studying history and philosophy of science on my own (no one in Philosophy was then interested in my questions)
  - Returned to the States for a year & concluded there was no career path (complex transcript, Affirmative Action, etc.)
- Immigrated to Australia in 1980 & ended up as knowledge systems analyst (i.e., "applied epistemology")
  - Personal computers were evolving much faster than lizards!
  - Technical writer and documentation manager for software house (1982-87) and the original Bank of Melbourne (1988-89).
  - Documentation and knowledge management systems analyst for Tenix Defence from 1990 until I retired mid 2007 (ANZAC Ship Project)
  - Practical questions: *What is knowledge to an organization or society? How can we evaluate / value knowledge claims. Why is this important? How should we manage knowledge?*

This talk is one of the outcomes of researching and writing a fugue on the theory of knowledge

- **Application Holy Wars or a new Reformation – A Fugue on the Theory of Knowledge** (see working draft)
  - Combines threads from my two major careers
    - Evolutionary biology
    - Documentation and knowledge management systems analysis and management
  - Started part time in late 2000 to survey the co-evolution of and revolutions in human cognition and the cognitive tools humans used
  - Because the story is complex, crossing many diverse disciplinary paradigms, I adopted a cyclically fugal structure of subject, counter-subject, several episodes with an interlude, and a cadenza and coda.
- The historical part of the story was easy
- Understanding life and knowledge at the organizational level was not!
  - My constructions are at odds with published dogmas of organization studies and most knowledge management practitioners
  - In trying to answer the foundation questions, as will be presented here, I have ended up unifying some quite disparate ideas into a common answer to most of them
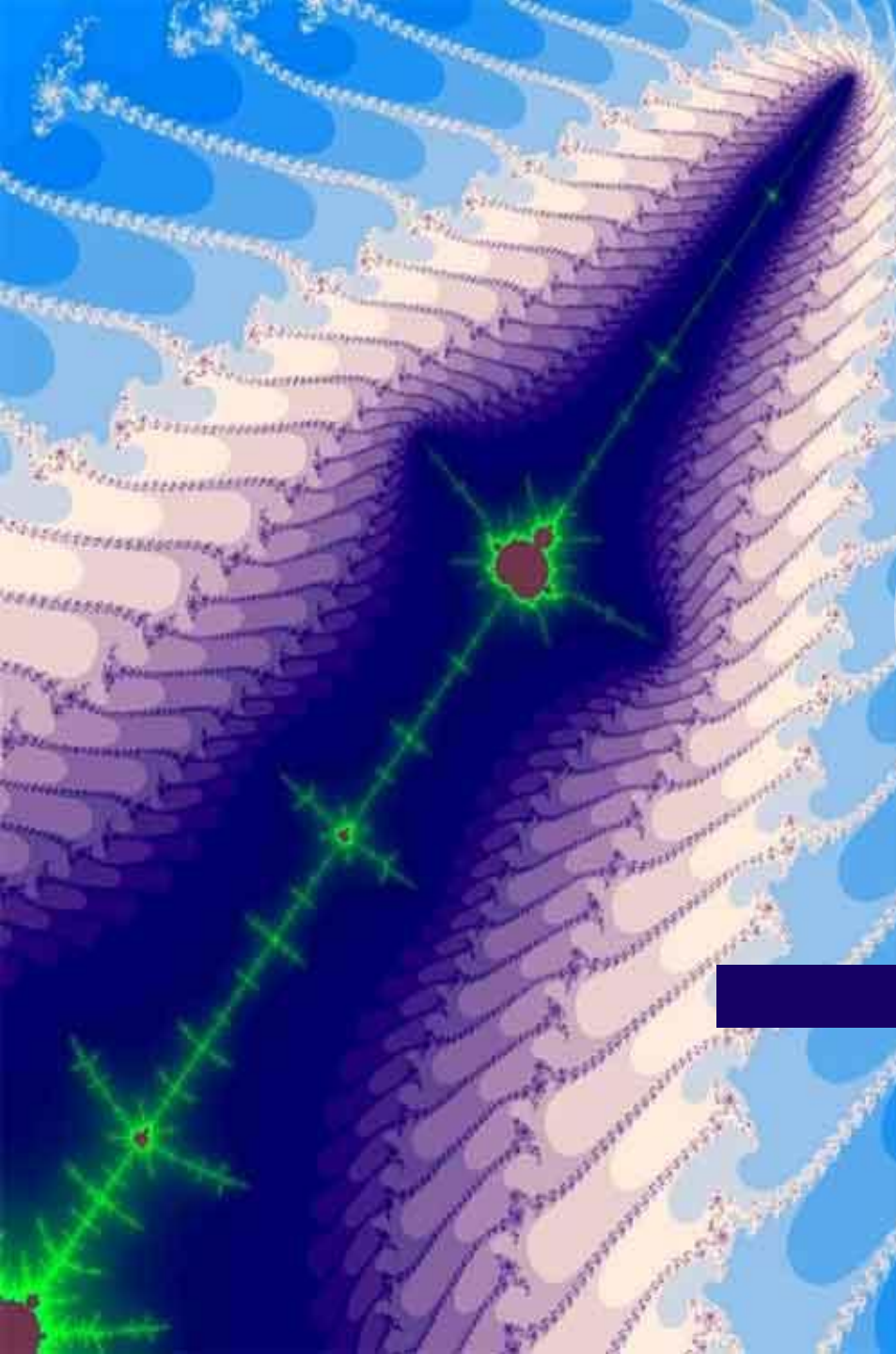
Science and Philosophy of Science in the 20ᵗʰ Century

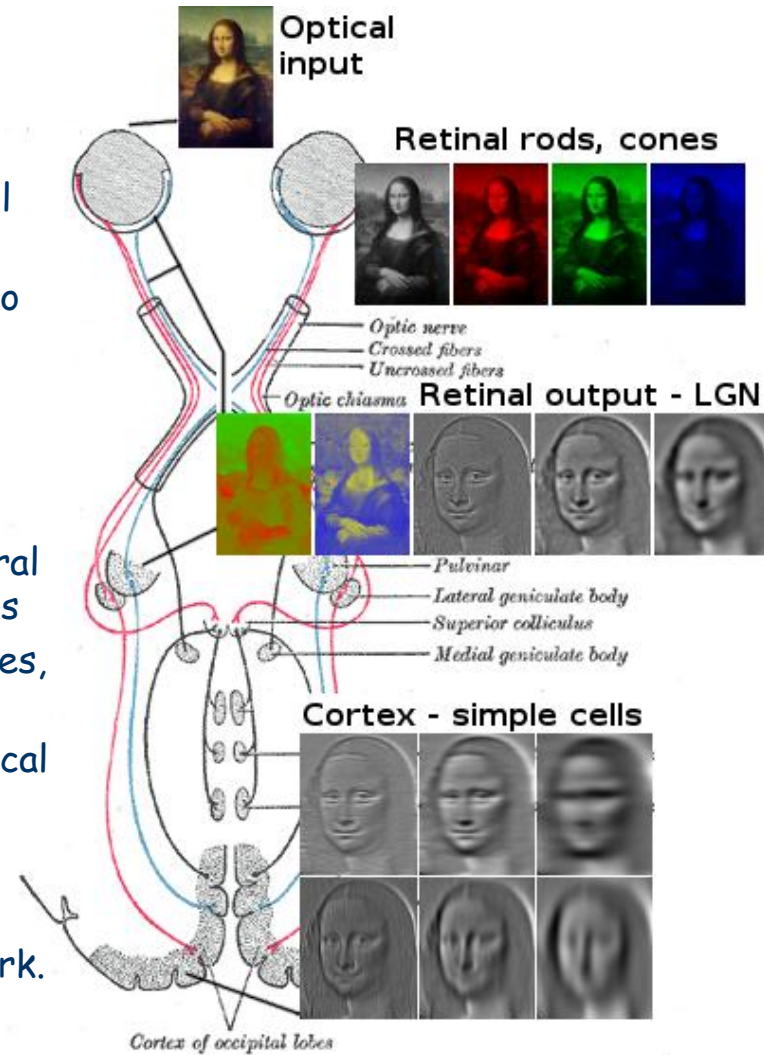# Human knowledge/dominance of the world appears to grow through time

- Prior science largely based on "natural history" observations
- 1687 Classical (Newtonian) mechanics
- 19th Century
  - Darwinian theory of natural selection
  - Maxwell's equations / theory of electromagnetism
- 20th Century
  - Chromosomal/genetic theories of inheritance
  - Relativity
  - Atomic theory
  - Electrodynamics/unification of forces
  - Quantum theory
  - Synthetic theory of evolution
  - Solid-state physics (i.e., transistors, microcomputing)
  - Plate tectonics
- All based on theoretical speculation tested in practice resulting in practical knowledge to control the physical world

Epistemology tries to explain the power of science to understand world

- Plato's "justified true belief"
- Vienna Circle & Logical Positivism (1930's)
  - Truth can be perceived and verified
- Post WWII
  - Constructivism and radical constructivism
    - Knowledge is constructed – does not/cannot "reflect" external reality
  - The historian
    - Thomas Kuhn
  - Anti-Nazi's
    - Michael Polanyi
    - Karl Popper
  - Popper's "irrationalist" students
    - Imre Lakatos
    - P.K. Feyerabend

Problems with Logical Positivism

- Problems
  - "Gettier's Problem"
  - "Problem of Induction" - any number of confirmations does not prove the next test will not be a refutation
  - The biological impossibility to know if a claim to know is true
- Vision does not form an image of external reality
  - Photons are not the objects reflecting them
  - Photons striking retina are converted into neural action potentials in primary photoreceptor cells
  - Neurons aggregate in the retina respond to lines, brightness, changing contrast, movements
  - A mental perception/construction is not identical to the external reality
- The brain does not perceive the world
  - Perception and cognition are consequences of propagating action potentials in a neural network.
  - Action potentials stimulated by physical perturbations to neurons

Optical input

Retinal rods, cones

Optic nerve
Crossed fibers
Uncrossed fibers
Optic chiasma
Retinal output - LGN

Pulvinar
Lateral geniculate body
Superior colliculus
Medial geniculate body

Cortex - simple cells

Cortex of occipital lobes

Clock, via Wikimedia

Constructivism

- Basic constructivist tenants
  - World is independent of human minds
  - "Knowledge" of the world is always a human construct
  - There is little point to be concerned about external reality because you cannot know what it is. You only know what you think it is

- Social constructivism
  - Social relationships and interactions construct socially held perceptions of reality and knowledge.
  - Truth is what people believe to be true

- Radical constructivism
  - Knowledge cannot be transported from one mind into another
  - Individual knowledge and understanding depends on personal interpretation of experience, not what "actually" occurs.
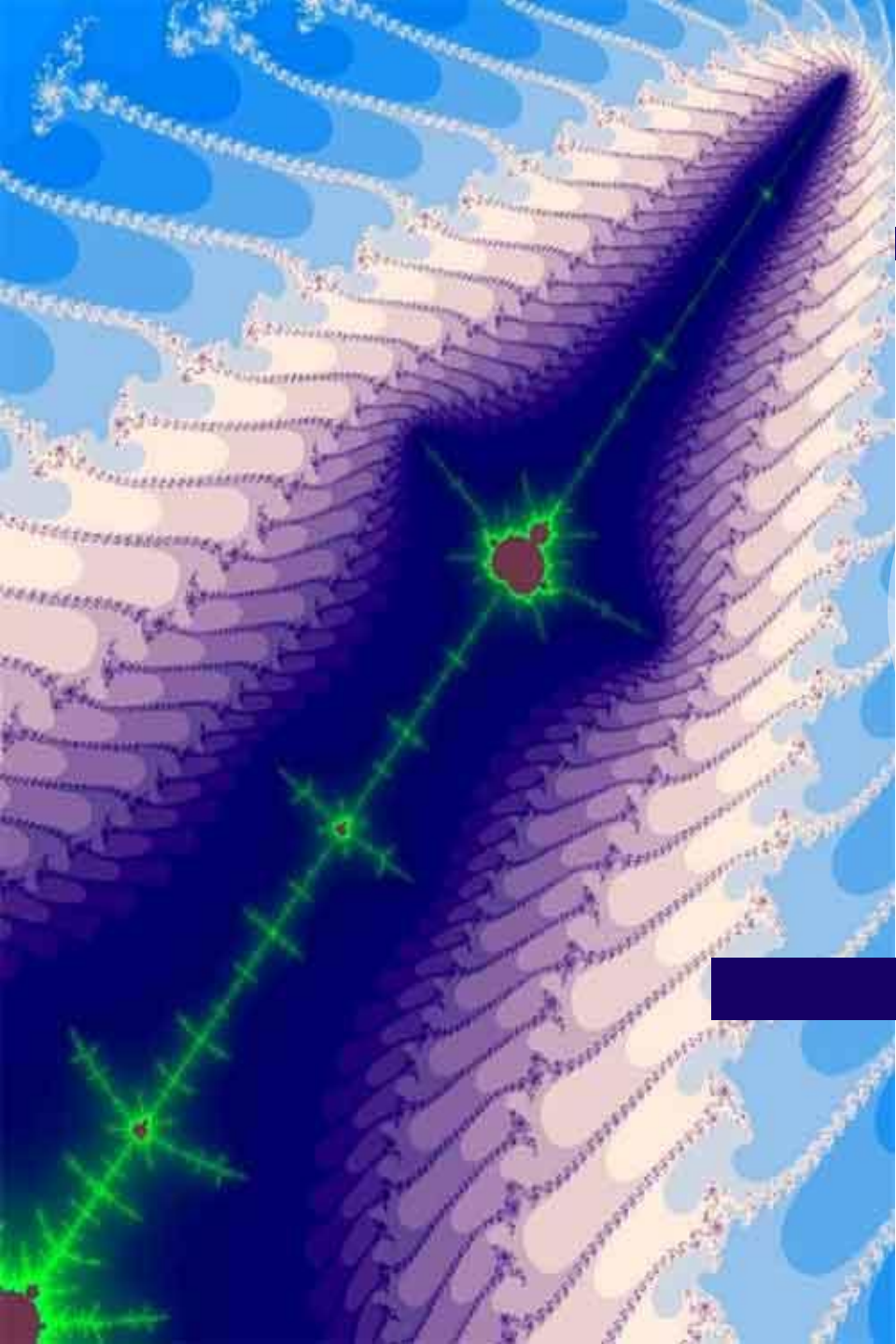
Philosophers who explained science to me

Thomas Kuhn

- Born 1922 Cincinnati, Ohio (Died 1996)
- PhD Physics (Harvard 1949)
- Studied history of science as Harvard Junior Fellow (Postdoc)
- Univ Calif Berkley 1957
  - Taught both history of and philosophy of Science
  - Professor History of Science 1961)
- The Structure of Scientific Revolutions (1962, 1970)
  - Key ideas
    - Paradigms
      - World views
      - Disciplinary matrices
      - Incommensurable usages of same words
    - Normal science
    - Revolutions
- "Structure" is a constructivist historical interpretation not epistemology

Reactions to Marxist and Nazi pseudoscience

- Three Austro-Hungarian expatriates with Jewish heritage escaped Nazis & ended up in England
  - Wittgenstein: logic and language
  - Polanyi: scientist turned philosopher
  - Karl Popper: philosopher of science
- Popper and Polanyi's opposite responses to Nazi logical positivism
  - Popper the philosopher built an epistemology to do better science; emphasized importance of "objective" knowledge
  - Polanyi the scientist sought ultimate truth in faith & belief; emphasized importance of "tacit" knowledge
- Popper's writing reflected conflicts with the others
  - Notorious affair of "Wittgenstein's Poker" (word games)
  - Less notorious but equally acrimonious affair of Polanyi's contribution to Popper's LSE seminar

Michael Polanyi

- Born 11 March 1891 (died 1976), Budapest as a Jew
  - 1914 medical diploma
  - 1919 completed doctorate in chemistry (Budapest), joined Kaiser Wilhelm Institute (Berlin)
  - 1923 converted to Catholicism
  - 1926 professor, Institute Physical- and Electrochemistry
  - 1933 accepted chair in physical chemistry Manchester Uni to escape Nazis
    - Nominee for Nobel Prize
    - Son – continuing the father's work, two students all won Nobel Prizes
  - 1948 resigned chemistry to take new chair in philosophy because of deepening religious streak and concerns over Nazi & Communist positivism
- Developed anti-positivist anti-reductionist epistemology of personal knowledge & tacit knowing
  - Absolute objectivity (objectivism) is a false ideal, all knowledge claims (including rule-based ones) rely on personal judgements ultimately based on faith and belief
  - Denied that scientific methodology can reveal truth
  - We believe more than we can know, and know more than we can say
- Polanyi, M. (1958) Personal Knowledge: Towards a Post-Critical Philosophy
  - At least partially a reaction to Popper's critical rationalism (no citation anywhere to Popper's work – see next slide)

Karl Popper
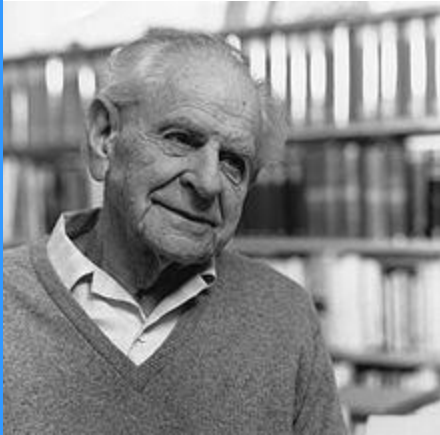
Karl Popper - b. 1902, d. 1994
"Objective Knowledge", 1972

- Born in Vienna to well-off Jewish family converted to Lutheran
- Early flirtation with Marxism but put off by pseudoscientific historical materialism
- Apprenticed cabinet maker & earned teaching qualification
- 1929 doctorate in psychology on method in cognitive psychology
- 1934 Logik der Forschung (Logic of Scientific Discovery 1959)
  - "solved" the problem of induction
  - Falsifiability as the demarcation between science and pseudo-science
- 1937 emigrated to New Zealand, completed Open Society and its Enemies

- 1946 emigrated to London where took readership logic and scientific method at London School of Economics; 1949 became professor
- 25 Oct. 1946 – the affair of "Wittgenstein's Poker" (Popper will not define words to avoid word games)
  - Edmonds, D. and Eidinow, J. (2001) Wittgenstein's Poker: The Story of a Ten-Minute Argument Between Two Great Philosophers
  - Munz, P. (2004). Beyond Wittgenstein's Poker: New Light on Popper and Wittgenstein. (full text)
- 6 March 1952 – the affair of Michael Polanyi's humiliation in Popper's LSE seminar (neither author / authors followers will cite the other)
  - Watkins, J. (1997) Obituary of Karl Popper, 1902-94. Proceedings of British Academy 94, 645- 654
- 1963 Conjectures and Refutations: the Growth of Scientific Knowledge
- 1972 Objective Knowledge: An Evolutionary Approach

Why many people who should know better ignore Popper

- Popper's intellectual arrogance
  - Popper mostly ignored or denigrated those he disagreed with (e.g., Polanyi)
  - Irritated many (most) academic philosophers (ref Wittgenstein & Polanyi affairs), especially ex positivists and constructivists
    - Disagreed with his earlier works, so ignored / unaware of his constructivist Objective Knowledge
    - Even until today few constructivists have cited Popper's strongly constructivist Objective Knowledge (one citation in all issues of the journal Constructivist Foundations)
- Contra Wittgenstein, Popper had a "negative attitude towards definitions".

  …clarity is an intellectual value since, without it, critical discussion is impossible. But I do not believe that exactness or precision are intellectual values in themselves; on the contrary we should never try to be more exact or precise than the problem before us requires (which is always a problem of discriminating between competing theories). For this reason I have stressed that I am not interested in definitions; since all definitions use undefined terms, it does not, as a rule, matter whether we use a term as a primitive term or as a defined term.

- Problems with undefined usage of language & barriers between schools
- Popper's use of 'objective' in the title Objective Knowledge caused those who thought knowledge could not be objective (i.e., in the sense that it was verifiably true) to immediately reject the book without reading it (ref constructivists)
  - Popper used "objective" in the different sense that knowledge could be objectified in tangible objects, i.e., "the world of the logical *contents of books, libraries, computer memories, and suchlike"* (1972: p. 74) and *"our theories, conjectures, guesses (and, if we like, the logical content of our genetic code)"* (1972: p. 73)
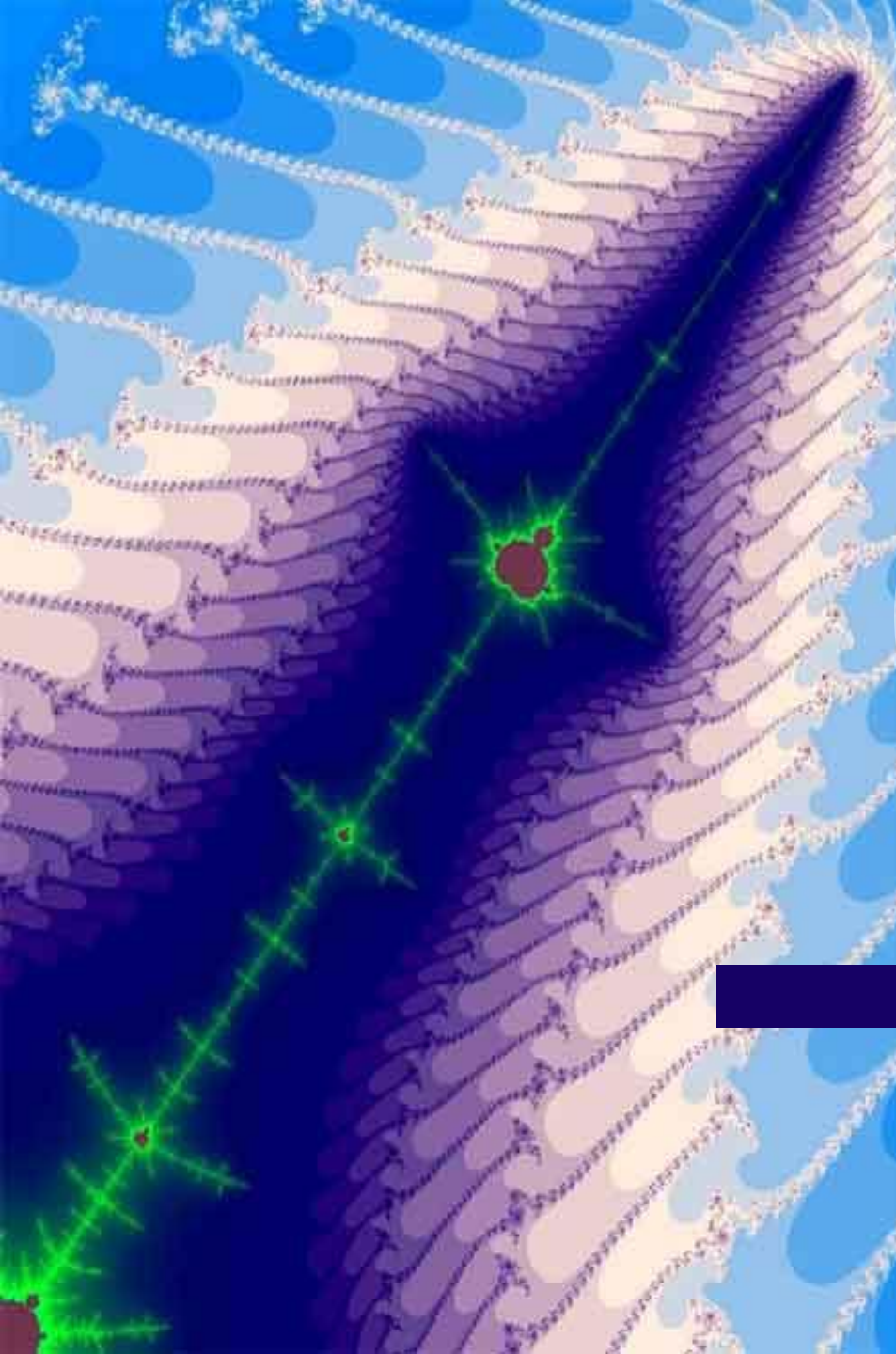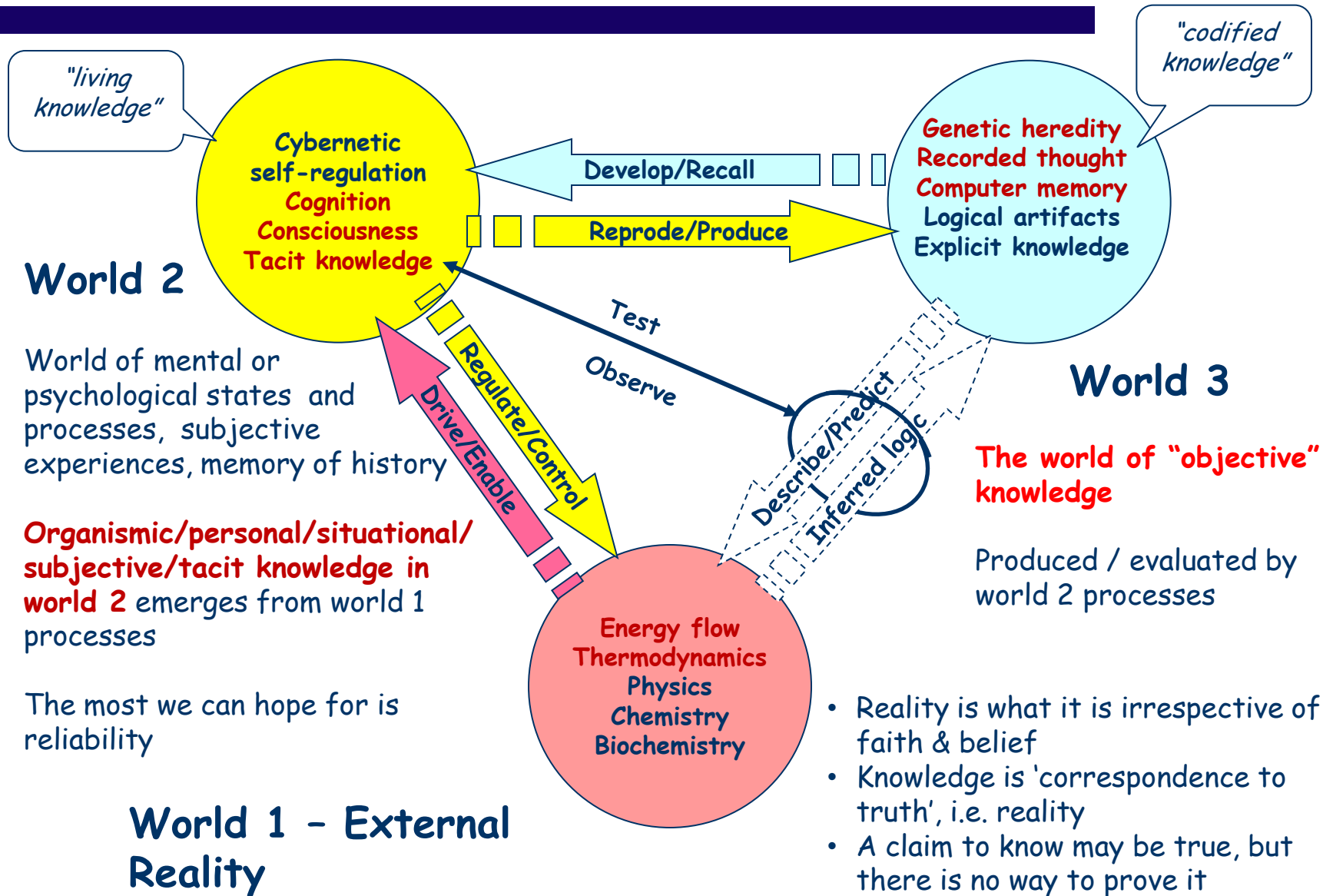
Evolutionary epistemology

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A biologically-based theory of the growth of scientific knowledge

Sources for evolutionary approach to epistemology

- Charles Darwin (1859) On the Origin of Species
- Konrad Lorenz – 1973 Nobel Prize (animal cognition and knowledge)
- Donald T. Campbell (1960, 1974)
  - Psychologist concerned with cognitive processes generating knowledge
  - (1960) Blind Variation and Selective Retention…. (paper)
  - (1974) Evolutionary Epistemology (chapter in Schilpp)
- Sir Karl R. Popper (≥ 1972 – knowledge is solutions to problems)
  - **(1972) Objective Knowledge – An Evolutionary Approach**
  - (1974) "The main task of the theory of knowledge is to understand it as continuous with animal knowledge; and … its discontinuity – if any – from animal knowledge" p 1161, "Replies to my Critics"
  - **(1994) Knowledge and the Body-Mind Problem**
- Knowledge revolutions
  - Thomas Kuhn (1960) The Structure of Scientific Revolutions
  - Stephen J. Gould (and Eldridge 1972) - Punctuated equilibria

Karl Popper's first great idea from Objective Knowledge: "three worlds" ontology

"living knowledge"

"codified knowledge"

Cybernetic self-regulation Cognition Consciousness Tacit knowledge

Develop/Recall

Genetic heredity Recorded thought Computer memory Logical artifacts Explicit knowledge

Reprode/Produce

World 2

World of mental or psychological states and processes, subjective experiences, memory of history

Organismic/personal/situational/ subjective/tacit knowledge in world 2 emerges from world 1 processes

The most we can hope for is reliability

Test

Observe

Regulate/Control

Drive/Enable

Describe/Predict
|
Inferred logic

World 3

The world of "objective" knowledge

Produced / evaluated by world 2 processes

Energy flow Thermodynamics Physics Chemistry Biochemistry

World 1 – External Reality

- Reality is what it is irrespective of faith & belief
- Knowledge is 'correspondence to truth', i.e. reality
- A claim to know may be true, but there is no way to prove it

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"Epistemic cut" concept clarifies validity and relationships of Popper's three worlds

- Popper did not have a physical basis to justify his ontological proposal
- **Howard Pattee** 1995 "Artificial life needs a real epistemology"
  - An "**epistemic cut**" refers to strict ontological separation in both physical and philosophical senses between:

    Knowledge of reality from *reality itself*, e.g., description from construction, simulation from realization, mind from brain [*or cognition from physical system*]. Selective evolution began with a description-construction cut…. The highly evolved cognitive epistemology of physics requires an epistemic cut between reversible dynamic laws and the irreversible process of measuring [or describing]….

  - Also known as "Heisenberg cut"
  - Different concept from "*epistemic gap*" separating "phenomenological knowledge" from "physical knowledge"
  - No evidence Pattee or Popper ever cited the other
- One epistemic cut separates the blind physics of world 1 from the cybernetic self-regulation, cognition, and living memory of world 2
- A second epistemic cut separates the self-regulating dynamics of living entities from the encoded knowledge of books, computer memories and DNAs and RNAs
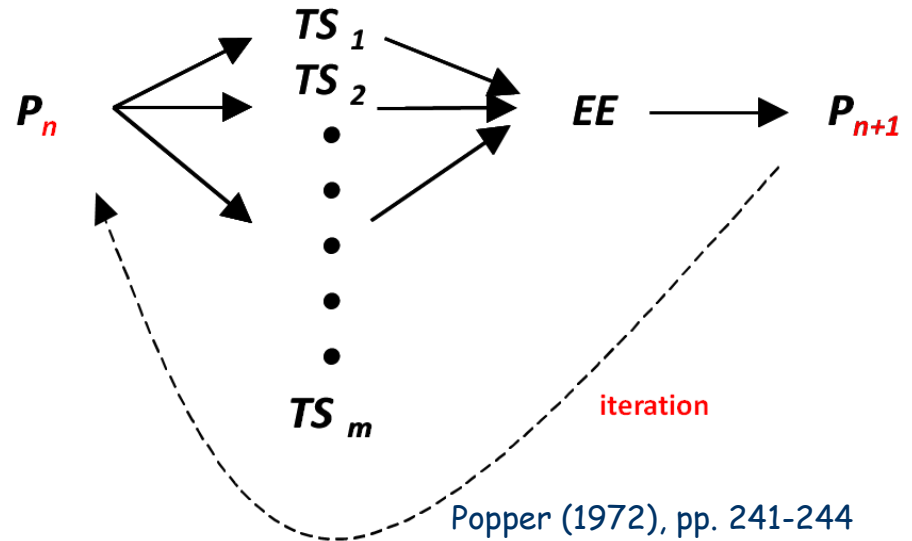- See Pattee (2012) *Laws, Language and Life*. Biosemiotics vol. 7

Popper's second big idea: "tetradic schema" / "evolutionary theory of knowledge" / "general theory of evolution"

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

$$P_n \rightarrow \begin{array}{c} TS_1 \\ TS_2 \\ \bullet \\ \bullet \\ \bullet \\ \bullet \\ \bullet \\ TS_m \end{array} \rightarrow EE \rightarrow P_{n+1}$$

iteration

Popper (1972), pp. 241-244

- **TS**s may be embodied in W2 "structure" in the individual entity, or
- **TS**s may be expressed in words as hypotheses in W3, 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
- Tested solutions/theories become more reliable, i.e., approach reality
- Surviving TSs are the source of all knowledge!
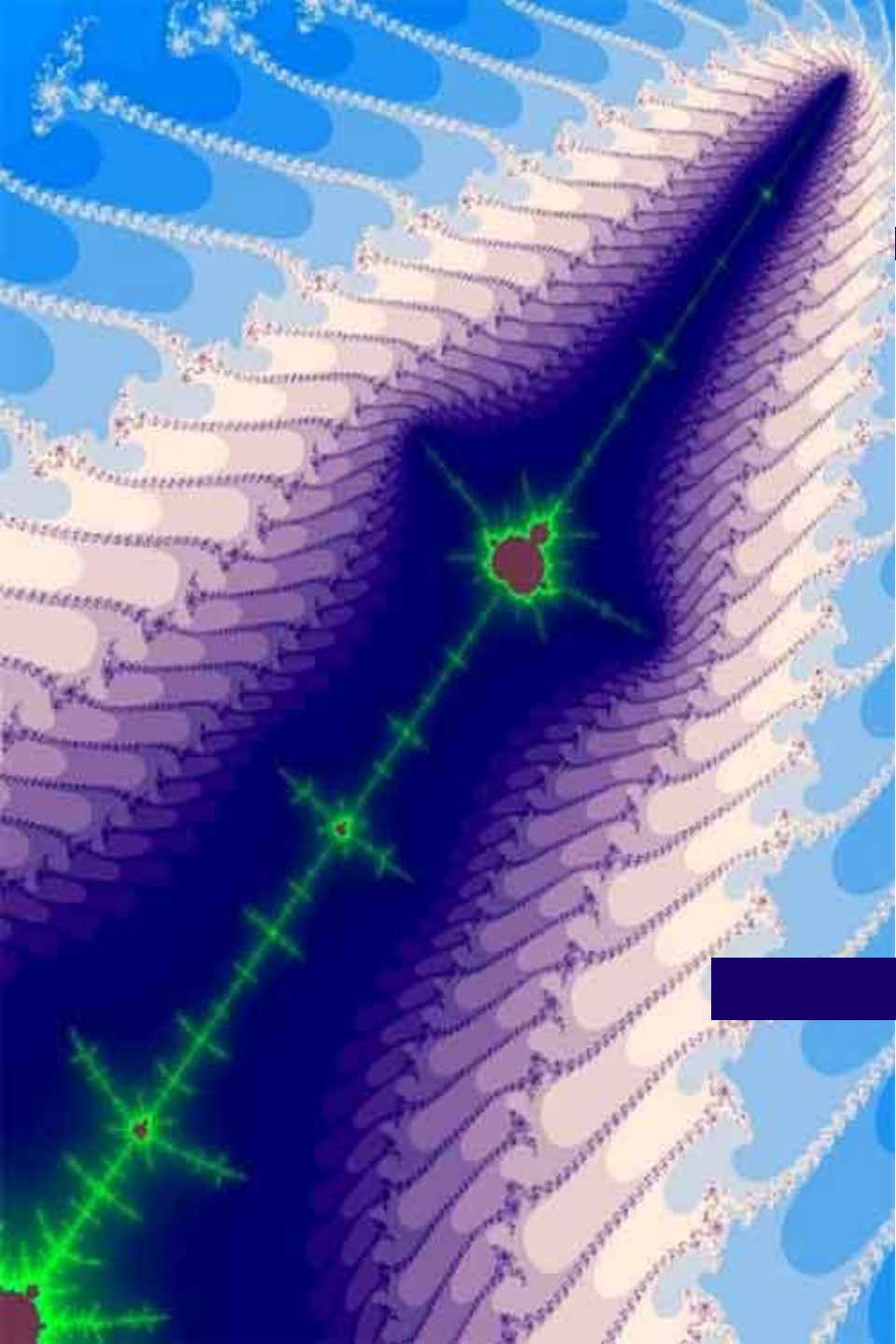
How Science Works

First take on what knowledge is

- Popper's **World 1** encompasses everything - it is the dynamic reality that exists independently of observation, knowing and knowledge
- To survive and flourish we must reliably understand how W1 works in order to dominate it
- **Observation**, **meaning** and **knowledge** dynamically emerge in **W2** as consequences of universal laws governing physical processes in **W1** as these processes impact living entities with an autonomous history able to distinguish themselves from the rest of the world. Erroneous beliefs may be fatal / eliminated
  - **Observation** is a *dynamic change propagated within the observing entity* resulting from an interaction with the world
  - **Meaning** is a *consequence of the observation induced change* in the constitution of the observing entity
  - **Knowledge** (in one sense) is *the persistent consequence of selective elimination on a history of observation and meaning* in world 2 or 3
- There is an epistemic cut between phenomena of W1 and the knowledge of the phenomena as represented in the living system (Howard Pattee, 1995)

Cyclic interactions between personal (W2) and explicit (W3) knowledge
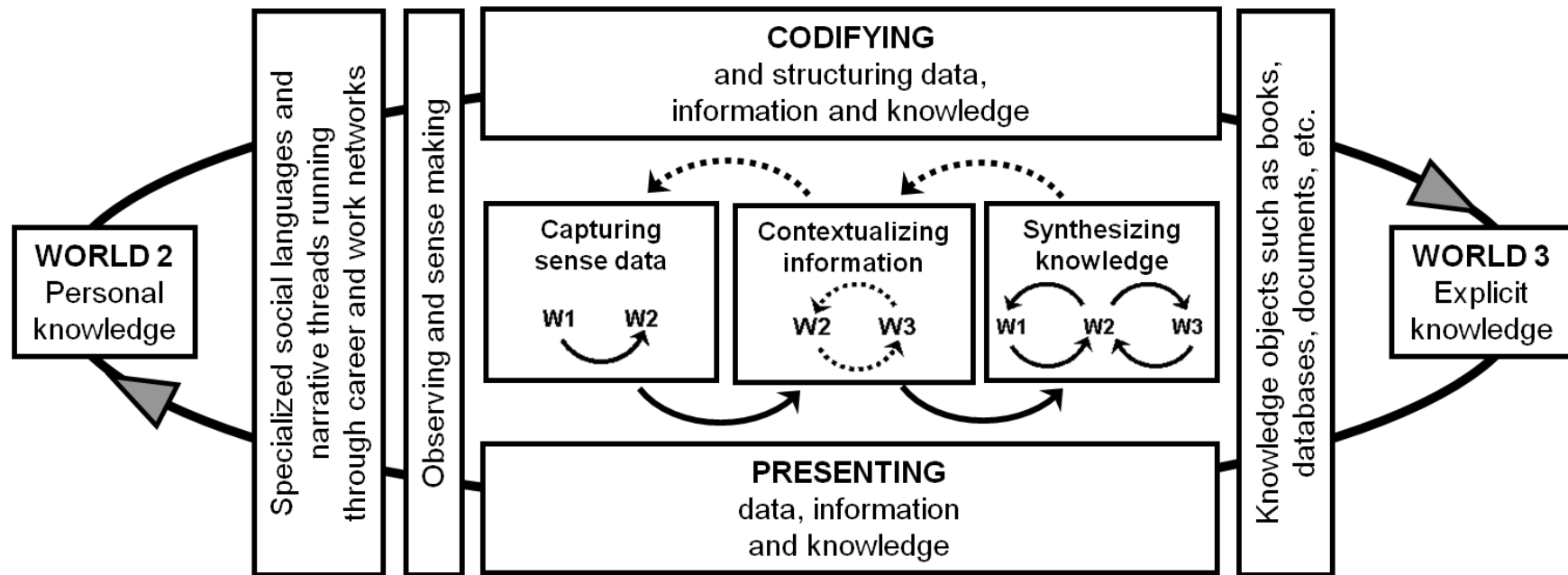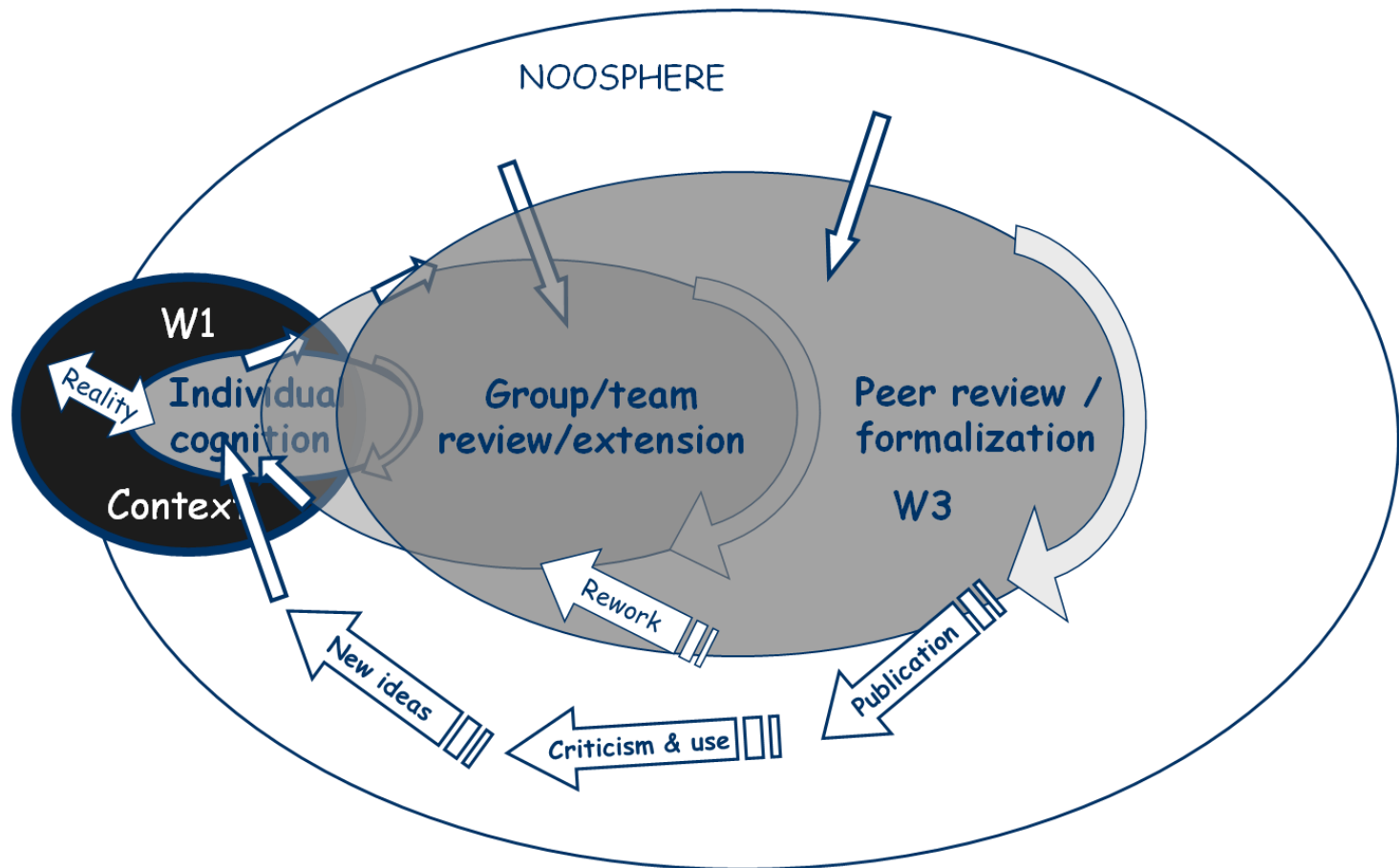

- Vines and Hall (2011) - Exploring the foundations of organizational knowledge
  - Applies evolutionary epistemology to understand individual and organizational processes in the growth of knowledge

Cyclic formalization of knowledge
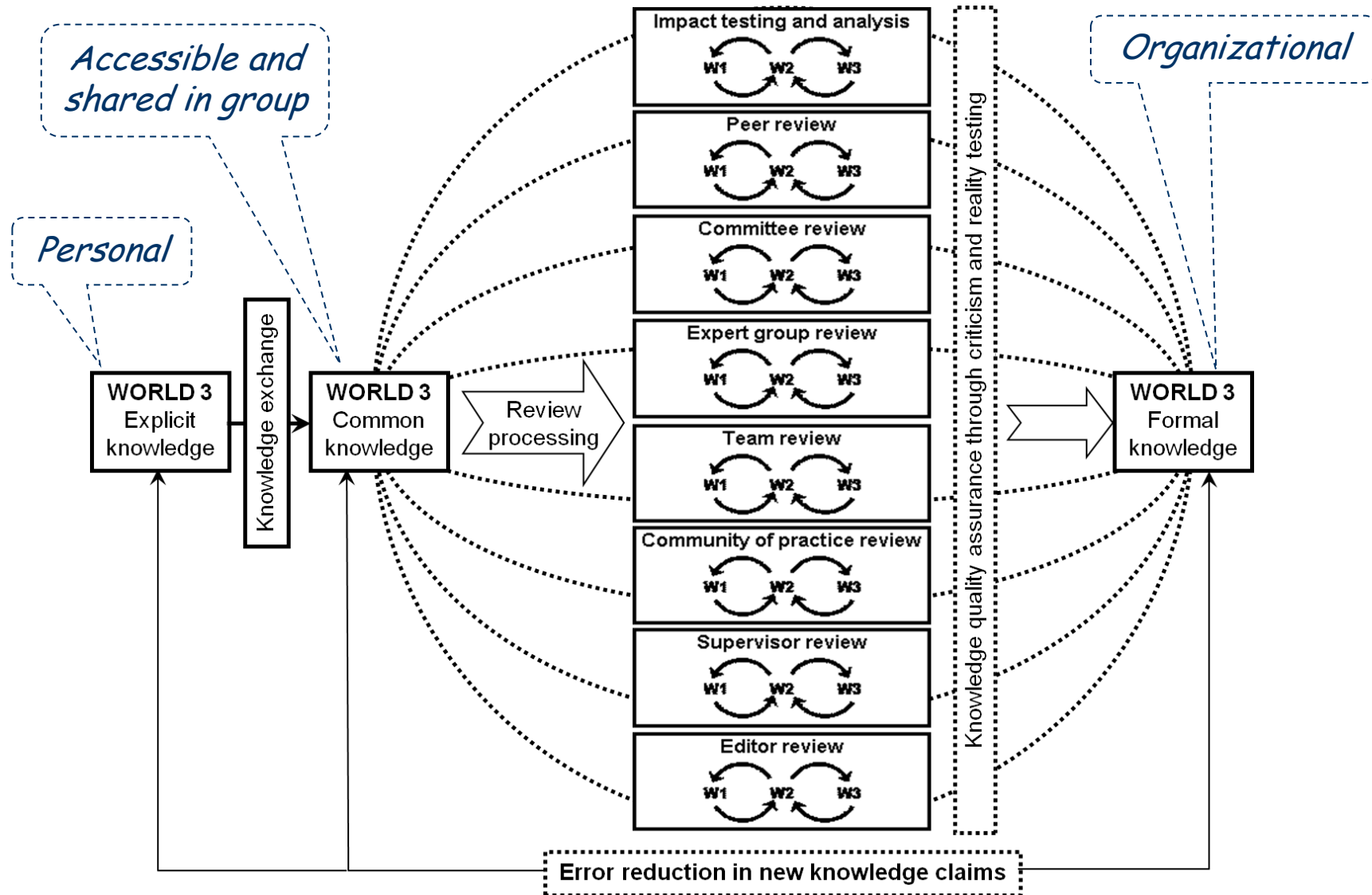
The cyclical construction and reconstruction of formalized scientific knowledge

- Hall, W.P., Nousala, S. 2010. What is the value of peer review – some sociotechnical considerations
- Vines, R., Hall, W.P., McCarthy, G. 2011. Textual representations and knowledge support-systems in research intensive networks

Developmental flows of scientific knowledge
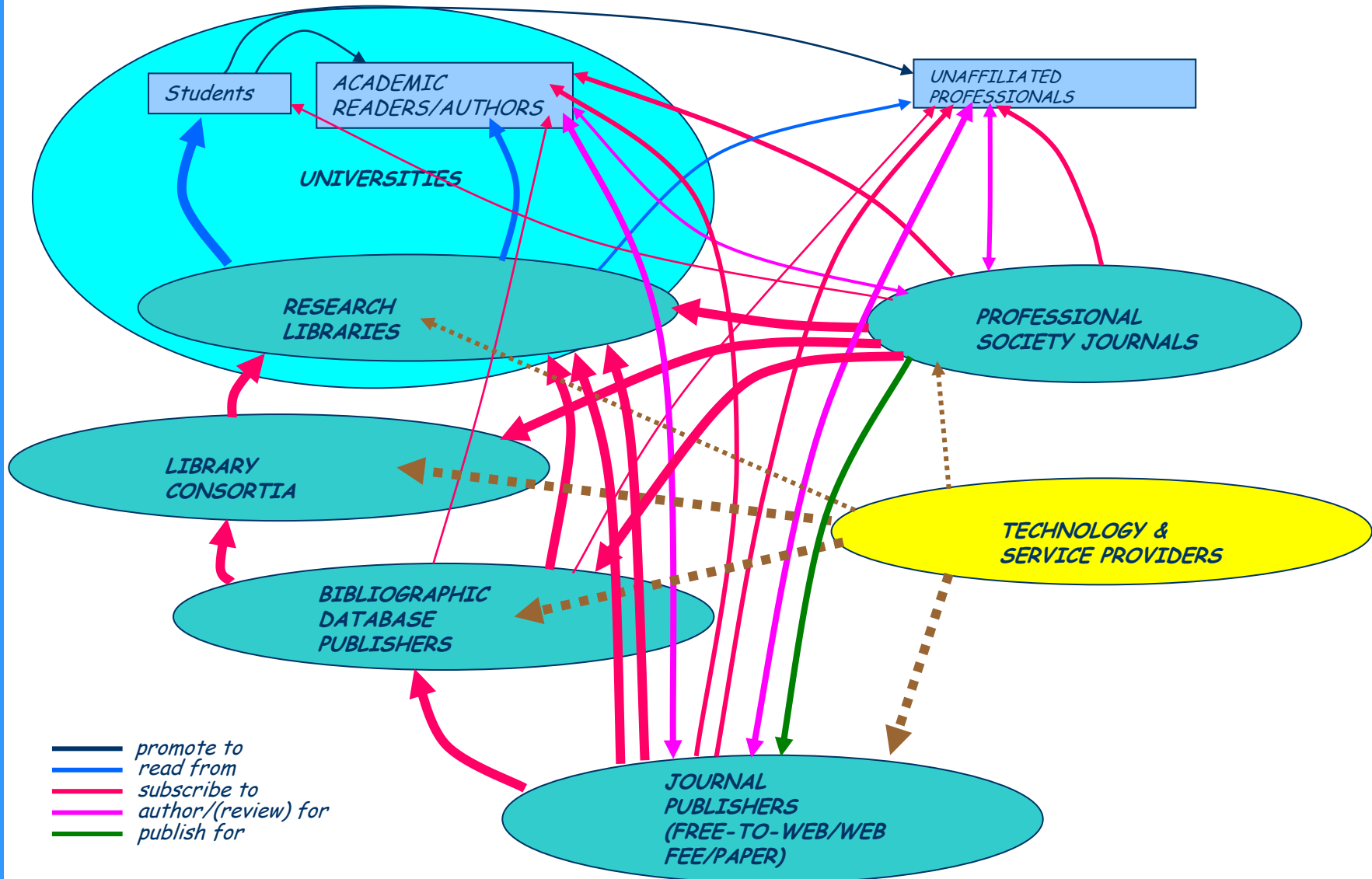
W.P. Hall - selected bibliography

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- Hall, W.P., Kilpatrick, B. 2011. Managing community knowledge to build a better world. Australasian Conference on Information Systems (ACIS) 30th November - 2nd December, 2011, Sydney, Australia.
- Hall, W.P., [Preview]. Application holy wars or a new reformation: A fugue on the theory of knowledge, 92 pp.