Evolution-theoretic Approach to Synthetic Study of Intelligence

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Points

1. To study intelligence, we need internal observation (endo-system view)
2. Two kinds of sciences:
   1. Analytic - exo-system view and method
   2. Constructive/synthetic - endo-system view and method
3. The essential driving force of a constructive method is the evolutionary method

Needs of the Endo-System View

- Study of intelligence needs different research methodology than natural sciences
- Behaviorism in experimental psychology, which followed natural science methodology, did not succeed
- Cognitive Science talks about internal processes and representations - observation from inside
- AI seeks for the definition of intelligence
  - Target: concept of intelligence in the abstract level
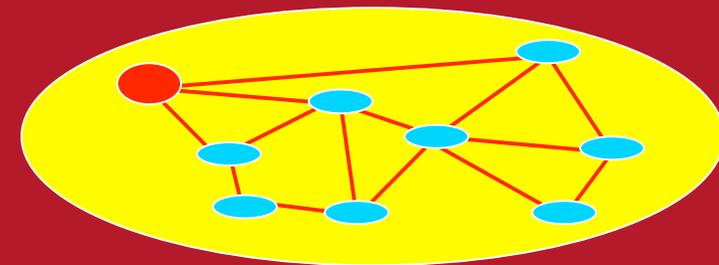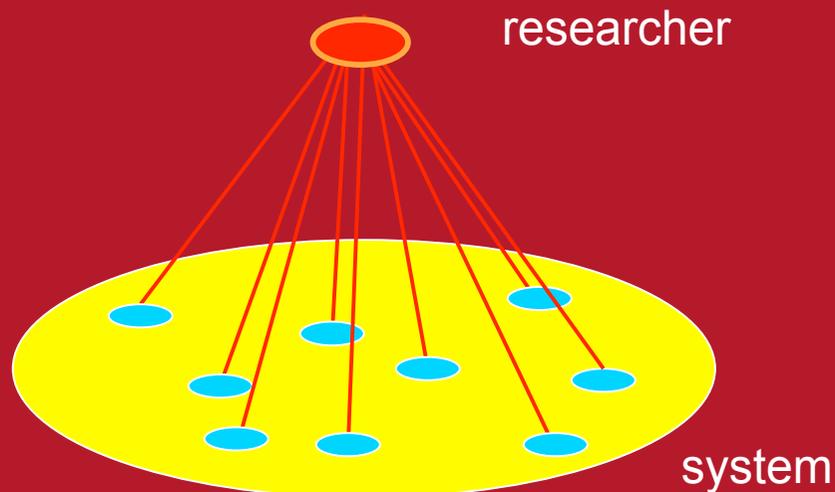 - Method: to construct a program that exhibits intelligent behaviors
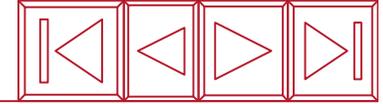
Exo and Endo-System Views

- Observation affects the system being observed

God's view
The theorist's view
= External observer

Agents' views
= Internal observer

researcher

system

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Yasunari Kawabata's "Snow Country"
- The famous first sentence -

- Original Japanese:

  国境の長いトンネルを抜けると雪国であった.

  * Yasunari Kawabata is a winner of the 1968 Nobel Prize in Literature

- English translation by E. Seidensticker：

  The train came out of the long tunnel into the snow country.

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View Points of A System
(Biased by Culture/Language)

- Japanese is expressed from insects-eyes-view
  - » Takehiro Kanaya
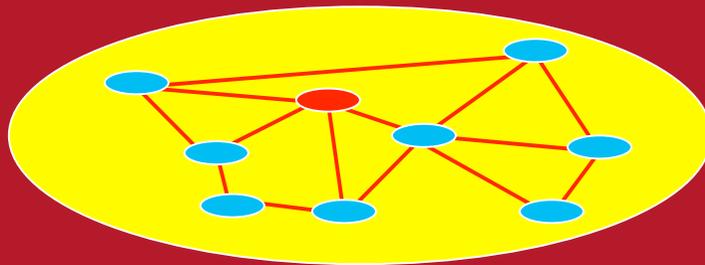 - » 金谷武洋「英語にも主語はなかった」(2004)

- English is expressed from birds-eyes-view

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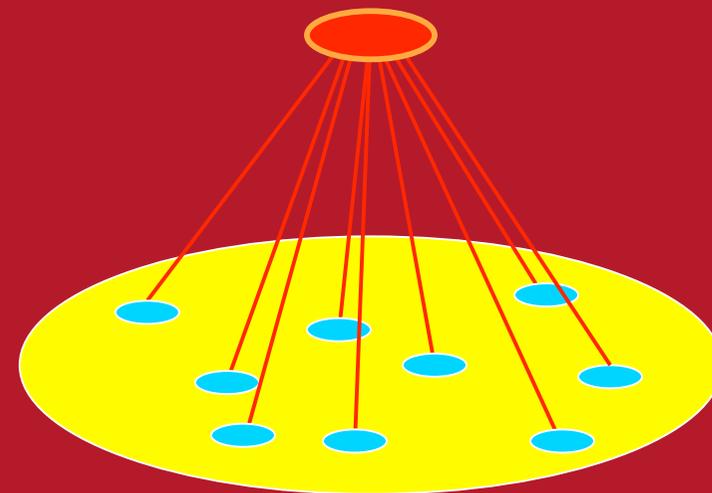
Synthetic Science vs. Analytic Science

- ## Synthesis
  - Agents' view
  - Insects' view

- ## Analysis
  - Theorists' view
  - God's eyes' view

- *Autopoiesis*
- *quantum physics*

Synthesis

- Simon, H. A. (1996). *The Science of the Artificial, The Third Edition*, MIT Press.
  - constructive science vs. analytical science
- Analytical science is to divide a system into its simpler subsystems and recursively analyze them till we understand every subsystems and the structure of their connection
- Cognitive Science (AI) includes researchers, a program and the environment of the execution of the program

Analysis and Synthesis

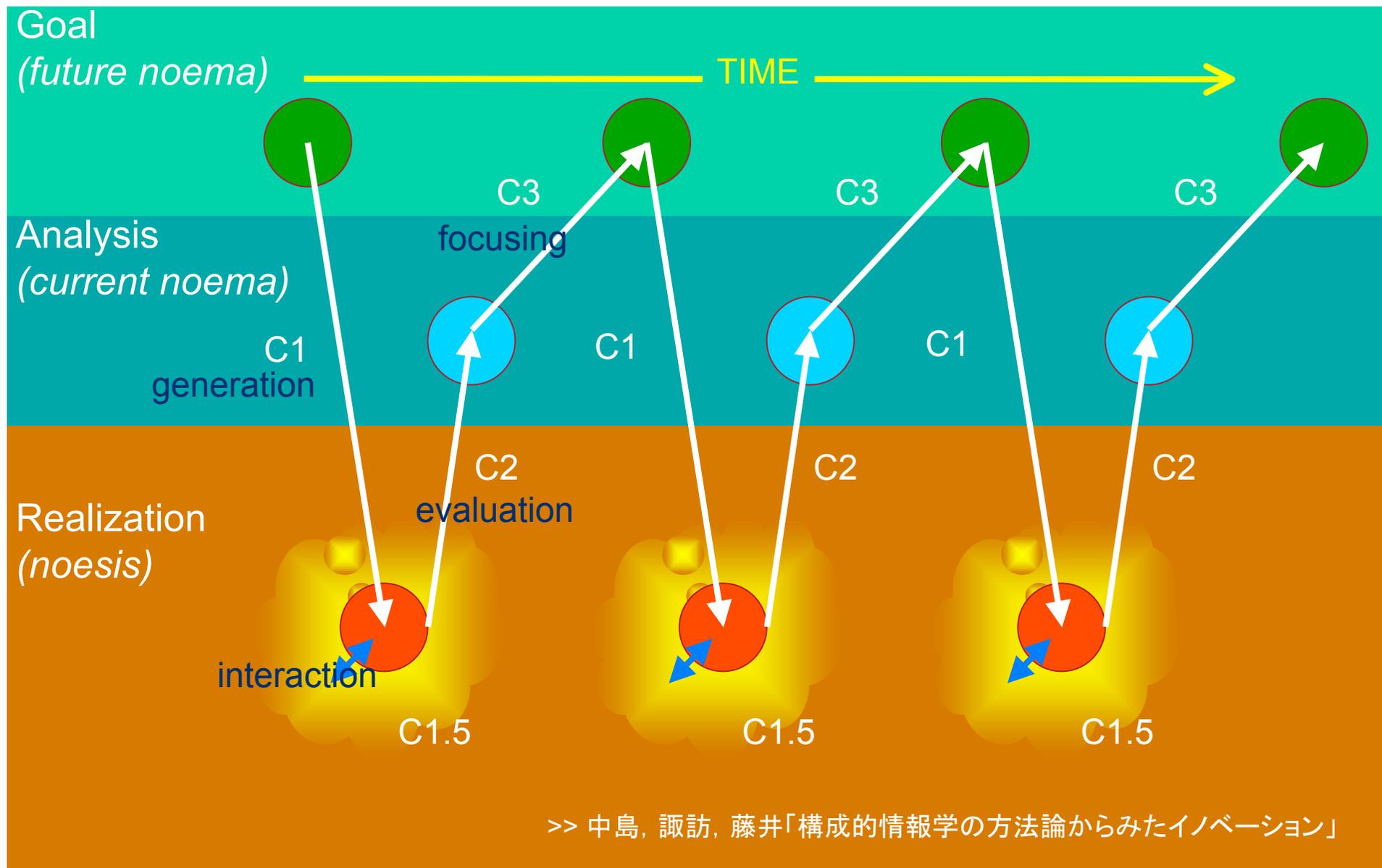- Analysis: from whole to parts
- Synthesis: from parts to whole

synthesis

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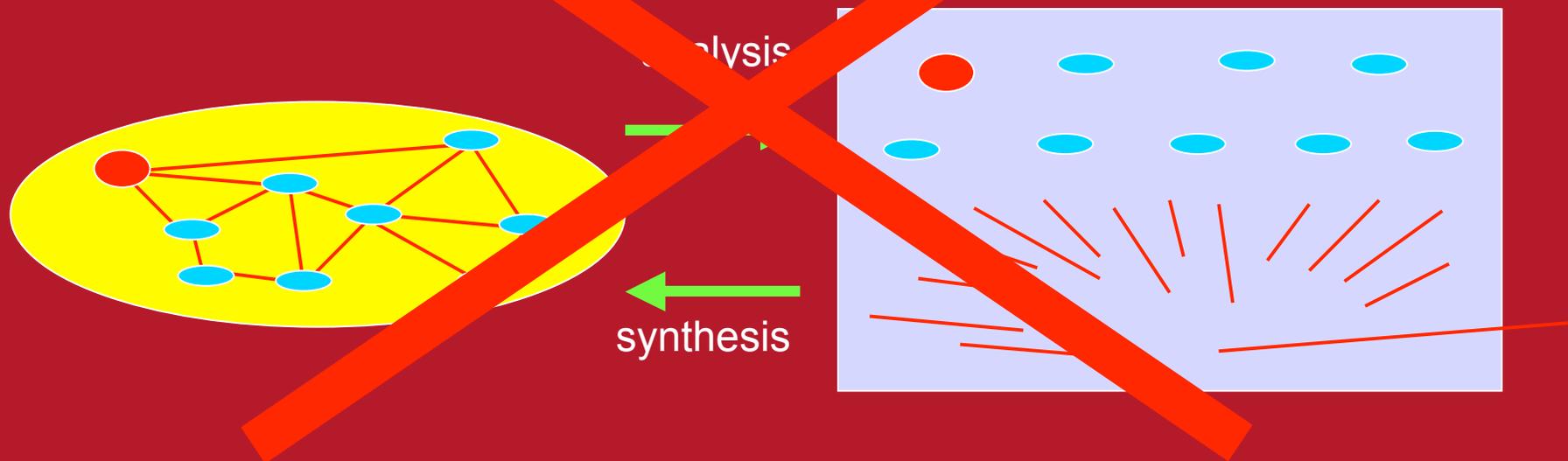
Why?

- In synthesis, the parts are not identified unless we know the whole
- The whole cannot be constructed unless we have the parts
- DEADLOCK...

FNS Diagram

>> 中島，諏訪，藤井「構成的情報学の方法論からみたイノベーション」

Evolutionary Method

- The FNS-diagram tells us the following:
  - We have to repeat a synthetic loop to approach our goal - future Noema (cf. Bin Kimura)
  - However, the goal itself may change during the process
- The process itself forms a complex and holistic system
  - We cannot directly control complex interactions
- Evolutionary method is the key here

Evolution Simplified

1. Random generation
2. Selection (note: criteria changes dynamically)

selection

generation

next generation's seed

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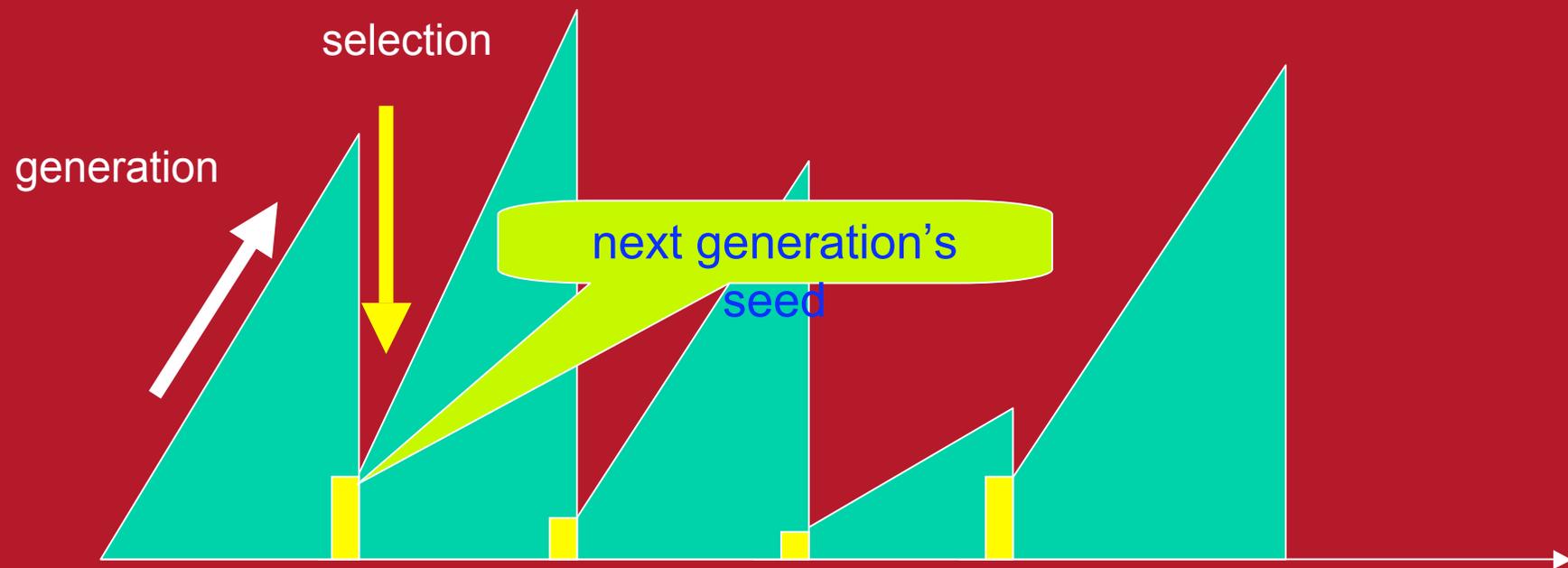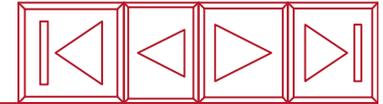
Genetic Algorithm (Wiki)

1. Choose initial population
2. Evaluate the fitness of each individual in the population
3. Repeat until termination: (time limit or sufficient fitness achieved)
   1. Select best-ranking individuals to reproduce
   2. Breed new generation through crossover and/or mutation (genetic operations) and give birth to offspring
   3. Evaluate the individual fitnesses of the offspring
   4. Replace worst ranked part of population with offspring

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Ichikawa's views of evolution

- A general process of ever changing systems with the following conditions
  1. Existence of self-replication unit (genome) to maintain regularity
  2. Existence of a system structure of self-replication units (existence of elements and a system that connects those elements)
  3. Possibility for mutation of the system structure
  4. Interaction (competition) among replicator systems (for frequency of replication)
  5. Existence of external environment

FNS Diagram for Constructive Sciences
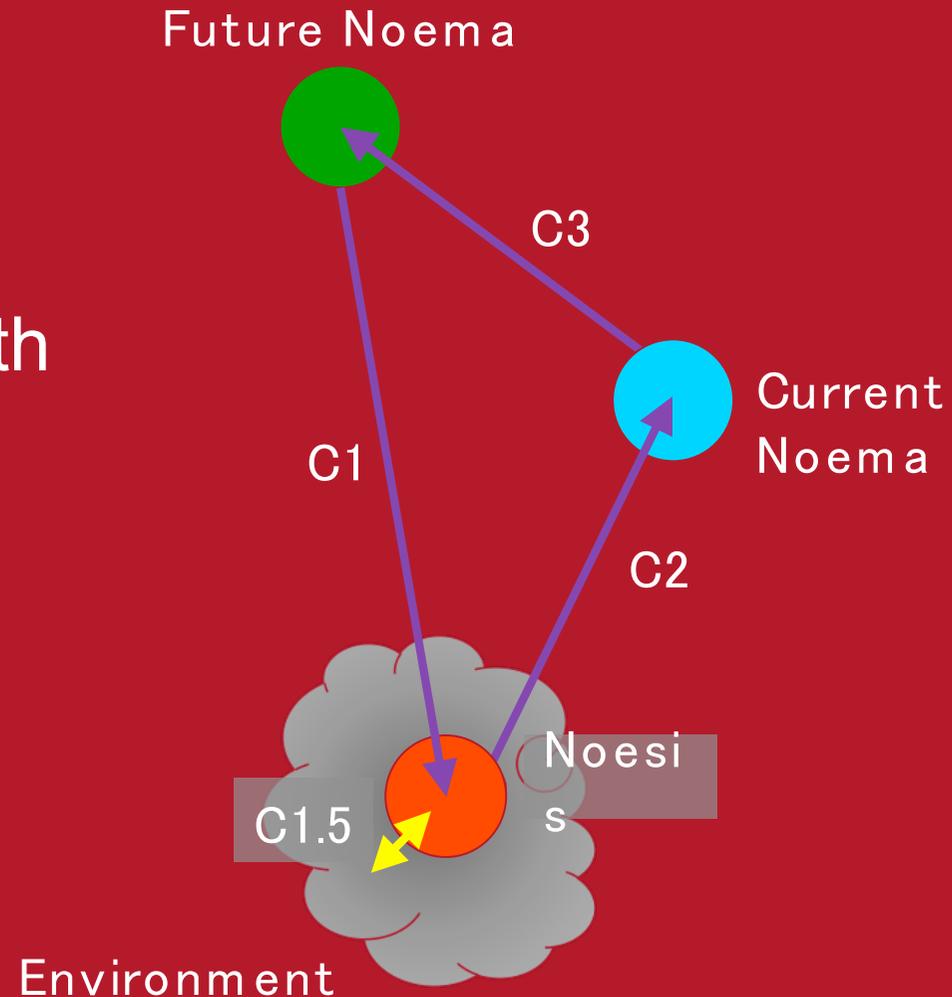
Future Noema
  C1: Generation
Noesis
  C1.5: Interaction with
    environment
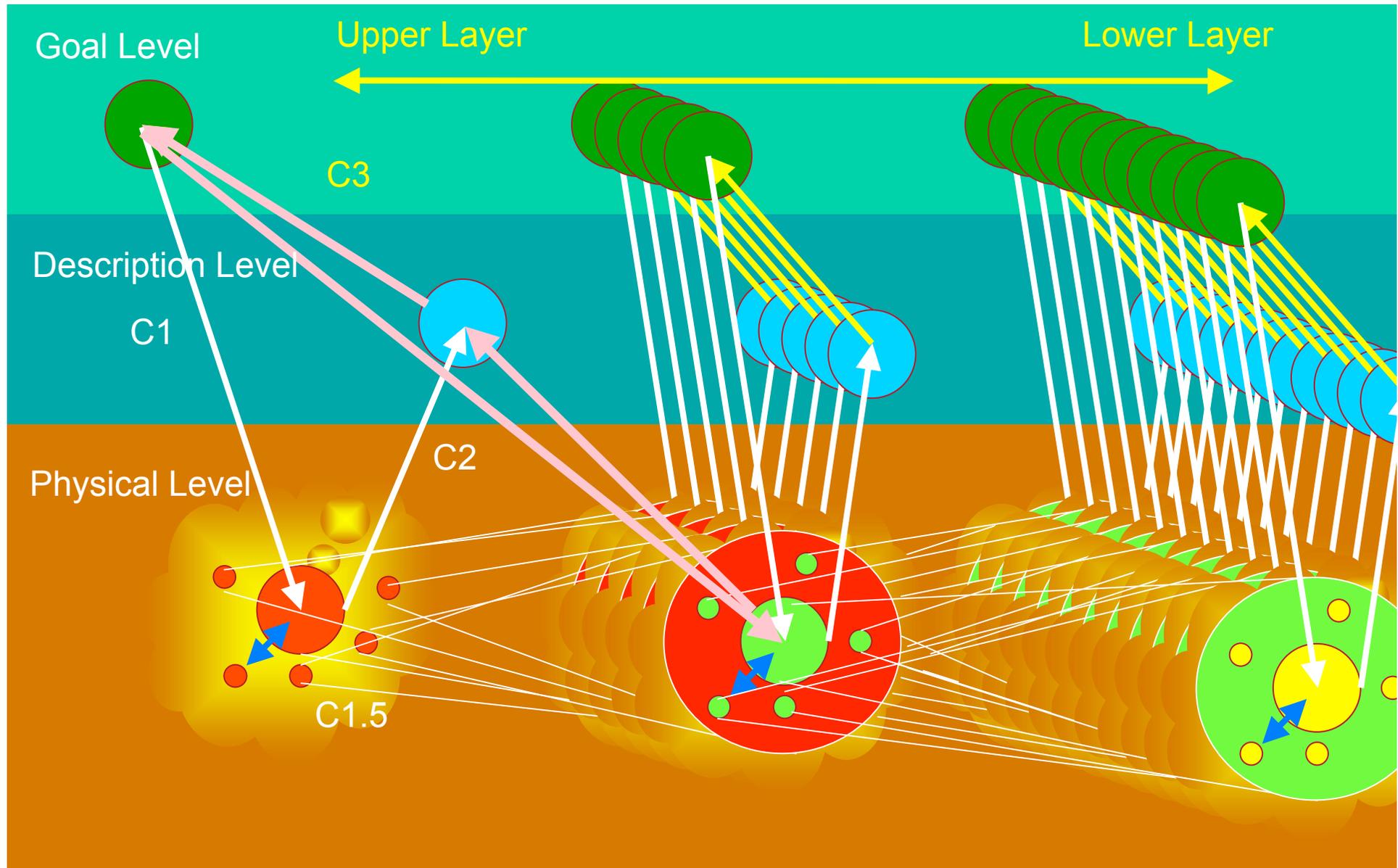 C2: Evaluation
Current Noema
  C3: Focusing (to
    future)
Future Noema (next)

Future Noema

C3

Current
Noema

C1

C2

Noesis

C1.5

Environment

Multi-Layered FNS Diagram

Difference between Synthesis and Evolution

- Natural evolution process does not have any intention or direction
  - Evolution occurs as a result of selection by nature
  - The concept of evolution does not include improvement
- But our synthesis of artifacts is an intentional process
  - For example, optimization method is applicable locally
  - Selections can be directional *(may be a bad idea)*

The Mind-Body Problem

- A human being must be understood in multi-levels
- How is the mind encoded as behavior of neural cells?
  - how can the decision of ``raising the right hand'' trigger the series of firing of neural cells
  - that eventually send signals to proper muscles of the right hand to cause it raise?
- Or is it the other way around?
- Is it the case that certain patterns of neural firing is affecting both the right hand and the cognition of the intention of raising the right hand?

Finding out the Vertical Causal Relationship

- The answer here is the evolution

- If we connect billions of neurons in arbitrary way, it does not function as desired. It is quite unlikely they represent a coherent mind. Only a certain connection, born as the result of long evolution, can support (or emerge) cognitive function.

The answer to the mind-body problem

- It just happens to be in a configuration so that mind and body correspond each other".
  - Both levels, mind and body, function independently.
  - The body is configured in a very specific way (through evolution) to correspond to the function of mind.
  - Otherwise, a human being did not survive the evolution process.

My Current Research Plan

- Cellular Automaton with evolution (changing rules and selection)
- Emergence of the upper level structure
- Feed back from the upper level structure to the lower level selection (adaptability)
- Fixation of the emerged structure

THE END