Goal for each pre:

5 minutes information

2 minutes “treasure”

3 minutes Discussion

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10 minutes for logistics, feedback

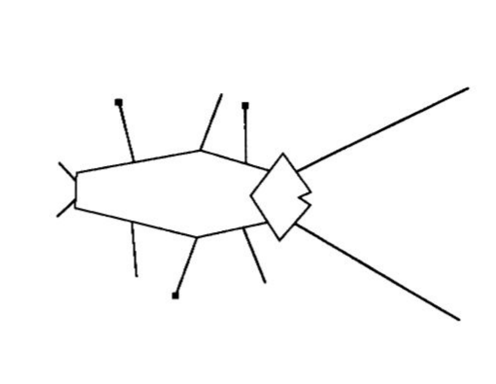
Week 7

Artificial Life

CSSE290

01

Will G



Will G

Our Ideology Affects Our Observations and Models

- The “What Matters?” Paper
- "Artificial Life is experimental philosophy. Philosophical claims as to the nature of life can be explored, challenged, and clarified through creating artificial life forms. Conversely our design strategies for creating Alife will be influenced by our philosophical assumptions"
- “Years of wasted efforts to answer the wrong questions may be saved by an afternoon in an armchair working out the right questions”

What Matters? Agent Concerns, Agent-designer Concerns

Inman Harvey

Evolutionary and Adaptive Systems (EASy) Group
University of Sussex, Brighton, UK
inmanh@gmail.com

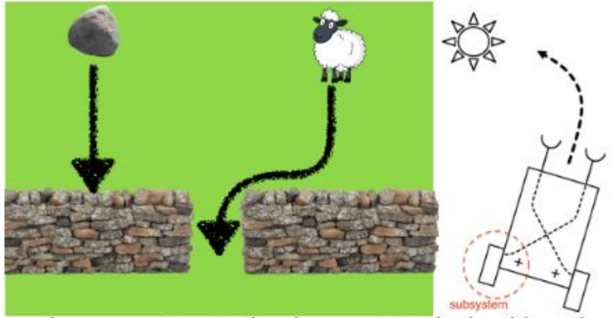


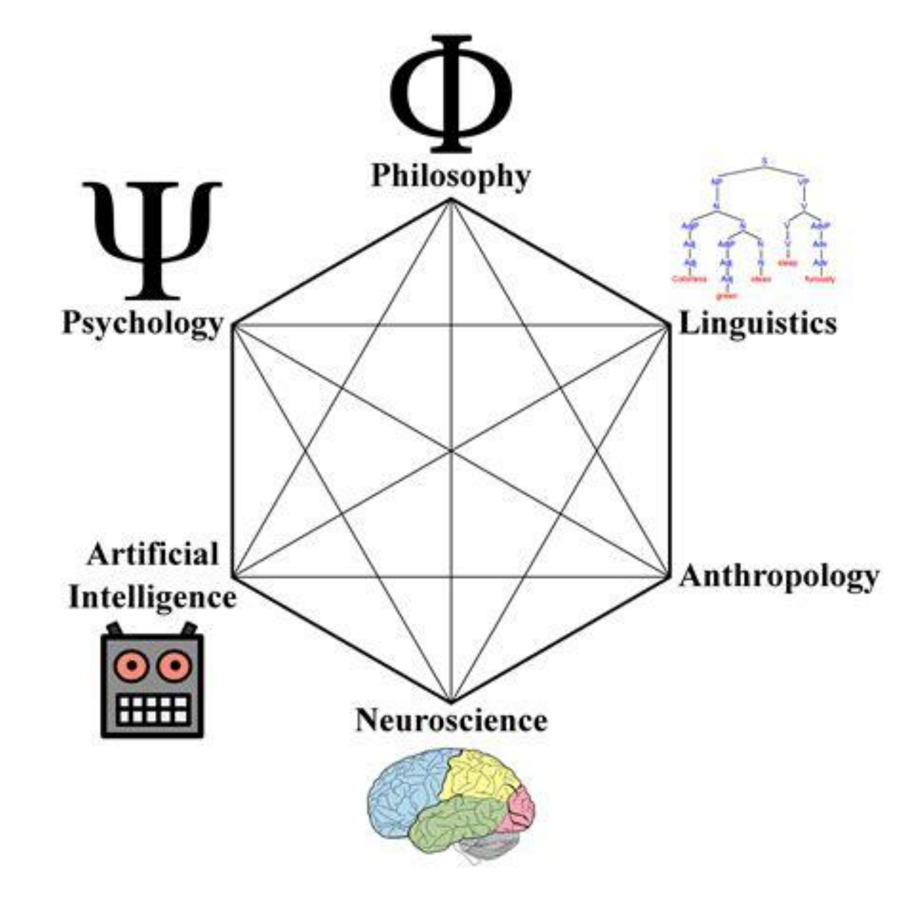
Fig.1. The gap matters to the sheep, not to the boulder. The light matters to the Braitenberg vehicle, not to the subsystem.

Will G

Our Ideology Affects Our Observations (cont'd.)

Dynamical approaches to cognitive science Randall D. Beer

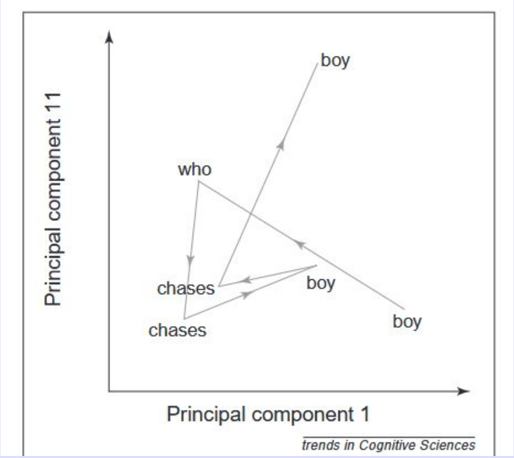
- Symbolic Models Assume cognition involves the manipulation of symbols according to syntactic rules.
- Connectionist Models Utilize networks of simple units (neurons) to model cognitive processes, emphasizing parallel processing and learning.
- Dynamical Systems Models Contrast with both by focusing on the continuous, time-dependent evolution of cognitive states.

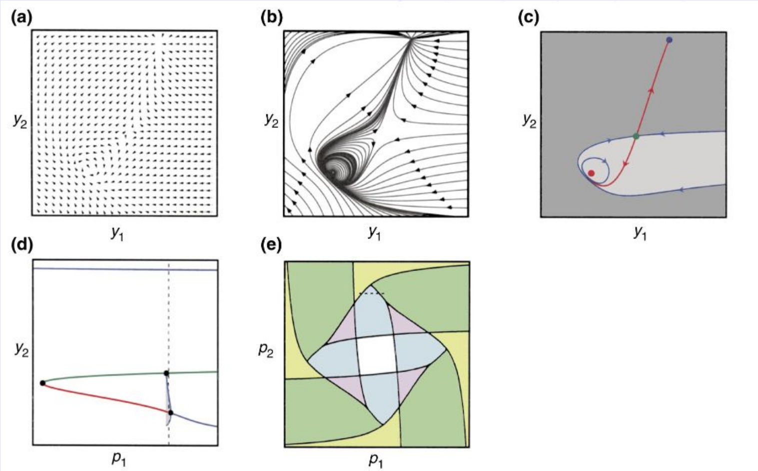


Will G

Dynamical Approaches

- Dynamical System Definition (according to ChatGPT):
  - A dynamical system is characterized by a set of variables and a set of differential equations that describe how these variables change over time.
- Cognitive processes are viewed as evolving over time, influenced by both internal states and external interactions.
- Interplay between internal dynamics and environmental factors.
- Rejection of static representations in favor of continuous change.



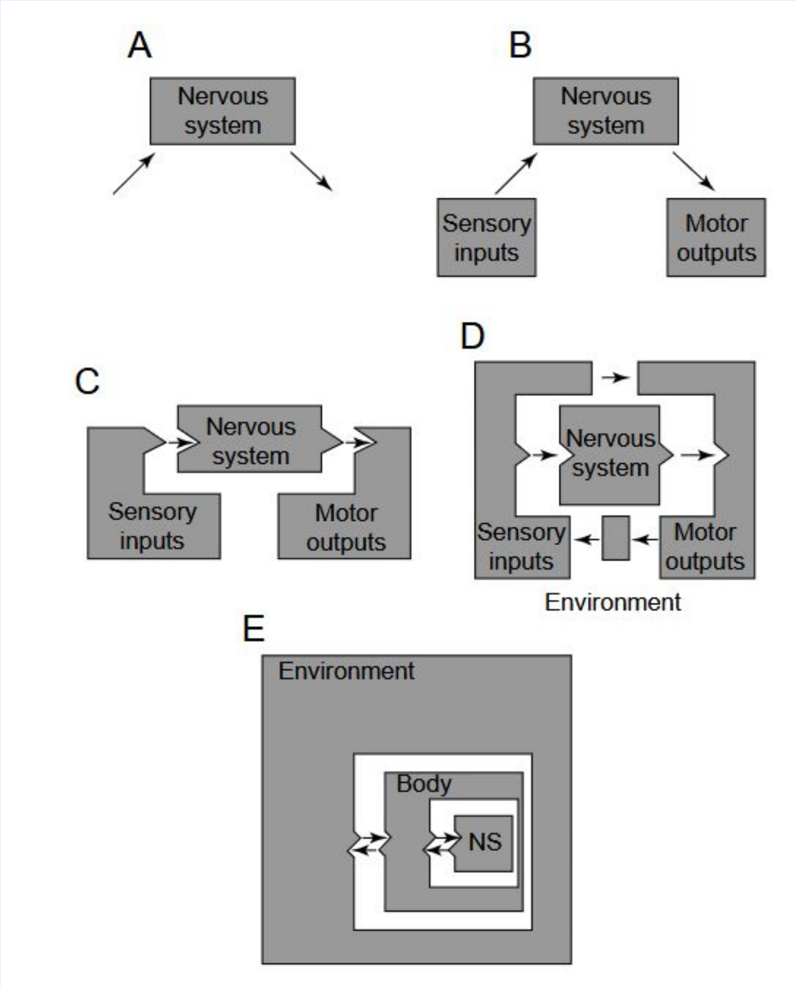


Will G

Cognitive Neuroethology

The brain has a body: adaptive behavior emerges from interactions of nervous system, body and environment. Chiel and Bier (1997)

- Models neural control in conjunction with body-environment interactions
- Captures the natural state of evolution and learning more closely
- “The most important evidence suggesting that the nervous system cannot be the exclusive focus for understanding adaptive behavior is that it continuously receives and responds to feedback both from the movements that it induces in its own periphery and from the surrounding environment”



Will G

Computational Neuroethology

"How Do We Compute The Entire System"

Evolving Dynamical Neural Networks for Adaptive Behavior

- Continuous-time recurrent neural networks (CTRNNs) are used as controllers. (Dynamical System!)
- Evolution is guided by external performance metrics rather than internal correctness. (similar to the simulated 3D organisms from the required videos for this week)
- Sensor-enabled controllers perform better than the sensorless ones. (shows importance of environmental awareness)

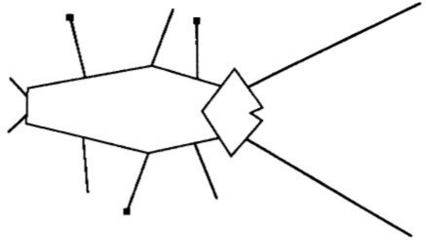


Figure 9
Simulated insect body model.

Figure 2
Examples of each of the four classes of near-patch behavior.

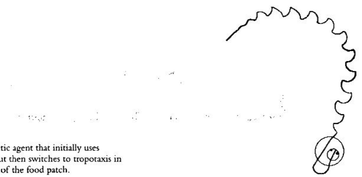


Figure 3
A chemotactic agent that initially uses klinotaxis but then switches to tropotaxis in the vicinity of the food patch.

Discussion

- Computational Neuroethology
- Cognitive Neuroethology
- Dynamical Approaches
- Our Ideology Affects Our Observations and Models

02

Steven Johnson

Steven

Sensorimotor Contingencies

- Kevin O'Regan: Sensorimotor approach to understanding "feel" in humans and robots (video)
    - Gives an overview of the sensorimotor approach
    - "life is simply a word that describes the way certain systems interact with their environment"
- Grounding Perception: A Developmental Approach to Sensorimotor Contingencies (paper)
    - Applies the approach to various robot-related tasks

Kevin O'Regan

- Former Director of the Laboratory of Perception at Paris Descartes University
- Psychologist that specializes in consciousness

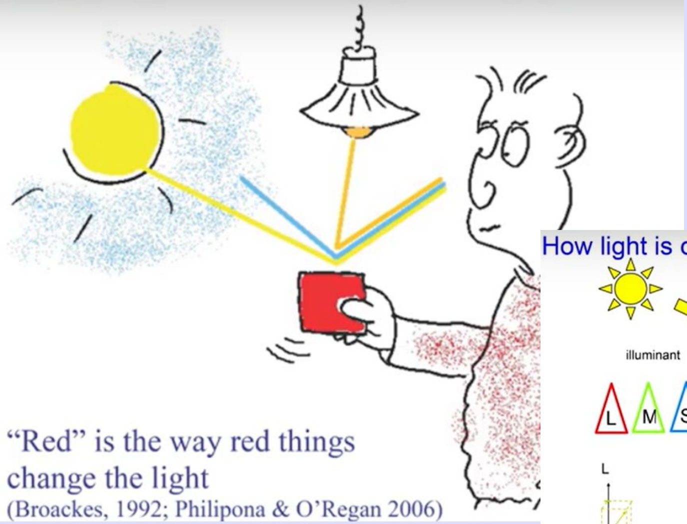
Kevin O’Regan

- "Consider a sponge, you feel a sponge, it's soft. Where is the softness of the sponge generated? That's a stupid question. Softness is not generated at all. Softness is a word that describes how soft things behave when you press on them they squish. Softness is a sensory motor law. It's a law that describes the relation between your actions and the sensory input."

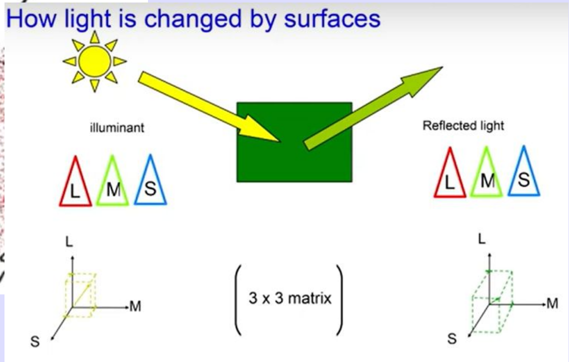
Steven

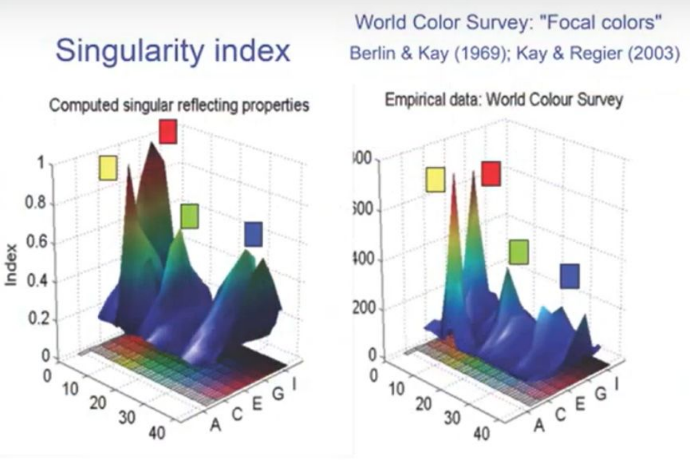
Kevin O'Regan

- Sensorimotor approach works for sponge but can it be extended to all sensations?
    - **That is the bet of sensorimotor contingency theory.**
- Example: observing "pure" red



How much
-Absorbed?
-Reflected?





Theory matches anthropological data – "Big win for philosophy"

Steven

Grounding Perception

- "Sensorimotor contingency theory offers a promising account of the nature of perception, a topic rarely addressed in the robotics community."
  - Overfocus on **how to perceive** rather than **what is perception**
  - Directly mentions O'Regan's work as groundbreaking but slow to spread due to
    - Paradigm shift requisite
    - Lack of clear formalization
- Traditional approach to robots are inflexible and break when conditions are changed

Steven

Grounding Perception

- Overall Strategy
  - Sensorimotor contingencies define a perceptive ontology (framework)
  - Predictive modeling as computational implementation of contingencies
  - An approach to allow a naive agent to build its own predictive models, and interpret the world with which it interacts

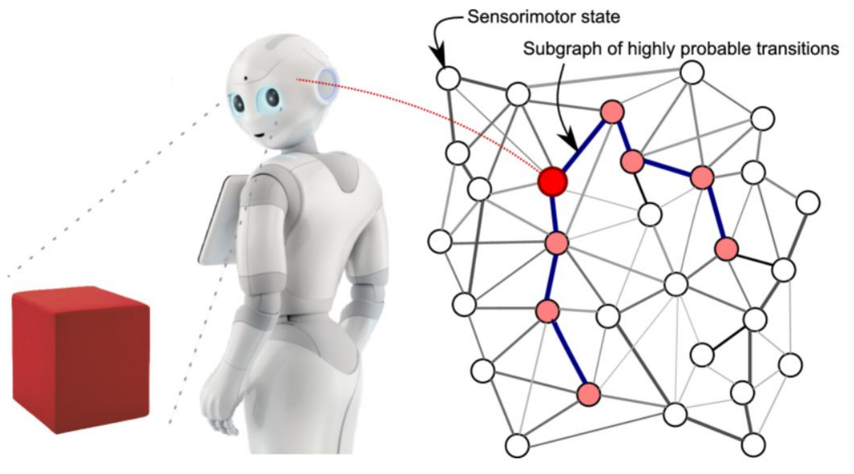


Figure 1: Schematic illustration. The agent's experience is a walk into the sensorimotor space. When experiencing a contingency, only a subgraph can be actively visited by the agent with a high probability .

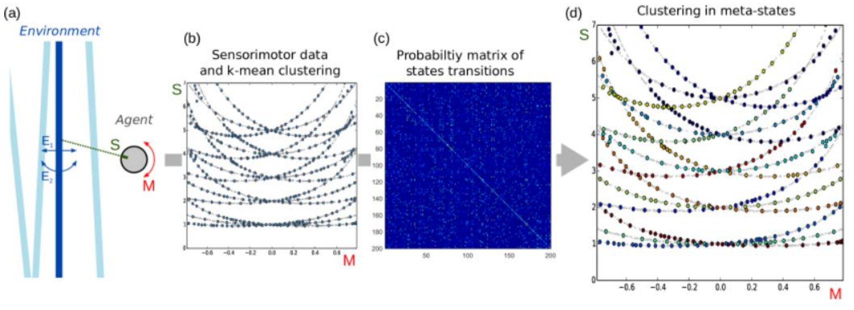


Figure 2: (a) Agent rotating and measuring its distance to a moving wall. (b) Clustering of the collected sensorimotor data using k-means (each line in the sensorimotor space corresponds to a single position of the wall). (c) Matrix T of estimated probabilities of transitions between the sensorimotor clusters (only the first 200 rows and columns are displayed for the sake of visualization). (d) Spectral clustering is applied to identify highly probable subgraphs in the matrix T. Each cluster is colored according to the subgraph it belongs to, which shows that each environmental state has been internally encoded by a corresponding subgraph.

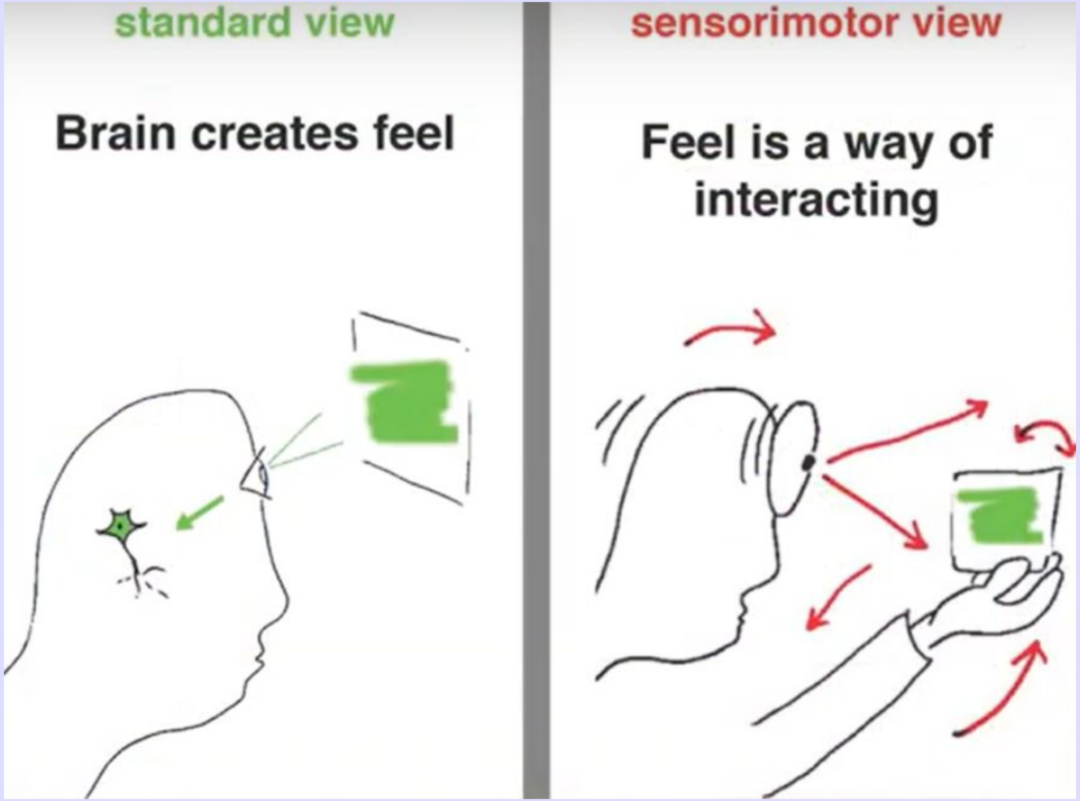
Steven

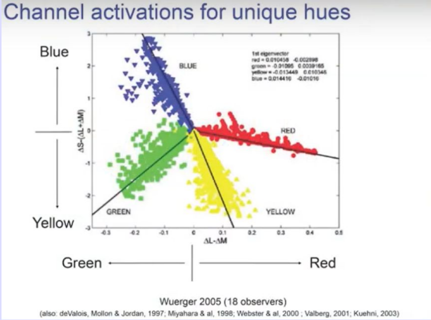
Grounding Perception

- Learning Sensorimotor Contingencies
  - A naive agent needs to learn what is predictable and when
  - **Predictive model:** The agent builds this model to predict outcomes of its actions and learn sensorimotor states through experience
  - **Hierarchical structure:** The agent builds a hierarchy of contingencies, enabling it to handle more complex tasks over time
- "Preliminary Applications" - each implemented with a separate algorithm
  - Perception of the environment
  - Perception of objects
  - Acquisition of a visual field

Steven

Recap





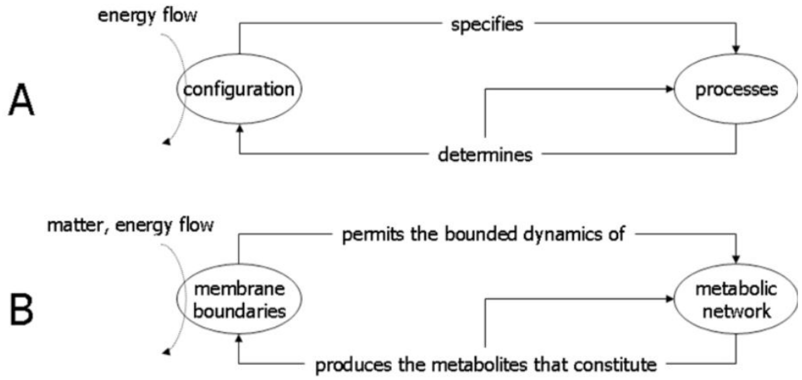
Found the non-uniqueness of unique hues interesting

03

Alex Brickley: Autopoiesis

Autopoiesis definition

"An autopoietic system produces a unity that is **topographically** and **functionally** segregated from its background. The operational closure (processes which produce components that are reinserted in the original processes by the means of other processes) of autopoietic systems is a general principle of organisation, which can be applied in many contexts" Olivier David



Alex Brickley

Talking Points

- What is Autopoiesis
- Inside and outside
- Homeostatic negative feedback loops
- Need a low level of randomness

1%

of cells in a human body are human cells, the rest are bacteria

Self organization

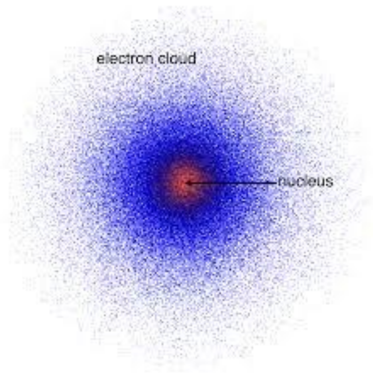
Lorem ipsum dolor sit amet, consectetur adipiscing elit.

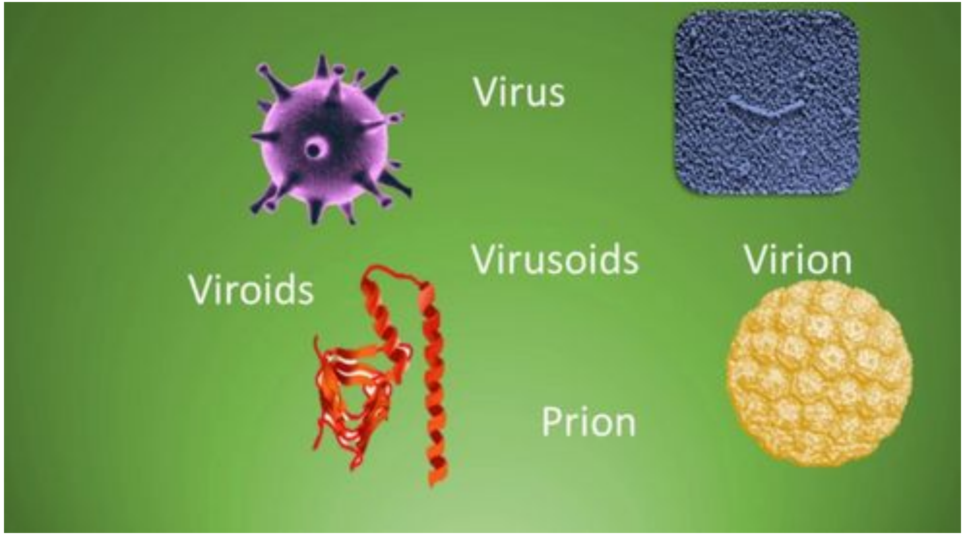
Humans are just a bunch of self organizing cells

Some bio-molecules are capable of responding to the environment

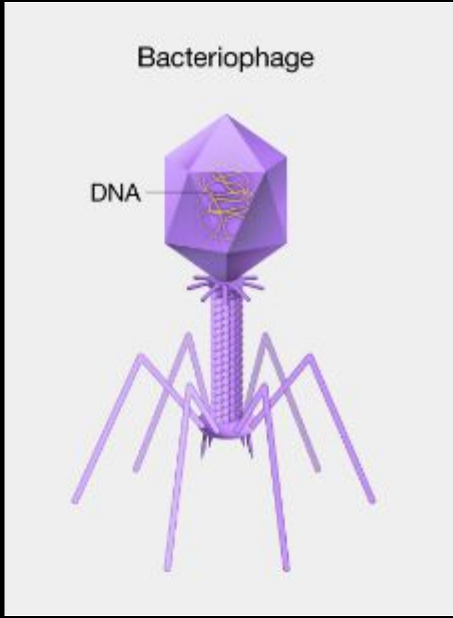
molecules are self organizing atoms

atoms are self organizing subatomic particles





Red Blood Cell



Terminal cells

Non-Terminal

Conway's game of life (glider)

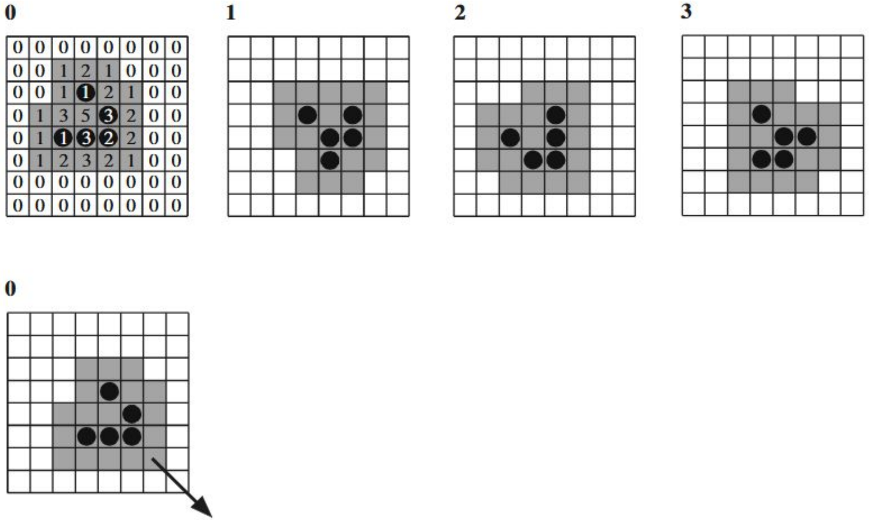


Figure 1. A glider in the game of life. Active cells are represented by a black disk, while inactive cells are empty. As indicated by the arrow, this glider moves diagonally downward and to the right by one cell every four updates. The set of cells that the main text argues should be identified with a glider is indicated in gray. In order to illustrate how the rules of life produce the 0 → 1 transformation, the number of active cells in the Moore neighborhood of each cell is given for the initial state 0.

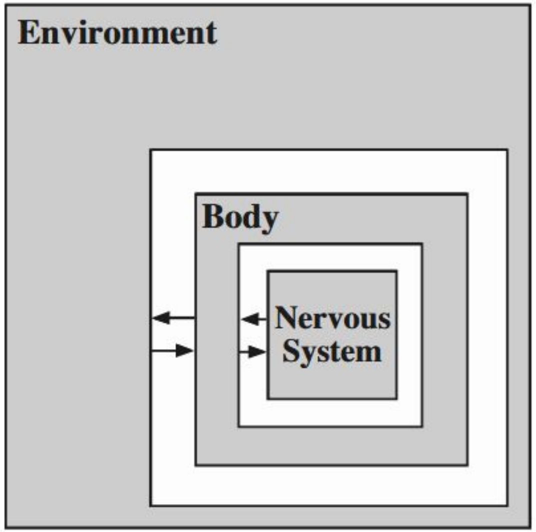


Figure 5. For the purpose of behavioral and cognitive analyses, an agent can be conceptualized as three interacting dynamical systems that represent its nervous system, its body, and its environment.

Treasure-Art

These paintings begin with a single mark made by a moderator and then continue to develop as the participants make additional marks inspired by the first. The painting continues in complete silence until one of the members of the group suggests by raised hand that he/she feels the painting is finished. At that point, the moderator takes a vote and determines whether or not it is, indeed, finished. The point, of course, is collaboration, but also (now I know the term) "autopoiesis."

04

Dominic Reilly

Dominic Reilly

Code demo for 2D version of Karl Sim’s Evolved Virtual Creature’s

Wrapping Up

Connection to prior weeks?

Provide Peer Evaluation (including Self)

Portfolio Reflection Entry

For Thursday
Review Resources
1 Paper Each Person
Develop Questions
for Dr. Iquierdo

Week 8 - Thursday, May 8 at 4pm Guest

We will use some of the time from 3-4pm to talk about his work and formulate questions you all would like to ask

Eduardo Izquierdo - Modeling C. Elegans

The Worm That No Computer Scientist Can Crack | WIRED

1. Role of simulation models in understanding the generation of behavior in C. elegans
2. The whole worm: brain–body–environment models of C. elegans - ScienceDirect
3. Evolution and Analysis of Minimal Neural Circuits for Klinotaxis in Caenorhabditis elegans
4. An Integrated Neuromechanical Model of Steering in C. elegans

Longer Deeper Papers:

A stochastic neuronal model predicts random search behaviors at multiple spatial scales in C. elegans | eLife

Connecting a Connectome to Behavior: An Ensemble of Neuroanatomical Models of C. elegans Klinotaxis | PLOS Computational Biology