

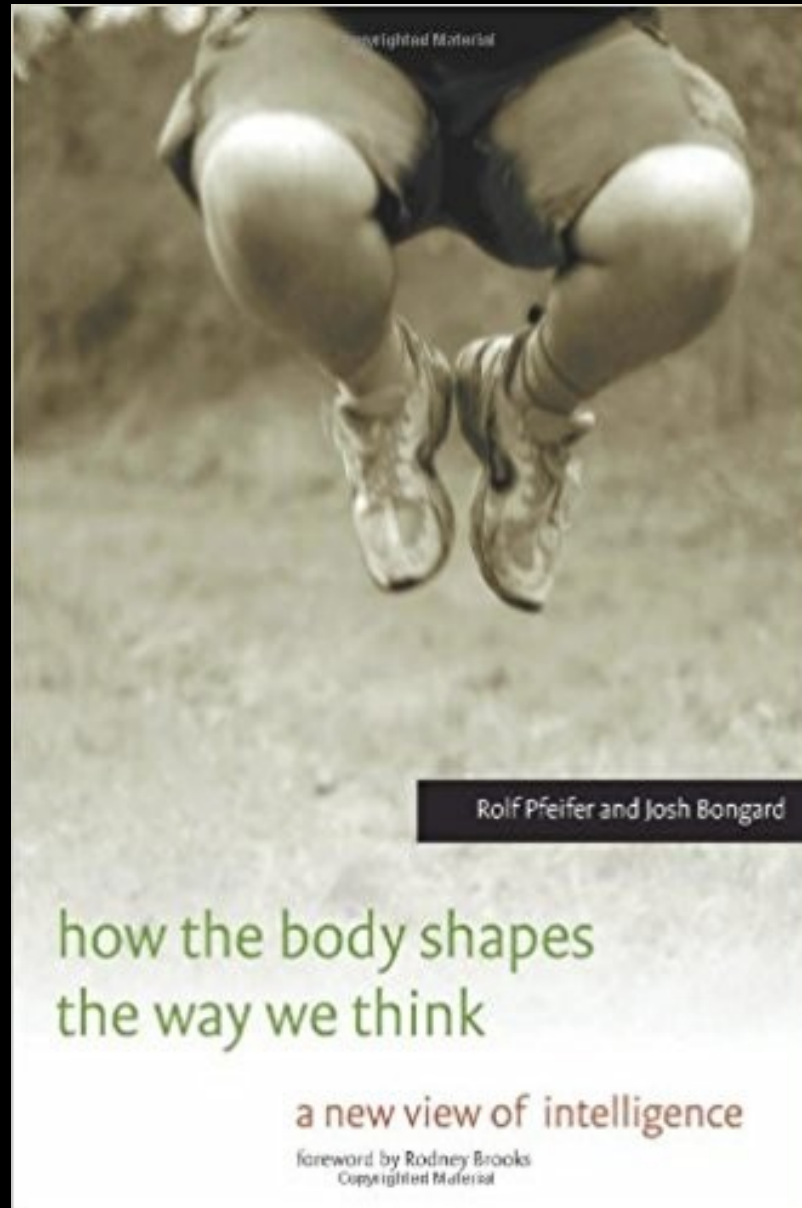


# **Modern Robotics: Evolutionary Robotics**

COSC 4560 / COSC 5560

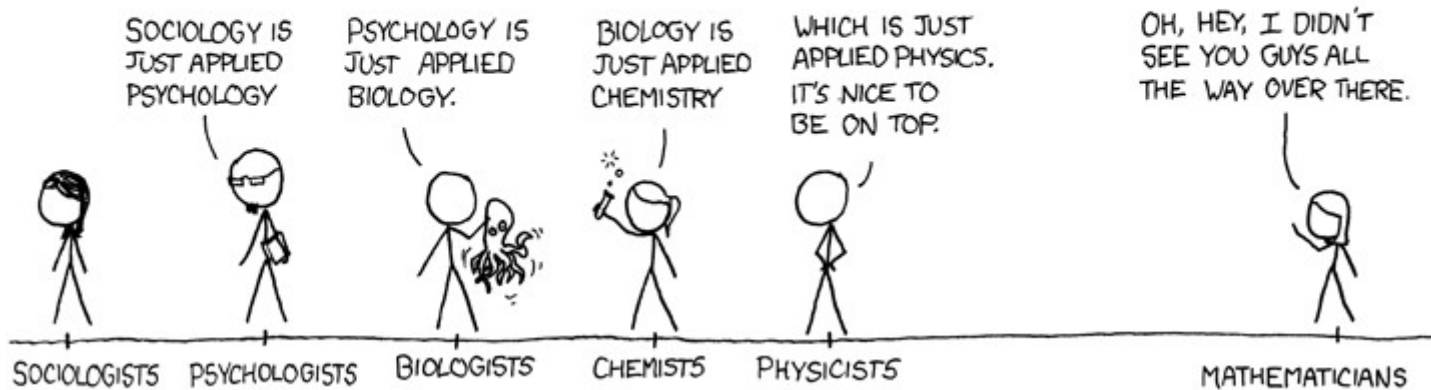
Professor Cheney  
2/7/18

# **Why Evolutionary Computation for Robotics?**



# FIELDS ARRANGED BY PURITY

→  
MORE PURE





**COGITO  
ERGO  
SUM**

“I think, therefore I am.”

“Do I exist?”



“There is something that is asking the question,  
Because there is an “I” in the sentence.  
Whatever that “I” thing is, it exists.”



The soul(/mind) surely exists;  
the body, I’ m not so sure about.

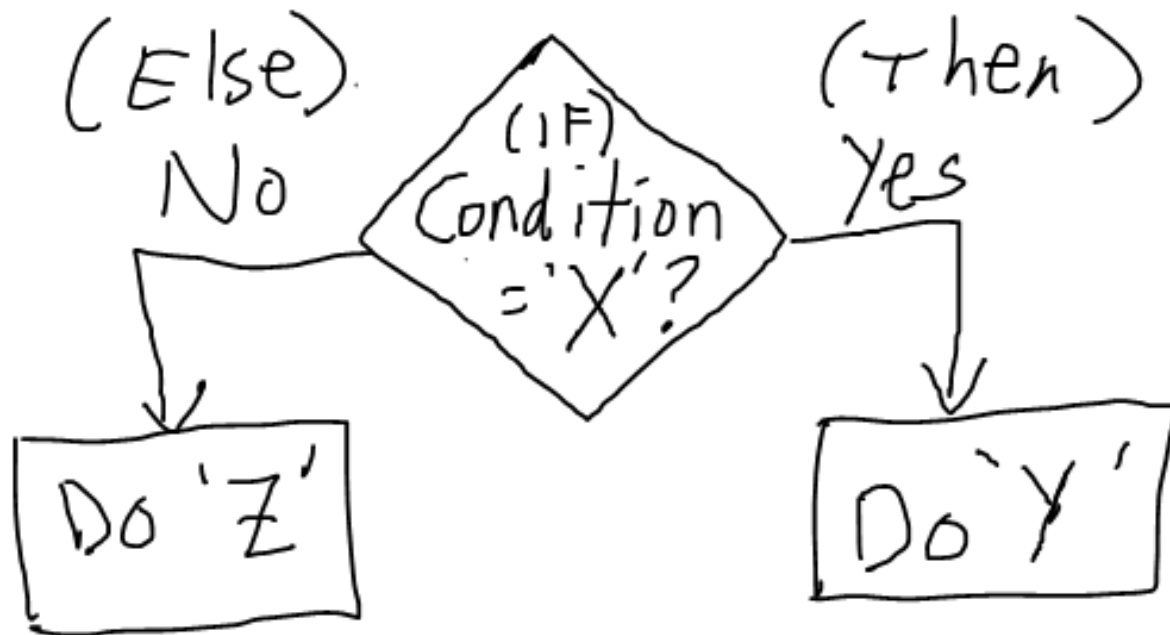


So the soul(/mind) and body are different.



Cartesian Dualism; “The Mind/Body Problem”

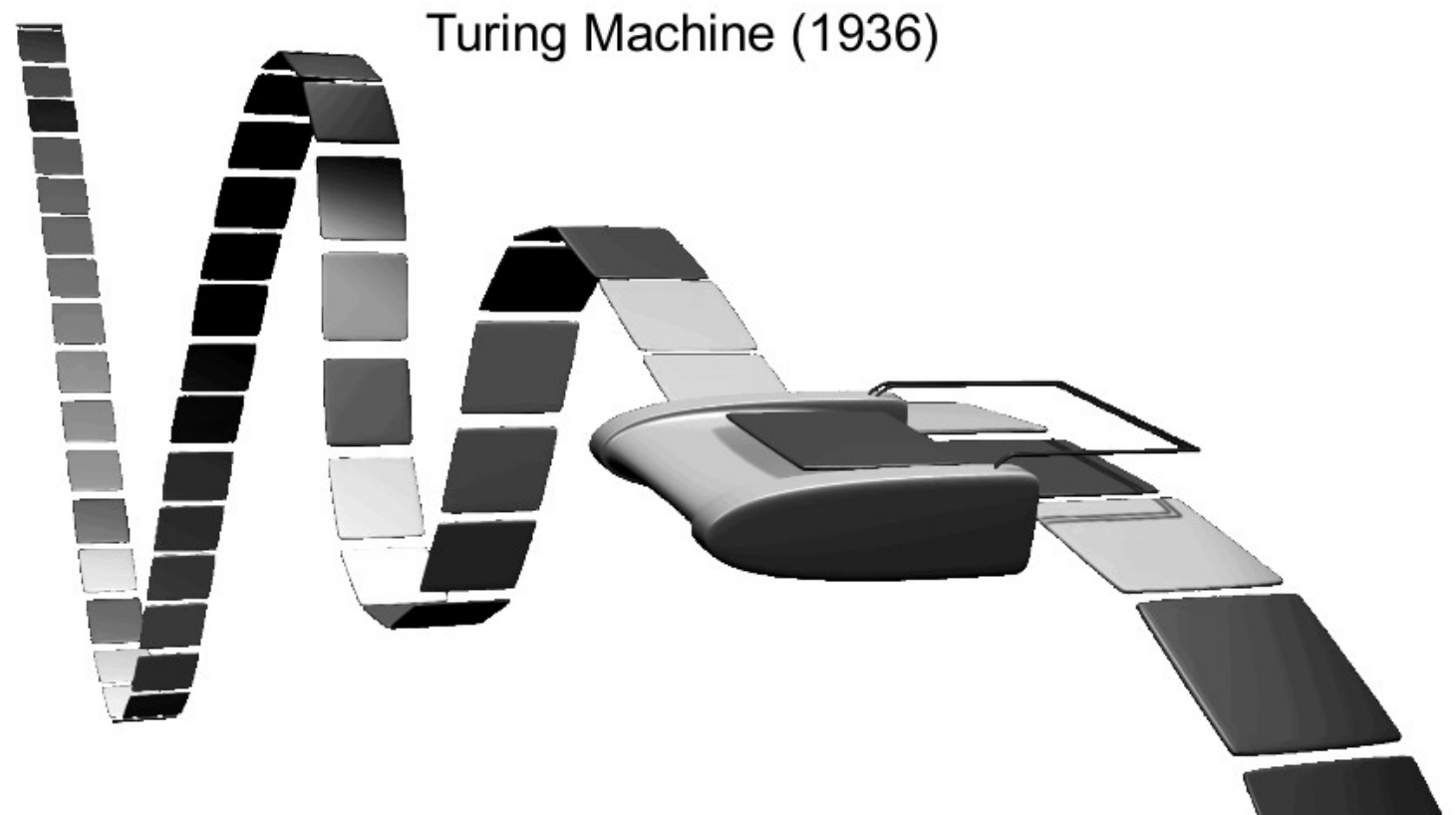






We tend to think input first, then information processing, then output.

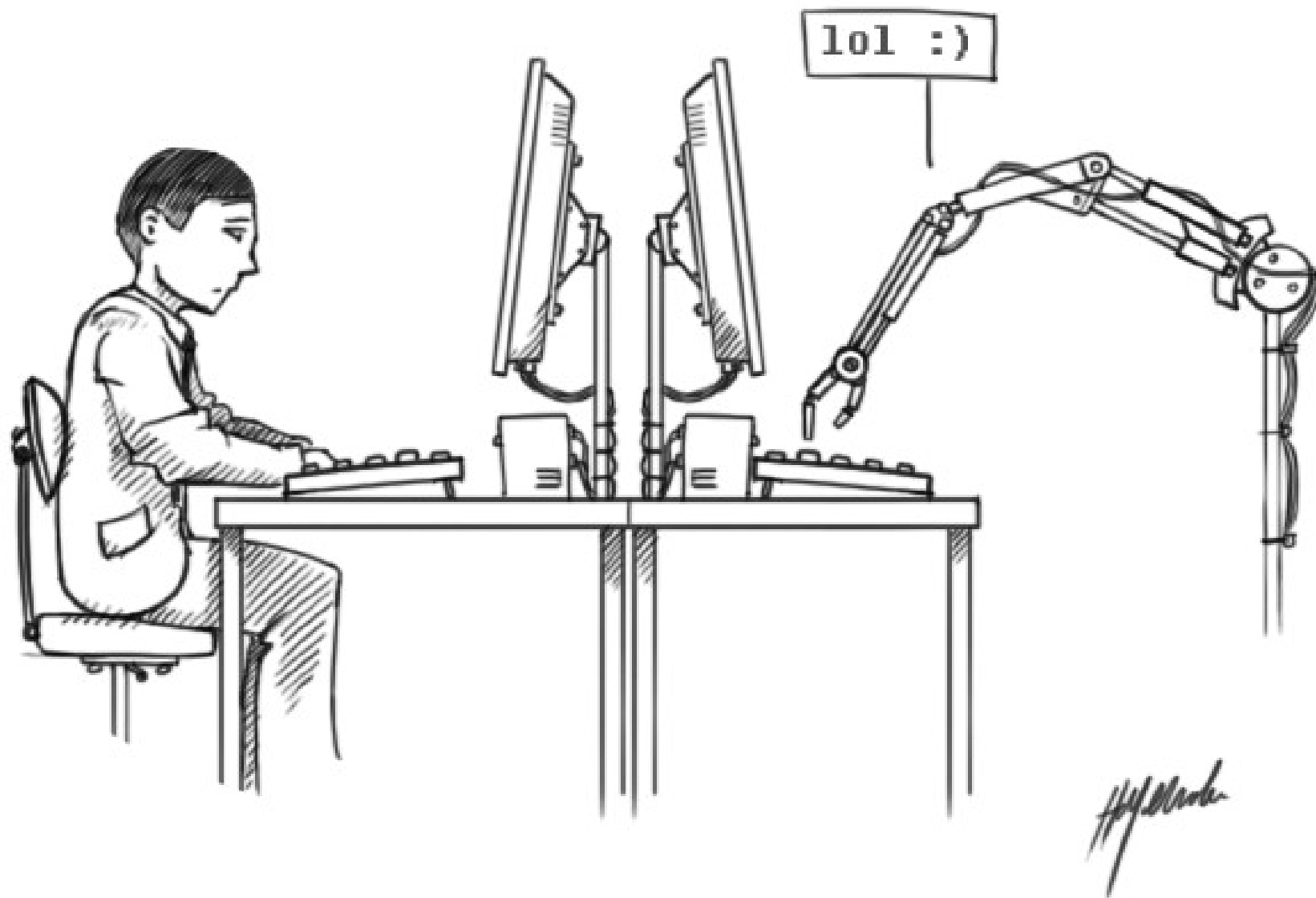
The very definition of a computer relies on this notion of input first, then processing, then output.

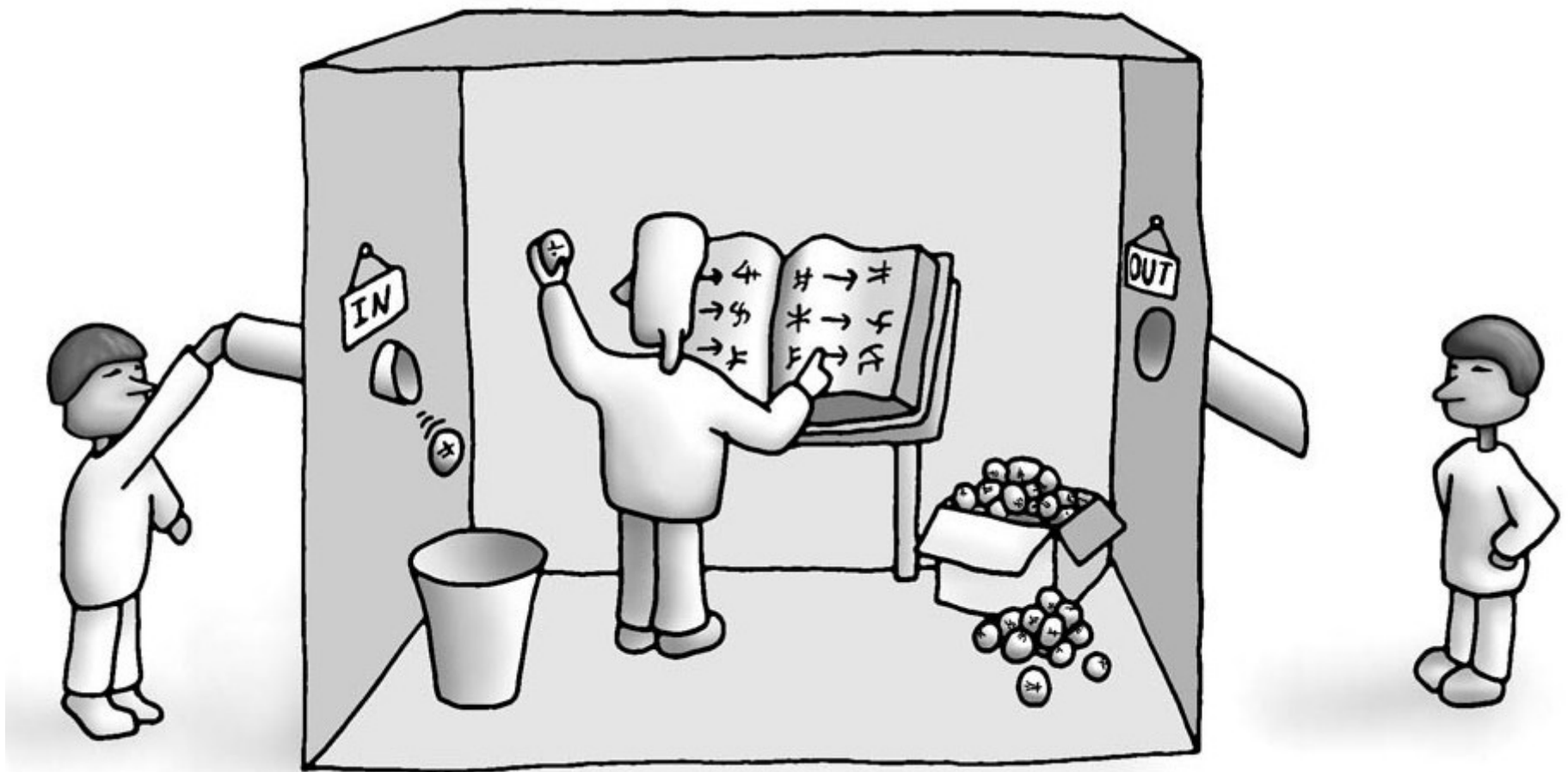


What is intelligence?

What is cognition?

What is consciousness?





## The Dartmouth Summer Research Conference on Artificial Intelligence (1956) [Origin of the word “**artificial intelligence**”]

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Proposal: “We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that

every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to (reproduce?) → simulate it.

An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and

improve themselves.

We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.”

# Intelligence without representation\*

Rodney A. Brooks

*MIT Artificial Intelligence Laboratory, 545 Technology Square, Rm. 836, Cambridge, MA 02139, USA*

Received September 1987

Artificial intelligence research has foundered on the issue of representation. When intelligence is approached in an incremental manner, with strict reliance on interfacing to the real world through perception and action, reliance on representation disappears. In this paper we outline our approach to incrementally building complete intelligent Creatures. The fundamental decomposition of the intelligent system is not into independent information processing units which must interface with each other via representations. Instead, the intelligent system is decomposed into independent and parallel activity producers which all interface directly to the world through perception and action, rather than interface to each other particularly much. The notions of central and peripheral systems evaporate everything is both central and peripheral. Based on these principles we have built a very successful series of mobile robots which operate without supervision as Creatures in standard office environments.

# Elephants Don't Play Chess

**Rodney A. Brooks**

*MIT Artificial Intelligence Laboratory, Cambridge, MA 02139, USA*

Robotics and Autonomous Systems 6 (1990) 3-15

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There is an alternative route to Artificial Intelligence that diverges from the directions pursued under that banner for the last thirty some years. The traditional approach has emphasized the abstract manipulation of symbols, whose grounding, in physical reality has . rarely been achieved. We explore a research methodology which emphasizes ongoing physical interaction with the environment as the primary source of constraint on the design of intelligent systems. We show how this methodology has recently had significant successes on a par with the most successful classical efforts. We outline plausible future work along these lines which can lead to vastly more ambitious systems.

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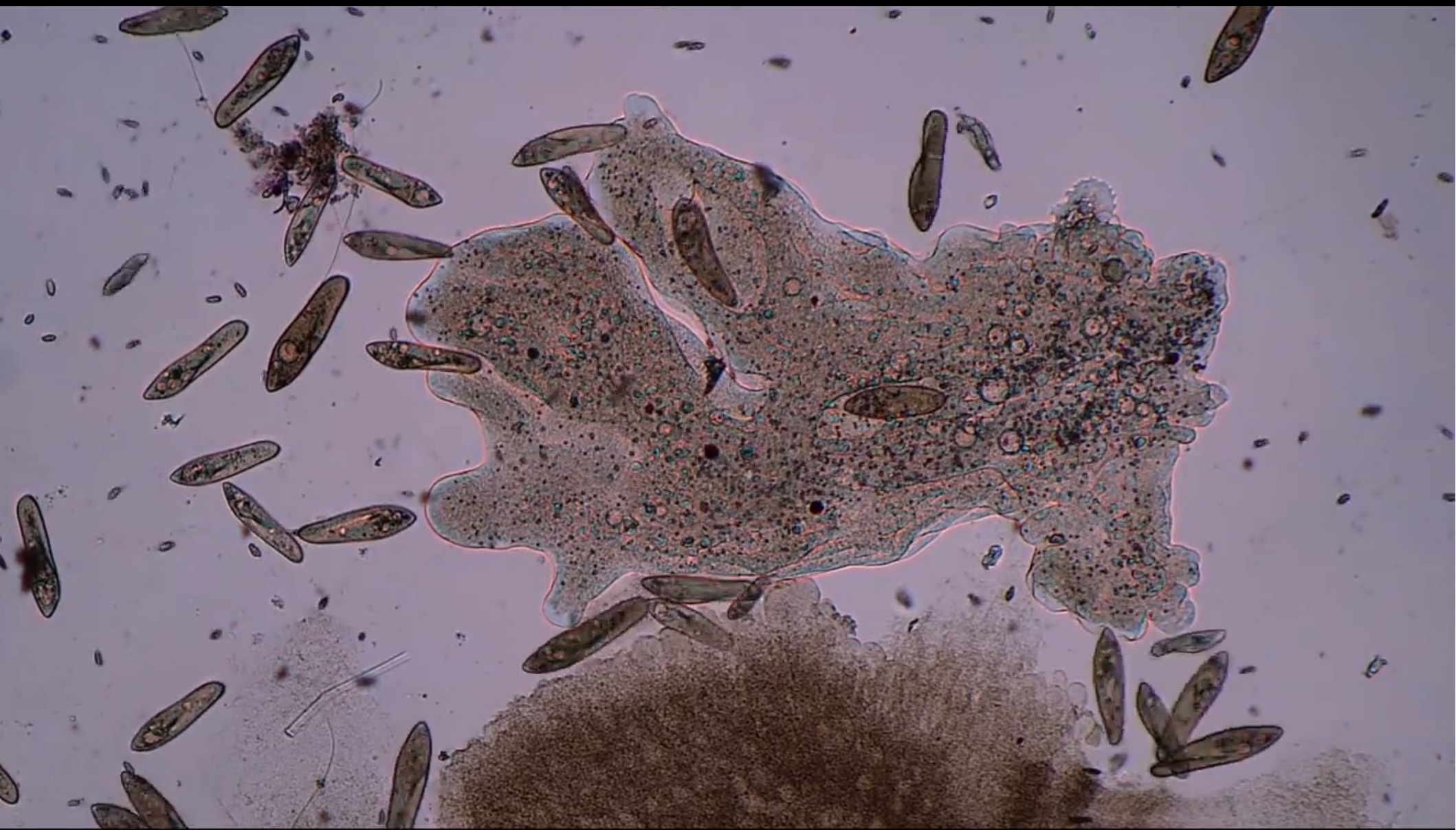
# On Having No Head: Cognition throughout Biological Systems

*František Baluška<sup>1</sup> and Michael Levin<sup>2\*</sup>*

<sup>1</sup> Department of Plant Cell Biology, IZMB, University of Bonn, Bonn, Germany, <sup>2</sup> Biology Department, Tufts Center for Regenerative and Developmental Biology, Tufts University, Medford, MA, USA



Tropism



Predator-prey behavior in amoeba and paramecia

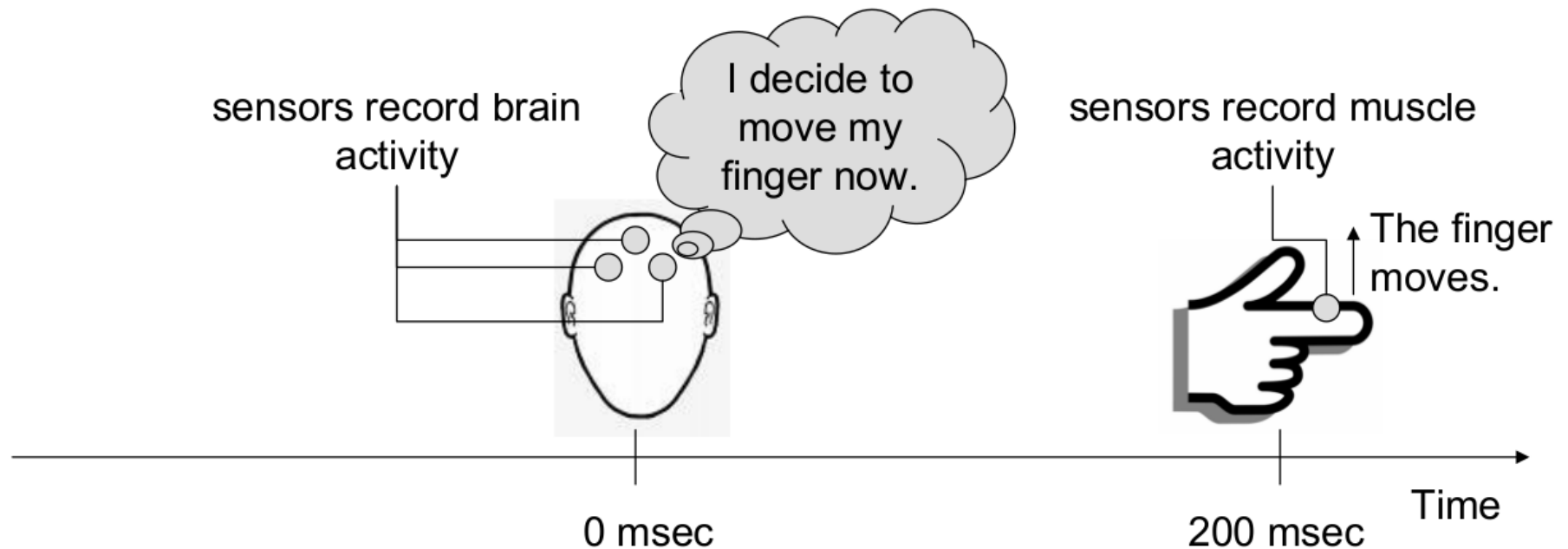
So plants/animals can perform  
“intelligent” behavior  
without a brain...

Example: Another aspect of human cognition: free will.

Most people believe that they have free will:

“I decide in my mind that I want to do something, and then I do it.”

Libet, B., Gleason, C. A., Write, E. W., and Pearl, D. K. (1983). Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential): The unconscious initiation of a freely voluntary act. *Brain*, **106**: 623-642.



## Warning: Thinking about thinking is misleading; introspection is dangerous

Example: Another aspect of human cognition: free will.

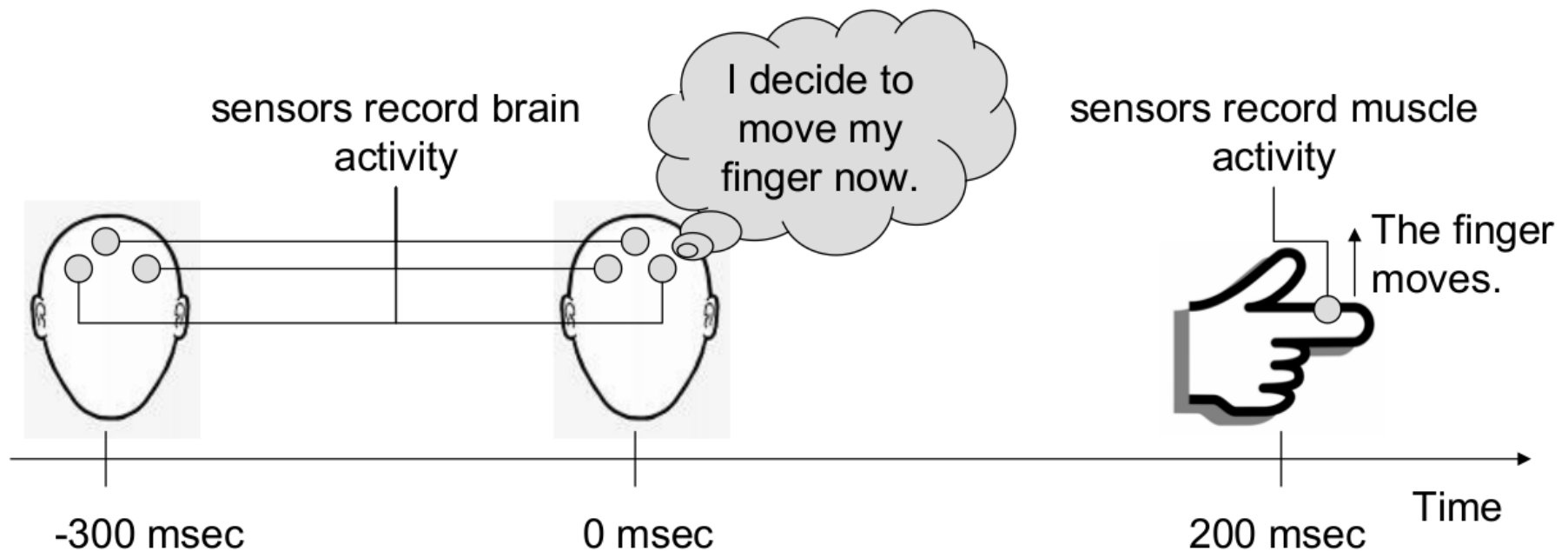
Most people believe that they have free will:

“I decide in my mind that I want to do something, and then I do it.”

→ Thinking about free will seems to imply that free will exists ... but does it?

Observation: Brain activity associated with the finger movement begins 300 msec before the subject experiences the conscious will to move the finger.

Conclusion: If free will is unconscious, and our consciousness has no control over it, then it can't be “free” will.





**Fear of light.**



Sensory signals

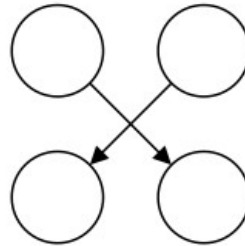


Muscle commands

*Neural networks  
in animals*



Sensor 1    Sensor 2

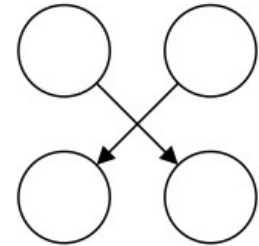


Motor 1    Motor 2

*Artificial Neural Networks  
for robots*



Input 1    Input 2



Output 1    Output 2

*Artificial Neural Networks  
for problem solving*

## **Embodied and Situated cognition**

(**Embodied cognition**: the way you process information is affected by the fact that you have a body.)

(**Situated cognition**: the way you process information is affected by the fact that you are physically situated in the world.)

A **complete agent** is an agent that is both situated and embodied.

Complete agents have three important properties that distinguish them from other kinds of agents:

1. They are subject to the laws of physics (by being in the world).

Q: Examples?

2. They generate sensory stimulation (through behavior).

Q: Examples?

3. They affect the environment (through behavior).

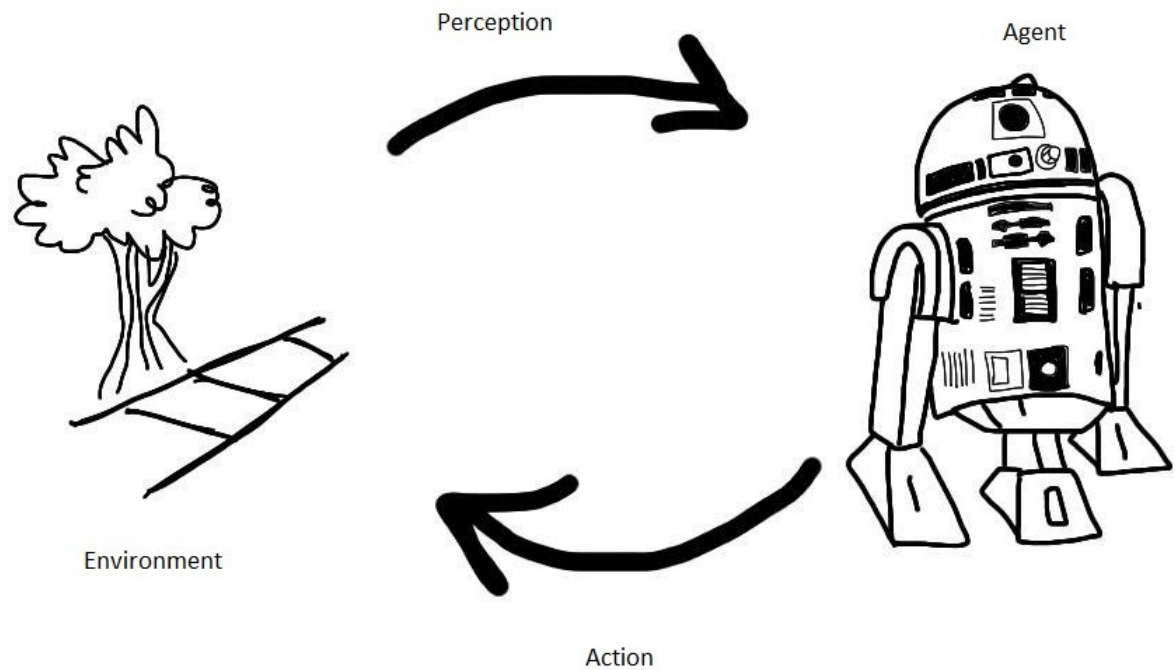
Q: Examples?



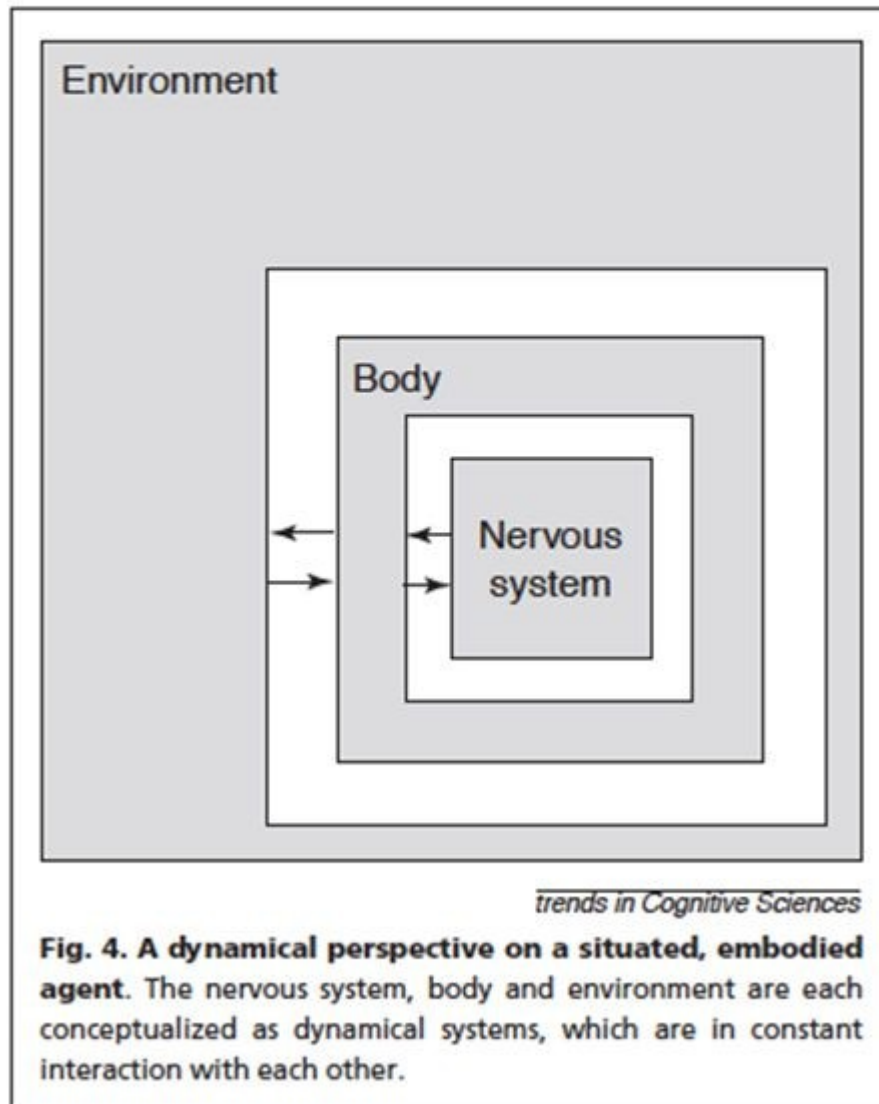
passive  
agent



situated &  
embodied  
agent



# Dynamical approach to cognition



- The brain is **embodied** in a biological body.
- The body is **situated** in an environment.
- Behavior is an **emergent** property of a brain-body-environment system.

Beer(2000)





PROCEEDINGS OF THE THIRD INTERNATIONAL CONFERENCE ON SIMULATION OF ADAPTIVE BEHAVIOR

PROCEEDINGS OF THE FOURTH INTERNATIONAL CONFERENCE ON SIMULATION OF ADAPTIVE BEHAVIOR

## From animals to animats 3

## From animals to animats 4



edited by Dave Cliff, Philip Husbands,  
Jean-Arcady Meyer, and Stewart W. Wilson

edited by Pattie Maes, Maja J. Mataric, Jean-Arcady Meyer,  
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