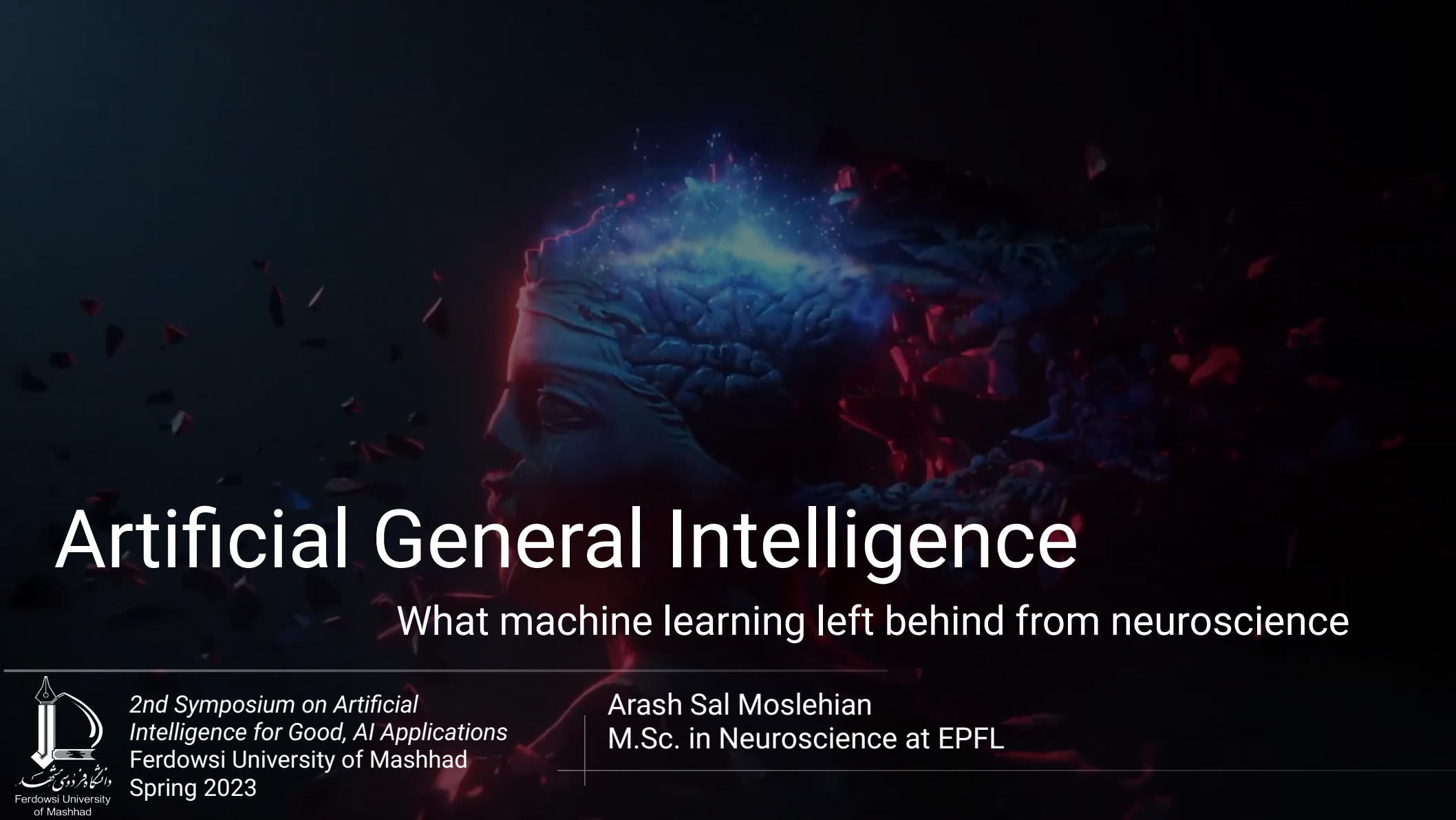


Artificial General Intelligence

What machine learning left behind from neuroscience

2nd Symposium on Artificial Intelligence for Good, AI Applications
Ferdowsi University of Mashhad
Spring 2023

Arash Sal Moslehian
M.Sc. in Neuroscience at EPFL

Contents

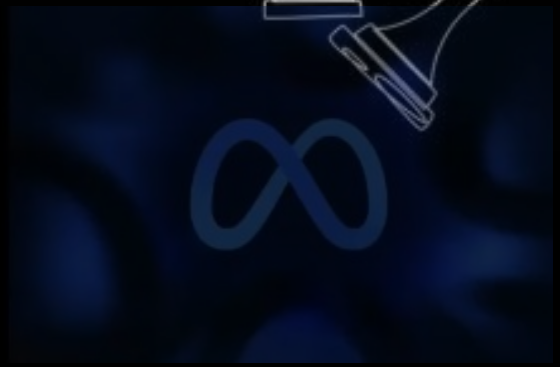
- What is AGI?
- The mirage of Generative AIs
- Artificial Neural Nets are not like your brain!
- Artificial consciousness
- Organisms vs AI agents
- Conclusion
- References

Artificial Intelligence

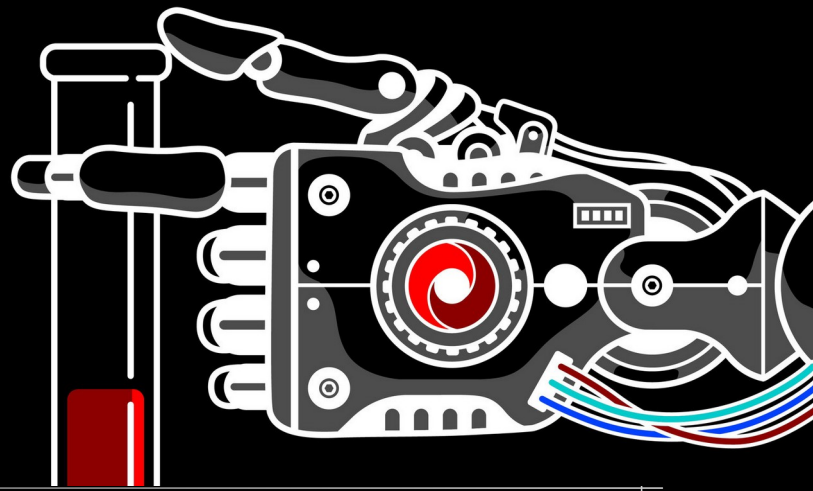
“An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves”

the Dartmouth Summer Research Project

Artificial Intelligence



Google AI



Artificial Intelligence

OpenAI

ChatGPT

Google

MusicLM

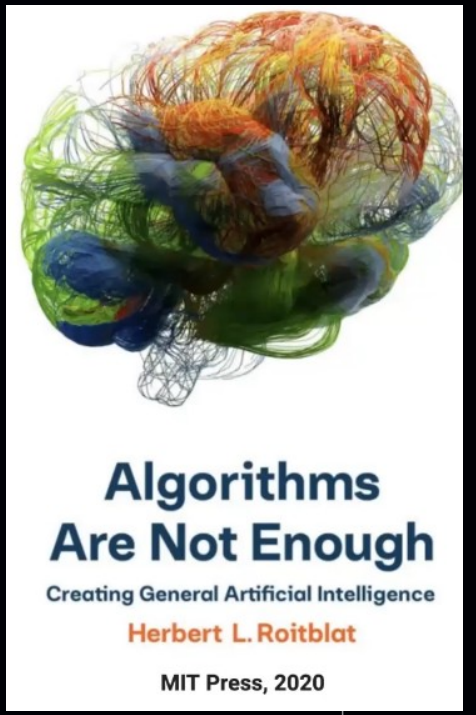
Artificial Intelligence

Most of today's AI systems are target-specific

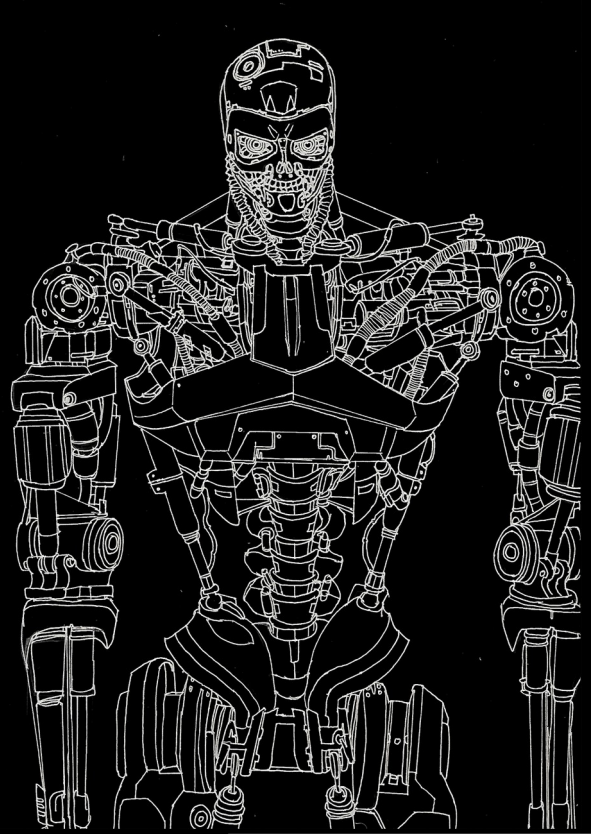
- an AI program capable of automatically planning tasks, is not usually capable of recognizing faces in photographs.

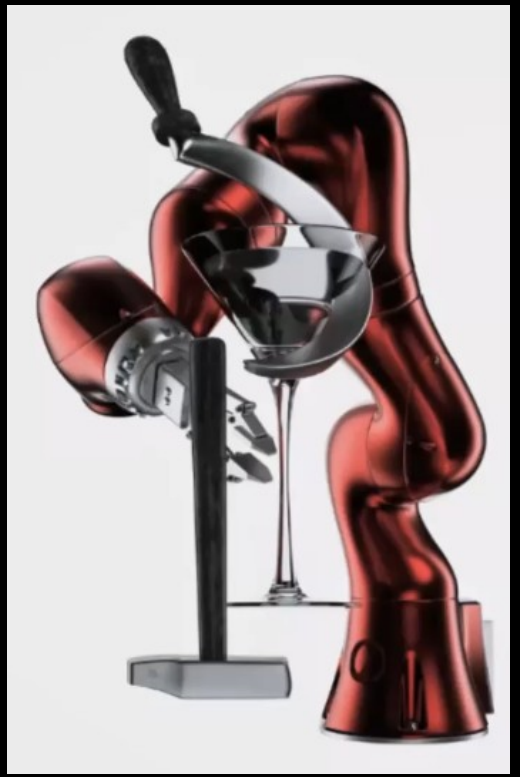
The Quest for Artificial General Intelligence

“general intelligence can be defined as the ability of combining analytic, creative, and practical intelligence”



Artificial General Intelligence





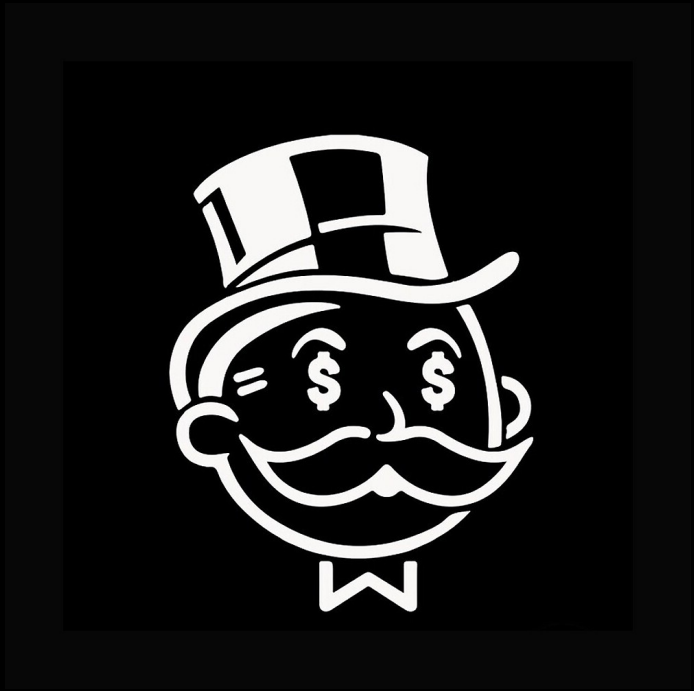
Fully Automated
Luxury Communism

Artificial General Intelligence

- They believed that AGI was possible within a few decades.
- The project was much more complicated than they had anticipated.

AGI and the Market

The market mostly focuses on instant short-term results



The Mirage of GPTs

- Great as a searching companion and software asset
- It only gives the illusion of understanding
- A next token prediction machine

The Mirage of GPTs

Sparks of Artificial General Intelligence:
Early experiments with GPT-4

Noam Chomsky: The False Promise of ChatGPT

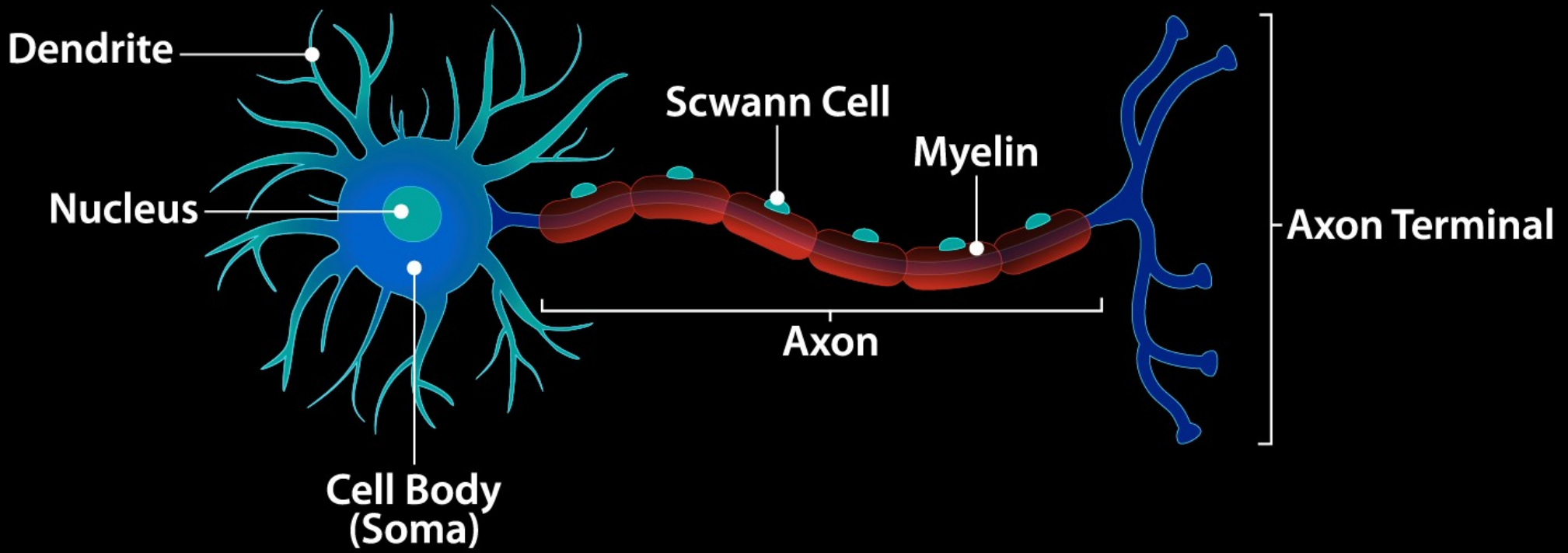
March 8, 2023

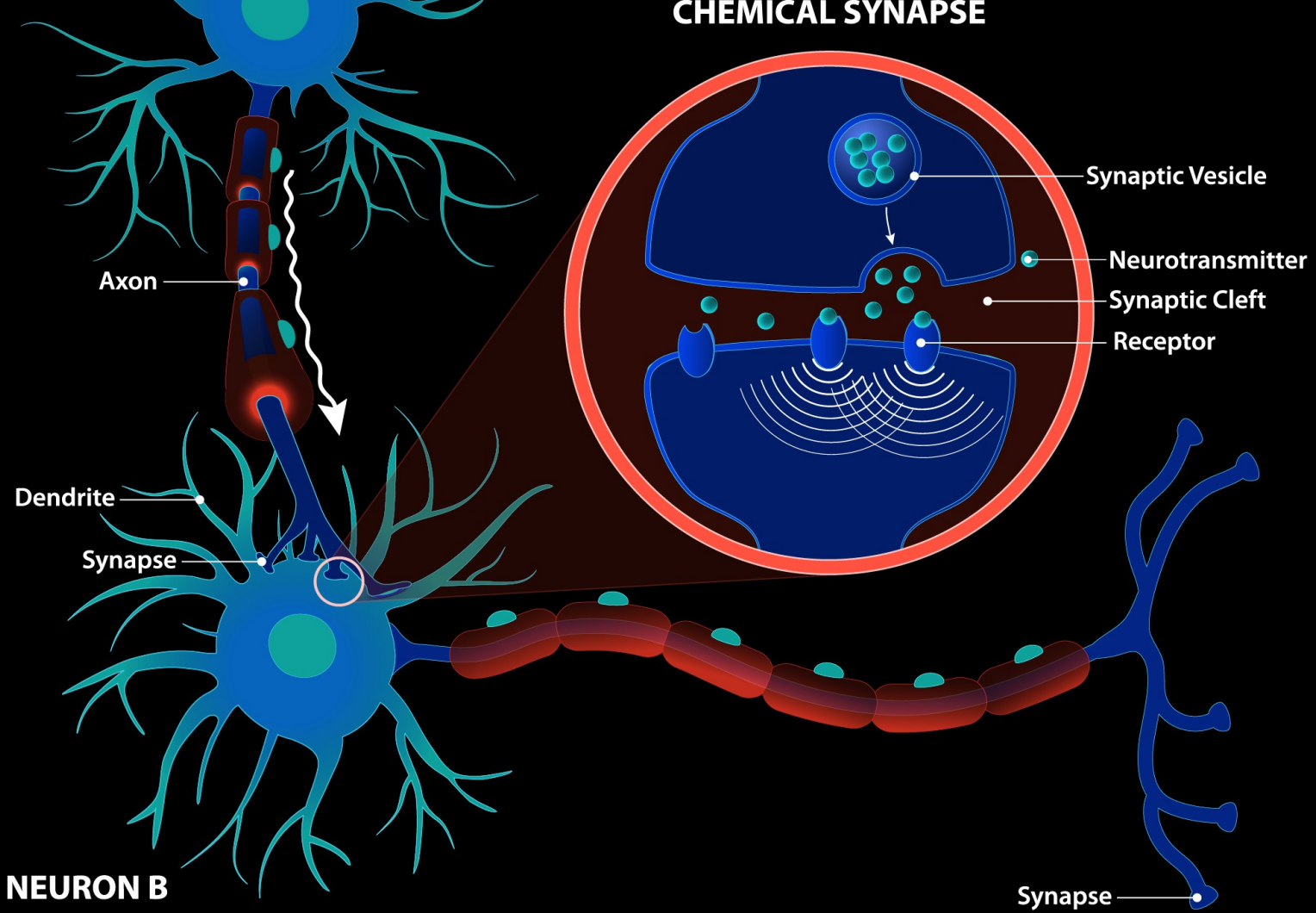
Artificial Neural Nets are not like your brain!

The biological brain understands physical objects in the environment in relation to other phenomena.

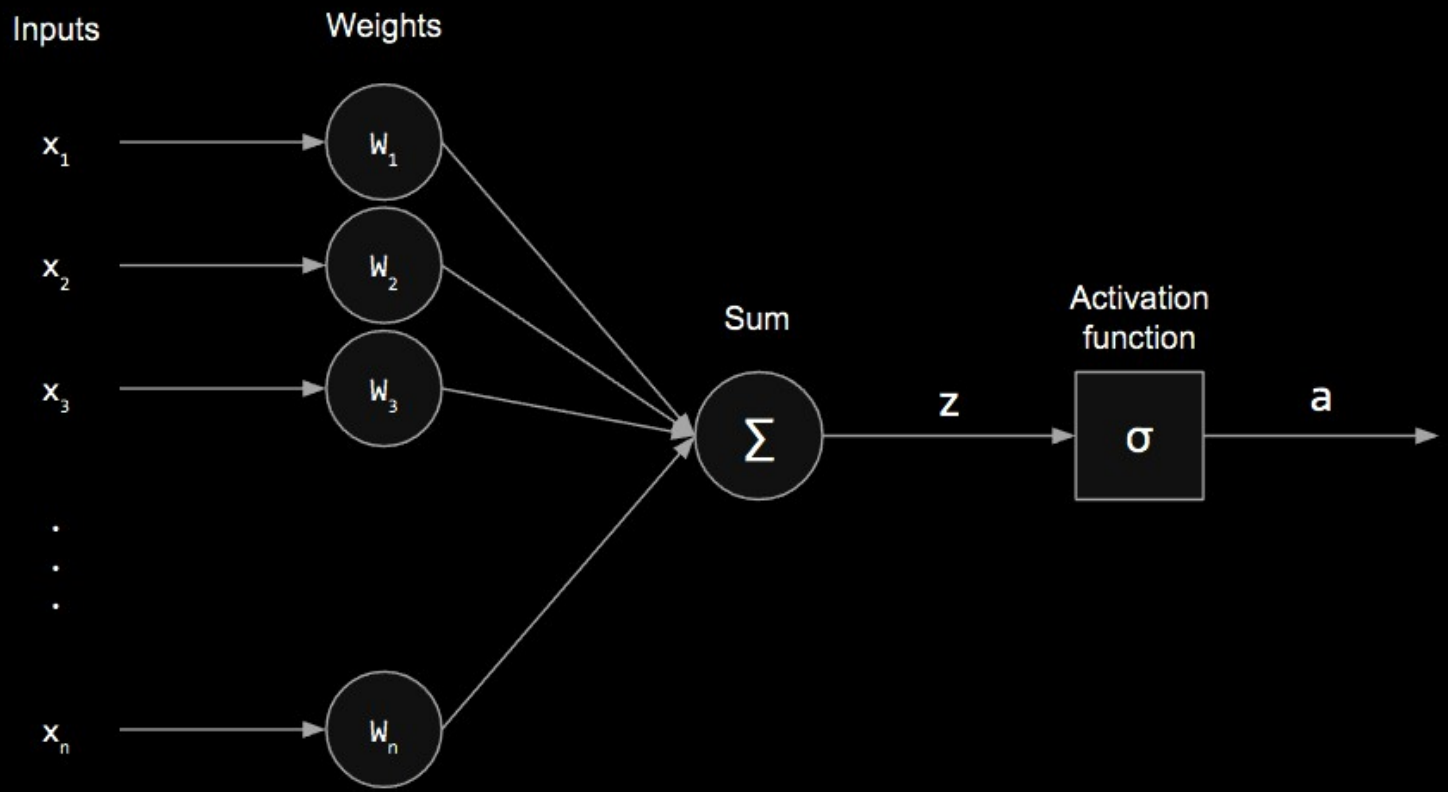
Machine learning analyzes massive data sets for patterns and correlations without understanding any of the data.

Neuron Anatomy




CHEMICAL SYNAPSE
Synaptic Vesicle
Neurotransmitter
Synaptic Cleft
Receptor
Axon
Dendrite
Synapse
NEURON B
Synapse

The Theoretical Perceptron



Neurons Are Slow!

- A maximum firing rate of about 250 Hz.

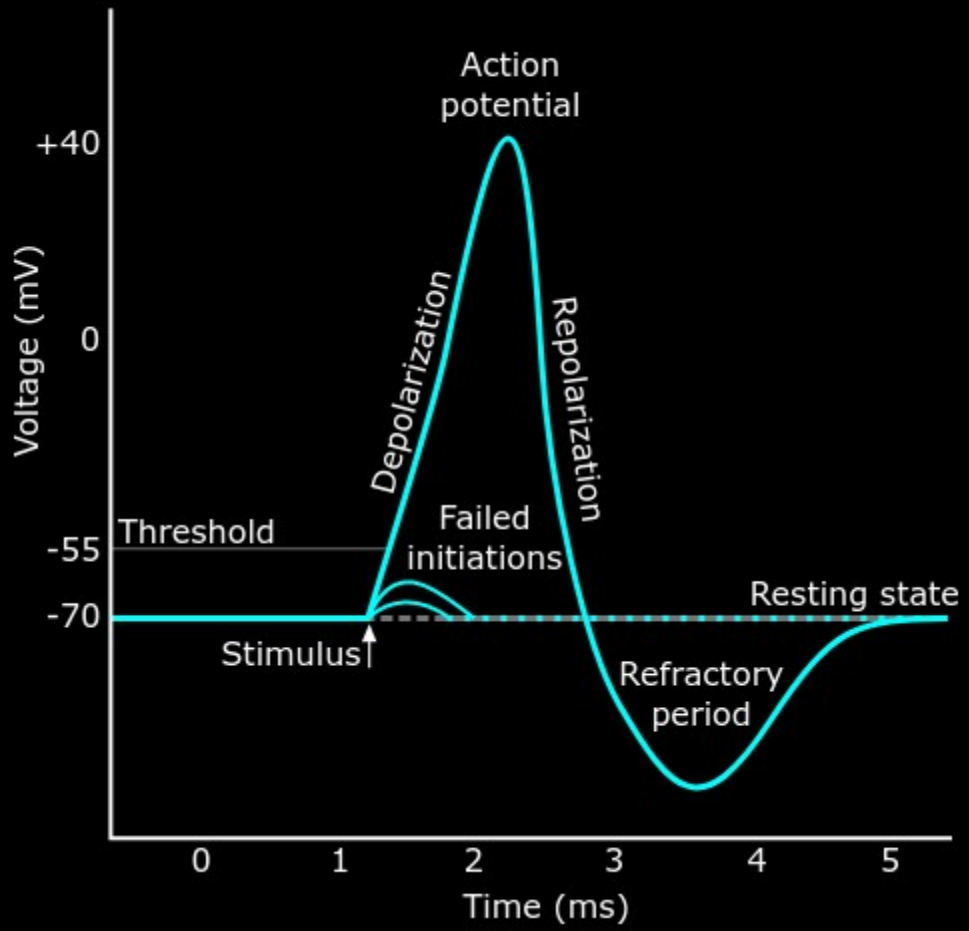
  1 spike / 4ms

- Transistors are way faster: 600Ghz

  2.5 billion spikes / 4ms

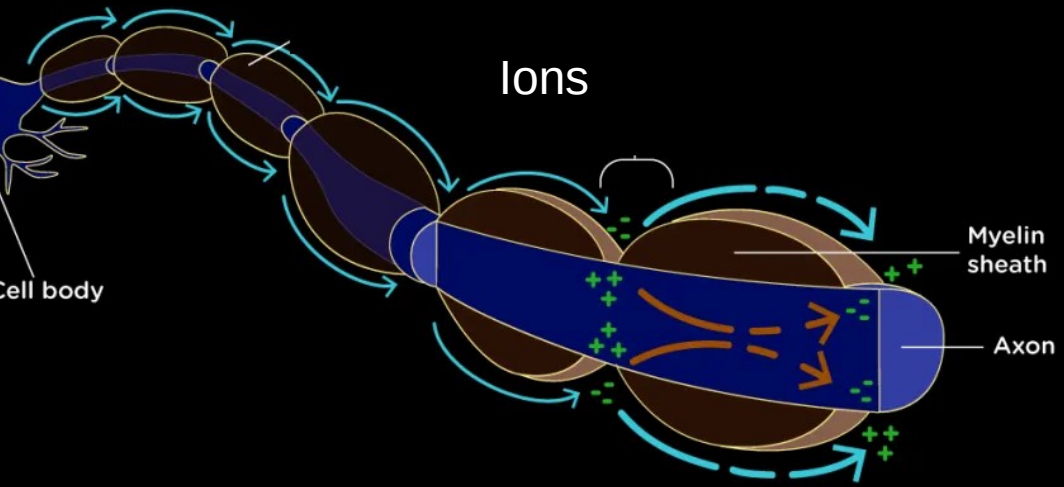
Neurons Are Slow!

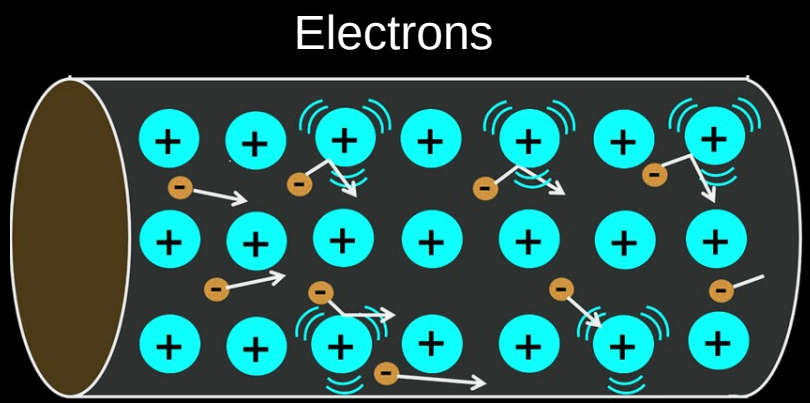
3ms rest after each spike



Neurons Are Slow!

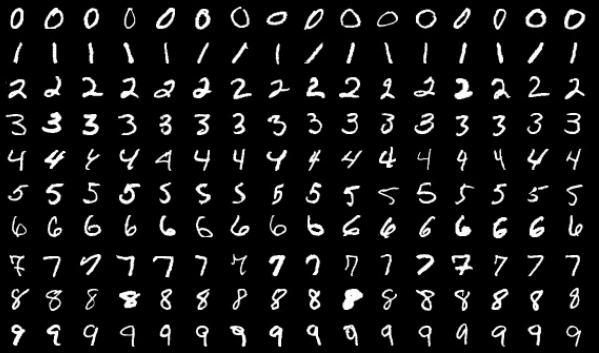
The time of arrival of signals at the perceptron does not matter, while the timing of signals in the biological neuron is vitally important.



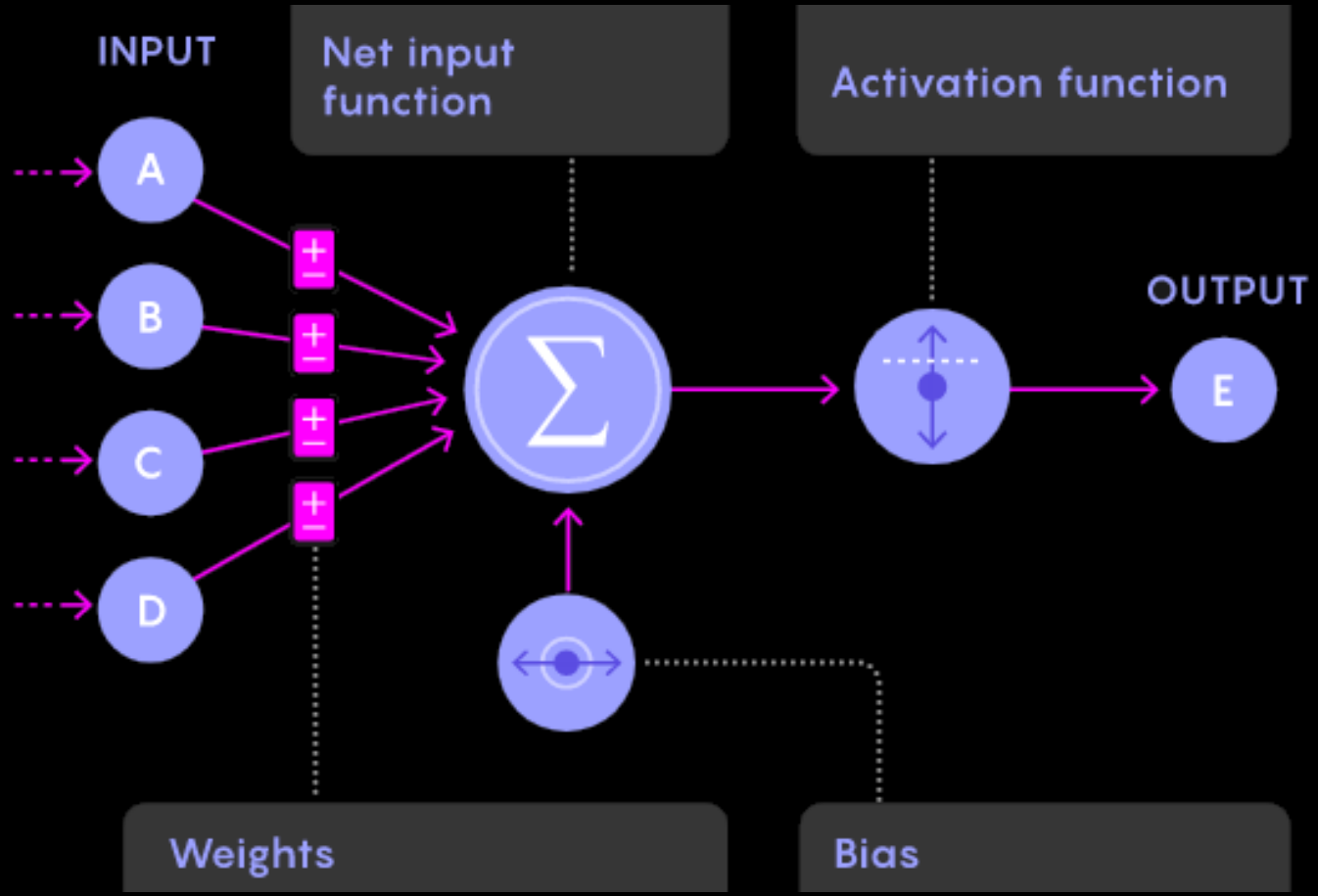


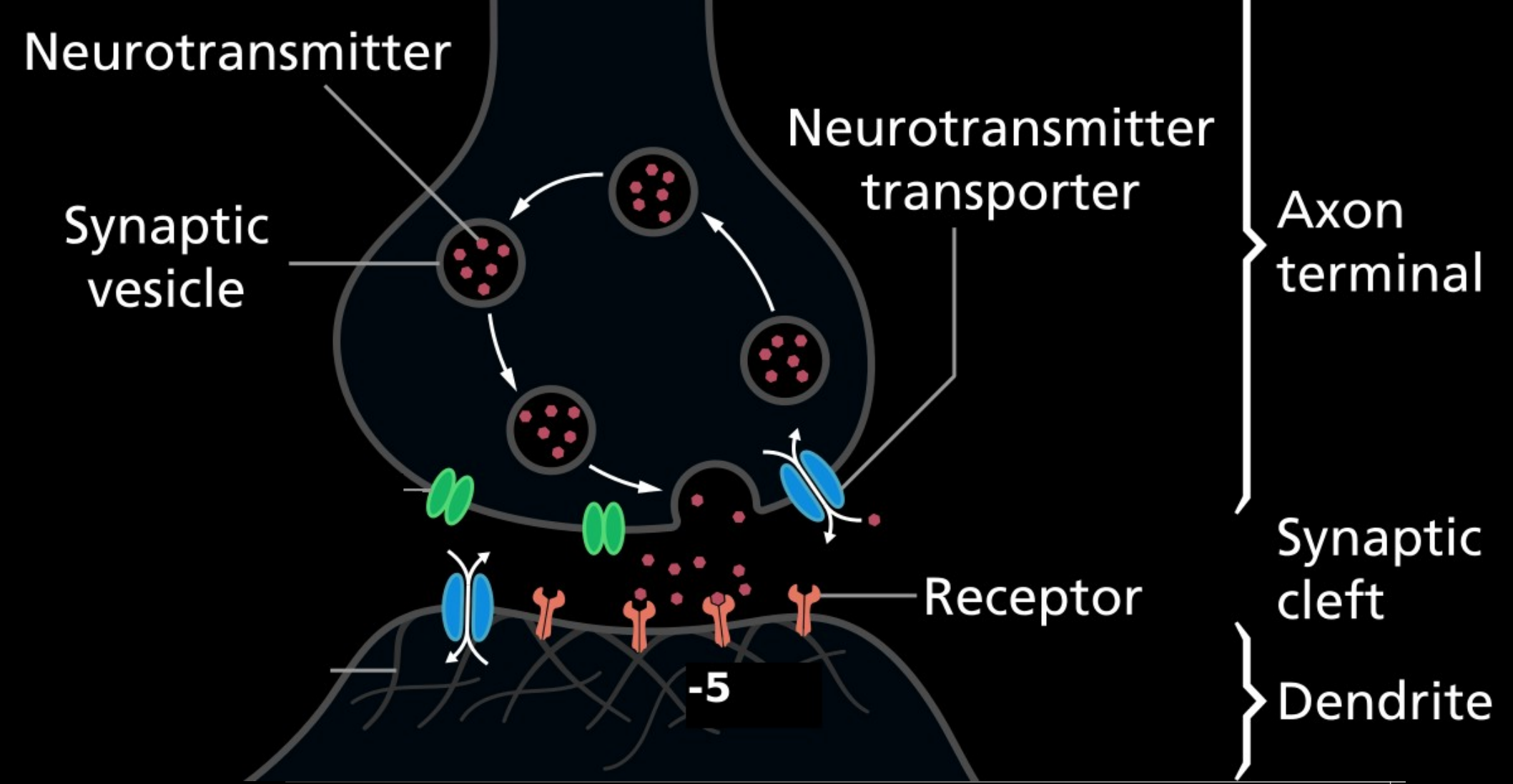
Neurons Are Slow!

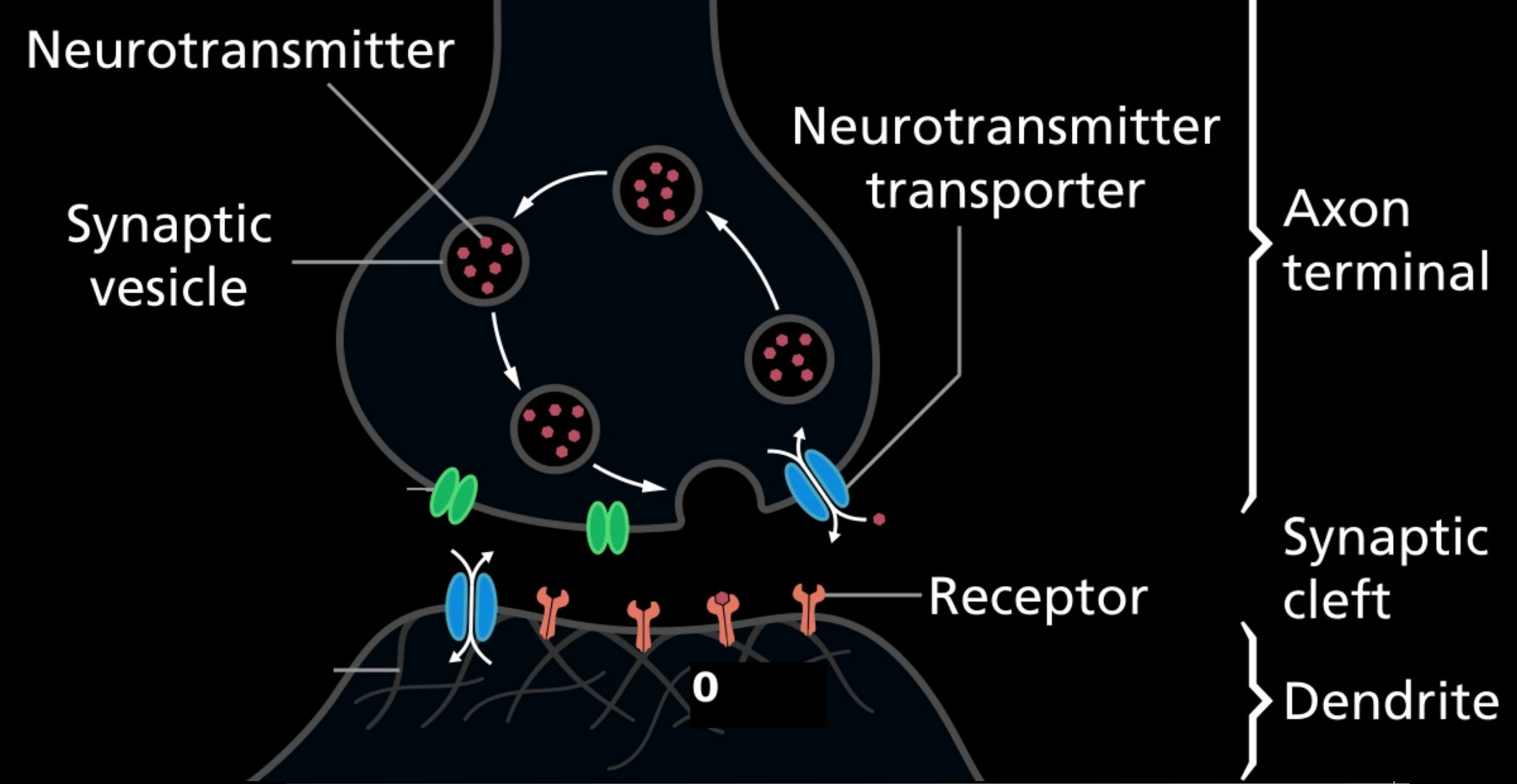
- If brain processes 1 image / second
- 16 hours! is needed for the 60,000 images of the MNIST dataset of handwritten digits
- But it only takes 10 minutes for you



Neurons Are Slow!



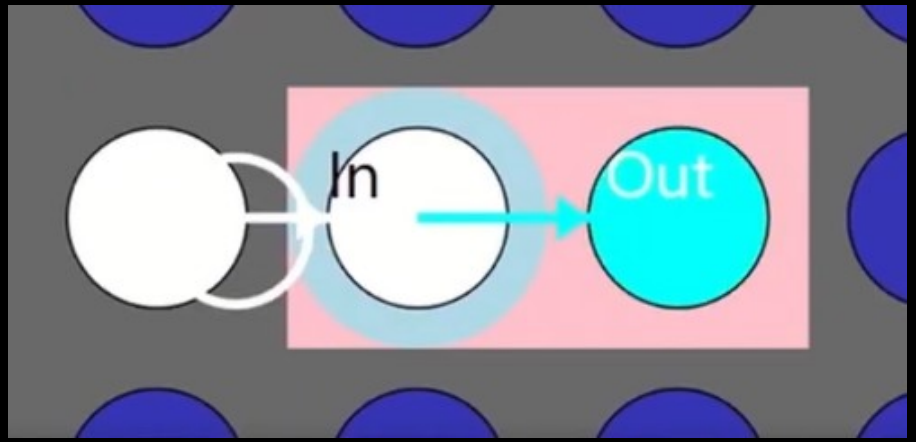

Neurotransmitter
Neurotransmitter transporter
Synaptic vesicle
Axon terminal
Synaptic cleft
Receptor
Dendrite
-5

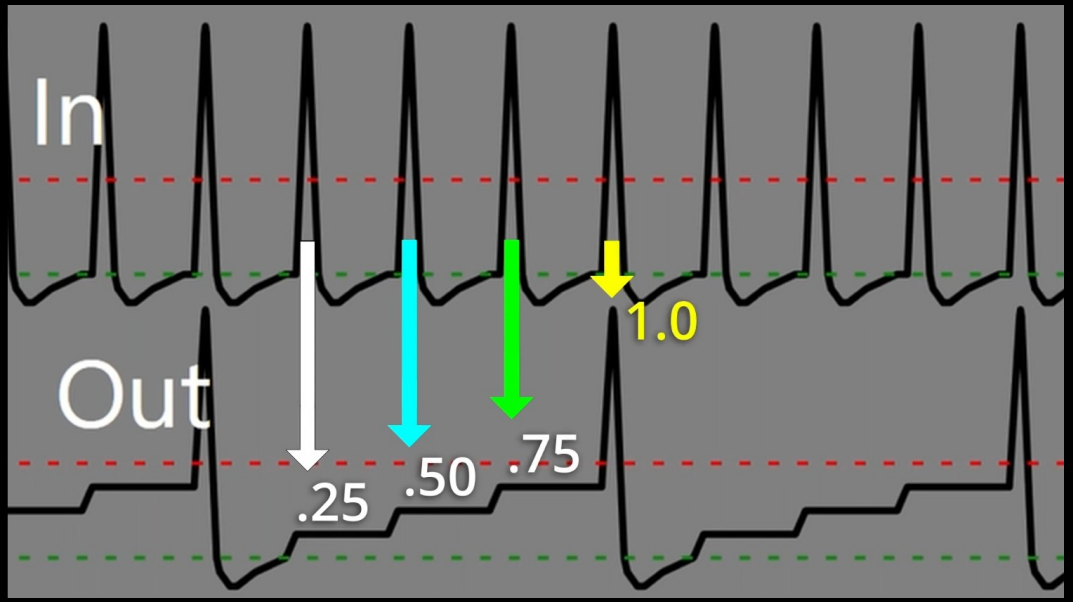

Neurotransmitter
Neurotransmitter transporter
Synaptic vesicle
Axon terminal
Synaptic cleft
Receptor
Dendrite

Phase

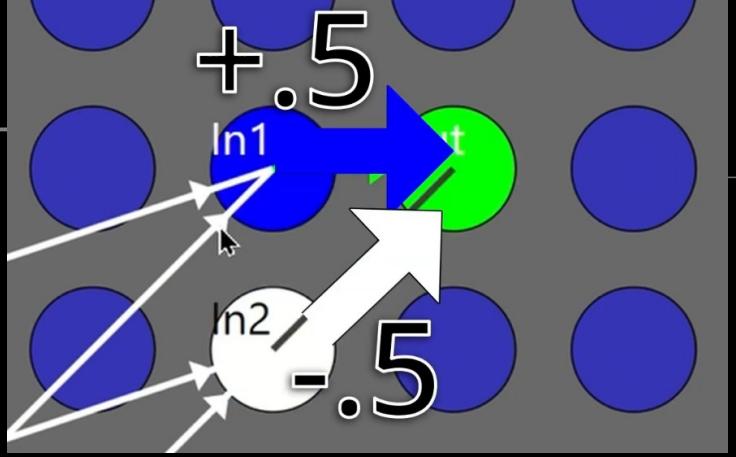
- The perceptron has an analog value
- The neuron simply emits spikes.
- The perceptron ignores the phase of an incoming signal and considers only the frequency

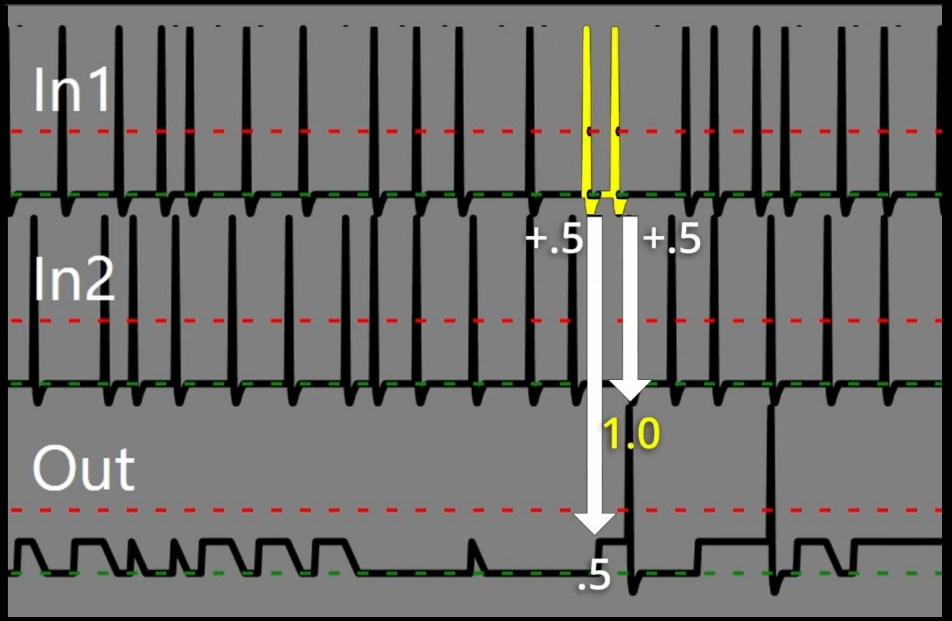
Phase

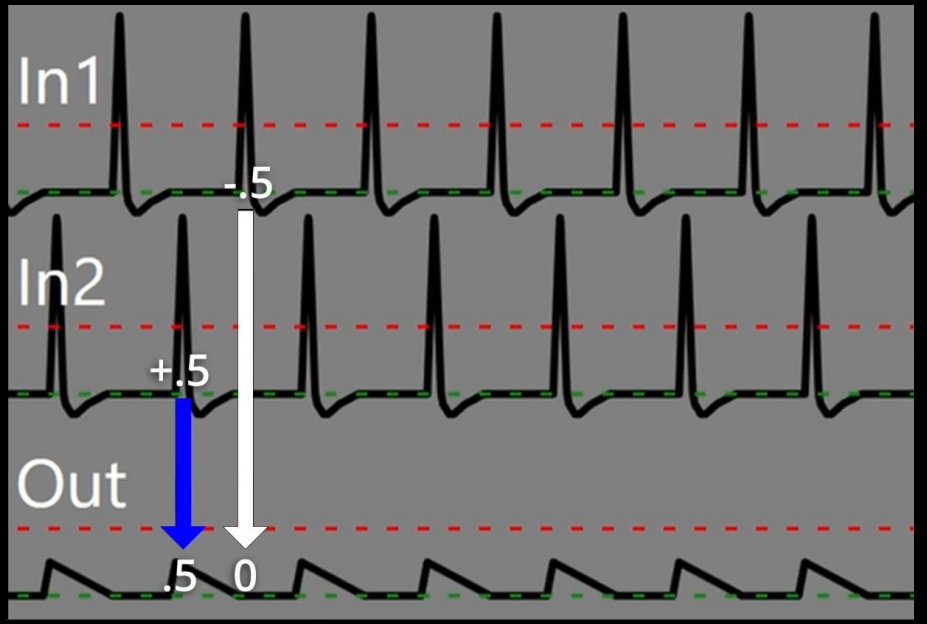




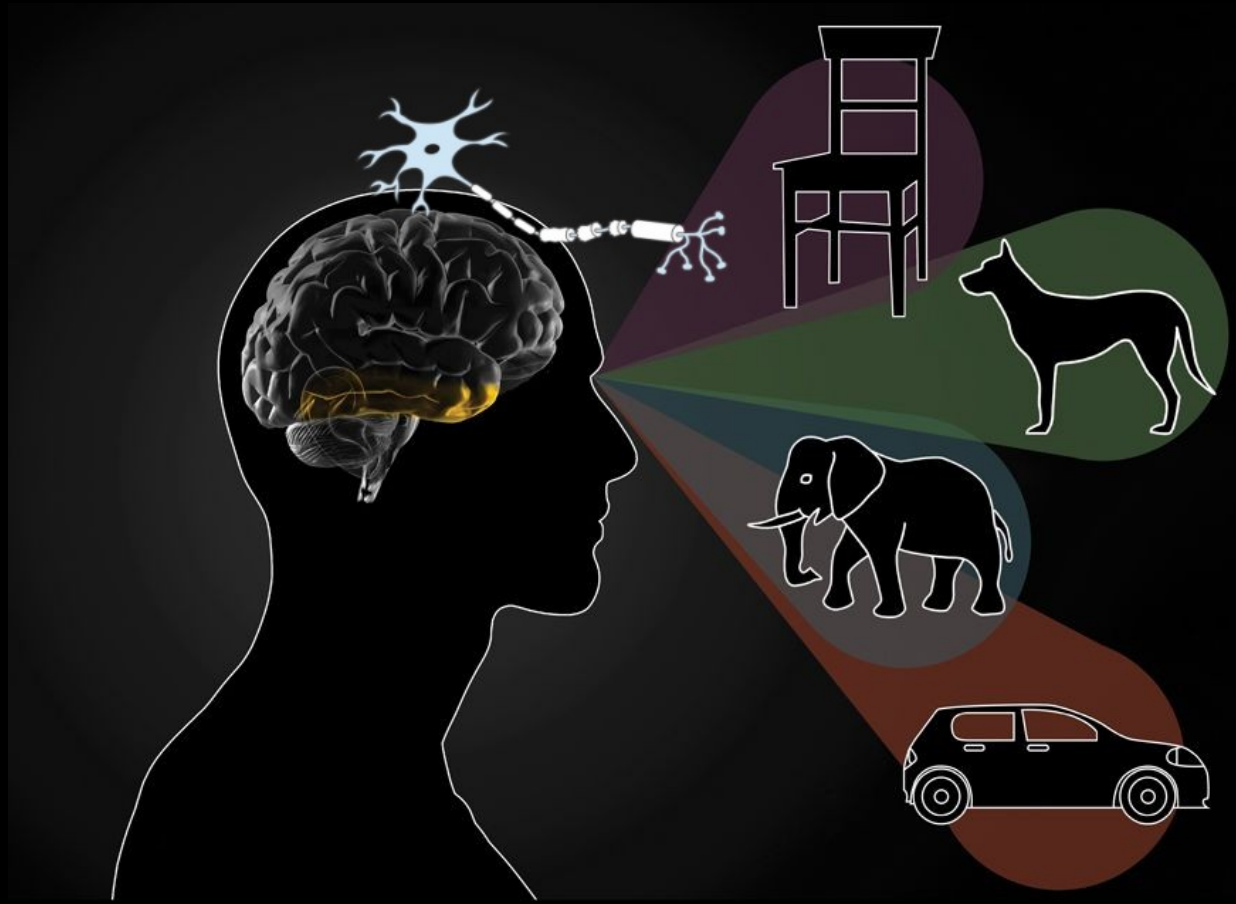
Phase



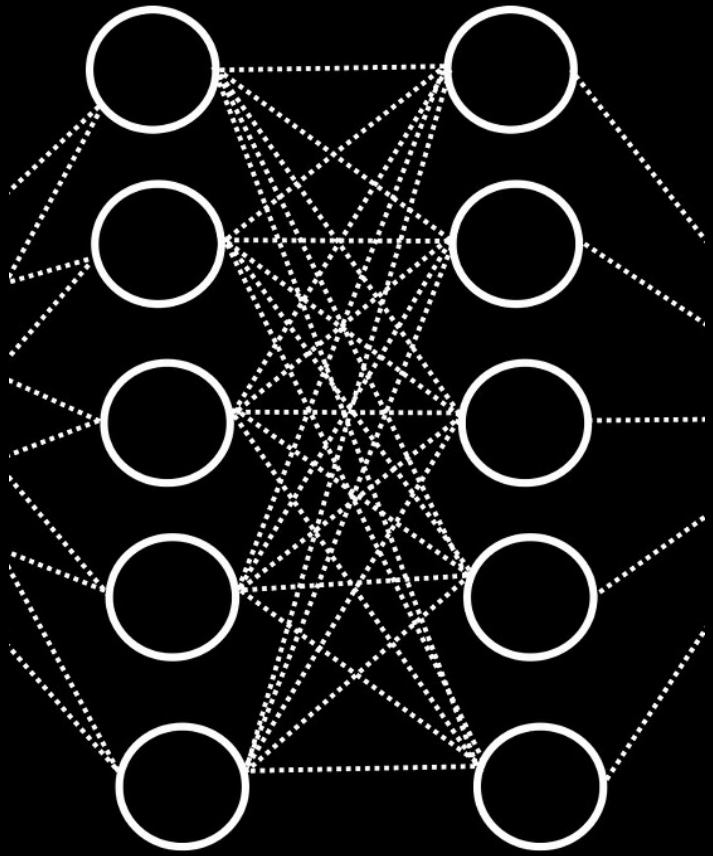


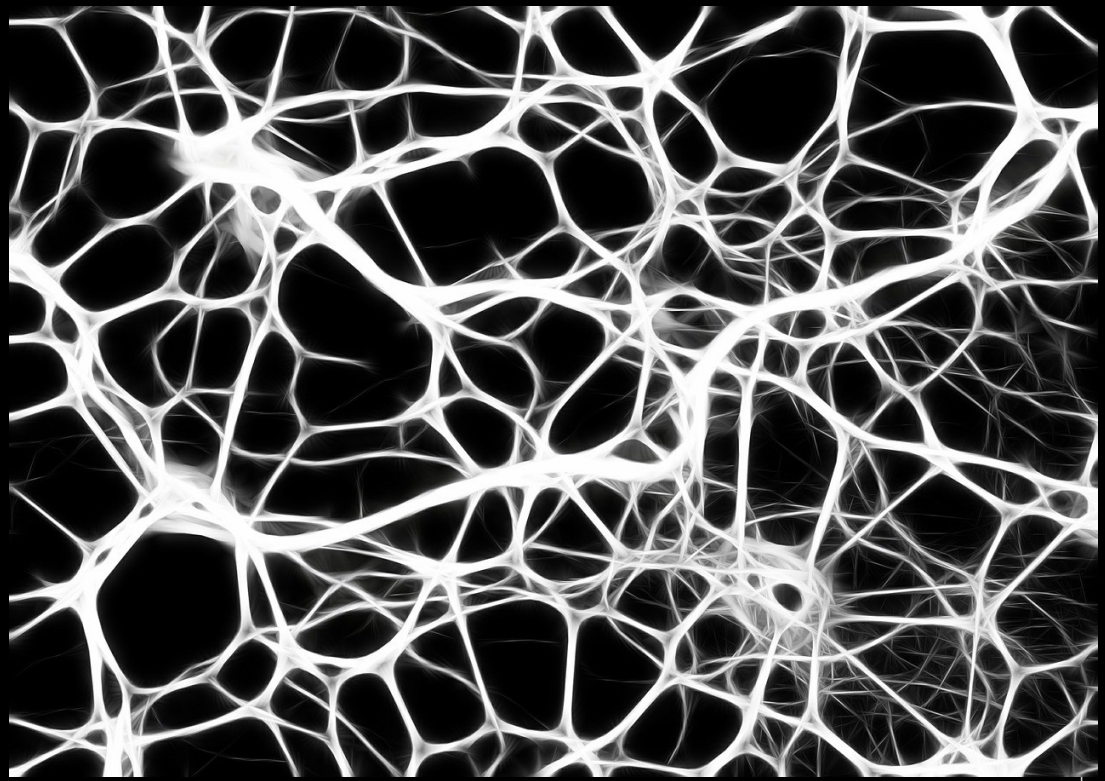


Single Spikes Have Meaning



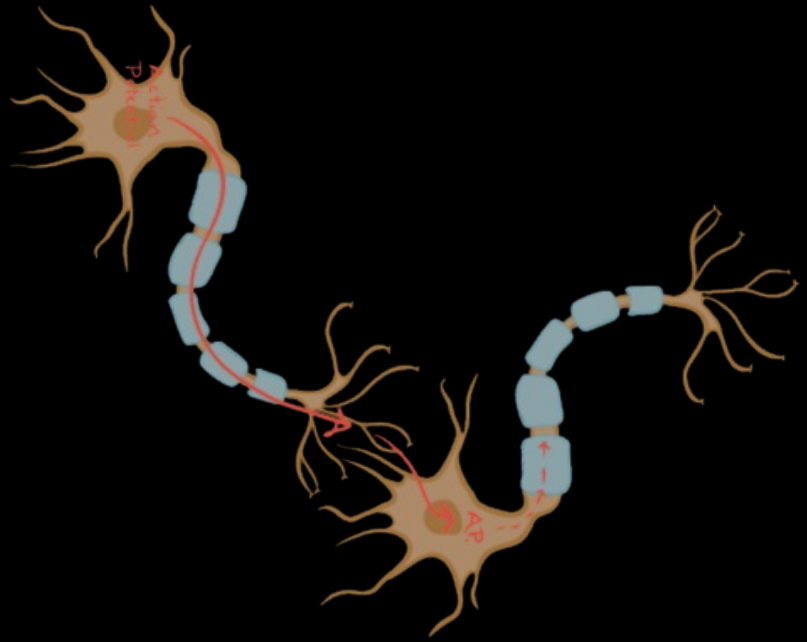
ML Neural Network

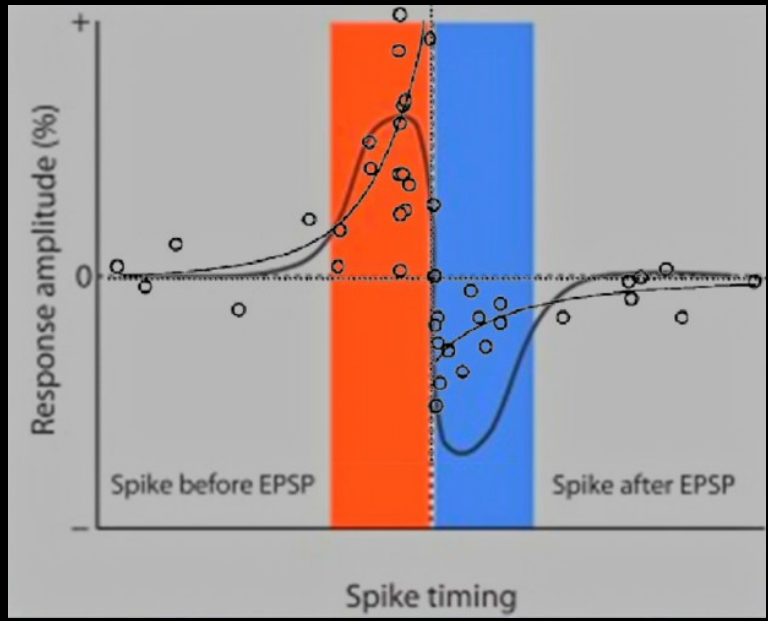




Hebbian Learning

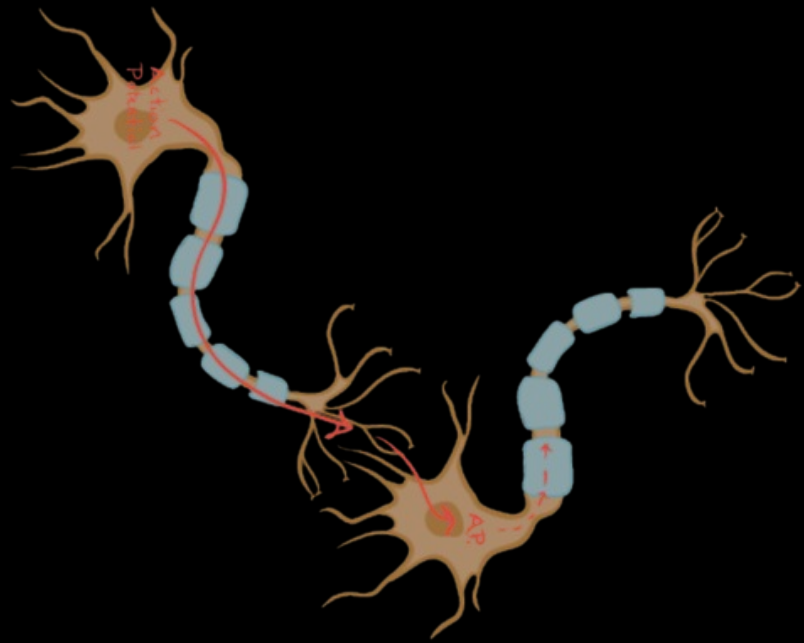
“Neurons which fire together, wire together.”





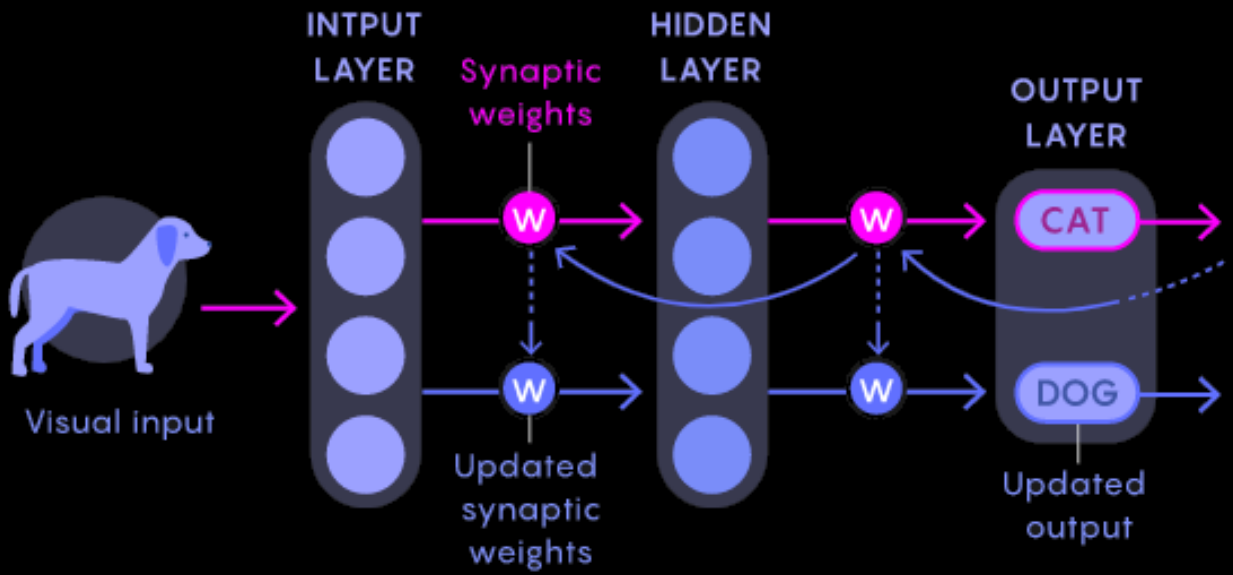
Hebbian Learning

- To make any substantive change in a synapse weight takes a number of repetitions.
- Imagine a computer where a single memory write of one byte takes about a second
- Any use of the network containing this synapse modifies the synapse

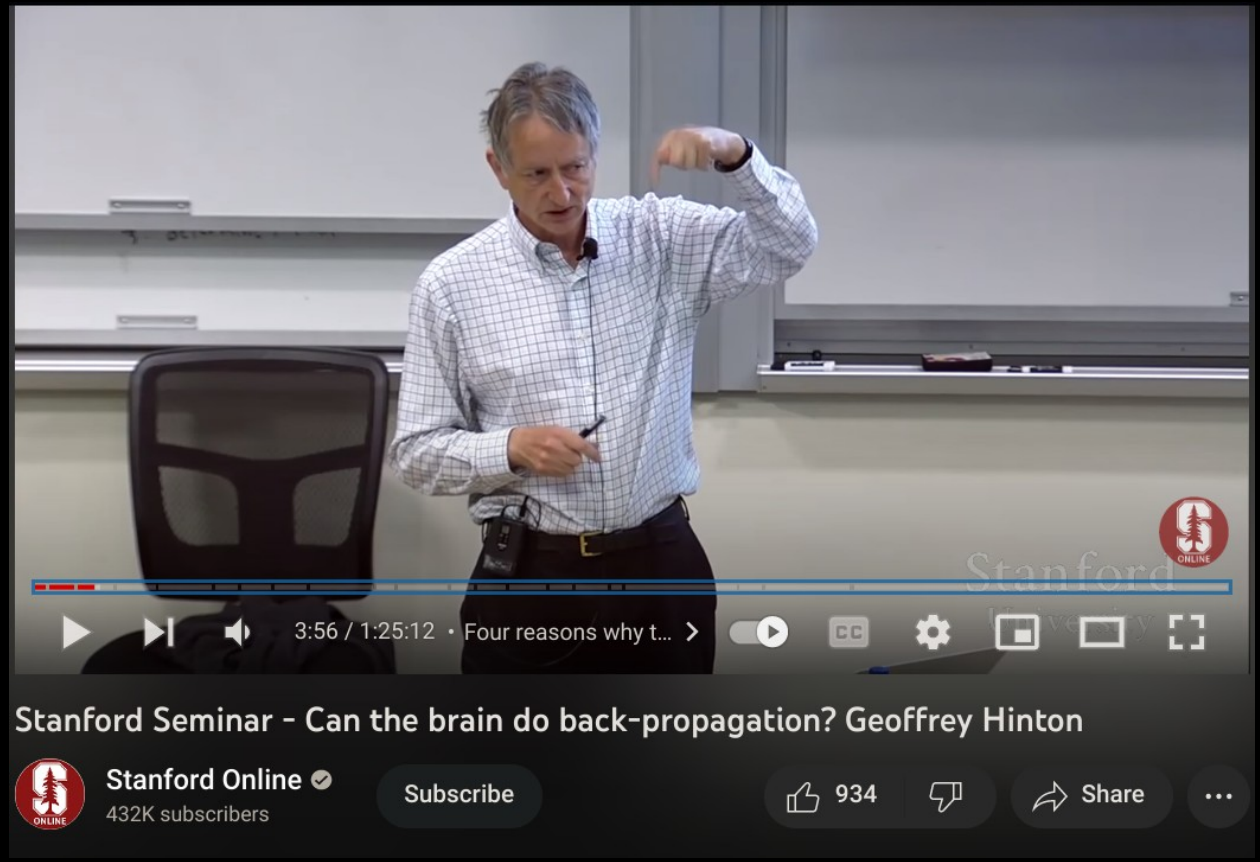


Can the brain do backpropagation?

In a biological system, there is no mechanism to dictate the weight of any specific synapse.

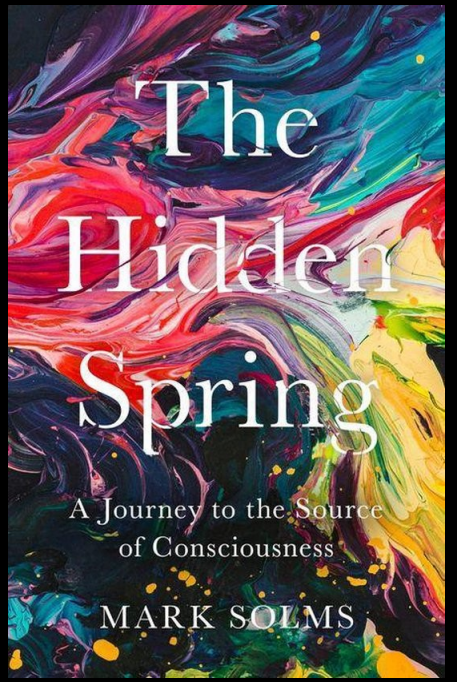


Can the brain do backpropagation?



Artificial Consciousness

What is Consciousness?



Consciousness

What is Consciousness?

Consciousness

Where am I?

Consciousness

- We must look deeper
- Focus on more primitive structures
- The answer may lie in **raw emotions**

Consciousness

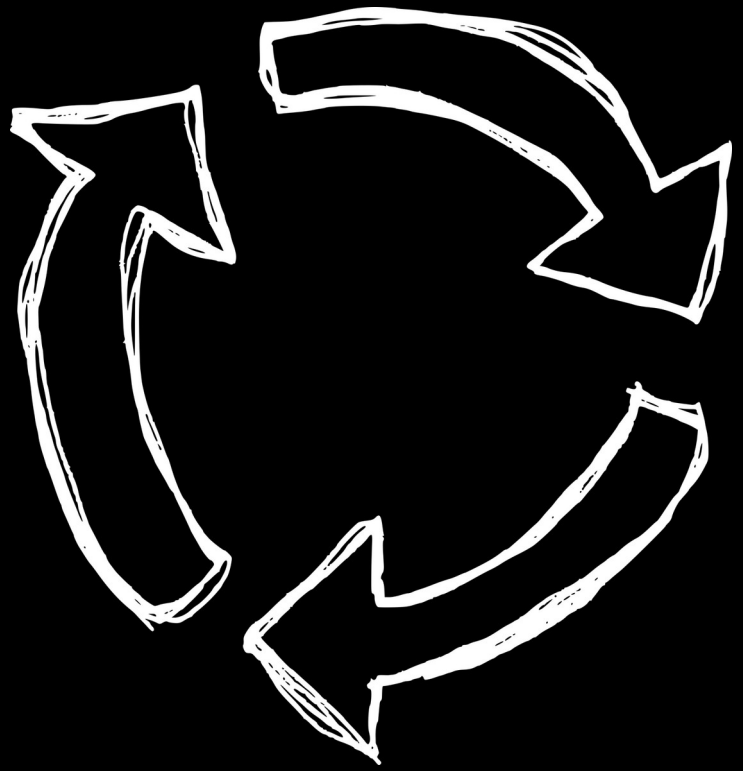
- Smart phones can do visual and audio processing
- What don’t all these things happen **in the dark?**

Function vs Emotion

Murderer
Thief
Fraud
...

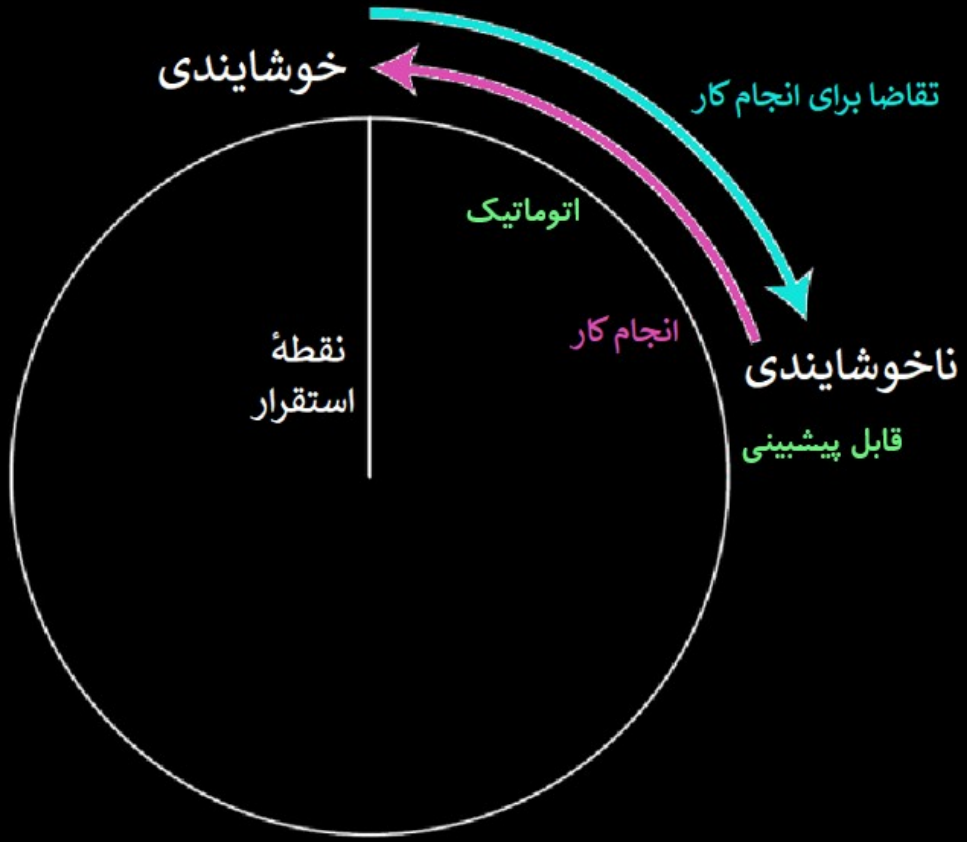
Kind
Warm
Generous
...

Homeostasis

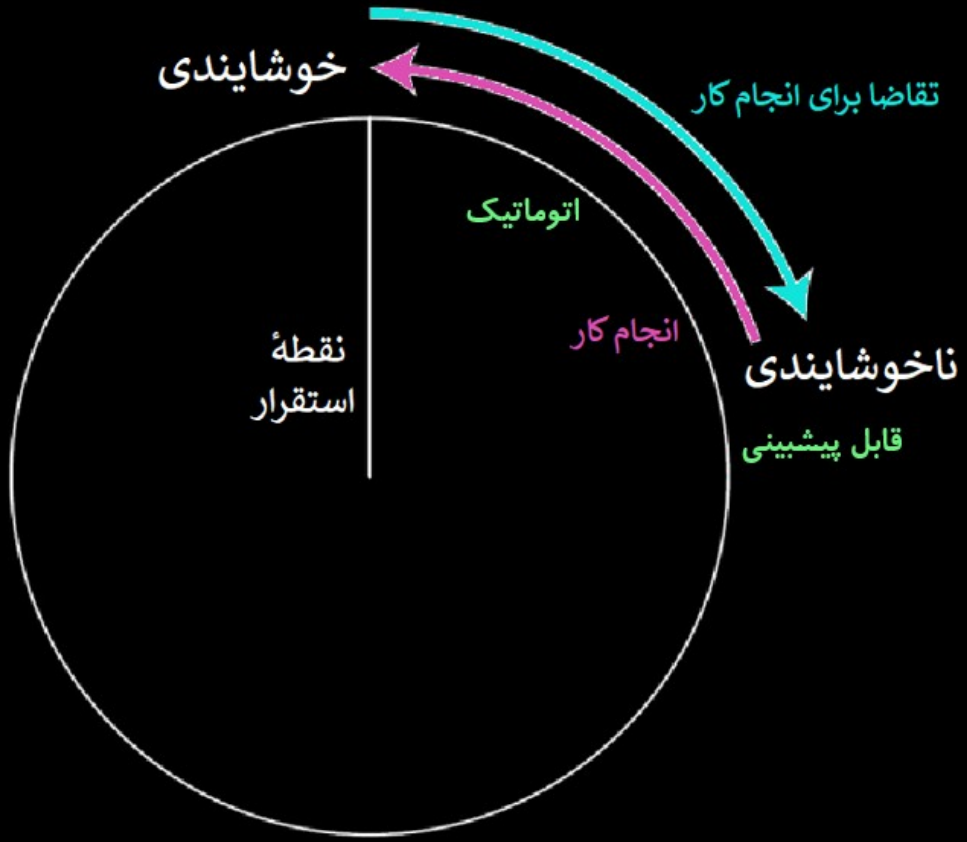


Entropy

Entropy


خوشایندی
تقاضا برای انجام کار
اتوماتیک
انجام کار
نقطهٔ
استقرار
ناخوشایندی
قابل پیشبینی

Entropy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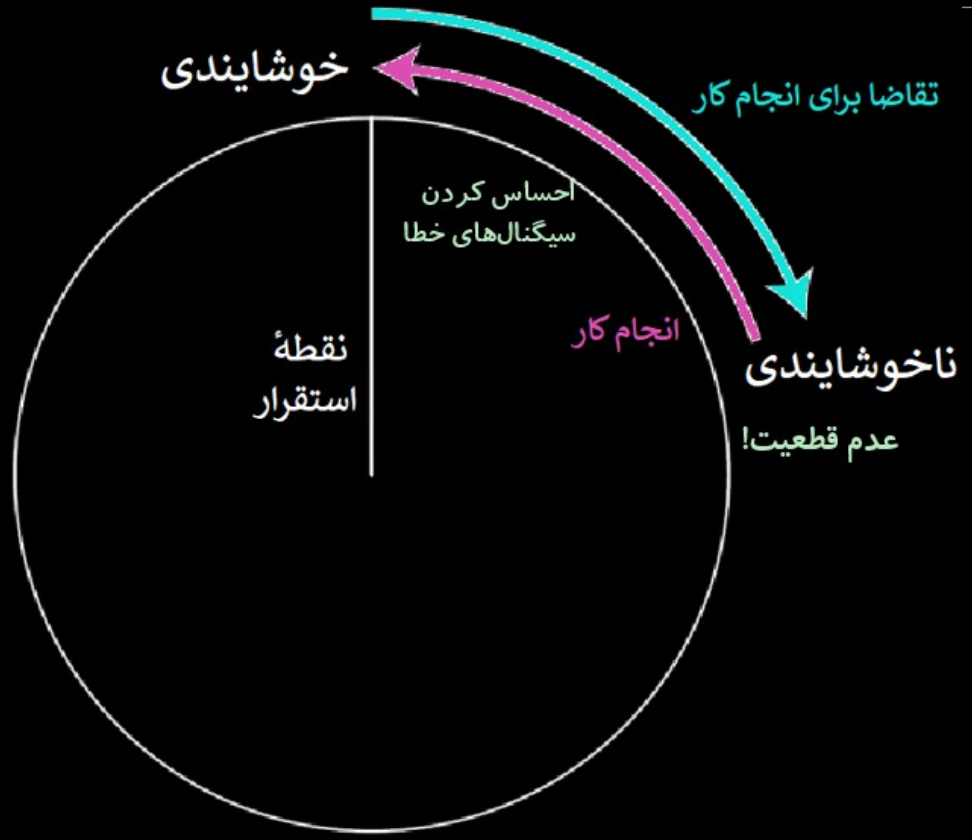
Entropy


خوشایندی
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انجام کار
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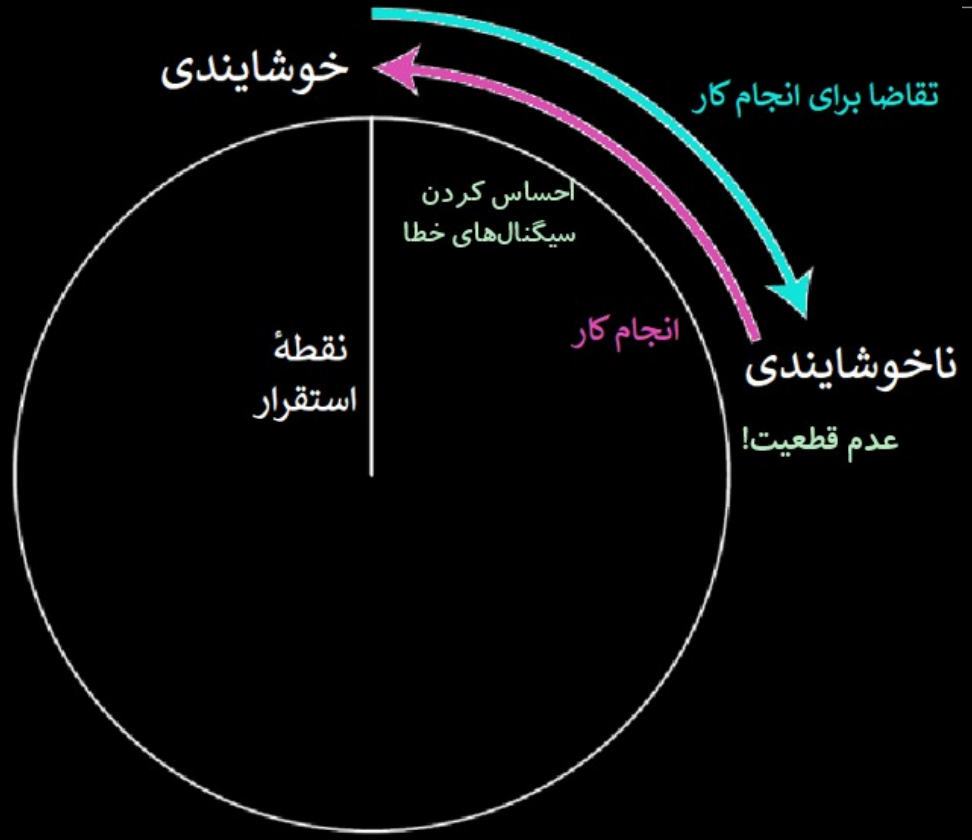
استقرار
ناخوشایندی
عدم قطعیت!

Entropy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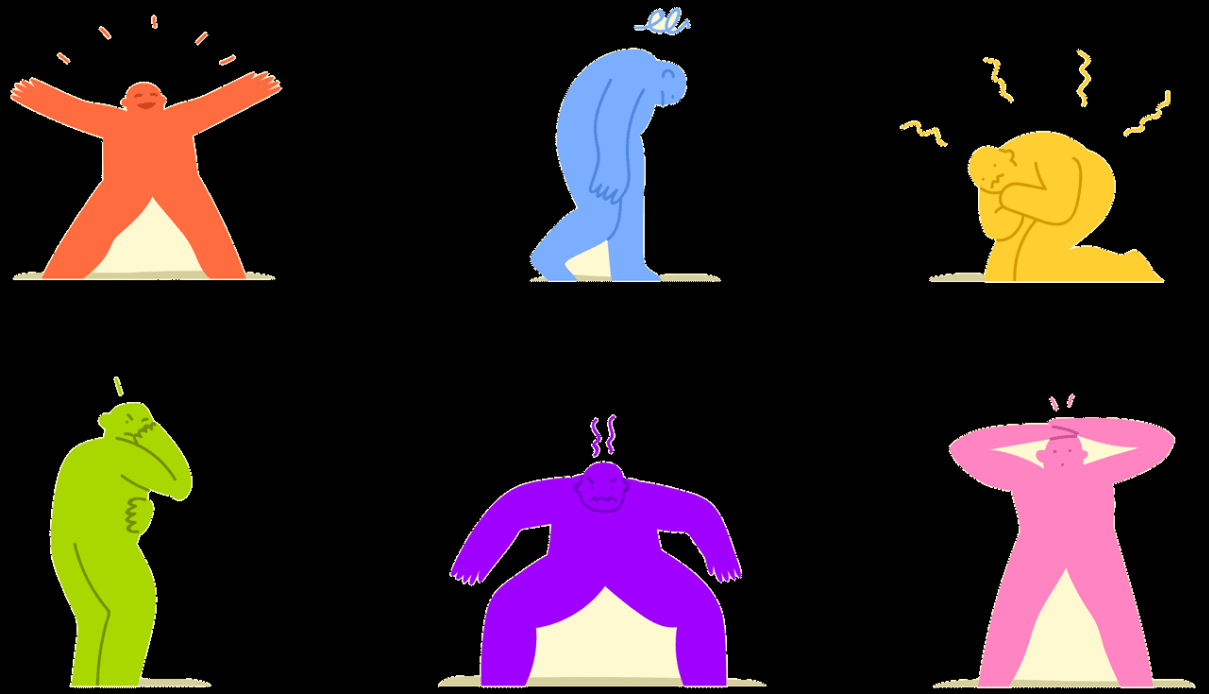
نقطهٔ
استقرار
ناخوشایندی
عدم قطعیت!

Emotions are important



Different types of emotions

- Bodily sensations
  - Hunger
  - Thirst
  - Cold and...
- Mental feelings
  - Anger
  - Search
  - Fear
  - Lust
  - Confusion/Discomfort
  - Taking Care of someone/something
  - Play

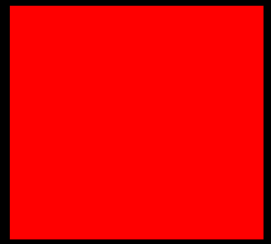
Voluntary Behavior

- Valence-based choices
- Experiential Learning
- Prioritizing Needs
- Resolving Conflict

Emotion vs Perception

Blue

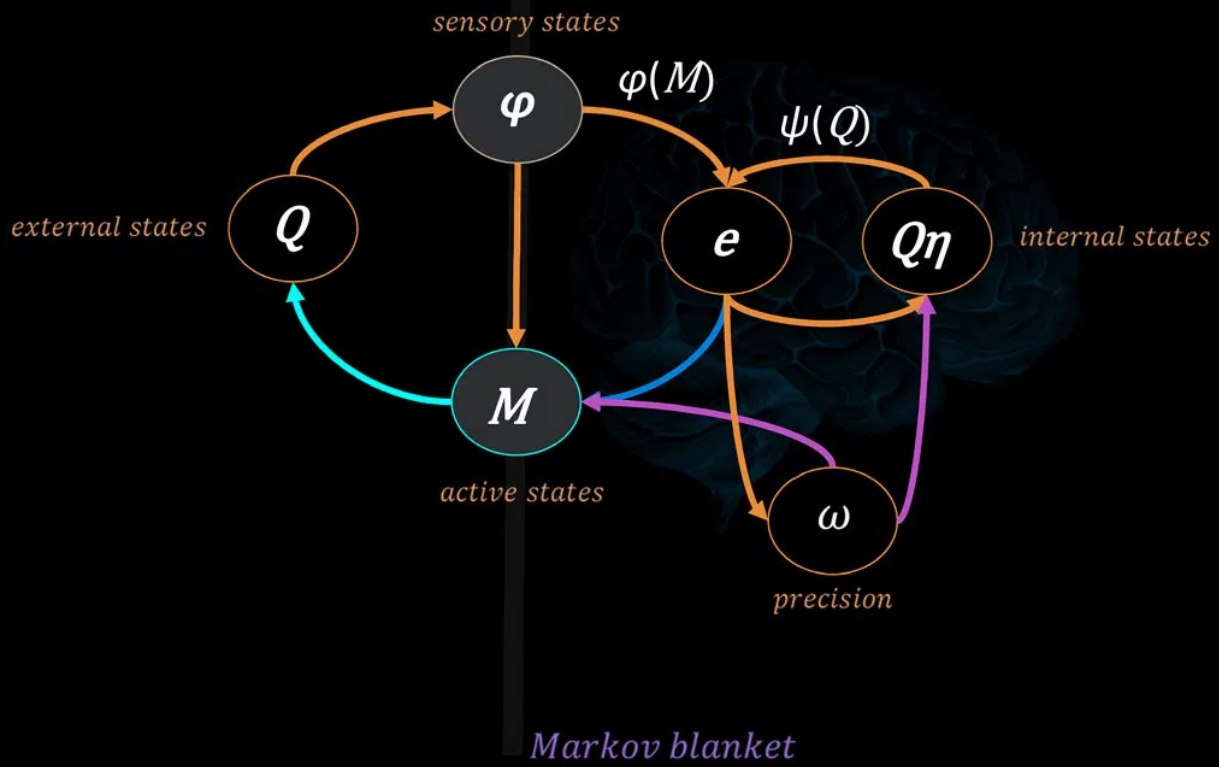
Red



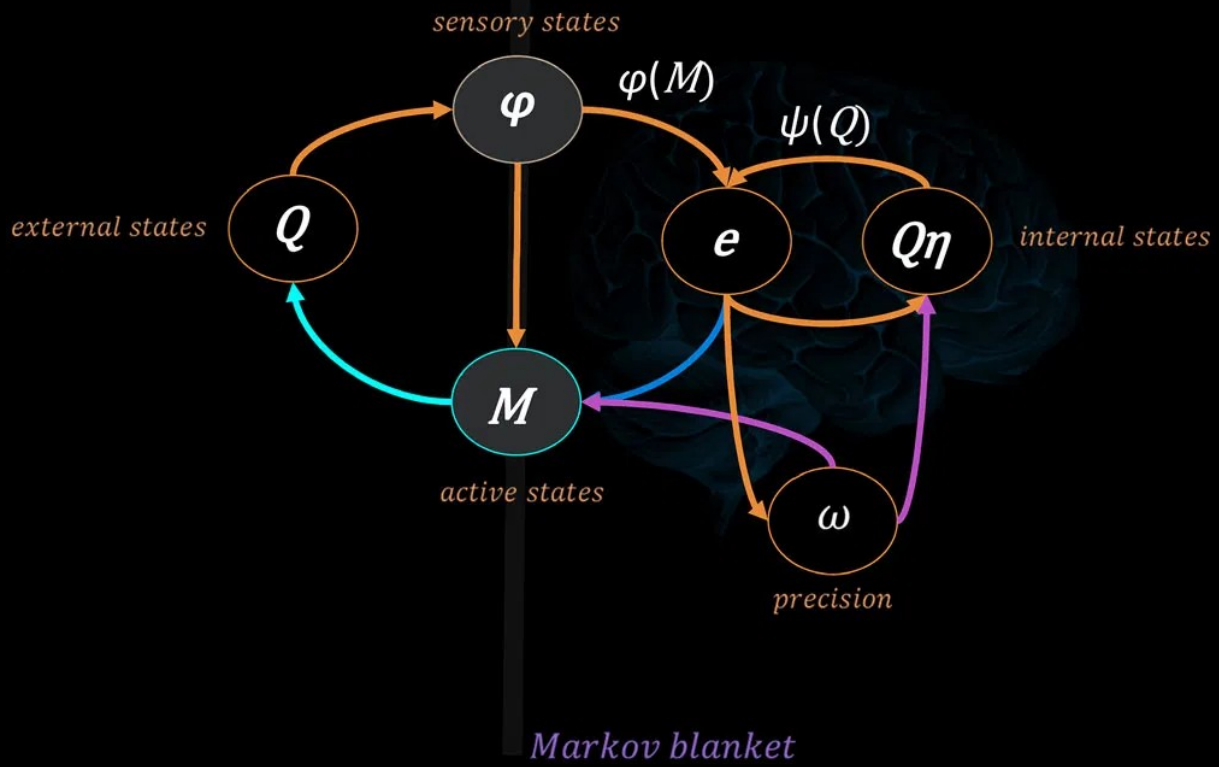
Emotions are a form of homeostasis

- If emotion is a form of homeostasis
- Then like other things in nature
- We can reduce it down to physcial laws

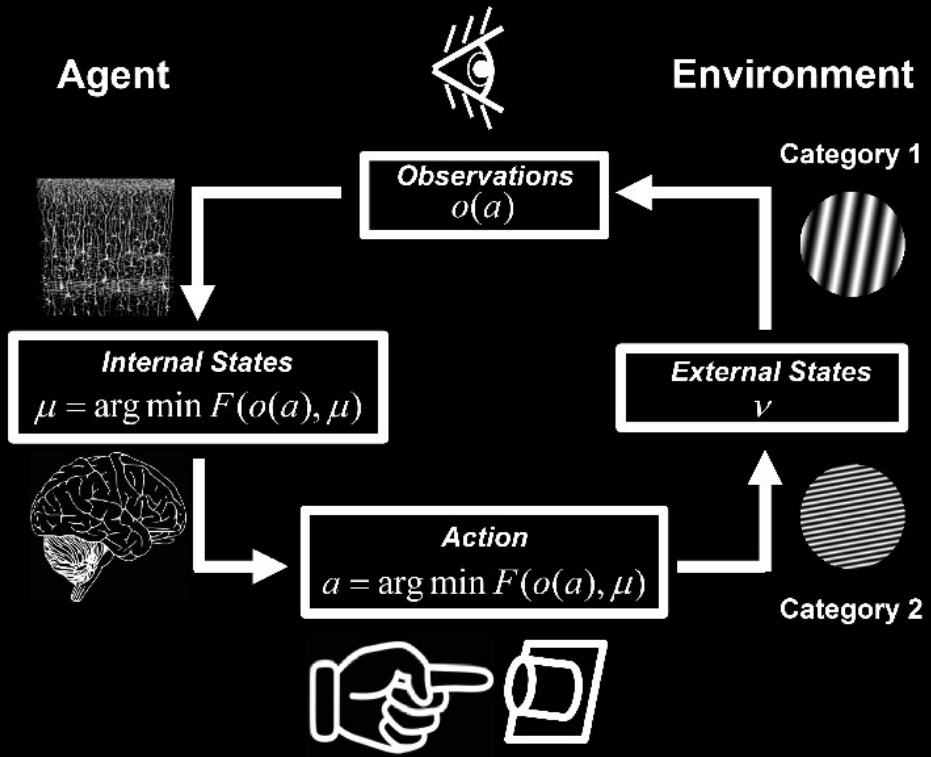
Markov Blanket



Markov Blanket



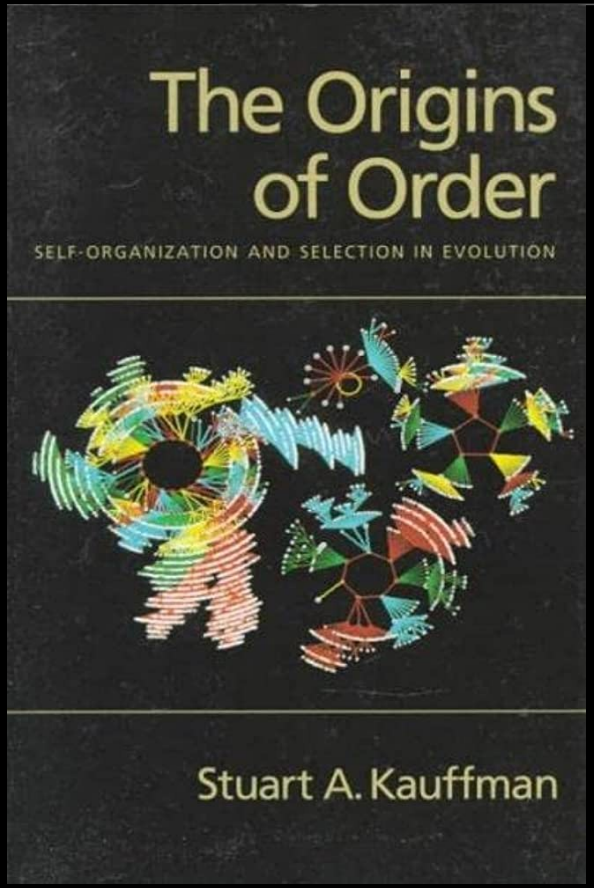
Free Energy Principle

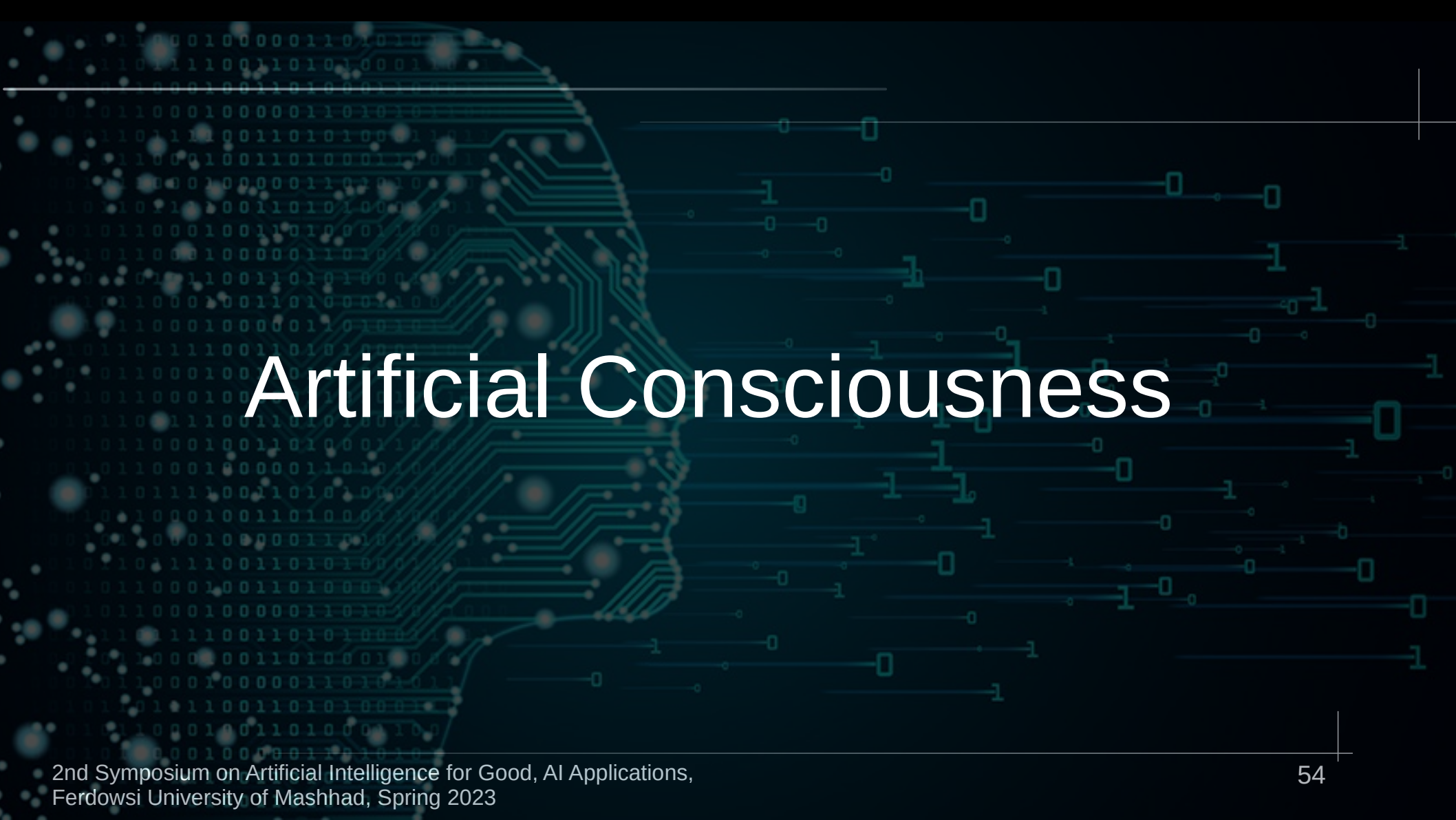


Free energy bound on surprise

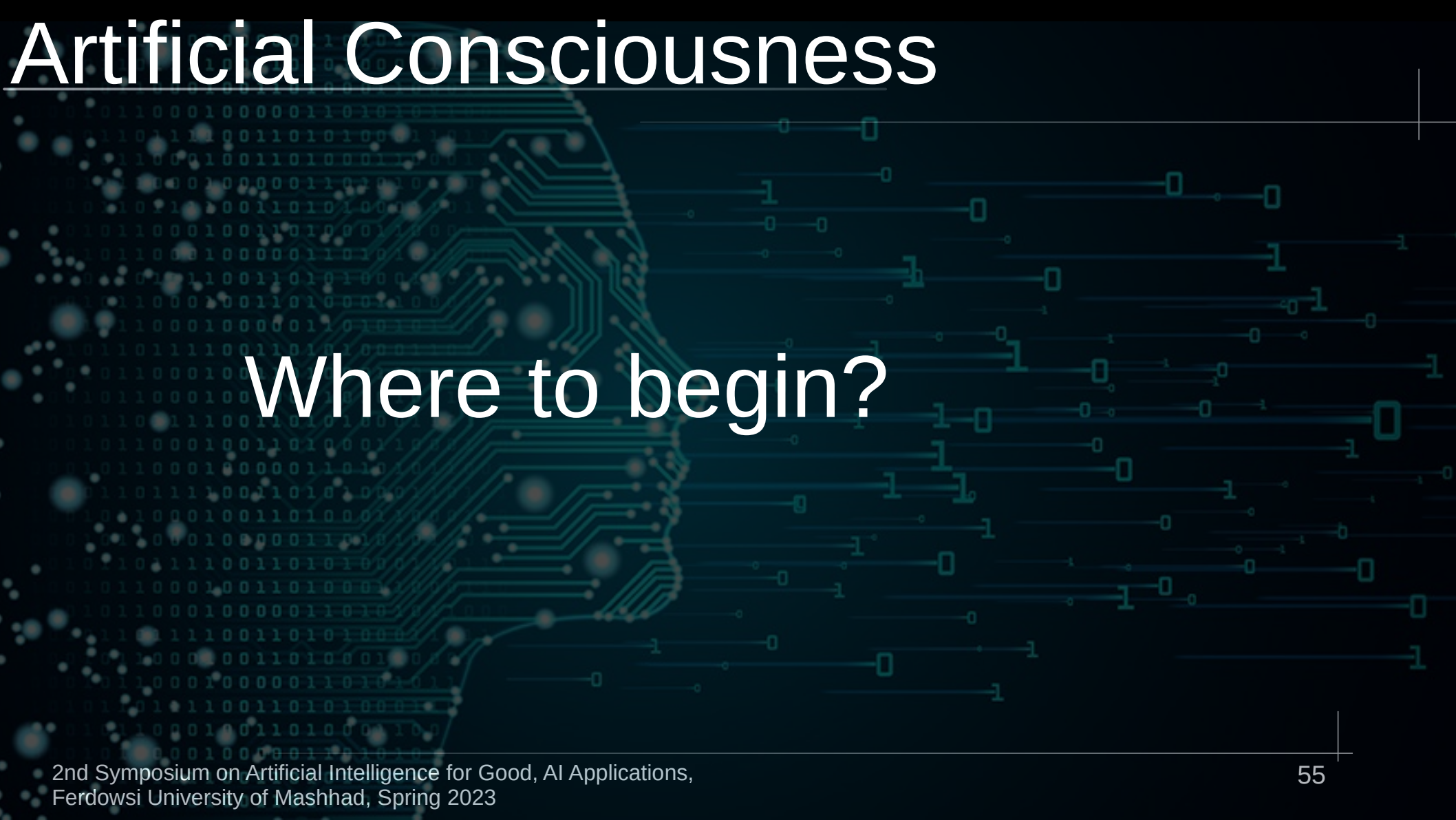
$$F(o(a),\mu) = \sum_{\nu} Q(\nu \mid \mu, m) \ln Q(\nu \mid \mu, m) - \sum_{\nu} Q(\nu \mid \mu, m) \ln P(o(a), \nu \mid M)$$

Self-organizing Systems




Artificial Consciousness

Artificial Consciousness



Organisms vs AI agents

How Organisms Come to Know the World: Fundamental Limits on Artificial General Intelligence

Andrea Roli [1,2*], *Johannes Jaeger* [3*] and *Stuart A. Kauffman* [4]

The ability to exploit ambiguities

3 + 8 = 2

5 + 1 = 0

9 + 1 = 1

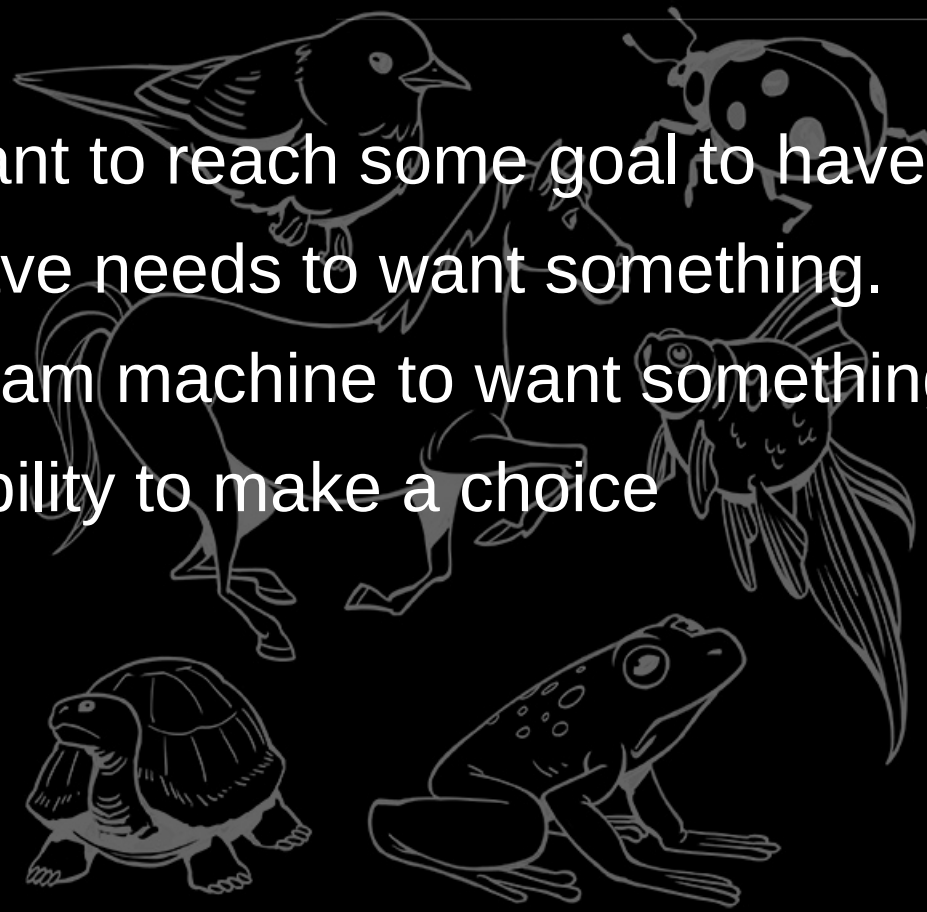
7 + 2 = 0

6 + 6 = 2

0 + 8 = 3

5 + 6 = ?

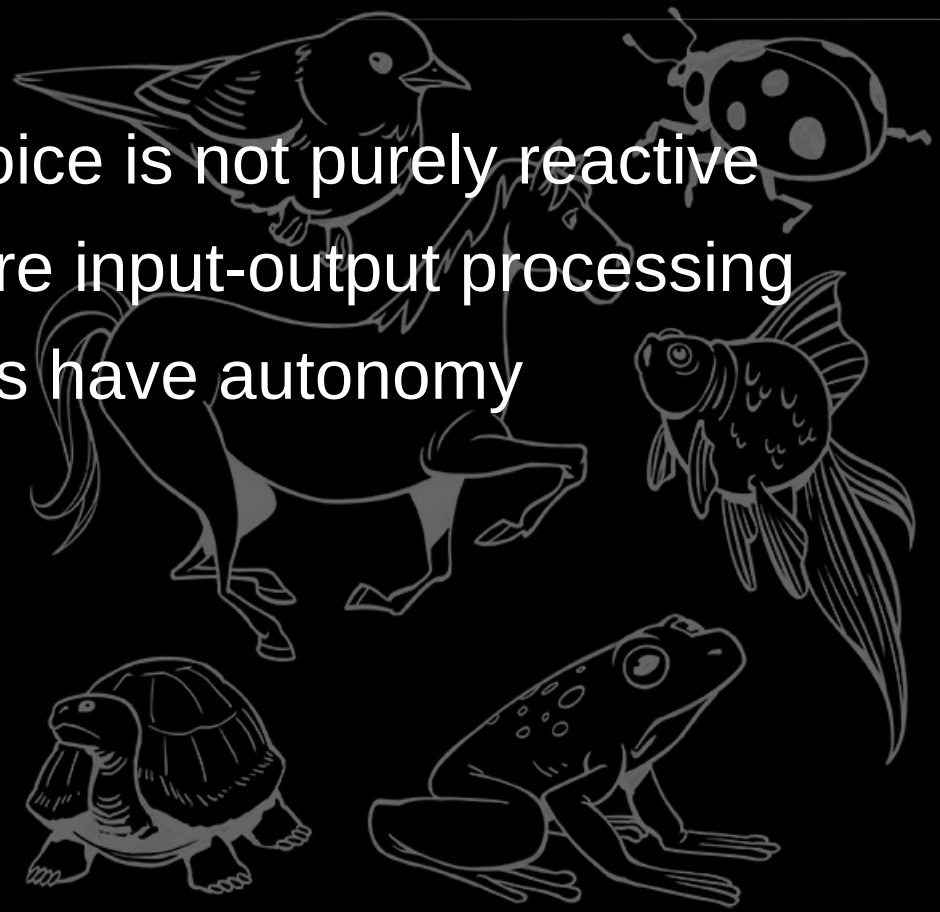
How could an AGI choose and refine its own goals?



- One must want to reach some goal to have a goal at all
- One must have needs to want something.
- How to program machine to want something at all?
- Needs the ability to make a choice

Bio-agency

- Making a choice is not purely reactive
  - It’s not pure input-output processing
  - Organisms have autonomy

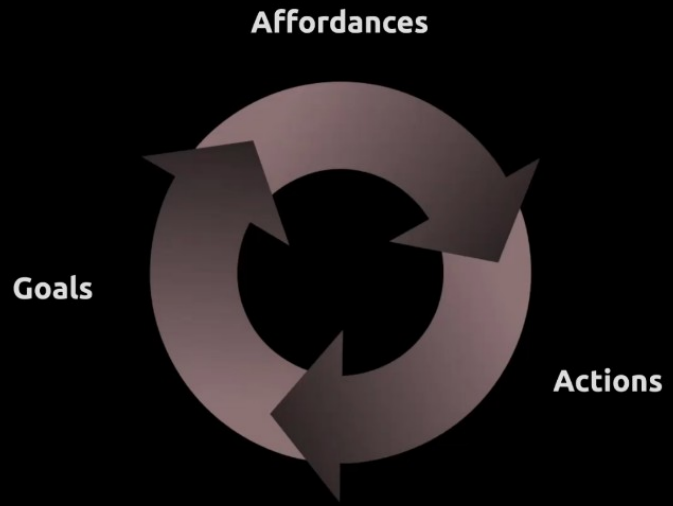


AI Agent

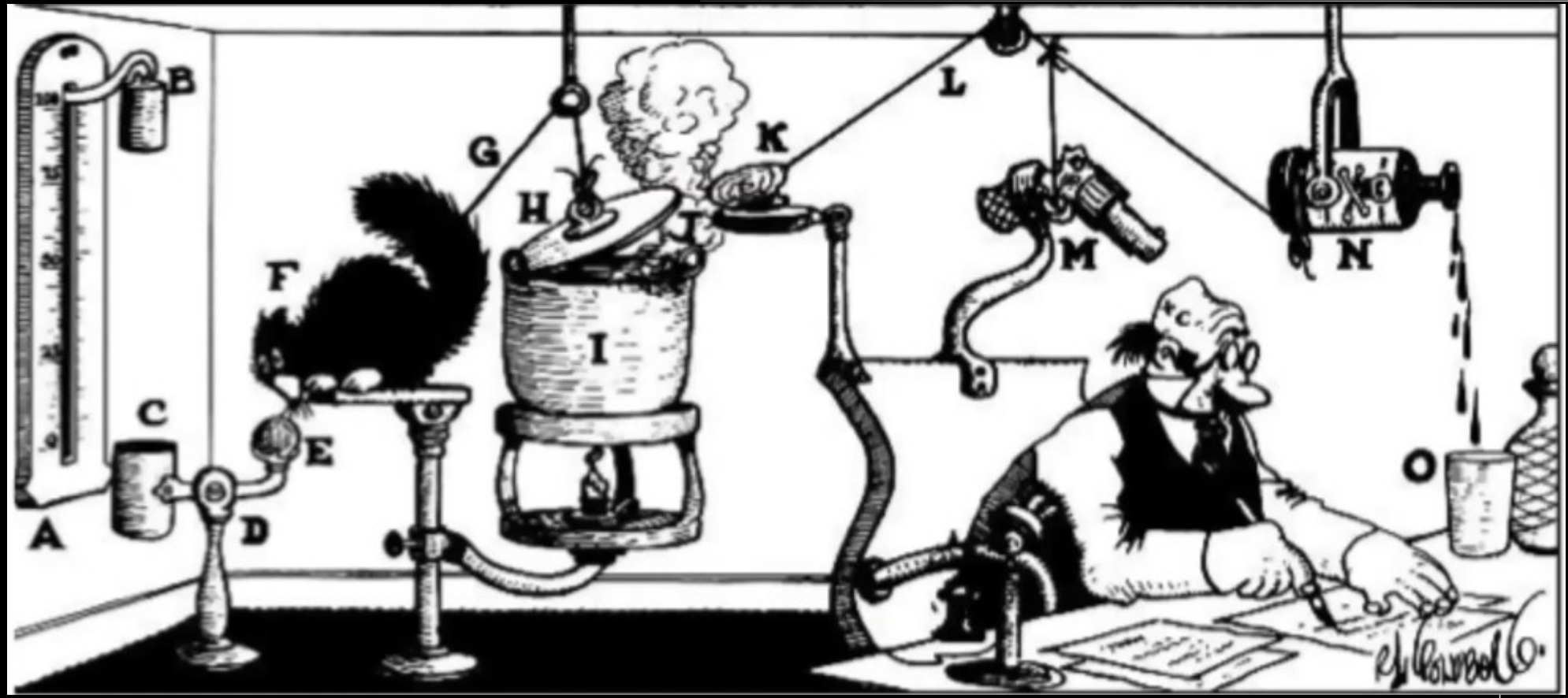
- an AI agent is an input–output processing device
- it is generally assumed that input-output processing is performed by some sort of algorithm that can be implemented on a universal Turing machine

Affordances

- “Affordances” refer to what the environment offers to an agent for “good or bad”



Jury-rigging



Jury-rigging

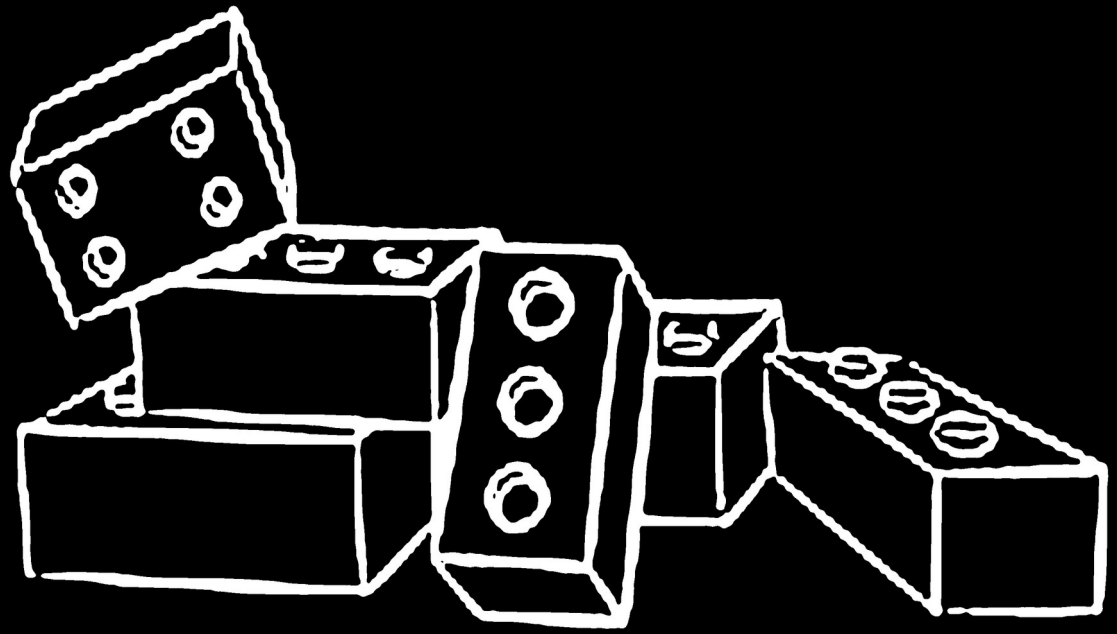
Any physical object has an indefinite number of alternative uses in the hands of an agent that cannot be known in advance

Jury-rigging

It is impossible to list all possible goals, actions, or affordances of an organismic agent in advance. In other words, organism can not only identify and exploit affordances, but they constantly generate new opportunities for themselves

Algorithms cannot jury-rig

Jury-rigging



Algorithms cannot generate meaning where there was none before

AGI

Organisms are not Turing machines.
AGI cannot be achieved in an algorithmic framework

Complexity and Evolution

organismic agency is a fundamental prerequisite for open-ended evolution

Notes

- How about deep-learning?
- Build organic computation devices or robots

Thank You

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