This is Your Brain on Computers, v. 2.0:

Present and Future Possibilities in Electronically Enhancing the Human Mind

Class III: Shifting Substrate

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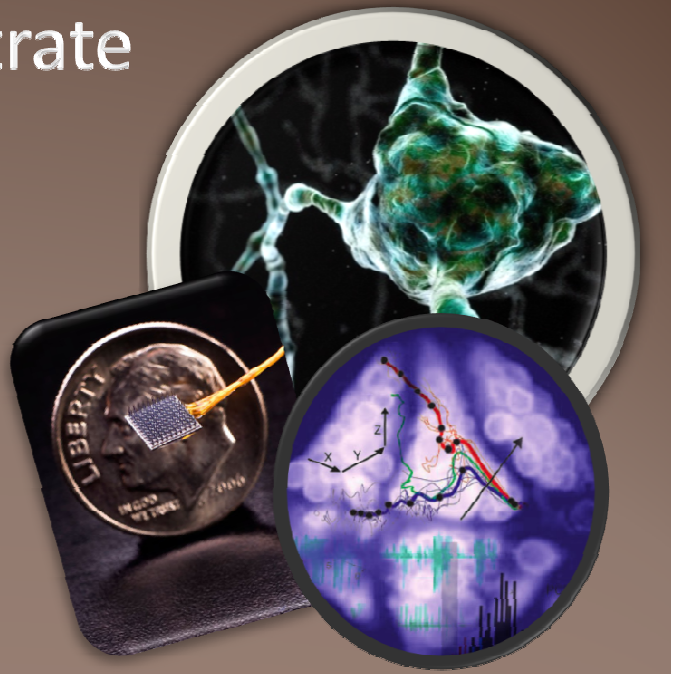
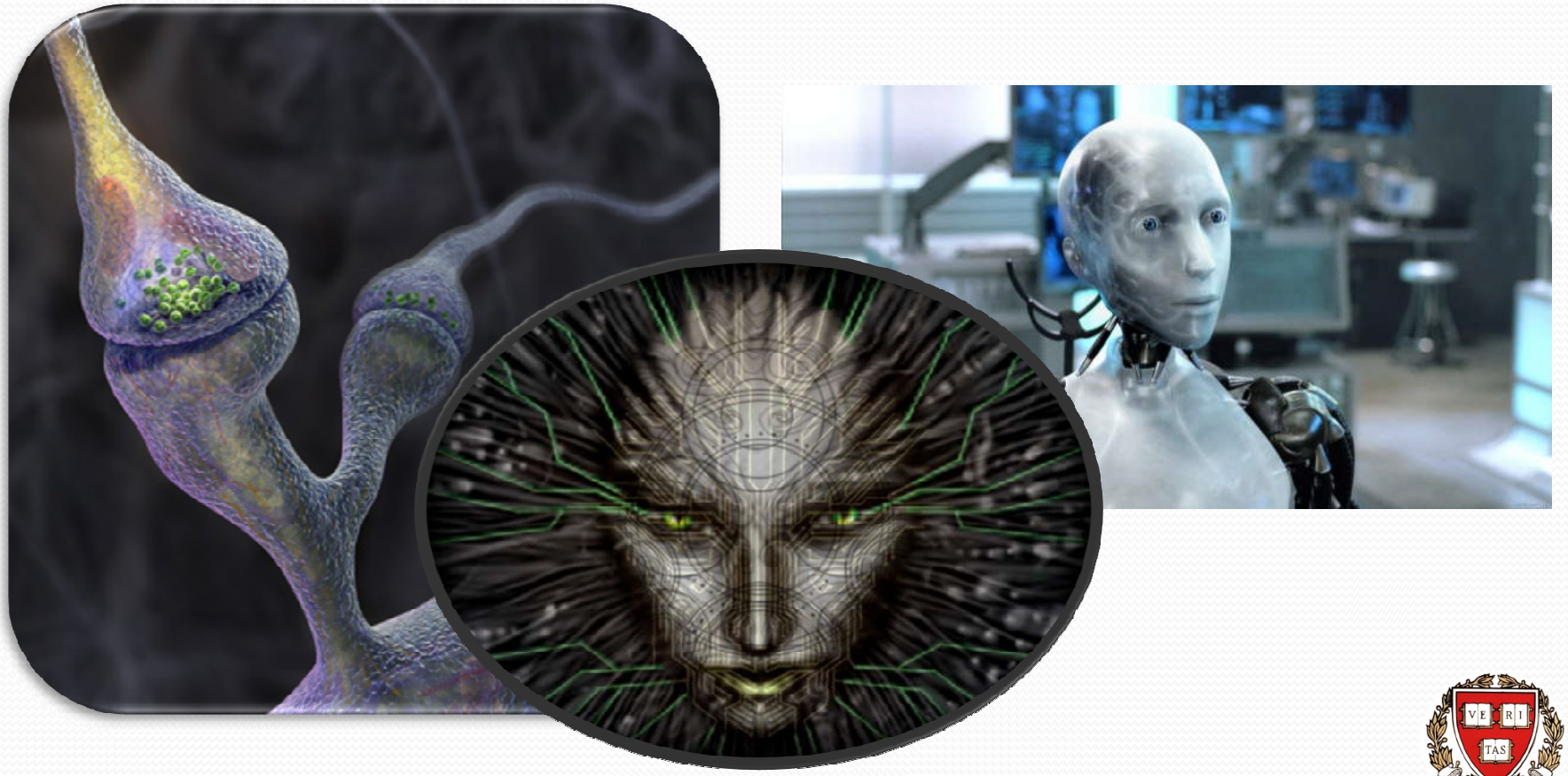


Class III: Shifting Substrate



Important Vocabulary

Consciousness: Subjective awareness of one's own existence

Free will: The ability to control one's own thoughts and actions

Stimulate: To activate

Simulate: To copy

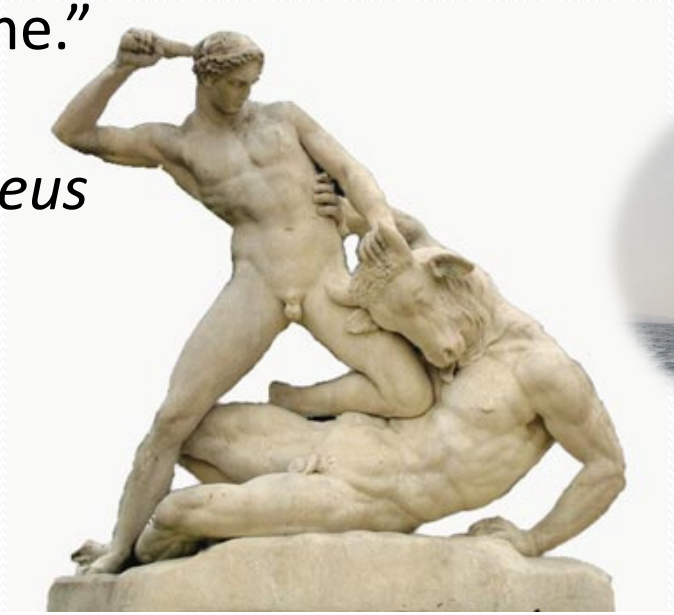
Algorithm: A standard mathematical transformation; a rule

***In vitro*:** Latin for "with the glass"; in an artificial laboratory container as opposed to in the body

The Ship of Theseus

"…For they took away the old planks as they decayed, putting in new and stronger timber in their place, insomuch that this ship became a standing example among the philosophers, for the logical question of things that grow; one side holding that the ship remained the same, and the other contending that it was not the same."

--Plutarch, *Theseus*
c. 70 A.D.

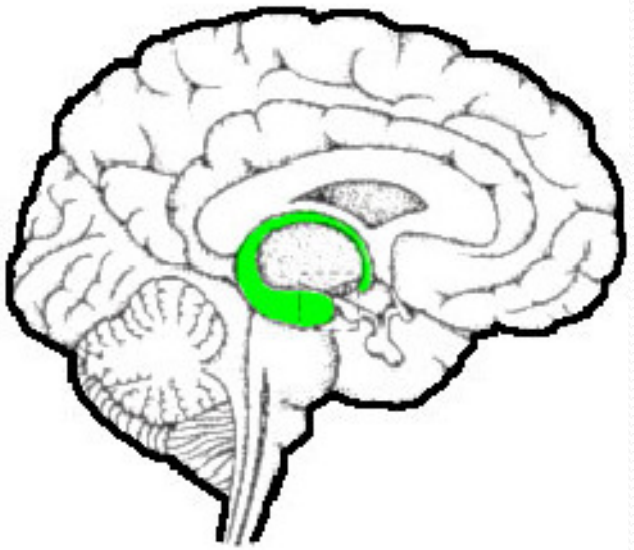


Artificial Hippocampus

- Developed by Ted Berger at the University of Southern California

- Multielectrode array that simulates hippocampal neuron activity

- Created by randomly stimulating very thin slices of hippocampus to determine the algorithms of their firing responses

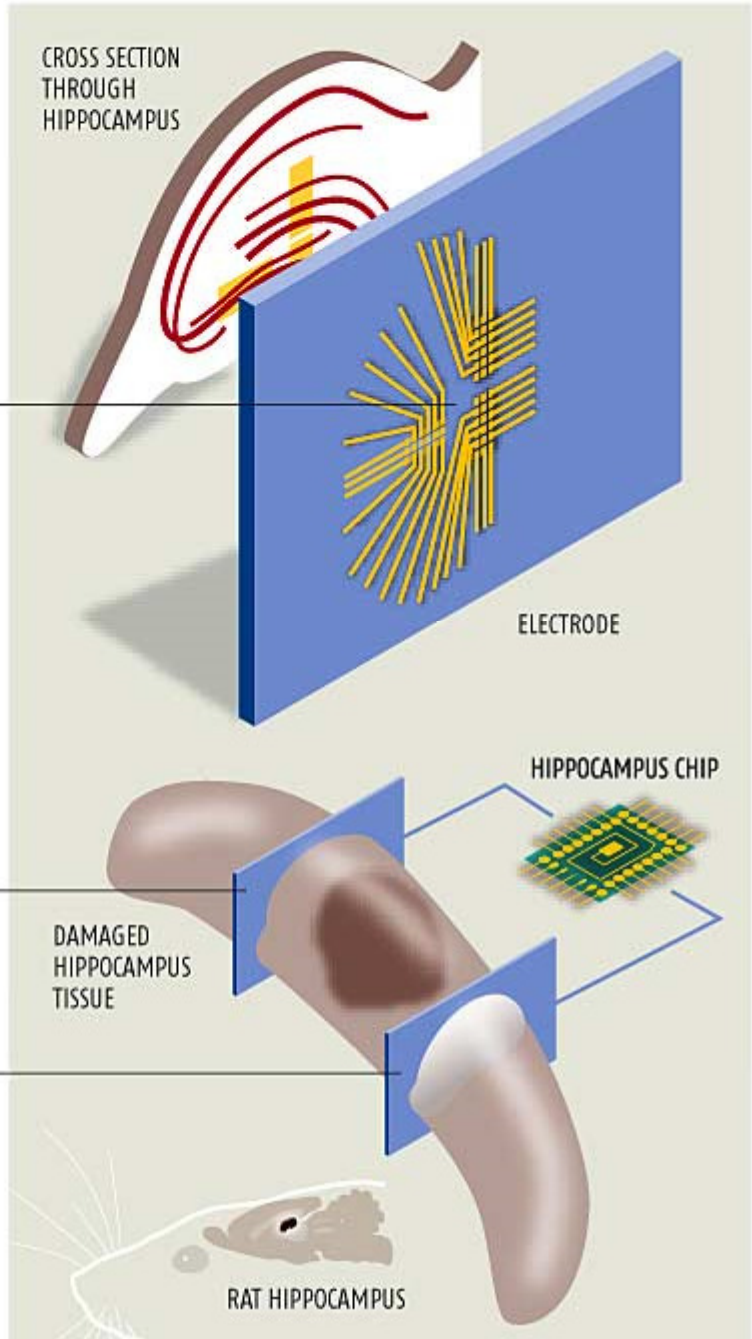


- Hippocampus chosen due to its highly organized structure (a high number of similar parallel circuits)

- Represents more than 10 years of work and funding by DARPA

HIPPOCAMPUS REPLACEMENT

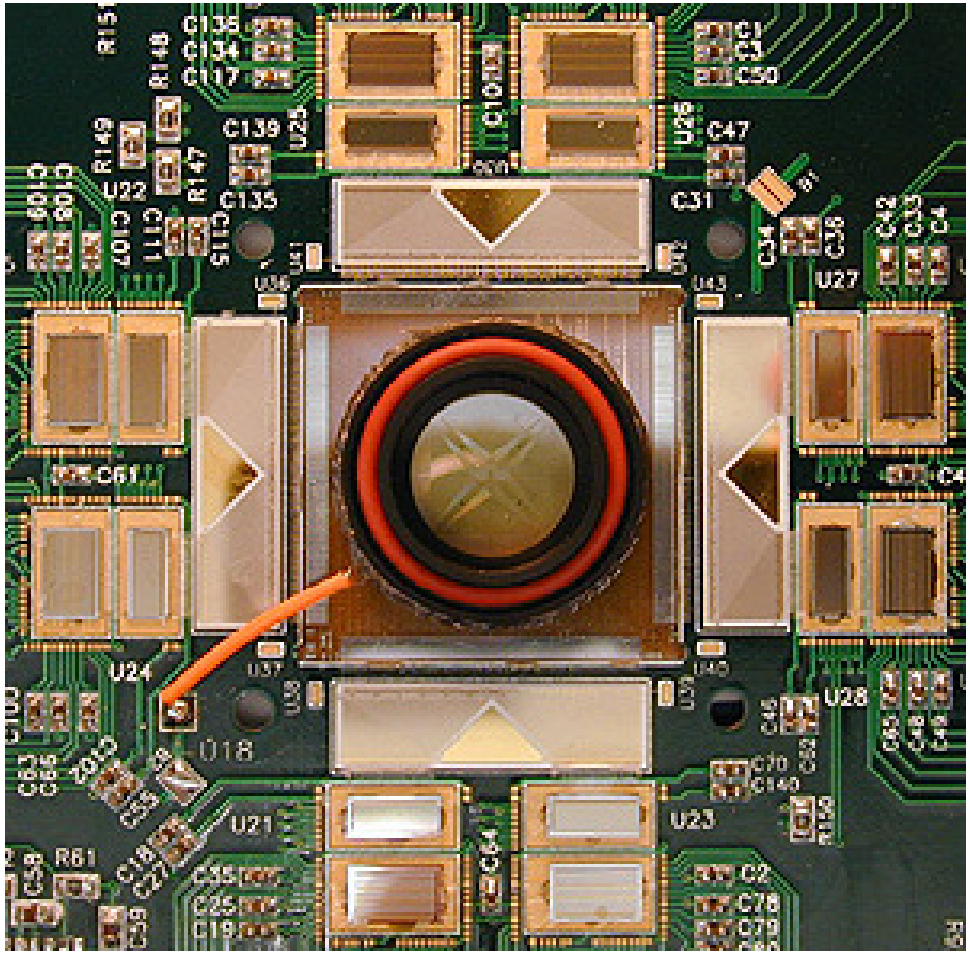
Chip takes over the processing of nervous signals normally performed by the hippocampus



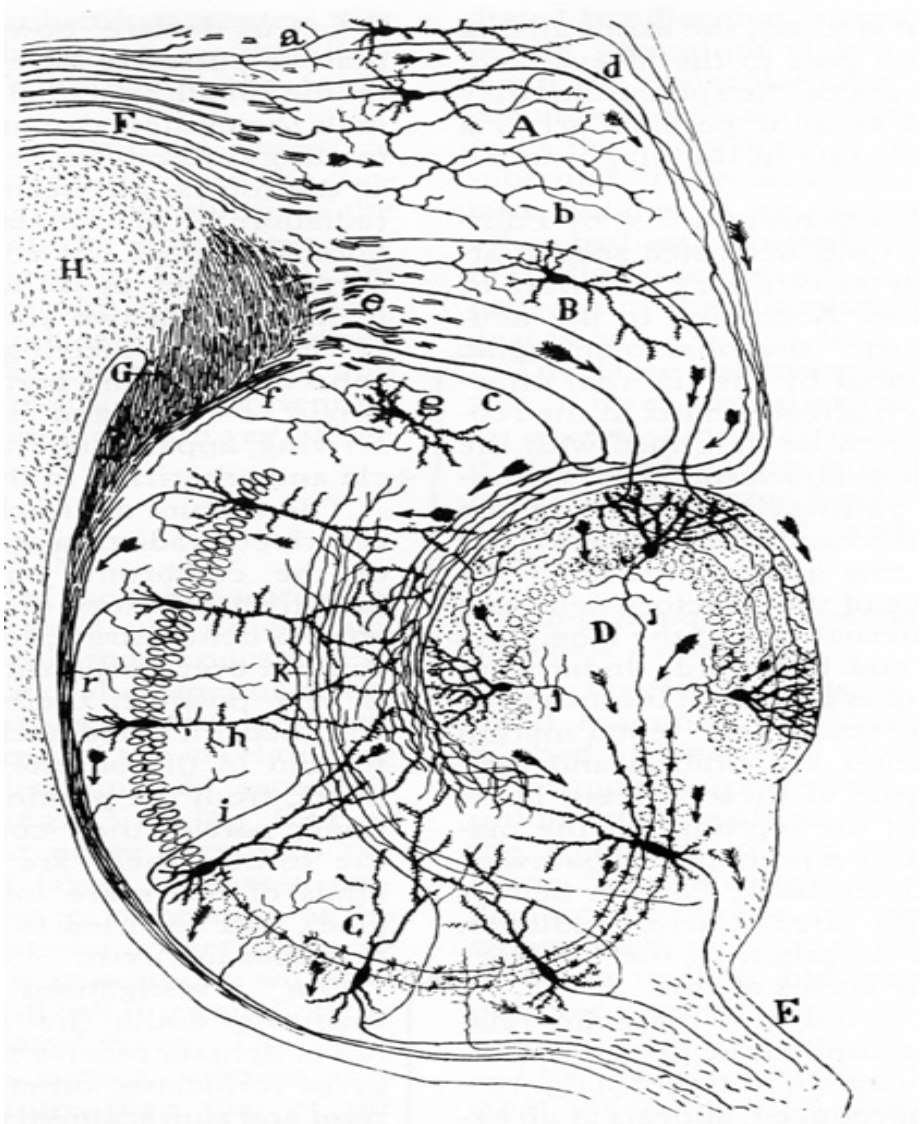
Multiple electrodes are placed on each array. They are positioned to mimic the structure of nerve tissue within a slice of the hippocampus, and make contact with other parts of the brain

Recording electrode array "listens" to neuron activity coming into the hippocampus and feeds it to the chip

Stimulating electrode array delivers the appropriate electrical output to the rest of the brain

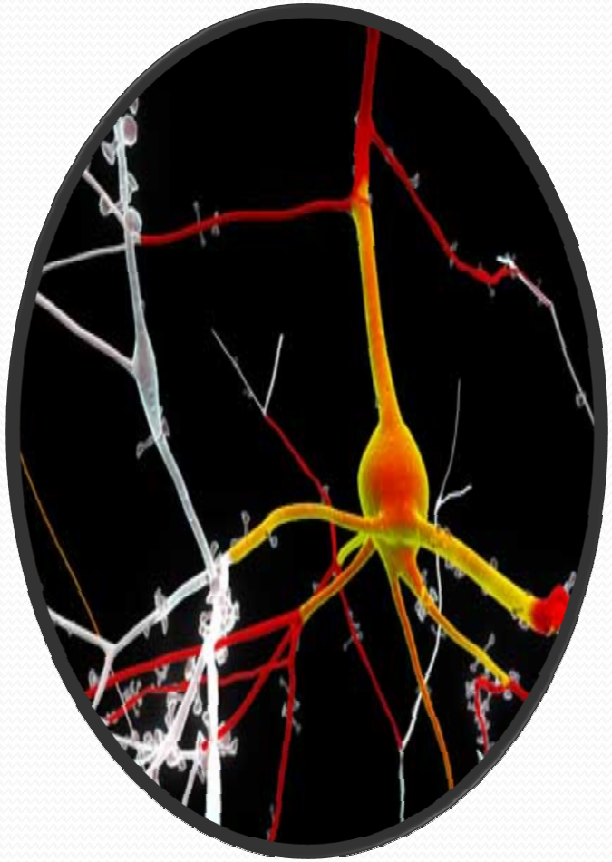


The artificial hippocampus consists of a silicon chip containing thousands of microelectrodes.



The hippocampus was selected for emulation because of its high number of simple, repeated circuits.

Blue Brain



- Developed by at the École Polytechnique Fédérale de Lausanne in Lausanne, Switzerland

- Simulates the appearance and activity of connected rat neurons

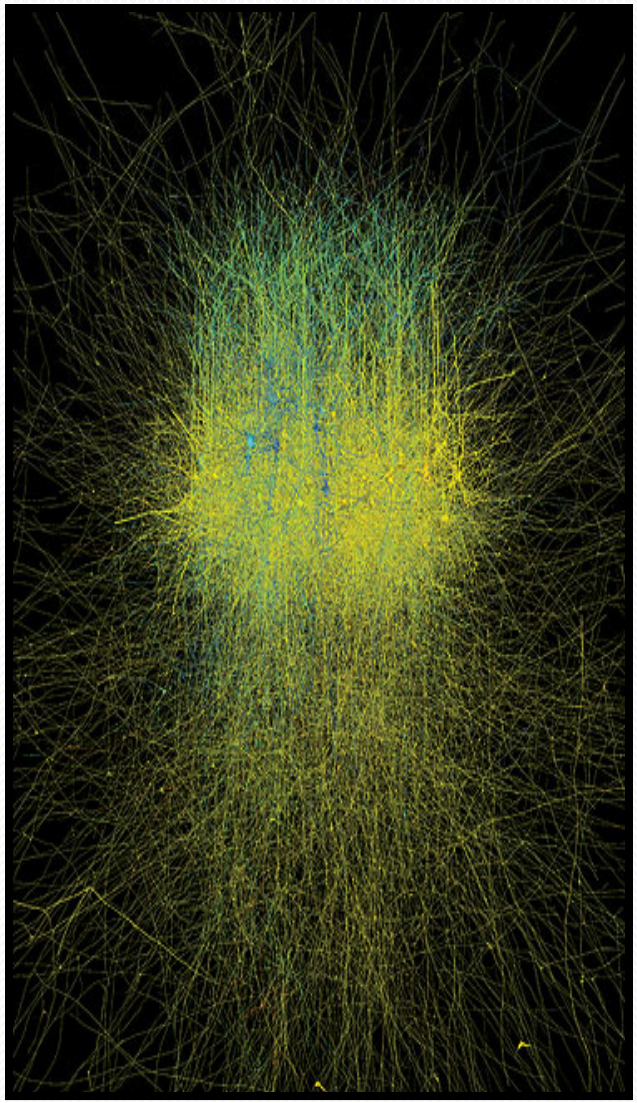
- Created by determining response algorithms of individual neurons by randomly stimulating them *in vitro*
    - Killed thousands of rats for this purpose

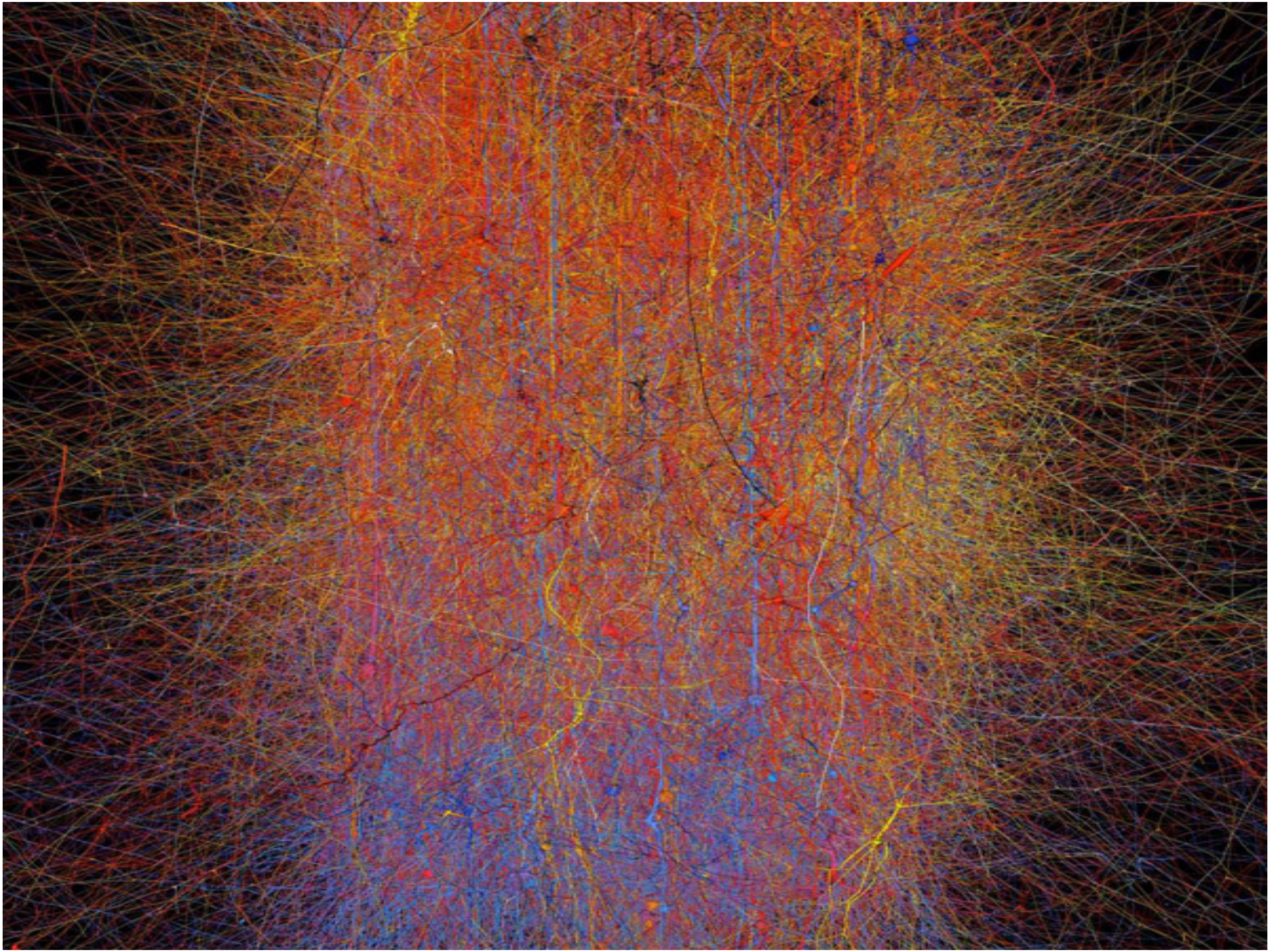
- Uses 8,192 processors that compute in parallel

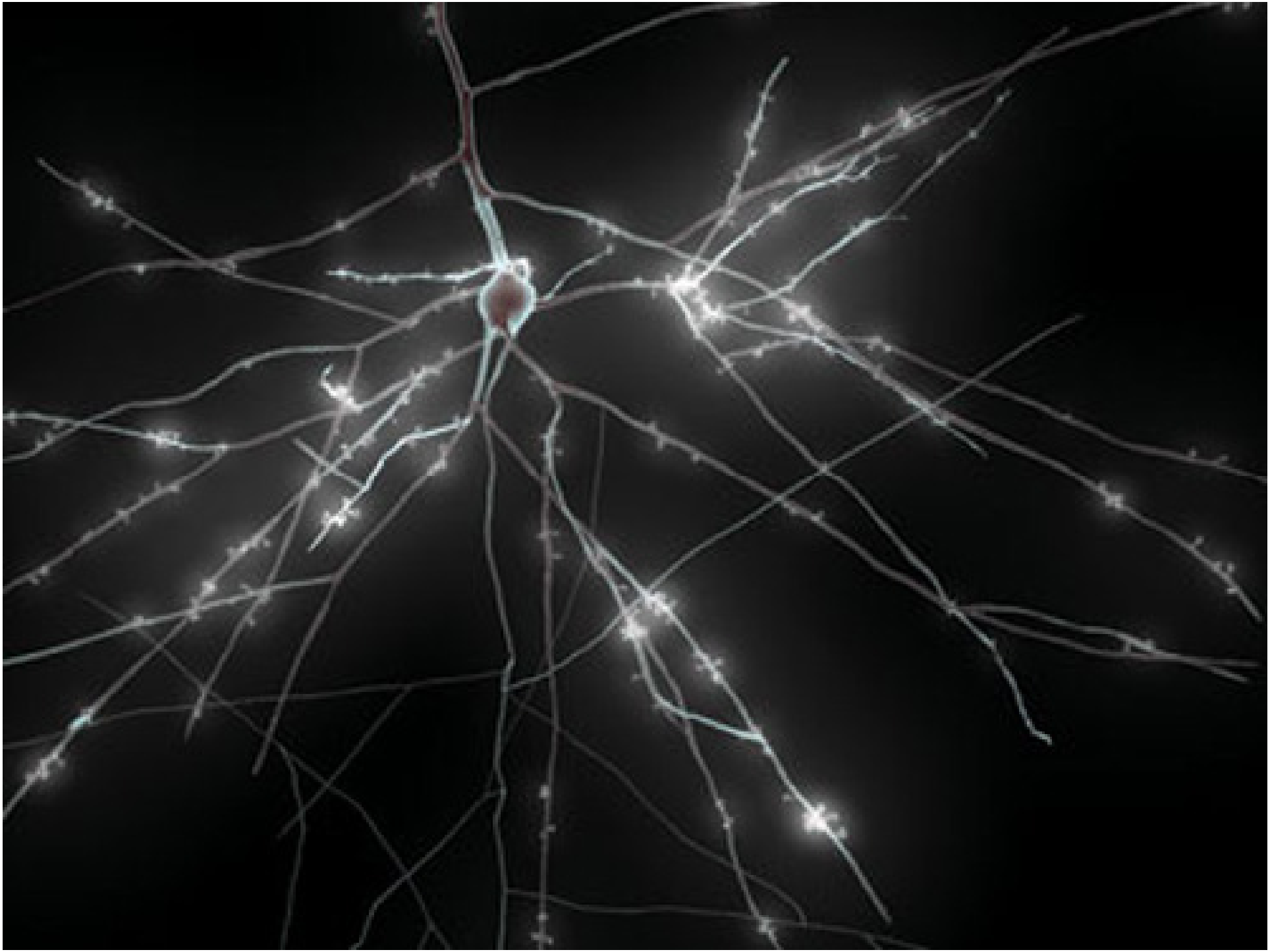
- Uses one processor per neuron
    - Contains its own production line that can create more than 400 types of “neurons”

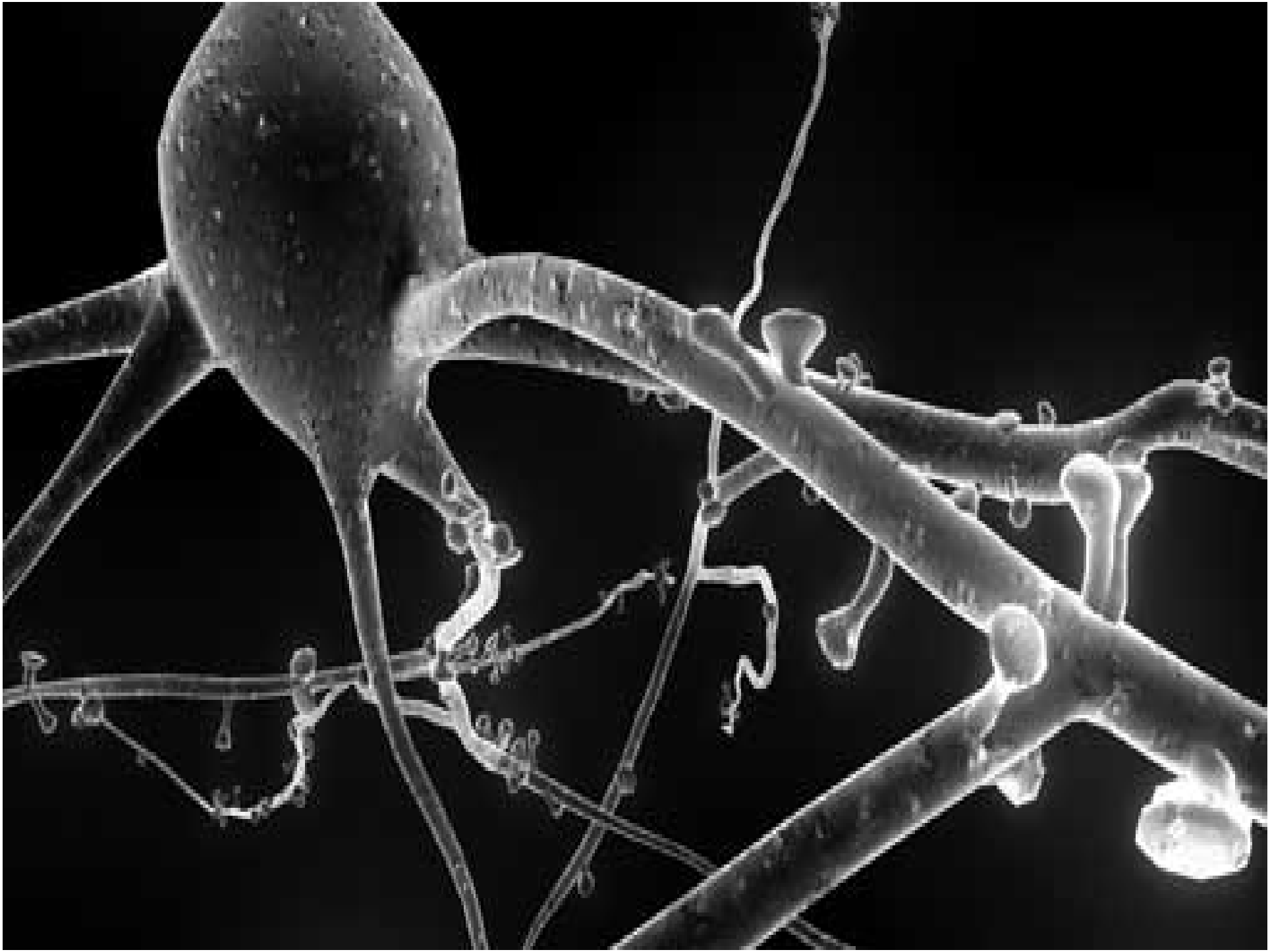
Blue Brain

- First entire cortical column of 10,000 neurons completed in November 2007
  - Contains more than 100 million connections between the processors
- Projected to include information about neural genes and proteins in the future
- Hope to be ready for a model of an entire human brain by 2015
  - Would, with current technology, require a computer the size of several football fields
  - Electricity bill would be $3,000,000,000 a year!









"Jack's Transformation": Theseus' Brain?

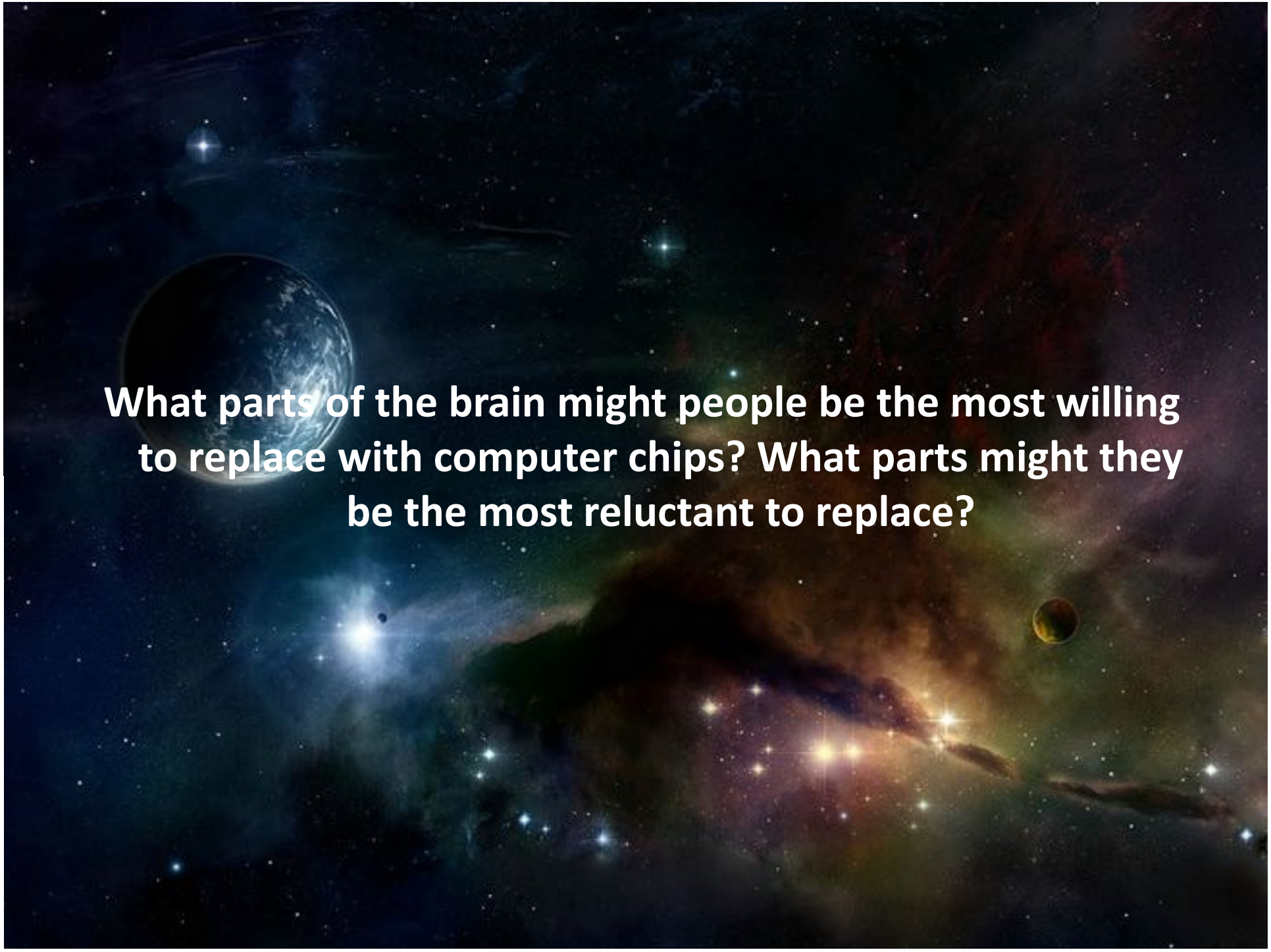
• What if your mother was able to replace her own hippocampus with an artificial one? Would she still be the same person?

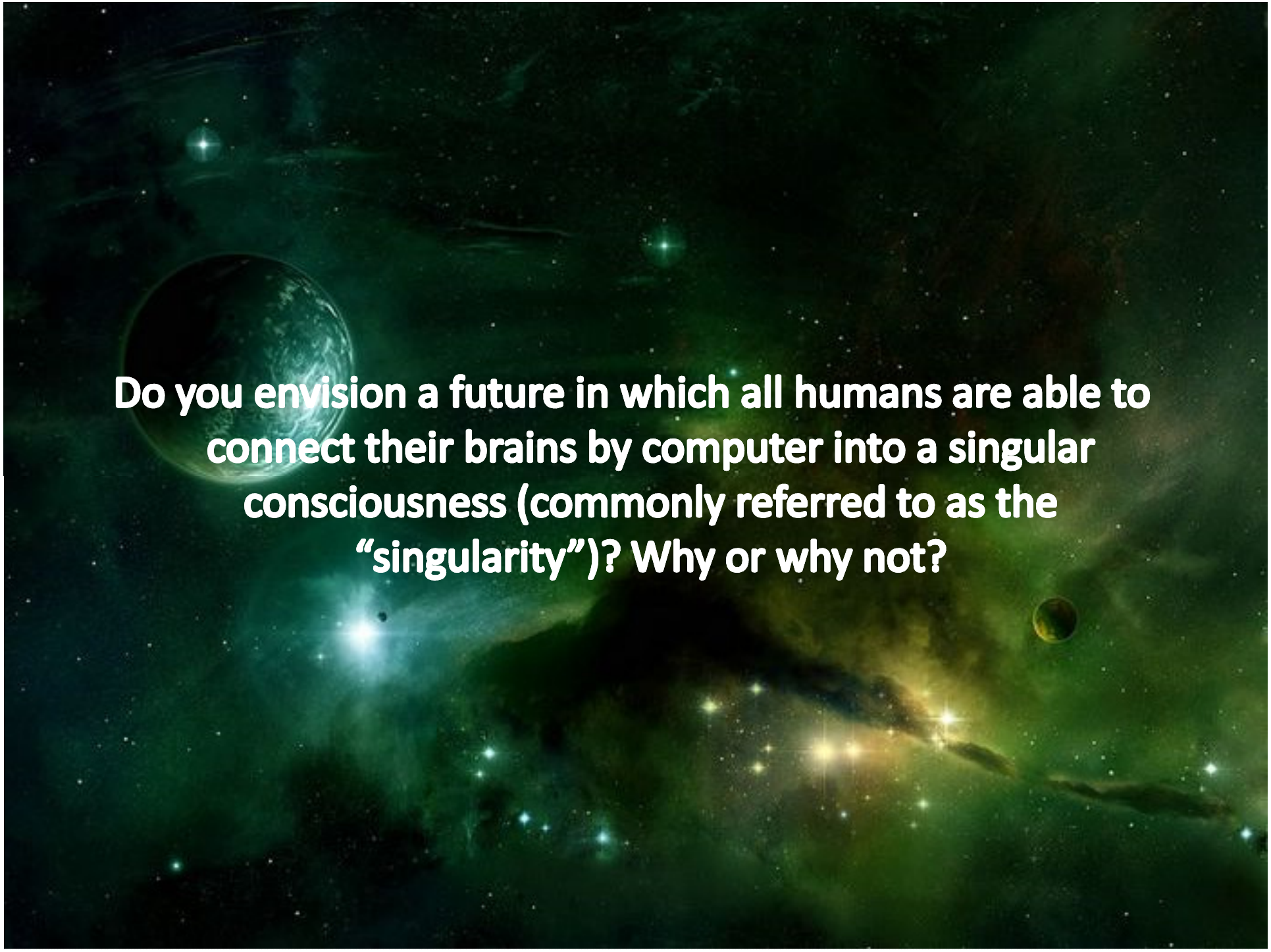
• What if, three years later, she also replaced her cerebellum? Would she still be the same person?

• What if she also replaced her occipital cortex? Her amygdala? Her prefrontal cortex?

• What if, little by little, she had eventually replaced her entire brain? Would she still be the same person?

• What if she made the transformation all at once?


What parts of the brain might people be the most willing to replace with computer chips? What parts might they be the most reluctant to replace?


Do you envision a future in which all humans are able to connect their brains by computer into a singular consciousness (commonly referred to as the "singularity")? Why or why not?


Any questions?