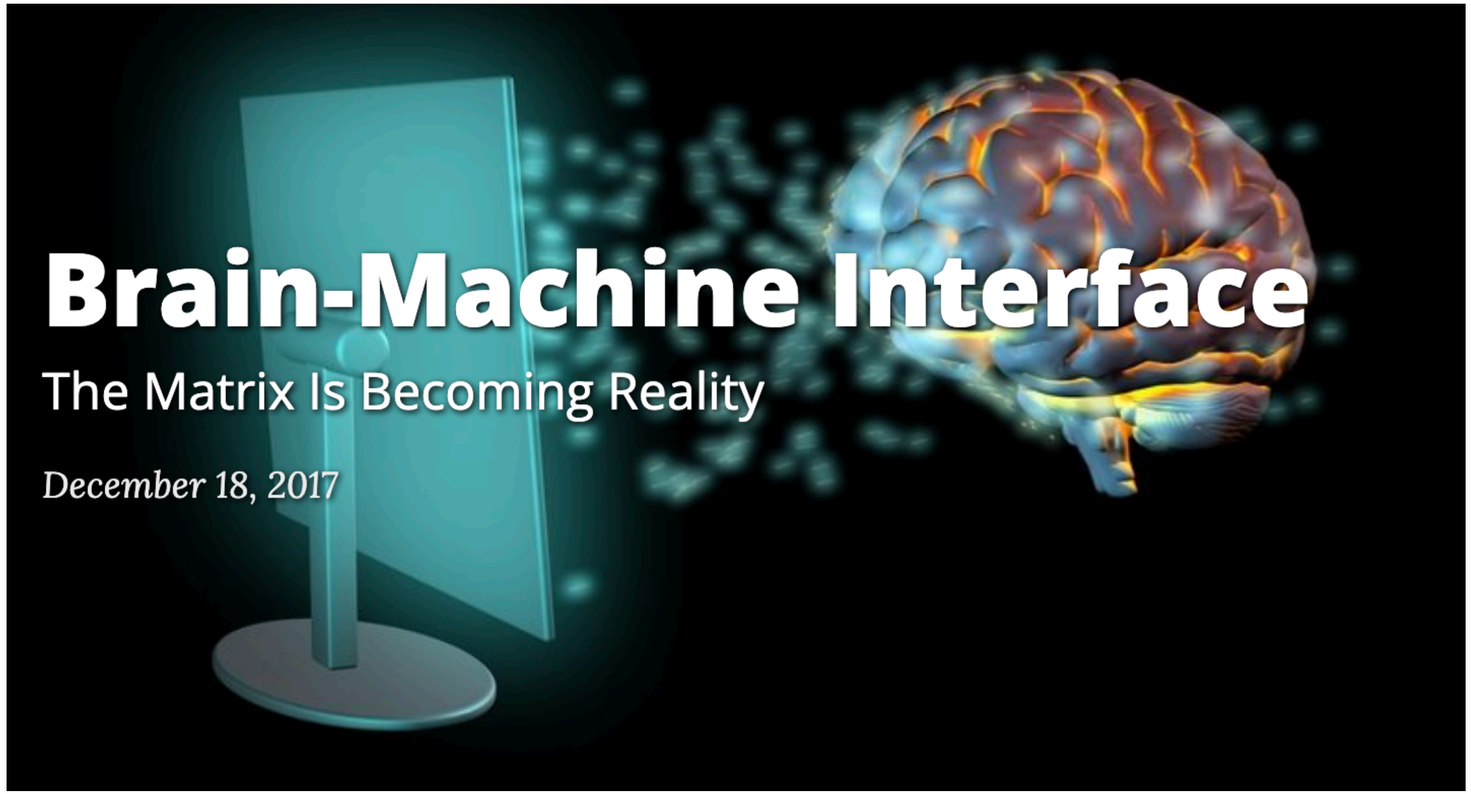
Torben Riise - March 2025



Gary Bettis:

The ultimate application of AI is to connect the human brain to a hard disk. The goal is to be able to upload and download information between the two media. It would expand the capacity of human “knowledge” to the near infinite.

But what else does it do? How about emotions? Or ethics? As we are getting closer to mastering this technology, are we ready socially?

BRAIN-COMPUTER INTERFACES

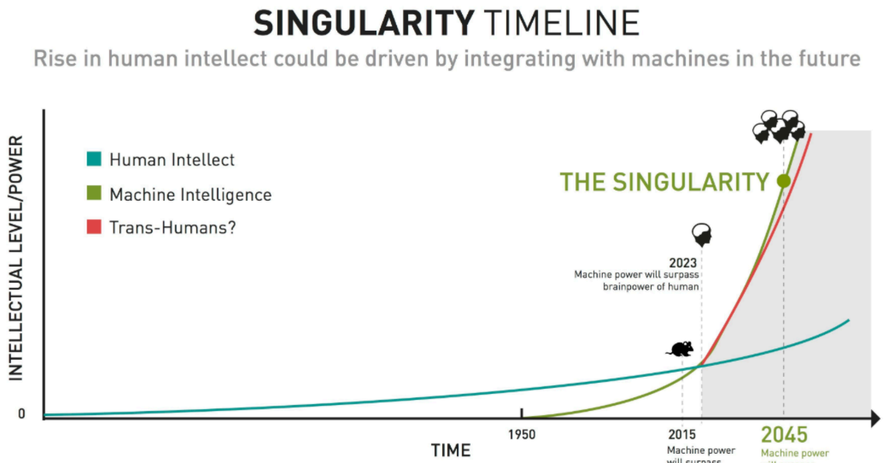
Before we can directly connect the human brain to the internet (and to each other), a great deal of **research is needed** in three main areas:

1. “Wetware”, i.e., the brain. Neurosciences, including neurotechnology
2. Hardware. Continuing to develop bigger, faster supercomputers.
3. Software. Will eventually be developed by AI.
    1. “Google’s AI is Learning to Make Other AI.” Google Brain, OpenAI, DeepMind.
    2. Research in all three areas is proceeding at an **increasingly rapid pace**, supported by both public and private initiatives.

BRAIN-COMPUTER INTERFACES

At first - just like personal computers and smartphones - BCI will consist of fairly '**primitive' devices**, but successive iterations will rapidly develop into very **sophisticated neurological instruments**.

Given the continually increasing speed of scientific discovery and development in general, this will probably happen **sooner than we think**.



“The human heart has hidden treasures,
in secret kept, in silence sealed;
the thoughts, the hopes, the dreams, the pleasures,
whose charms were broken if revealed.”

Charlotte Brontë

Can AI Read your Mind? (TED talk - 44 min)

First 7:30 min

Peter Diamandis:
Imagining the Future: The Transformation of Humanity
TEDx, December 2016 (18:52 min)

https://www.youtube.com/watch?v=7XrbzlR9QmI

Start at 10:33 min

We already have Computer Brain Interfaces

- Ultrasound
- fMRI
- CT/PET
- Brain-connected **implants** in the form of medical aid. For example
- **cochlear** implants stimulate the auditory nerve, allowing deaf people to hear

Examples of the newest implant technologies are . . .

Implants for restoring vision

1. **Orion cortical implant** by Second Sight
. . . is now in a clinical trial with Cortigent

2. **Prima** by Pixium Vision (acq. by Science Corporation)
. . . is now in three clinical trials for late stage Macular Degeneration

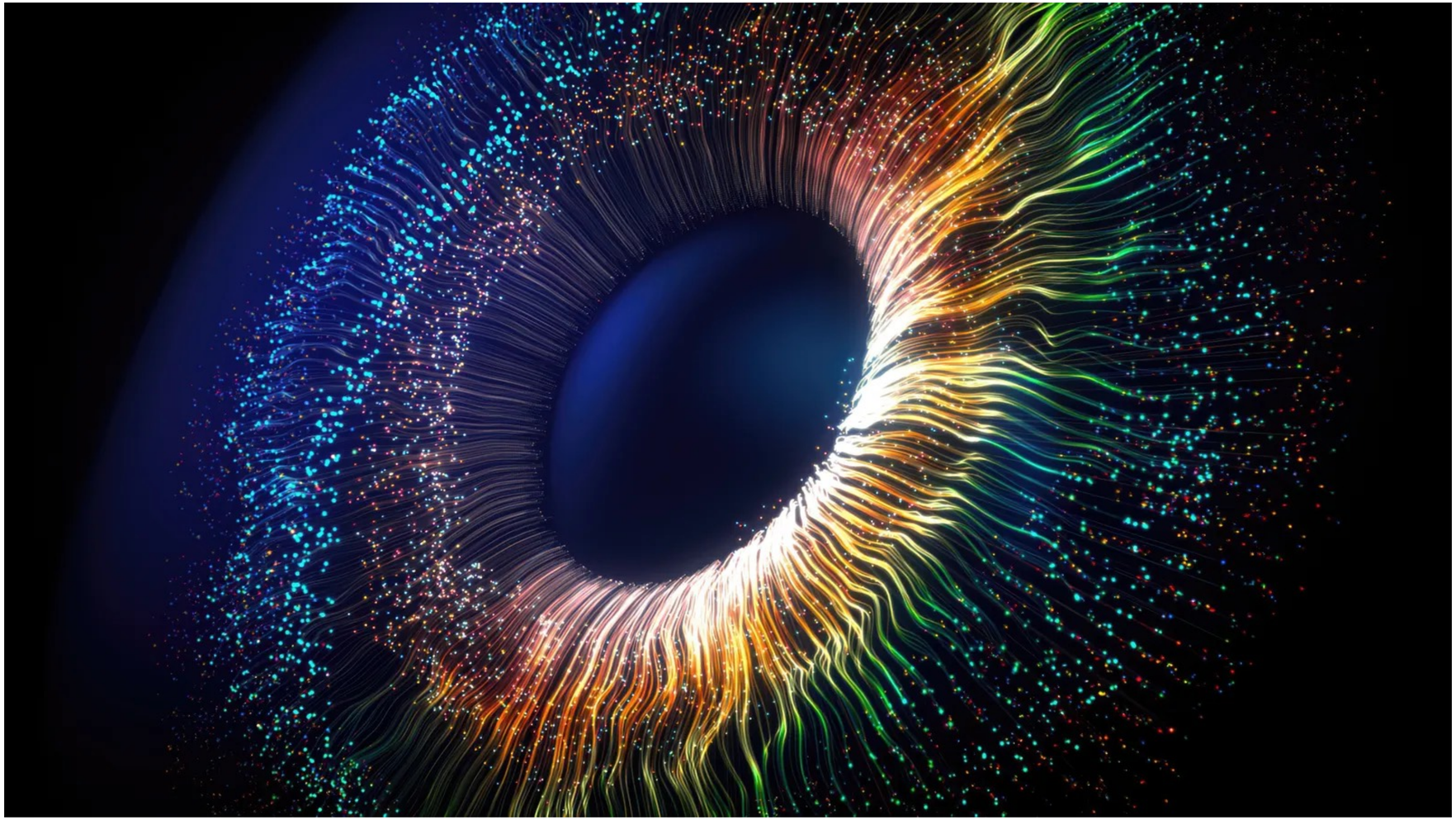
3. **Blindsight** by Neuralink
Very little information is available

The Orion Unit

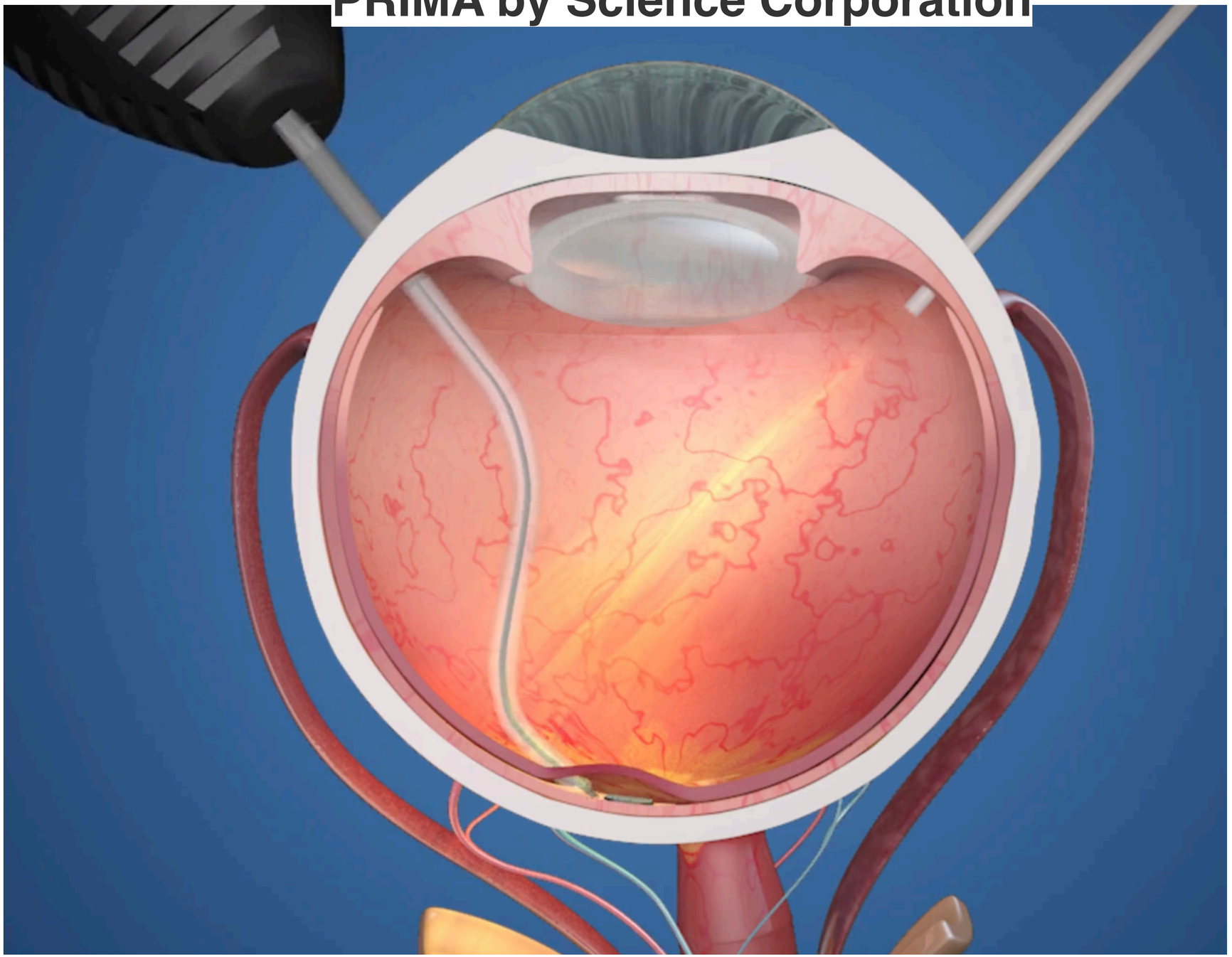
A data processing unit converts images captured by a miniature video camera mounted on glasses into a series of small electrical pulses.

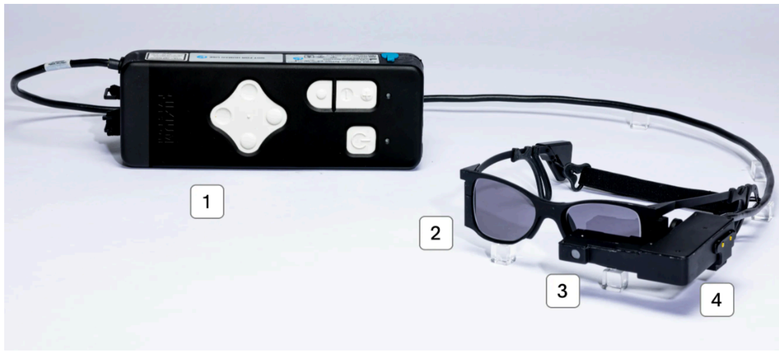
These electrical pulses are wirelessly transmitted to the surgically implanted microelectronic unit in the brain, bypassing the diseased or injured visual pathway and providing the perception of light patterns.

PRIMA by Science Corporation's retinal implant allowed some people who lost their central vision to read, play cards, and recognize faces.

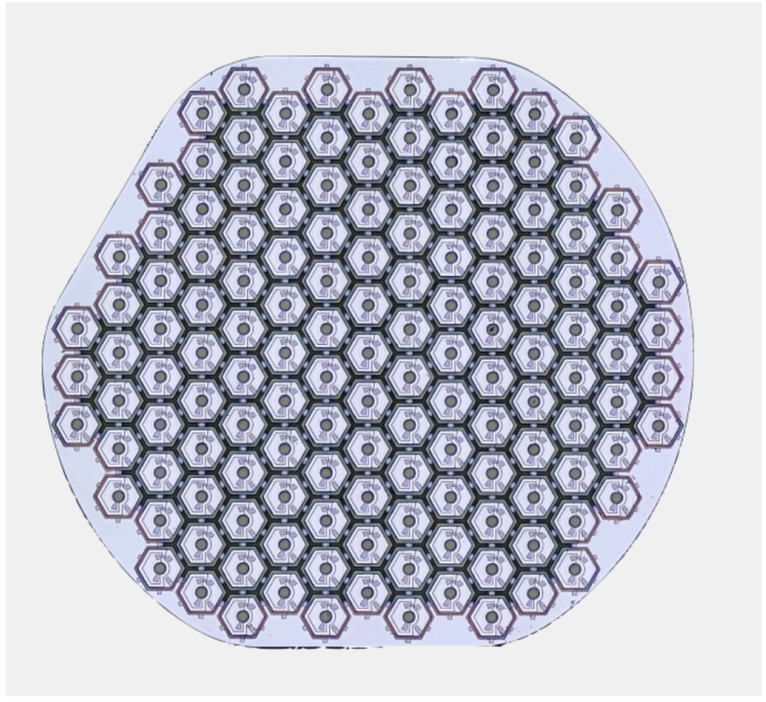


PRIMA by Science Corporation





Retinal ganglion cells,



The problem with most of these technologies is: They are invasive:
Destroys neurons 10-100x the number of neurons you connect with

The goal is non-invasive devices that detect neuronal activity at a distance - ideally through the skull, simply wearable.
One such approach is
- biohybrids probes (Science Corporation)

Biohybrids

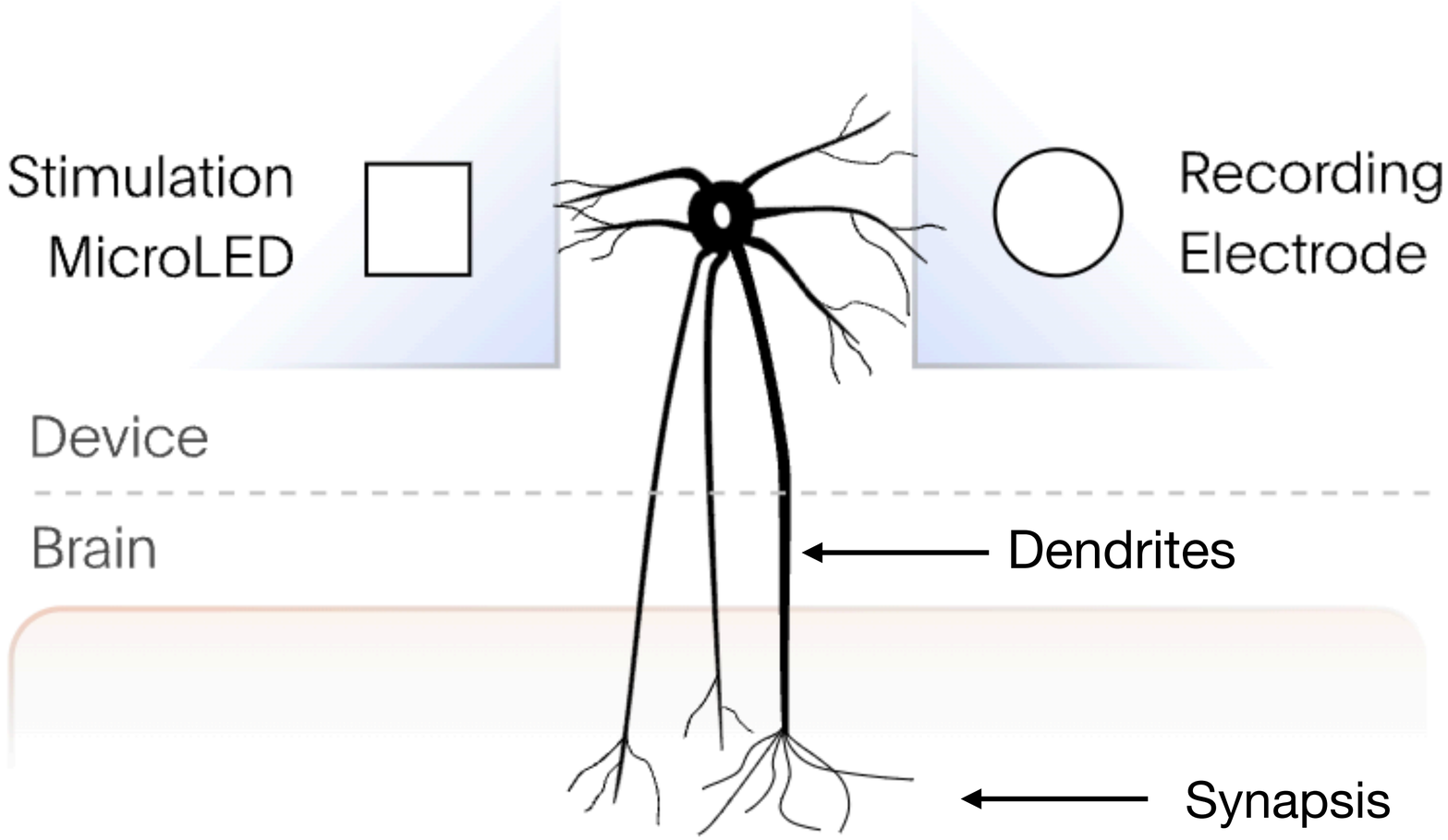
Question: Since the brain is already largely composed of neurons, what if we just add *more neurons?*

Answer: Instead of integrating electronics into the brain, let's integrate neurons into **electronics**. Then, their axons and dendrites will grow out into the brain, joining the existing neurons*)

Strategy:
- embed stem cell-derived neurons *in vitro* into electronics, and
- engraft into the brain so they will form new biological connections. Engrafting a million neurons (on far less than a cubic millimeter) might produce over a *billion* synapses!

*) Details: https://science.xyz/technologies/biohybrid/

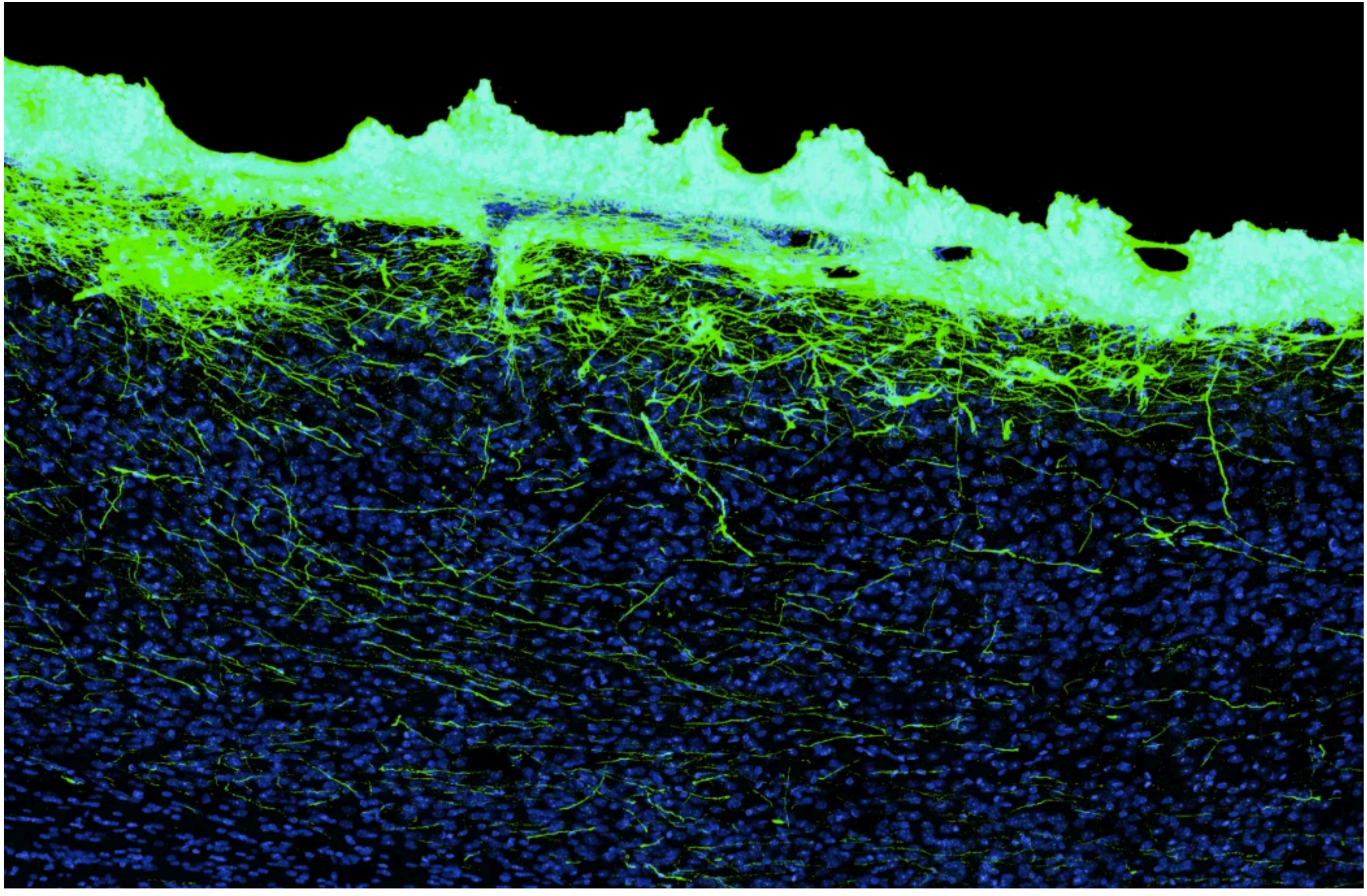
Embedded Neurons



Size: 1 mm3

hundreds of thousands of microLEDs and electrodes for stimulating and recording the neurons' activity

Result: A stable way to read and write information from the neurons anchored to the device.



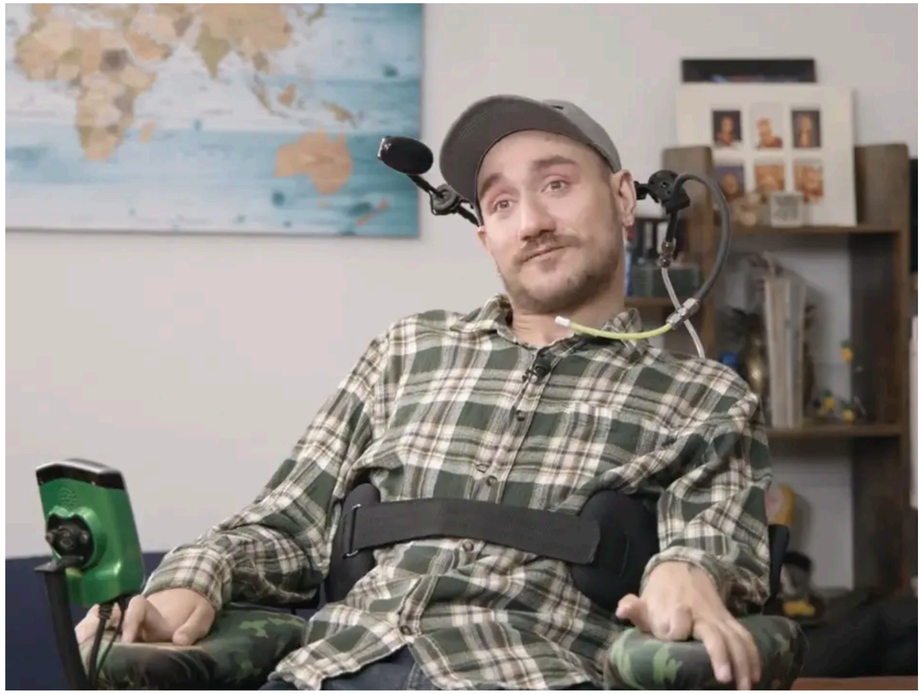
Musk”s brain-computer interface (BCI) company, Neuralink , has made significant progress in developing its brain-computer interface (BCI) technology, achieving several milestones in recent years.

1. Human trials
2. Technological Advancements
3. FDA Approval & Future Goals
4. Competition

1a. Human Trials

- Neuralink, successfully implanted its device in three human patients - As of January 2025, implants are functioning effectively.

- The first patient, Noland Arbaugh, **received his implant about a year ago**, has been able to perform tasks like playing video games, chess, and browsing the internet **using only his thoughts**.



The second patient, Alex, has a spinal cord injury, is using the implant to play video games and learn computer-aided design software for creating 3D objects.

Details about the third implant recipient remain undisclosed.

1b. Human Trials

Neuralink is currently conducting **two new clinical trials:**

One is designed for an initial group of **5 patients**; it seeks to enable thought-based **control of external devices** such as computers and smartphones. This trial is scheduled to end in 2026.

The other study focuses on allowing **3 patients**; it seeks to **operate assistive technologies** such as robotic arms. This trial is expected to conclude in 2031.

These technologies can transform the lives of people with severe physical disabilities, improving their autonomy and quality of life.

2. Technological Advancement

The Neuralink device uses **ultra-thin, flexible threads** embedded with 1,024 electrodes spread across 64 flexible threads, each thinner than a human hair.

The **implant process** is performed using a **robotic system** (R1), designed for high precision and scalability.

These electrodes **facilitate direct interaction** between the human brain and external devices - allowing neural monitoring and stimulation.

The devices have been upgraded with more electrodes, higher bandwidth, and longer battery life since the first implant.

3. FDA Approval & Future goals

Neuralink received FDA approval in **May 2023** to begin human trials under its PRIME study. New trials are registered and supervised by the Food and Drug Administration.

Neuralink aims to **finalize its device design** for pivotal trials involving **20–40 patients**, a step toward regulatory approval for **broader use.**

Challenges: Regulatory hurdles and the need for **long-term safety data** remain significant challenges before commercial deployment.

4. Competition

45 clinical trials involving BCIs are currently underway worldwide by companies like Synchron, Blackrock Neurotech, and Onward Medical.

Their technology is advancing BCI technology through **less invasive or more versatile** methods.

Synchron's BCI, for instance, uses minimally invasive techniques, while Blackrock Neurotech combines neural recording with stimulation.

Other aspects

The price and accessibility of the devices currently **limit their scope** mainly to research and clinical trials.

Reducing production costs and improving device scalability will be essential to ensure this technology benefits more people around the world.

The path to mass commercialization still faces the challenge of public acceptance. However, **The advances so far have been extraordinary, laying the foundations for a new era of integration between humans and technology.**

Neuralink and competitors have billion dollar endorsements . . . but you **don’t have to be a billion-dollar company** to work in this field.

Introducing . . . GALEA

Enhancing the human mind with Smarter AI

Other Approaches

1. Neural Laces

2 . Computer-Brain Organoids

1. Neural lace
also called "neural prosthetics”

. . . a new type of cognitive technology will **link humans and machines** and each other **via only our thoughts and over the cloud.**

Neural lace is expected to arrive within 10 years!

Computer-brain organoids

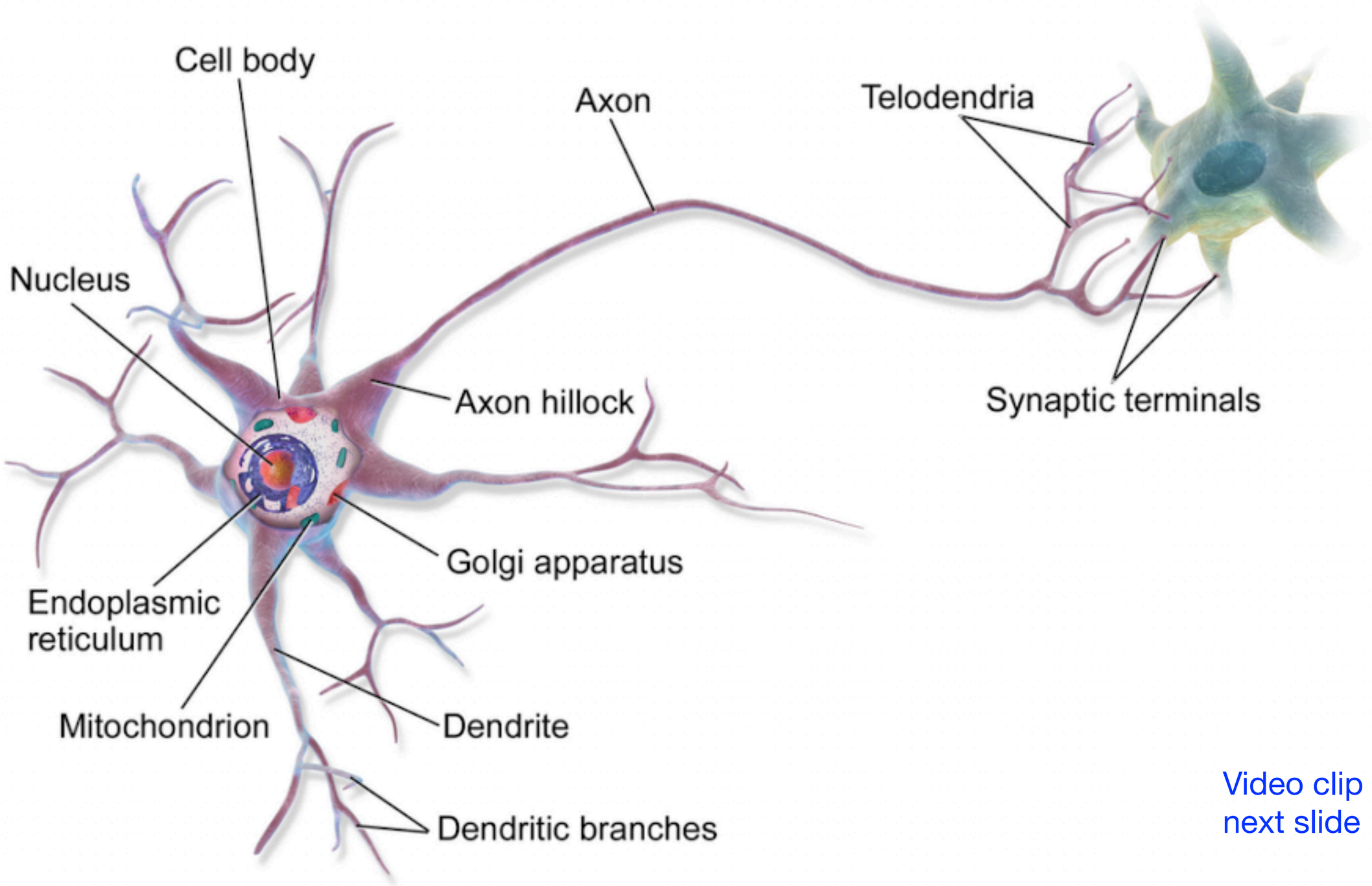
brain organoid-based biocomputers

- **Brain organoids** are 3D-structures made from human **pluripotent stem cells**, which are made into **neurons and glial cells**.

These organoids are identical to the human brain in the fetus and show **functional properties** like

- spontaneous electrical activity
- synaptic connections, and even
- myelinated axons (insulation critical for neural signaling)

Objective: **integrate** *lab-grown* brain organoids with computational systems



Video clip on next slide

Computer-brain organoids

Organoid Intelligence (OI)

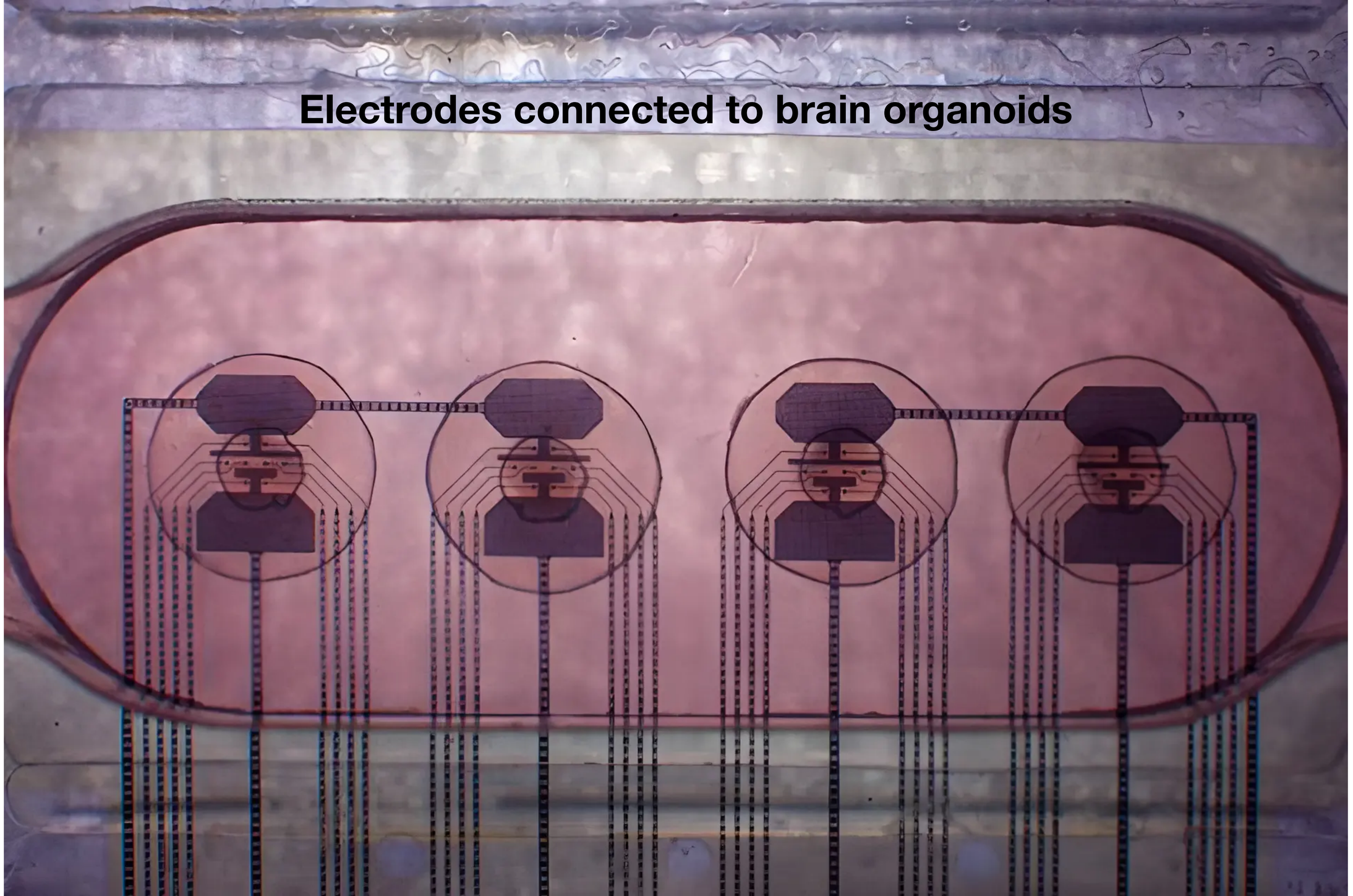
The use of Brain Organoids in Computing

- OI refers to the use of brain organoids as **“biological hardware”** for computing.

This field aims to leverage the brain’s
- superior energy efficiency
- parallel processing capabilities, and
- ability to handle complex and uncertain data

- Brain organoids are **connected** to computer systems via **electrodes** or other interfaces to send and receive information and learn (next slide).

Electrodes connected to brain organoids



Brainoware

merging biology with technology

By connecting brain organoids to AI tools via high-density electrode arrays, the organoids can **recognize vowel sounds**. Eventually, they can process audio data and perform computational tasks like speech.

Current brain organoids are extremely small compared to the human brain (fewer than 100,000 cells*)

They still **lack the complexity** needed for advanced cognitive tasks - but as we get there, they raise a new set of ethical questions. Welcome 2035!

*) the Brain has >170 billion cells (neurons and glial cells)

And in case you wondered . . .

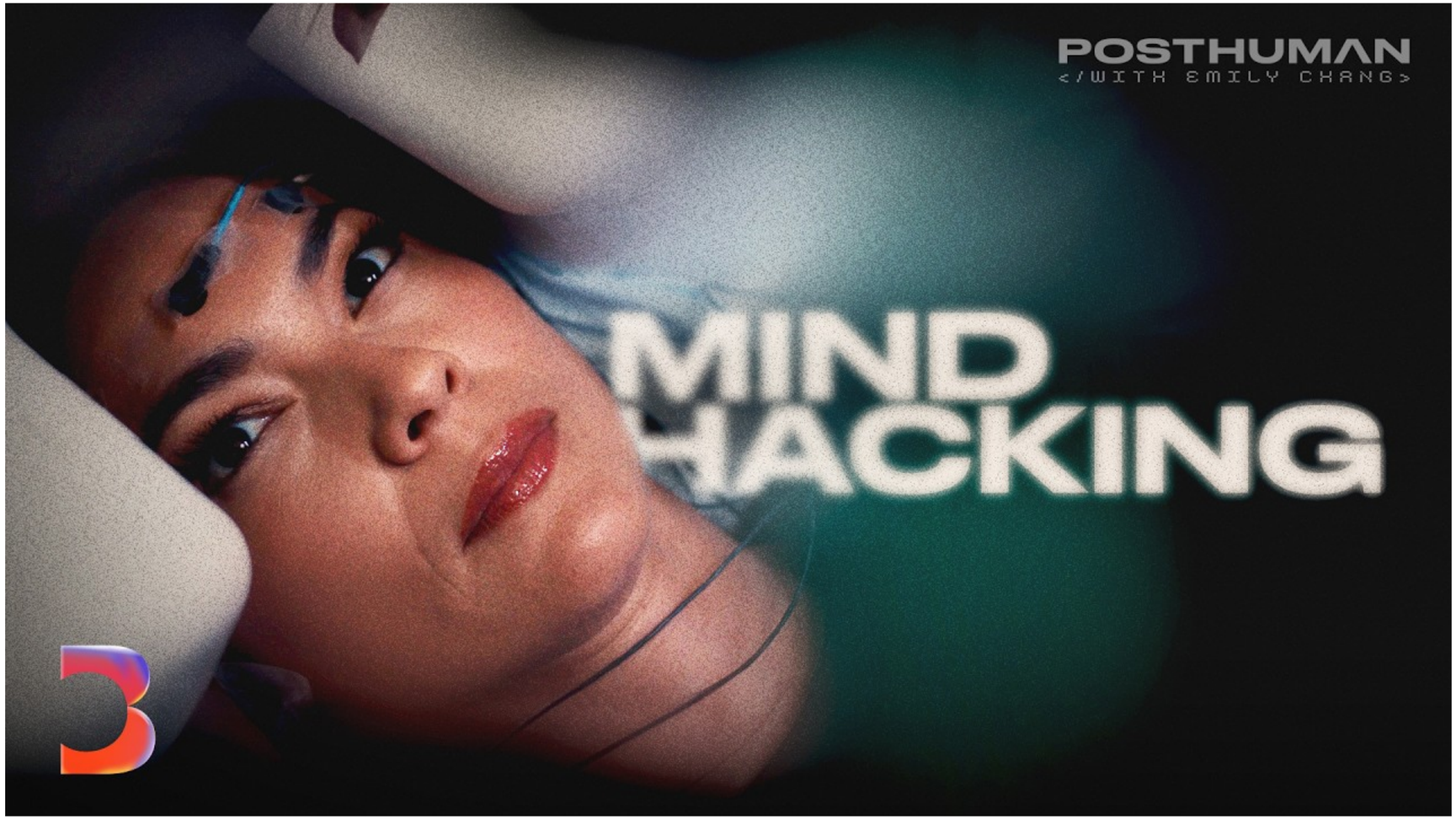
Memory in brain organoids is thought to result from **changes in synaptic strength and architecture due to *repeated stimulation*.**

These changes encode **patterns of input and output** relationships, which can be recalled later when similar stimuli are encountered.

Details:
https://newatlas.com/computers/finalspark-bio-computers-brain-organoids/

The Thrill and the Threat of Mind hacking

25 min



7 Days With AI

https://www.youtube.com/watch?v=PRdcZSuCpNo

(7:24 min)

Thank You!

Torben Riise 3.6.2025