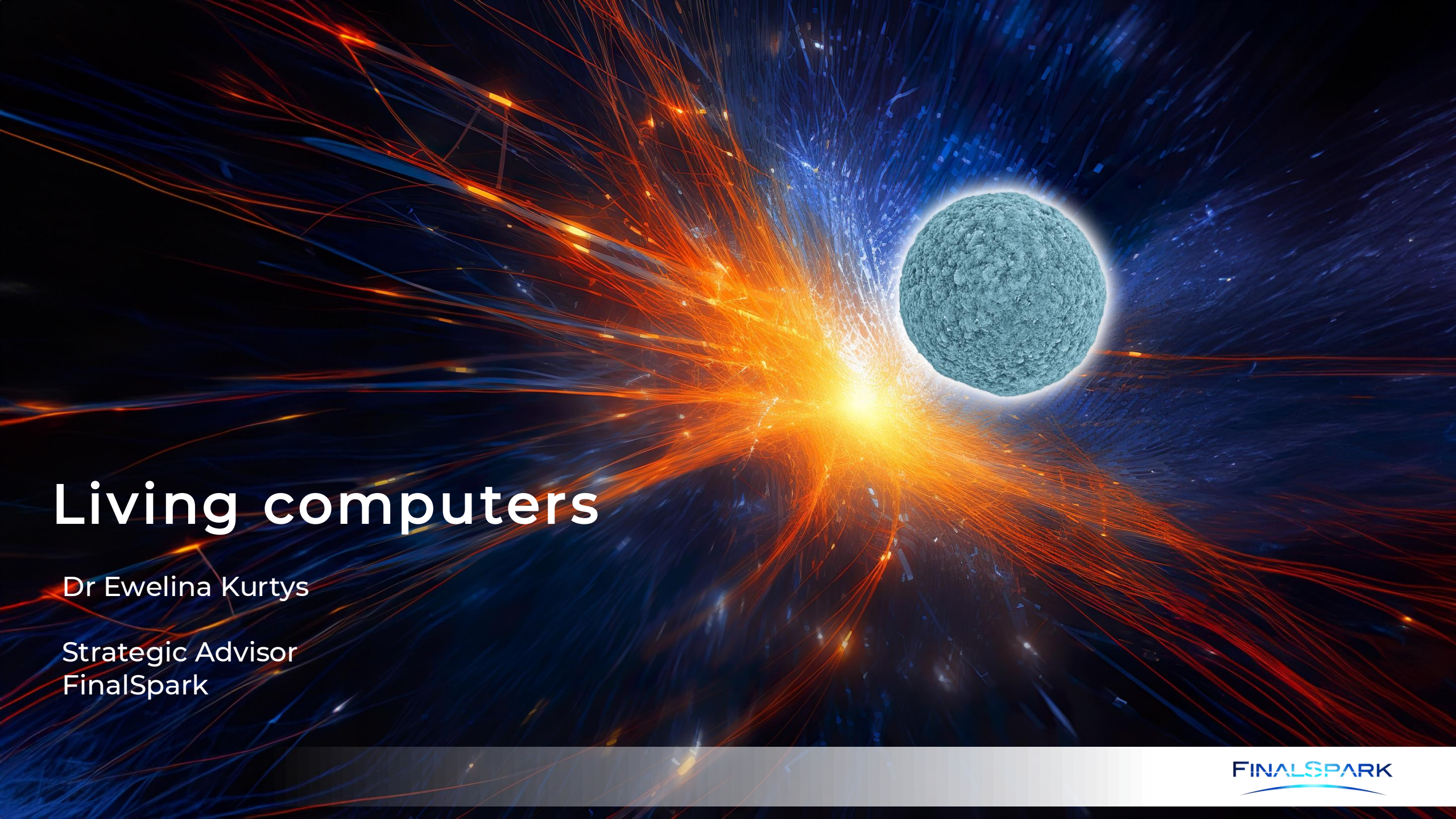


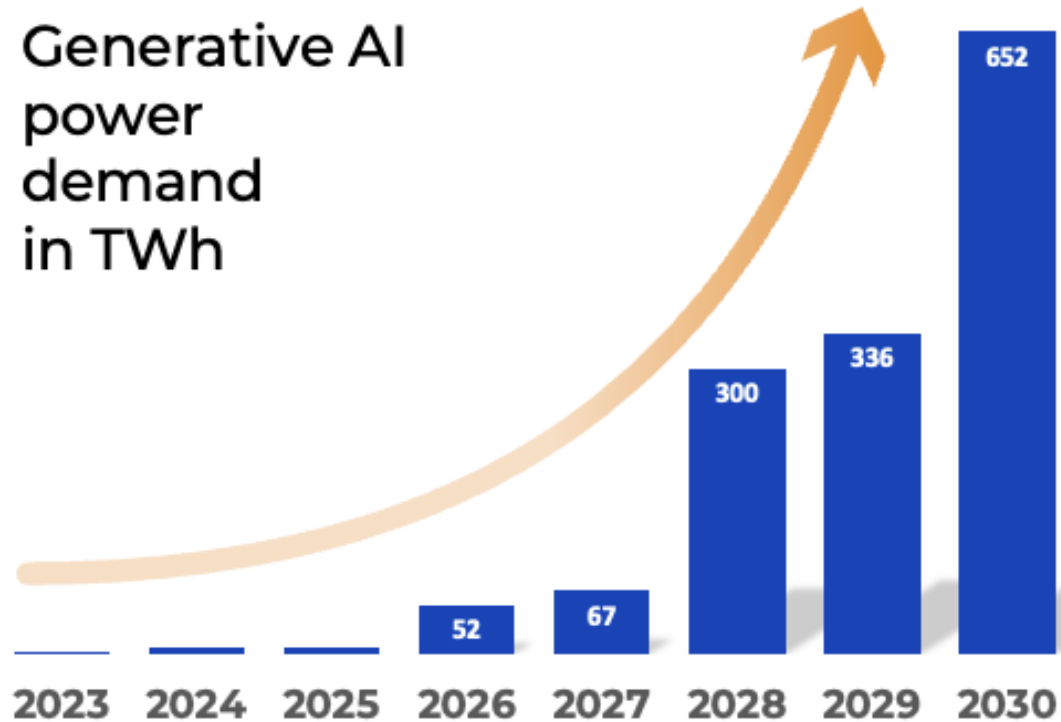


Living computers

Dr Ewelina Kurtys

Strategic Advisor
FinalSpark

Generative AI
power
demand
in TWh

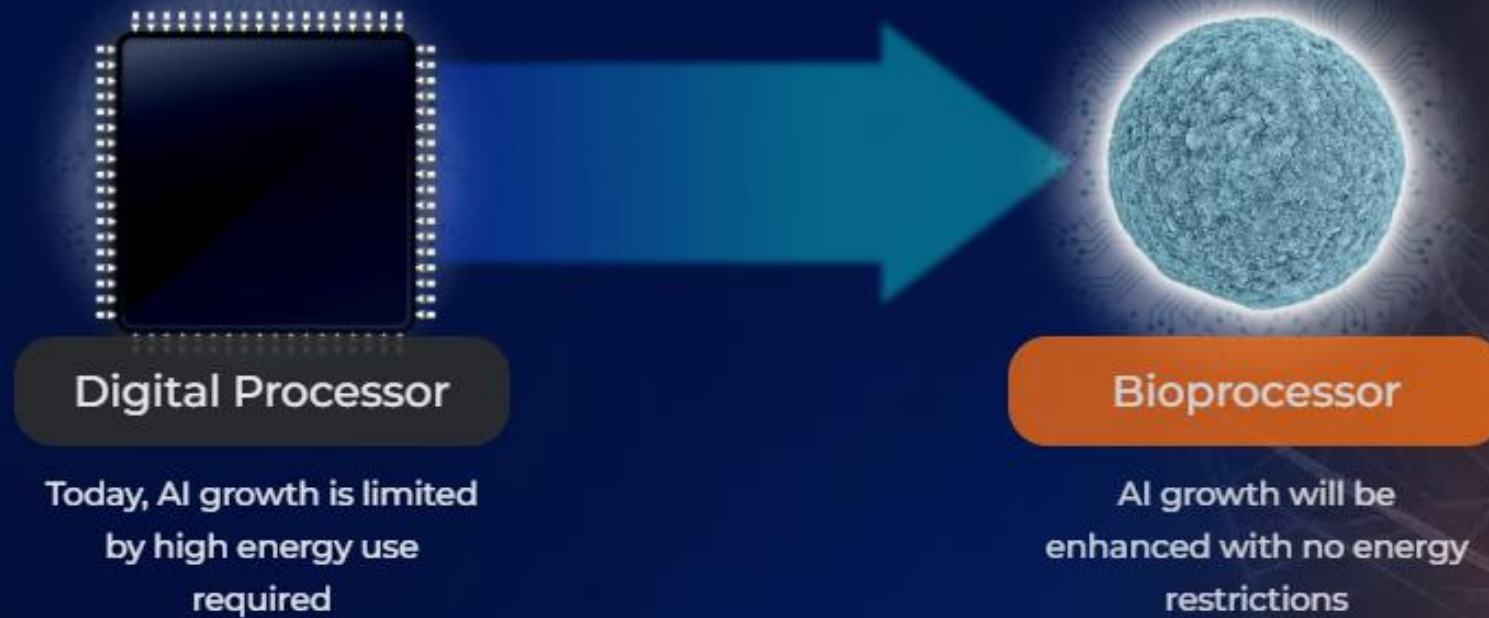


US energy consumption for 2023 is 4000TWh

The current AI
technology has a
scalability problem

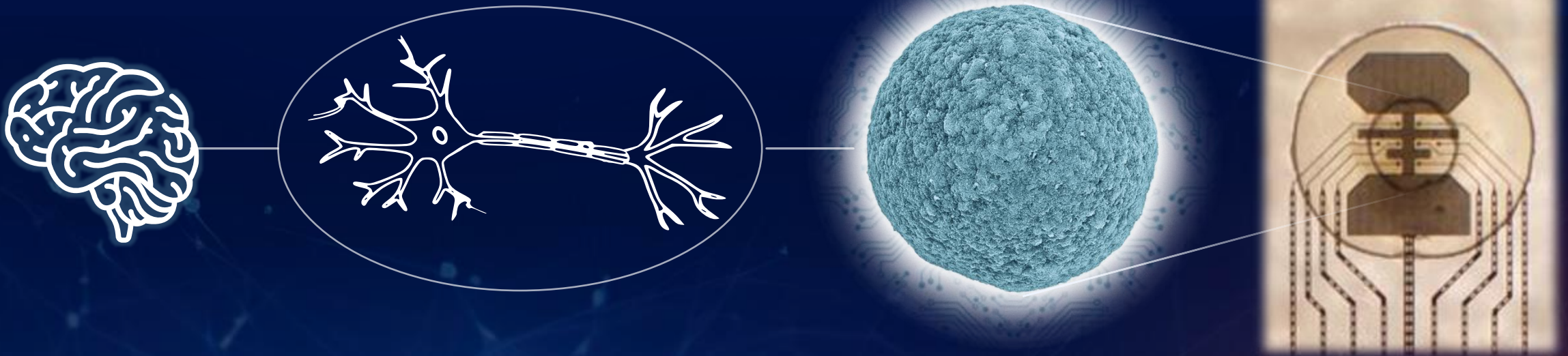
BIOCOMPUTING

FROM DIGITAL TO BIO



WE USE LIVING NEURONS FOR COMPUTATIONS

Leveraging **living neurons** as the core processors of groundbreaking biocomputers



WHY LIVING NEURONS?



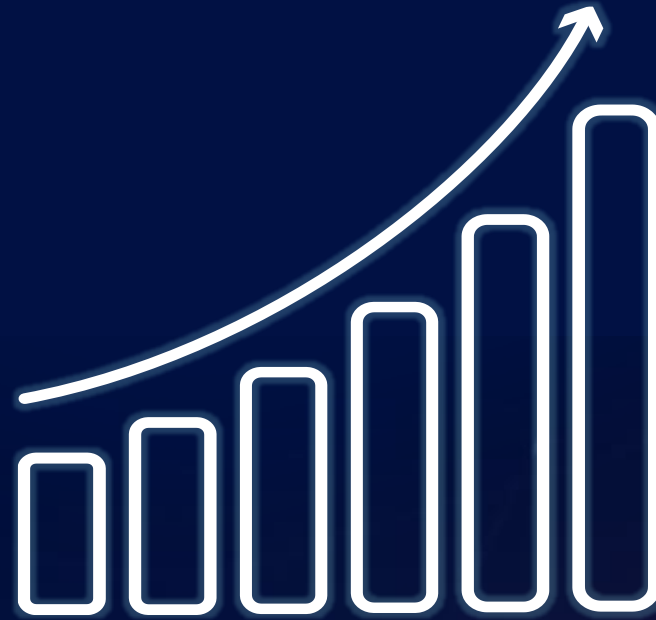
Because it works



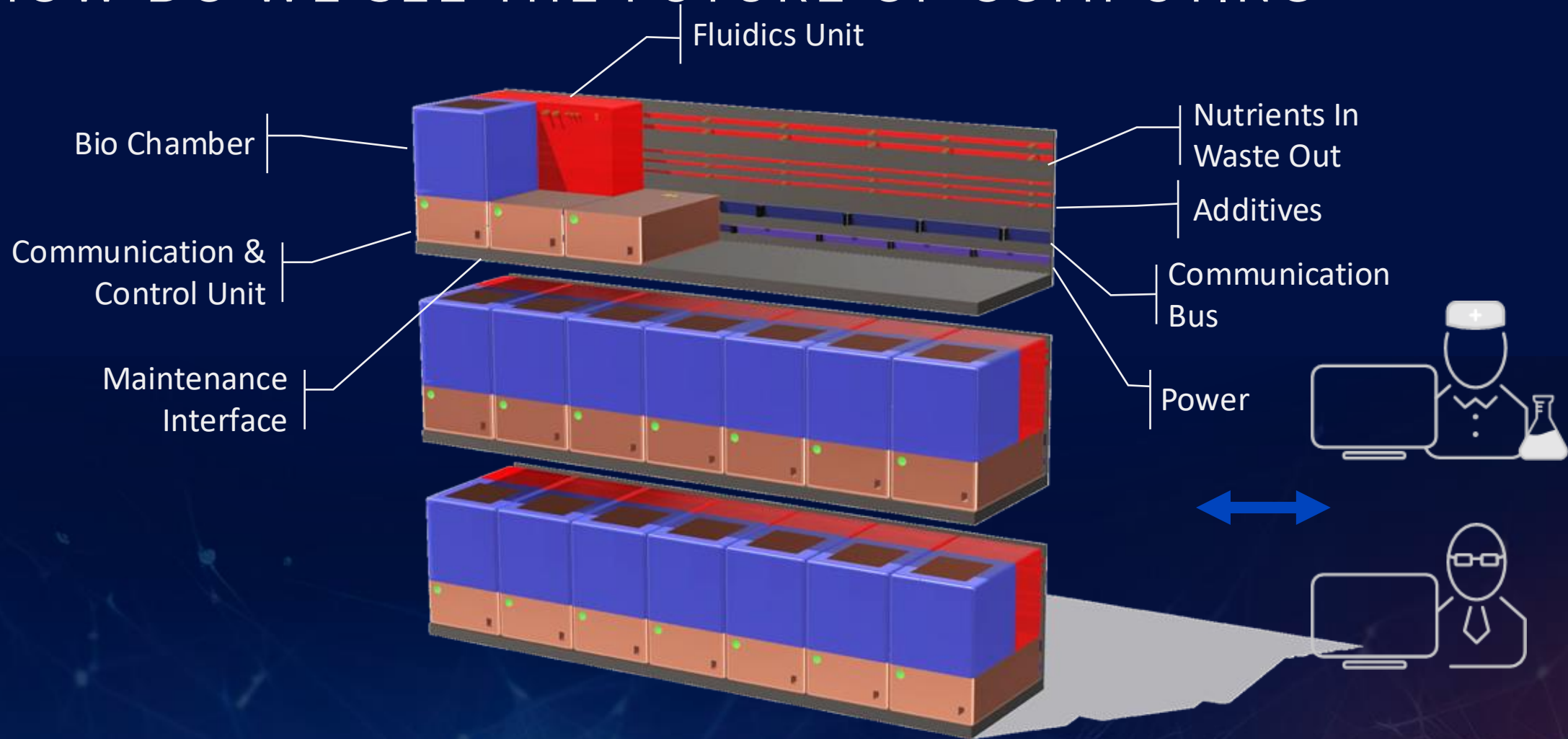
Because it's 1 million times more energy efficient



Because it's scalable

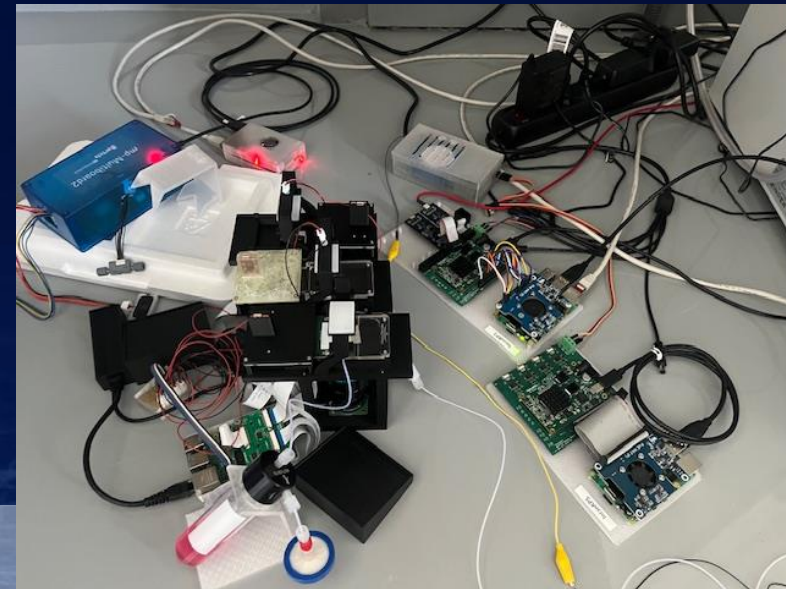
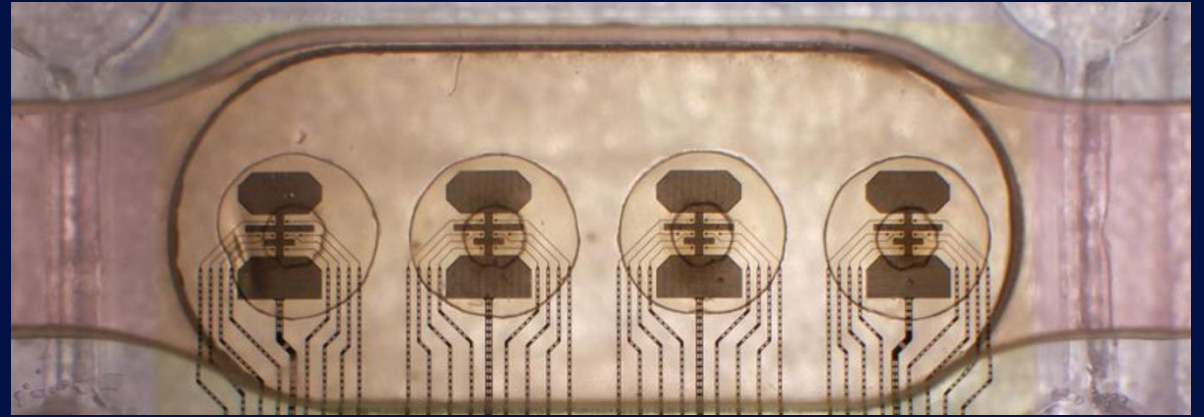
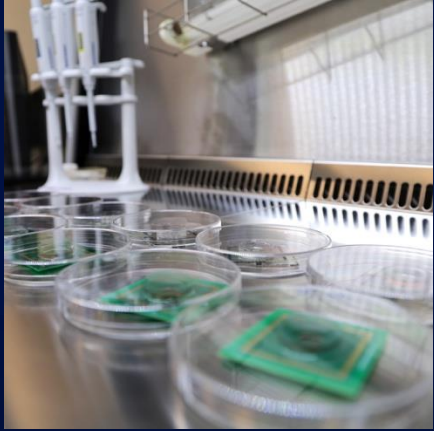


BIOSERVERS: HOW DO WE SEE THE FUTURE OF COMPUTING

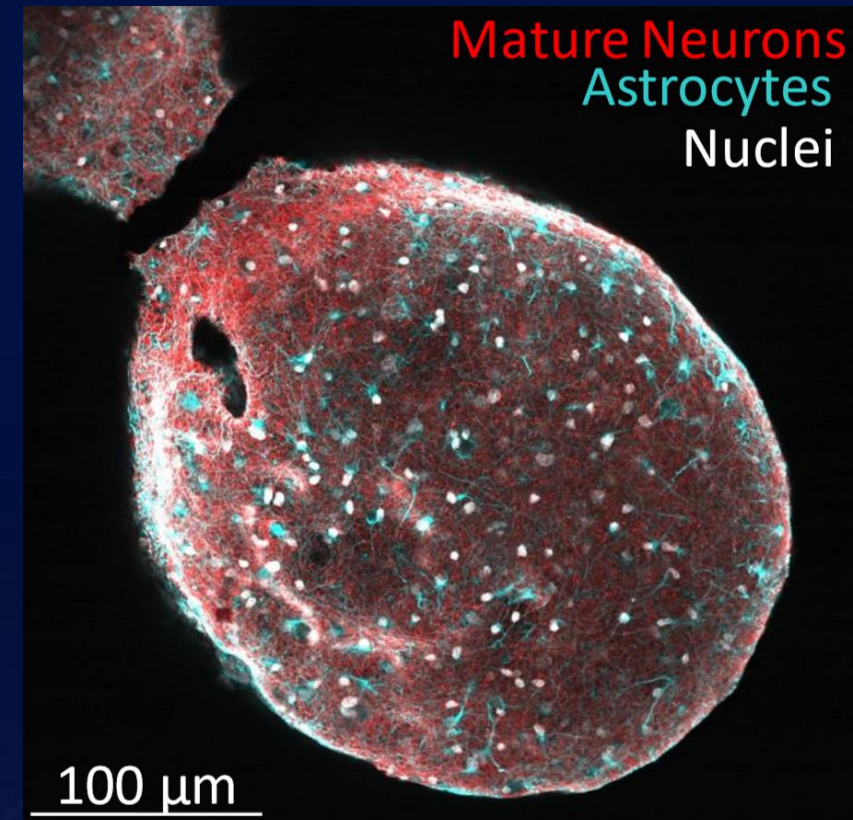
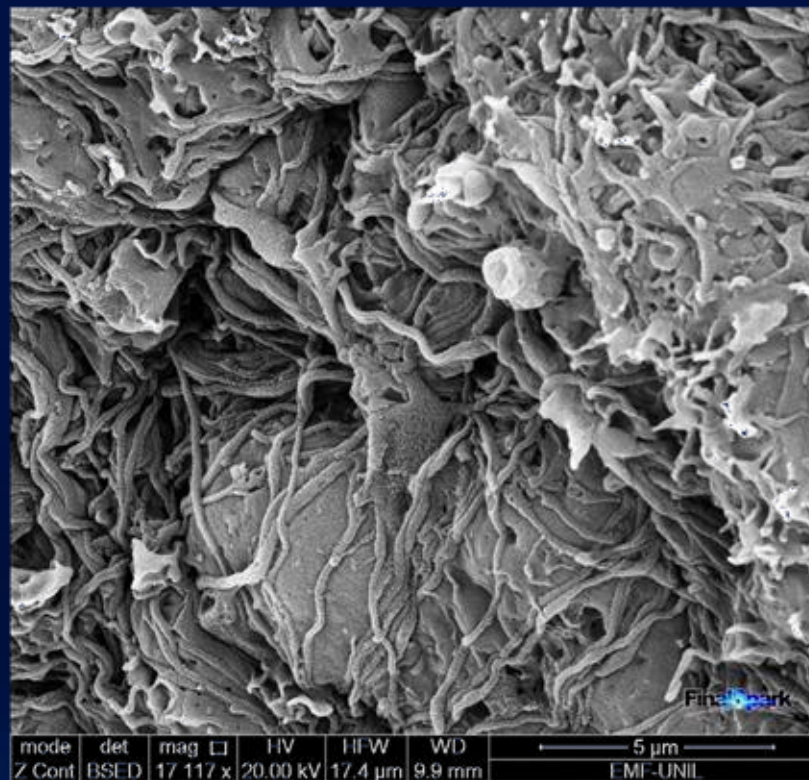
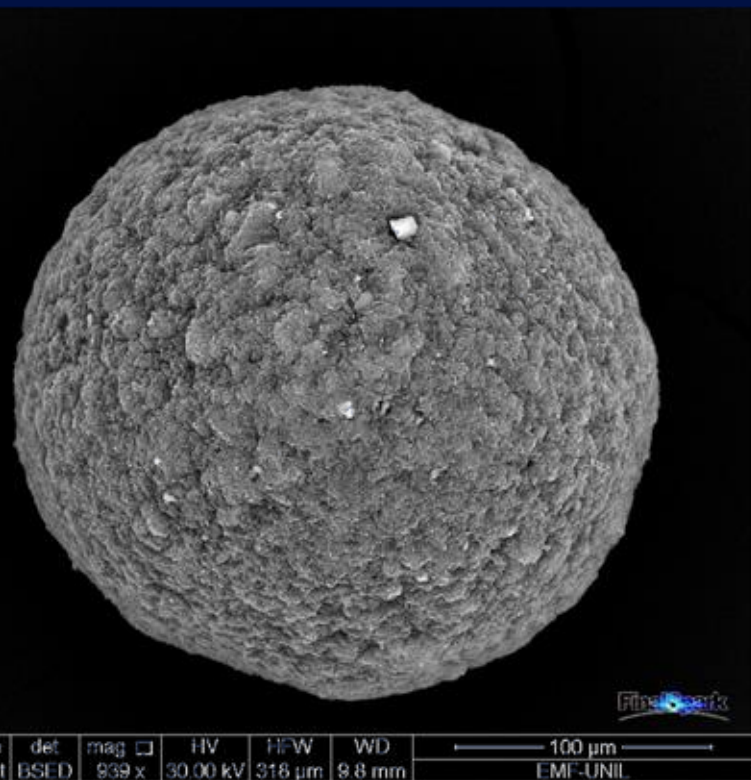


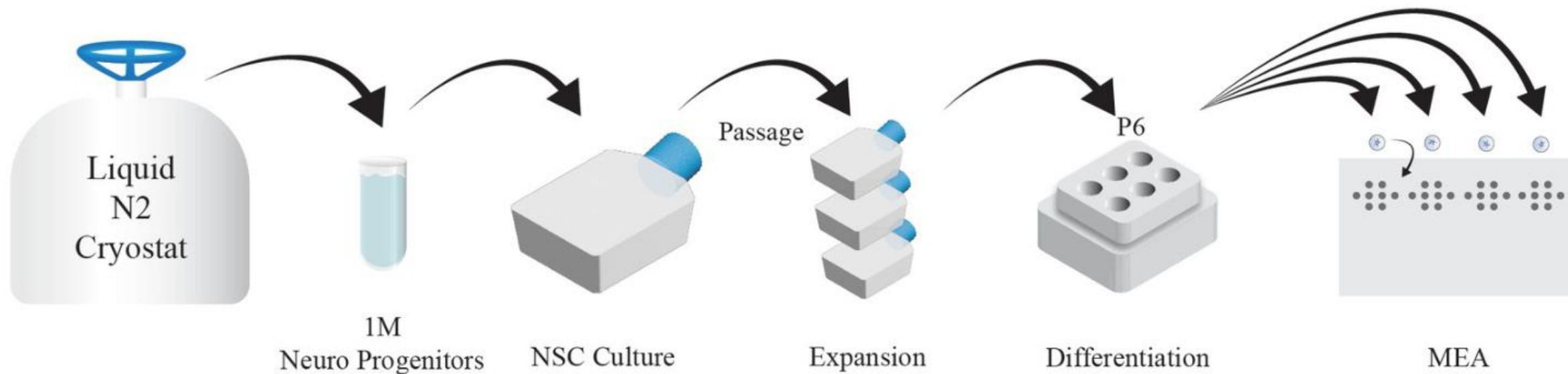
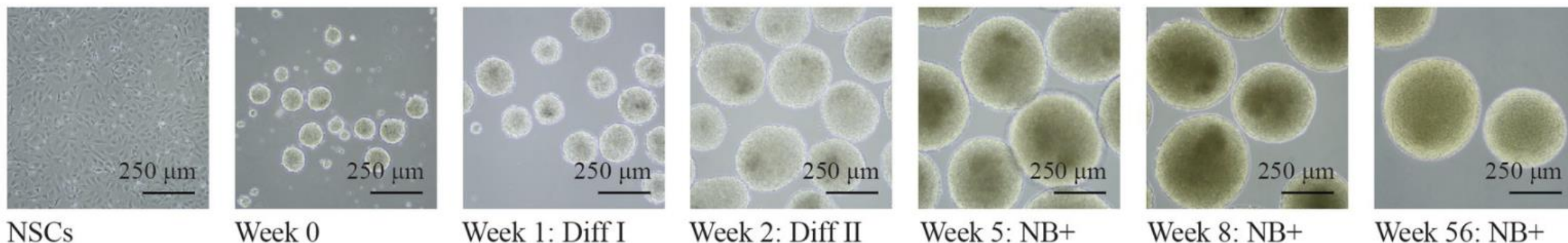
INSIDE OUR LAB

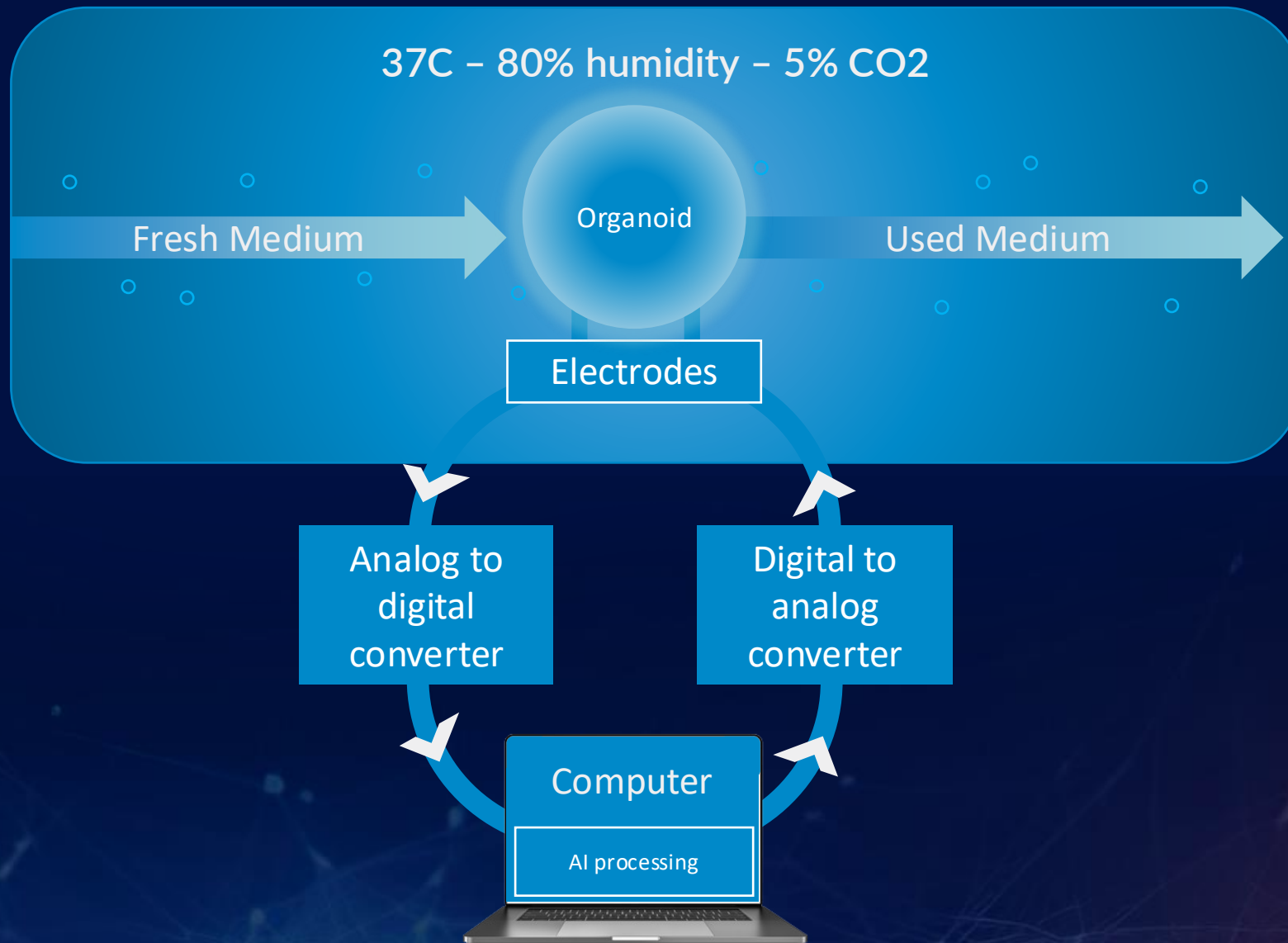
WORK AT THE LAB

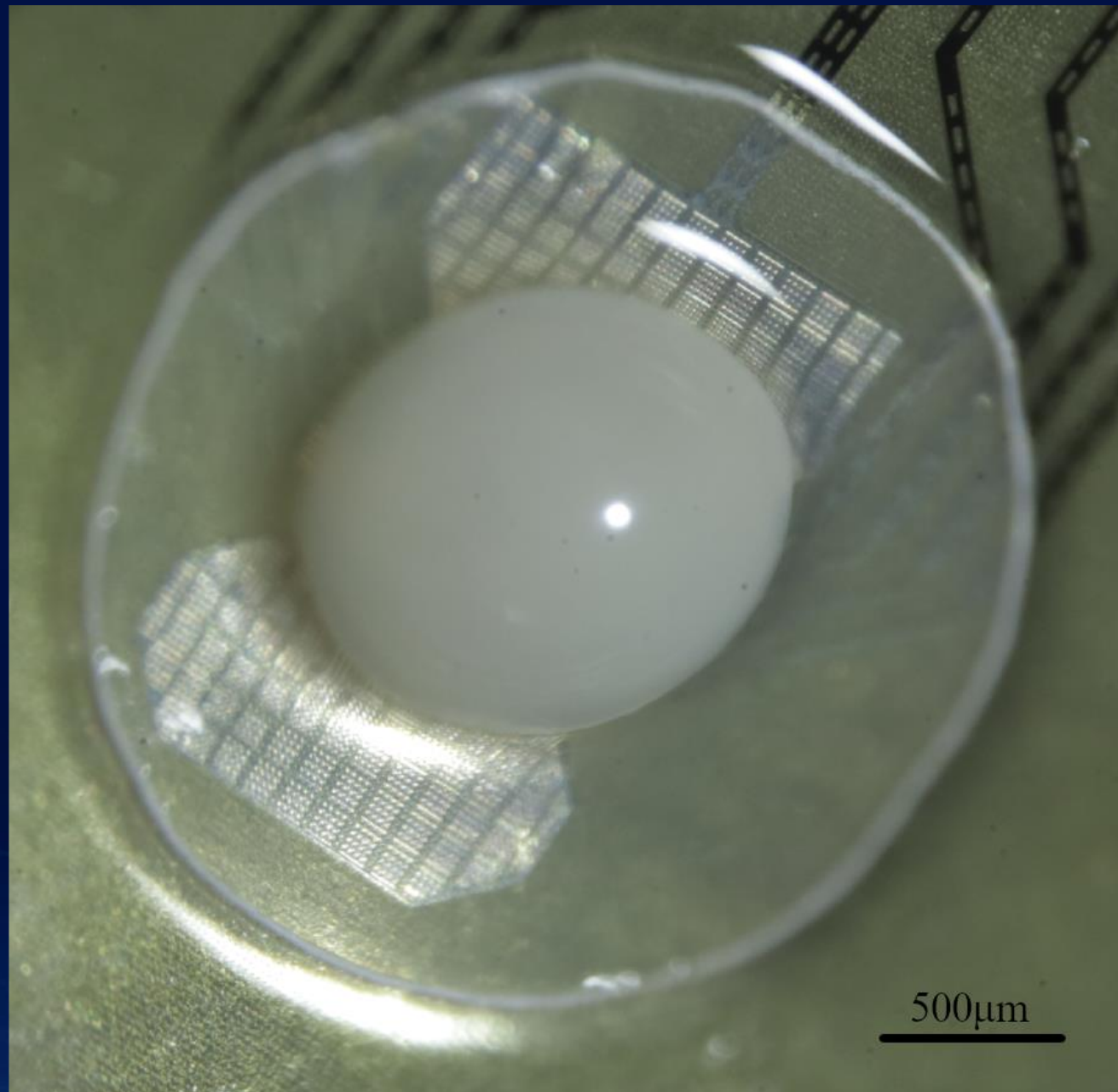


ONE OF OUR ORGANOIDS UNDER MICROSCOPE

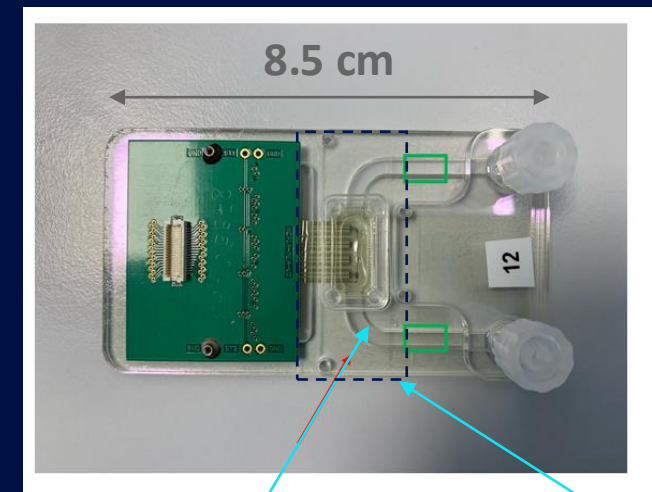
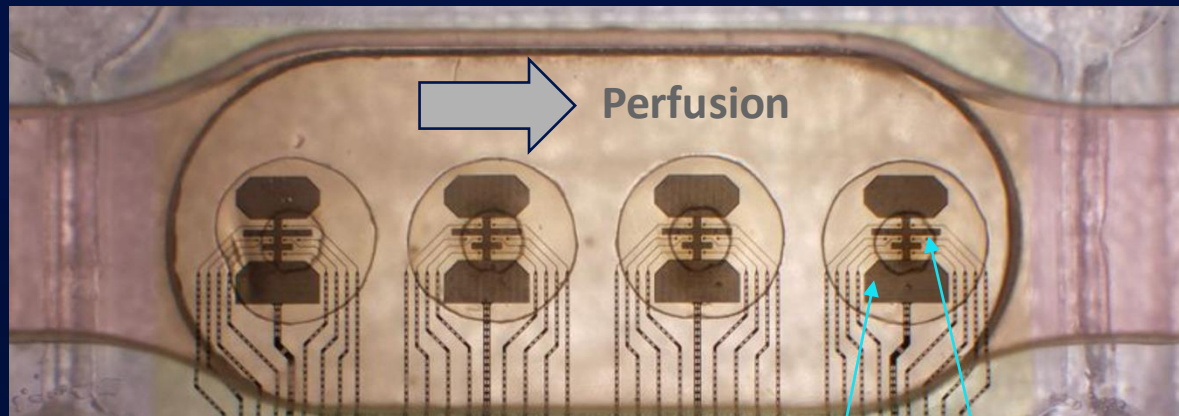


A**B**





BRAIN ORGANOIDS AND MEA



Channel for
medium

Membrane

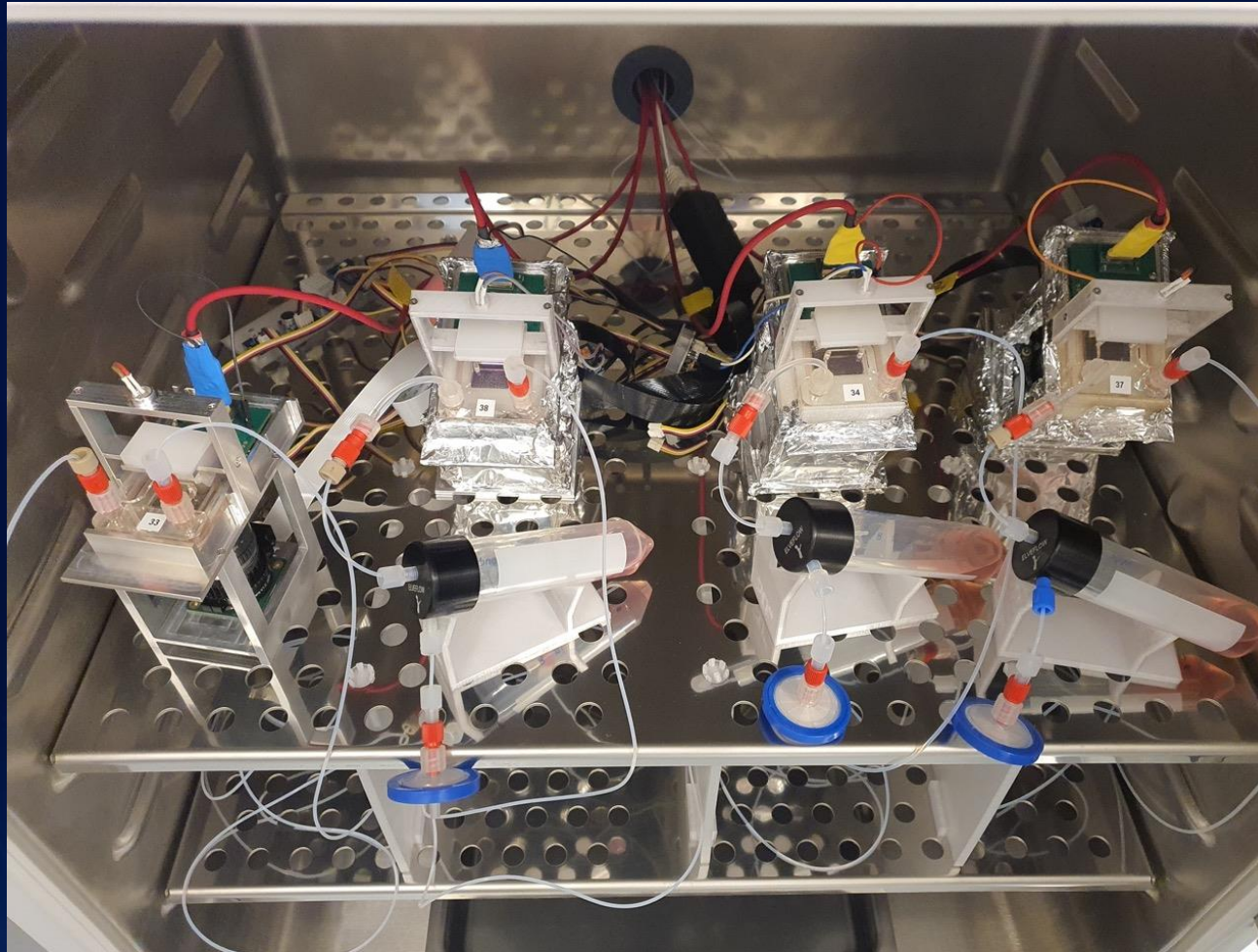
Membrane

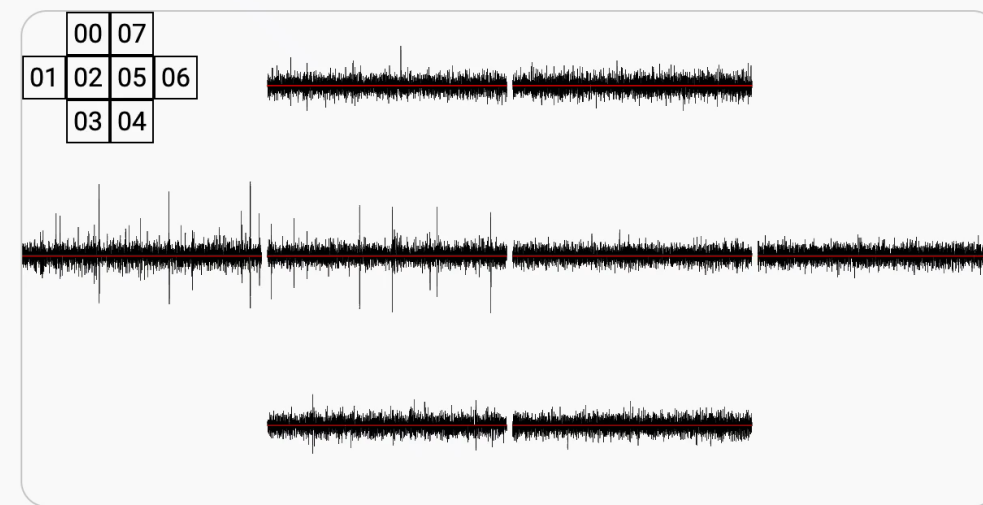
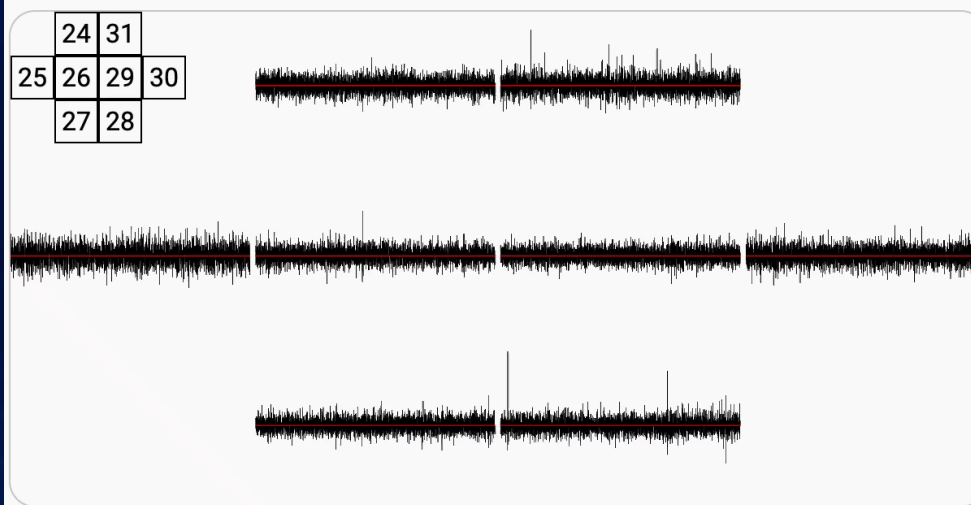
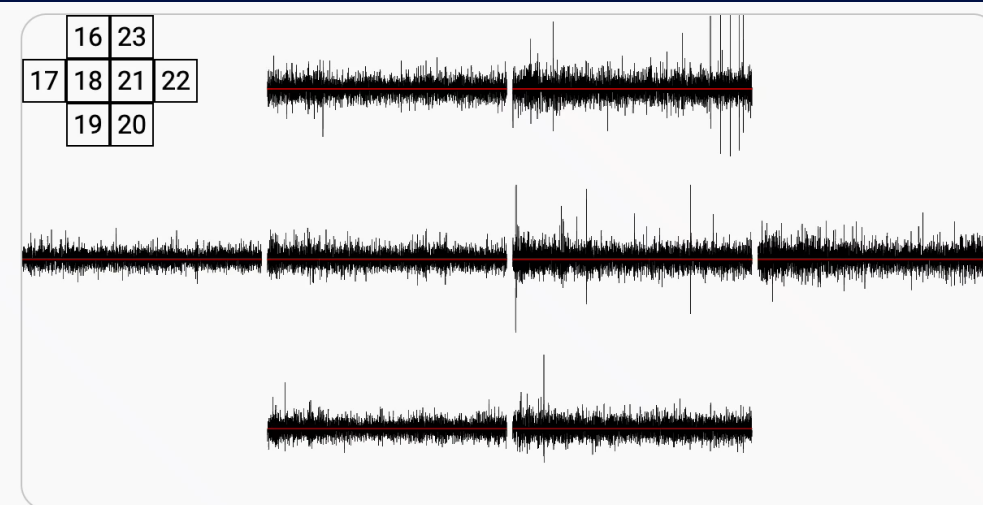
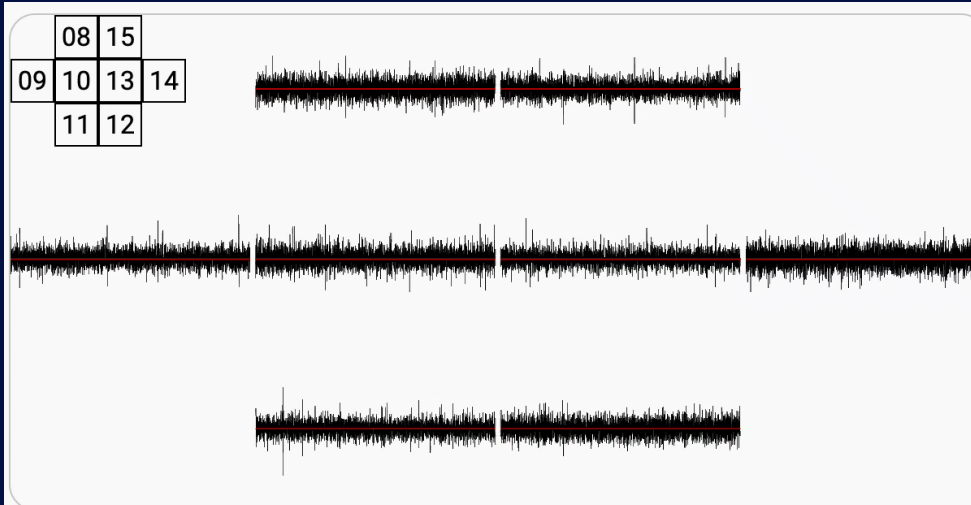
PTFE

Neurosphere

Culture medium

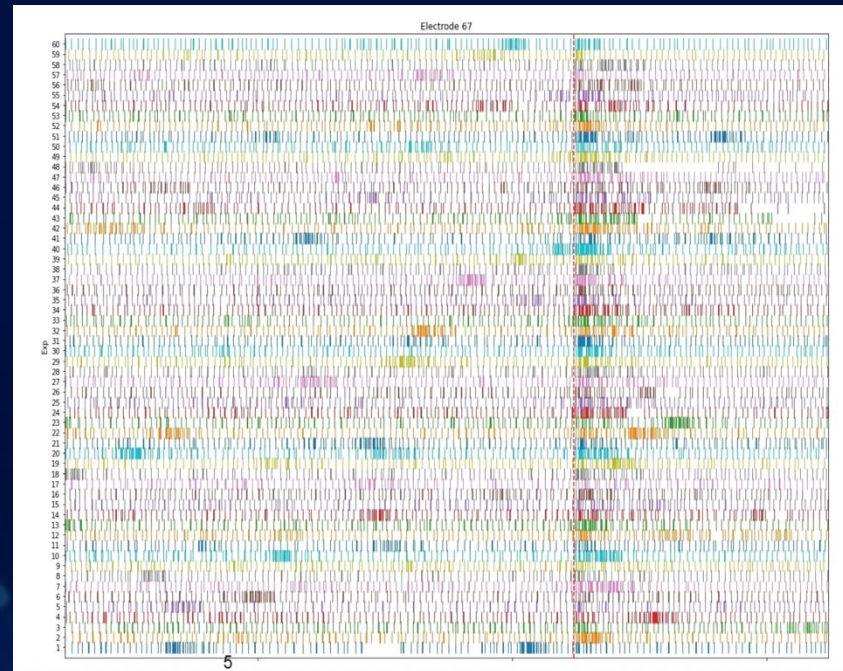
WORK AT THE LAB





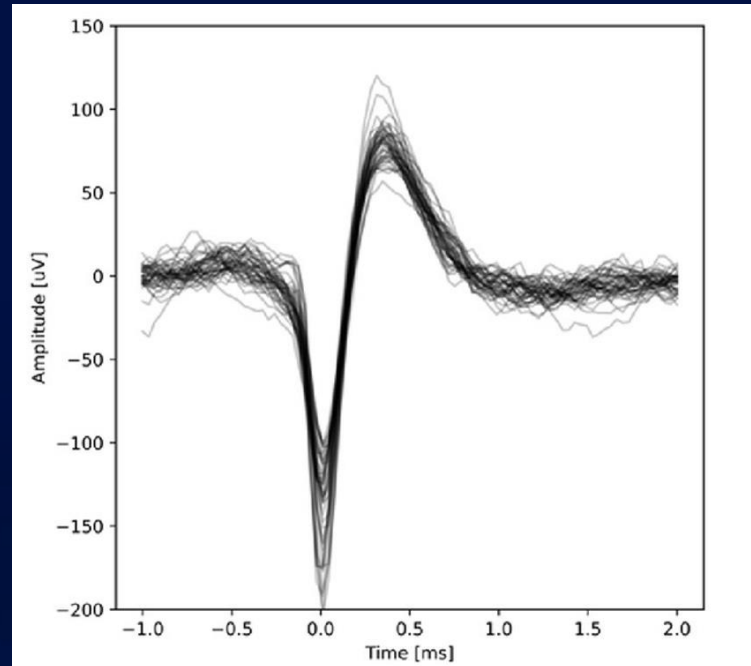
Typical data we collect

- Spike trains: event-based



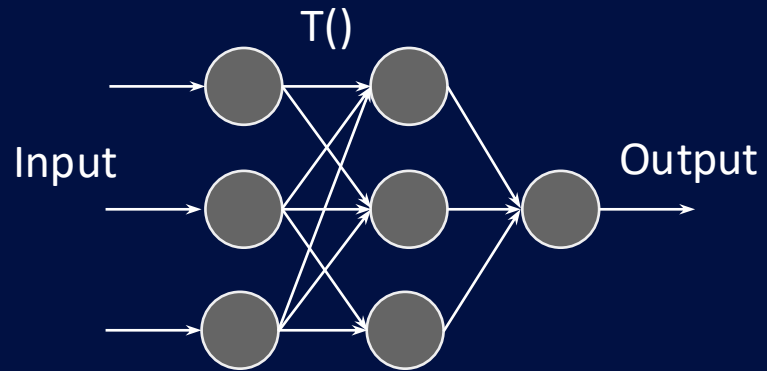
2 external stimulations: 100nA (interval 50 ms)

- Action potential



SCIENCE BEHIND

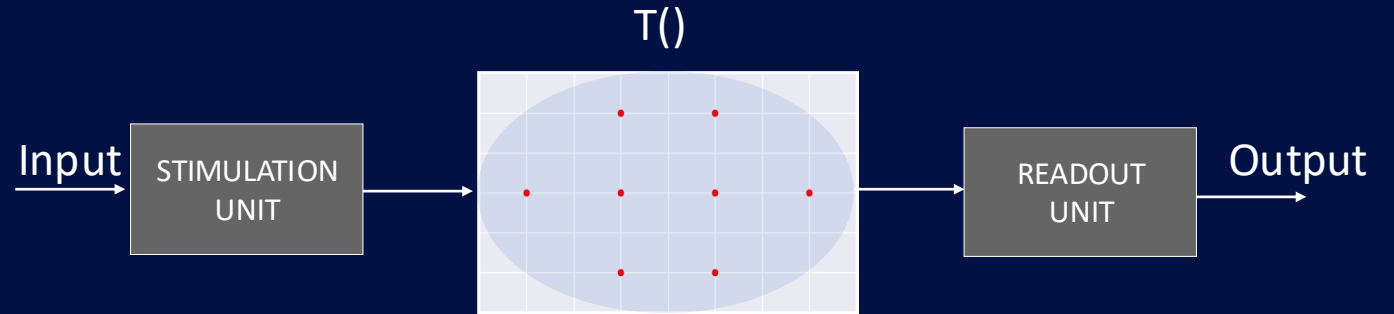
SIMILARITIES BETWEEN ARTIFICIAL AND BIOLOGICAL NEURAL NETWORKS



$$\text{Output} = T(\text{Input}, \langle \text{State} \rangle)$$

$$\text{Loss} = f(\text{Output}, \text{Target})$$

If Loss = 0 then Output = Target

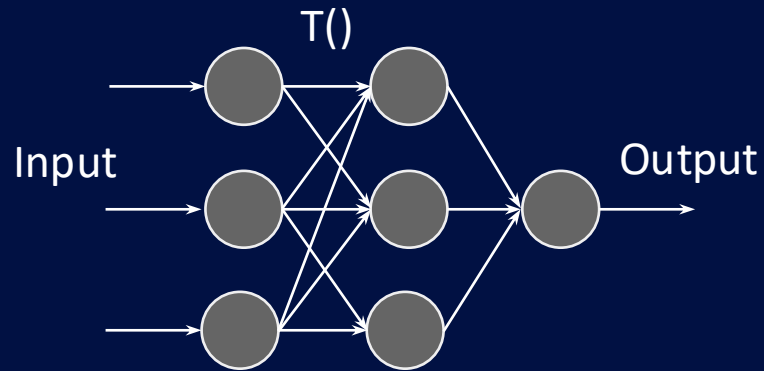


$$\text{Output} = T(\text{Input}, \langle \text{State} \rangle)$$

$$\text{Loss} = f(\text{Output}, \text{Target})$$

If Loss = 0 then Output = Target

DIFFERENCES BETWEEN ARTIFICIAL AND BIOLOGICAL NEURAL NETWORKS



We know $T()$

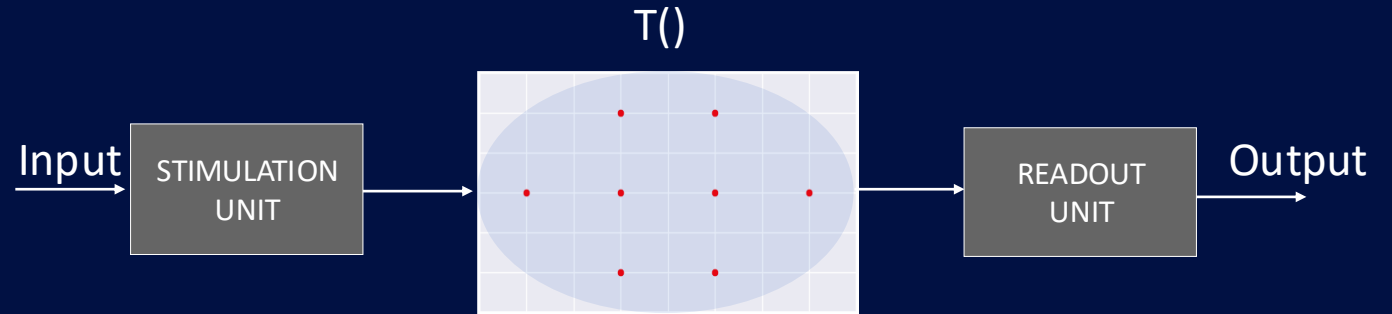
We know $\langle \text{State} \rangle = \{W_{jk}^l\}$

We can compute symbolically $\frac{\partial f}{\partial W_{jk}^l}$

Simple gradient descent:

$$\Delta W_{jk}^l = \alpha \frac{df}{dW_{jk}^l}$$

How to update state in order to minimize Loss?



We do not know $T()$

We do not know $\langle \text{State} \rangle$

We know that $T()$ and $\langle \text{State} \rangle$ are changing over time

... 😊

WHAT DO WE WANT TO ACHIEVE?

The goal

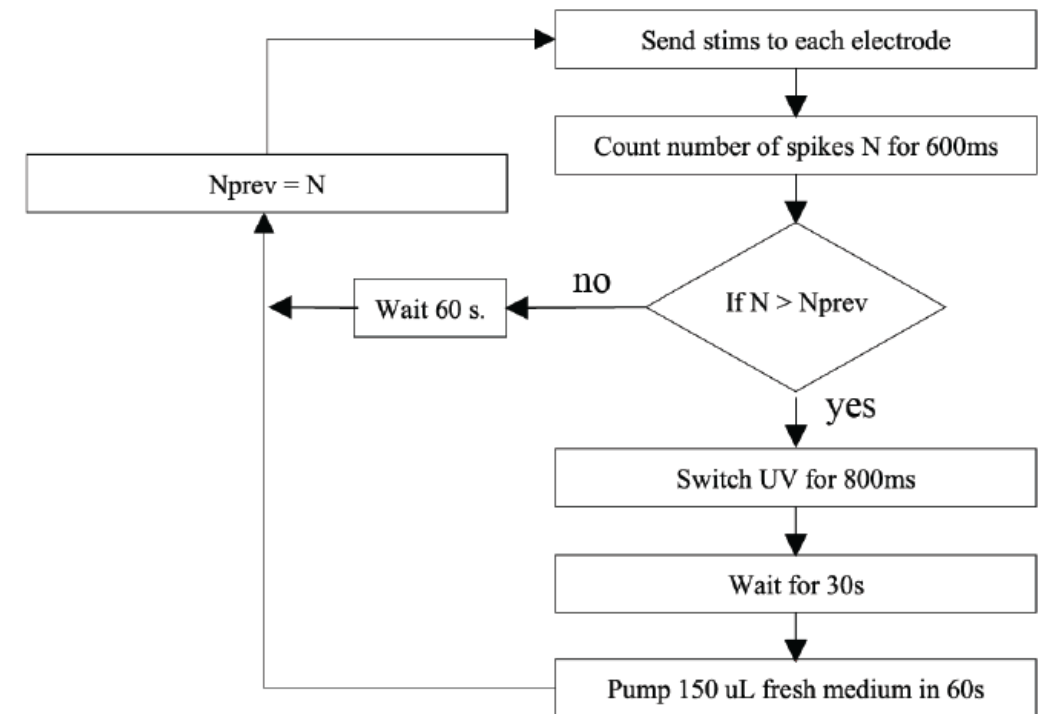
input



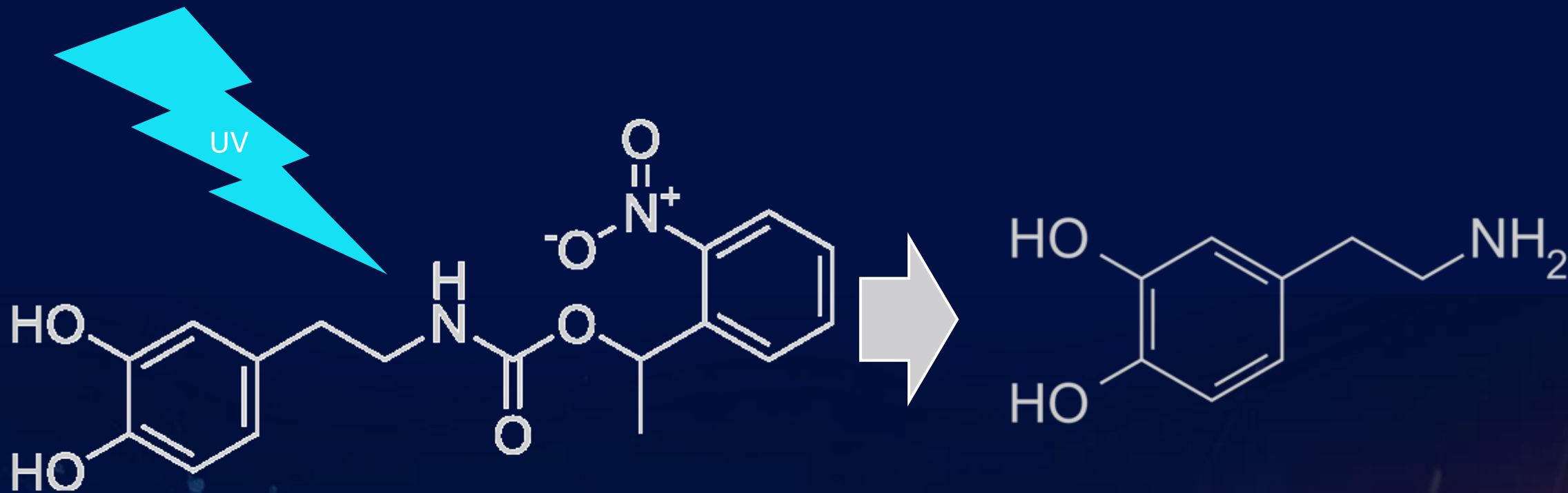
output

CLOSED LOOP LEARNING

```
for _ in range(4*60):  
    for i in range(8):  
        trigger.send(recordingTriggers[i])  
        time.sleep(0.01) # 10 ms  
  
        nb_spikes = read(trigger, intan, listeningTrigger) # Read number of spikes  
        nb_spikes_ns = np.sum(nb_spikes[all_electrodes])  
  
        diff_spikes = nb_spikes_ns - nb_spikes_ns_history[-1]  
        nb_spikes_ns_history.append(nb_spikes_ns)  
  
        if diff_spikes > 0: # Increase of spike activity  
            triggerUV.send(800) # trigger UV for 100 ms  
  
        time.sleep(30) # Wait 30s before removing dopa  
  
        # Increase speed of the pump to 5 rpm (to remove dopa)  
        peristaltic.rpm(5, PeristalticDirection.CounterClockWise)  
        time.sleep(60) # wait 1 min
```



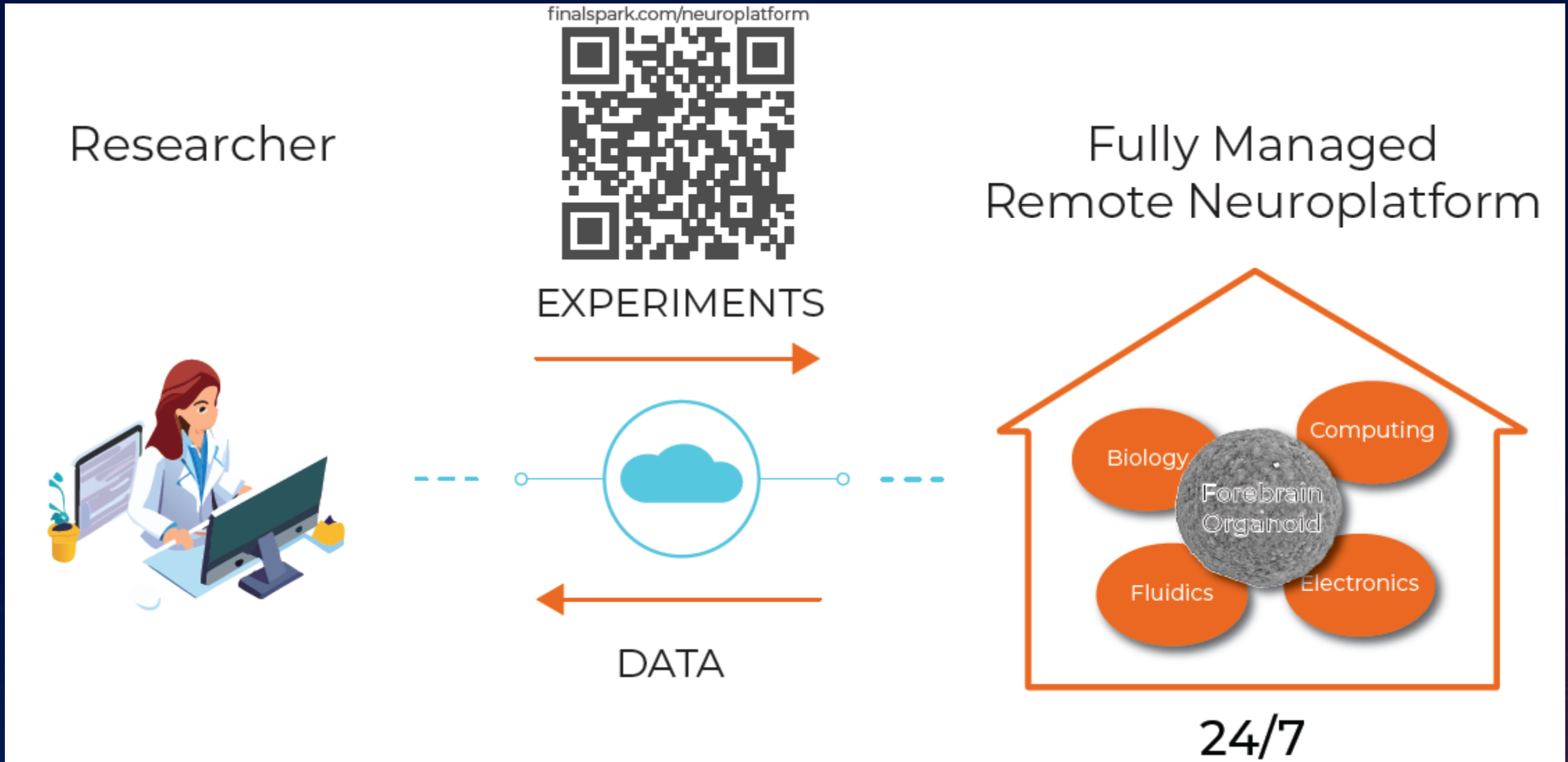
UNCAGING OF DOPAMINE (NPEC)





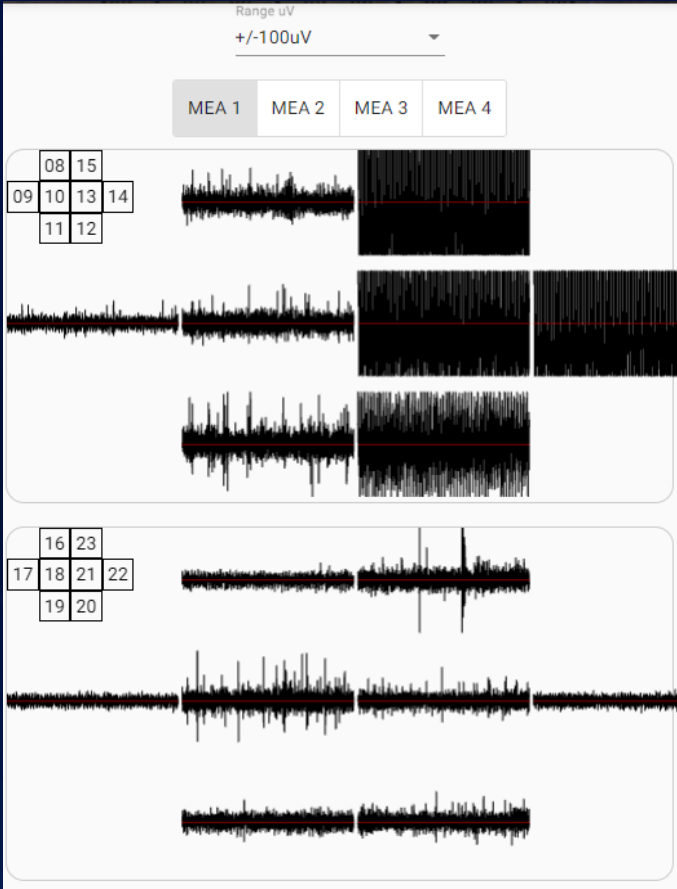
FINALSPARK NEUROPLATFORM

TODAY: REMOTE RESEARCH PLATFORM

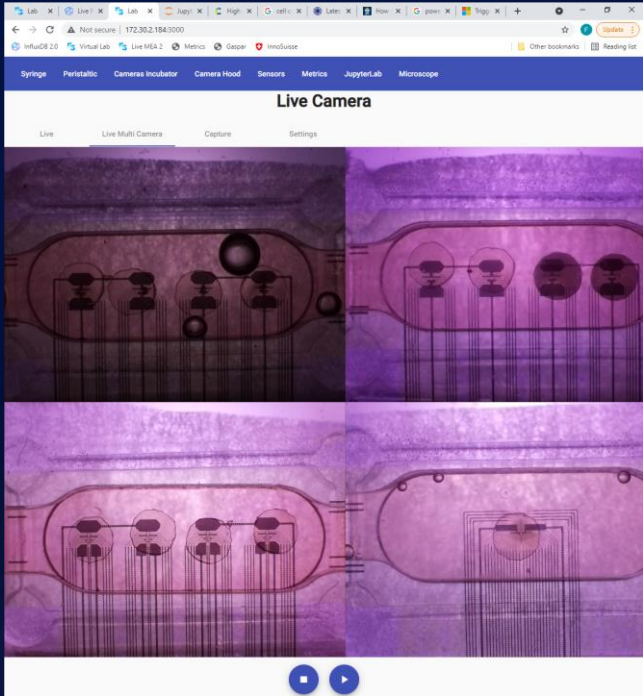
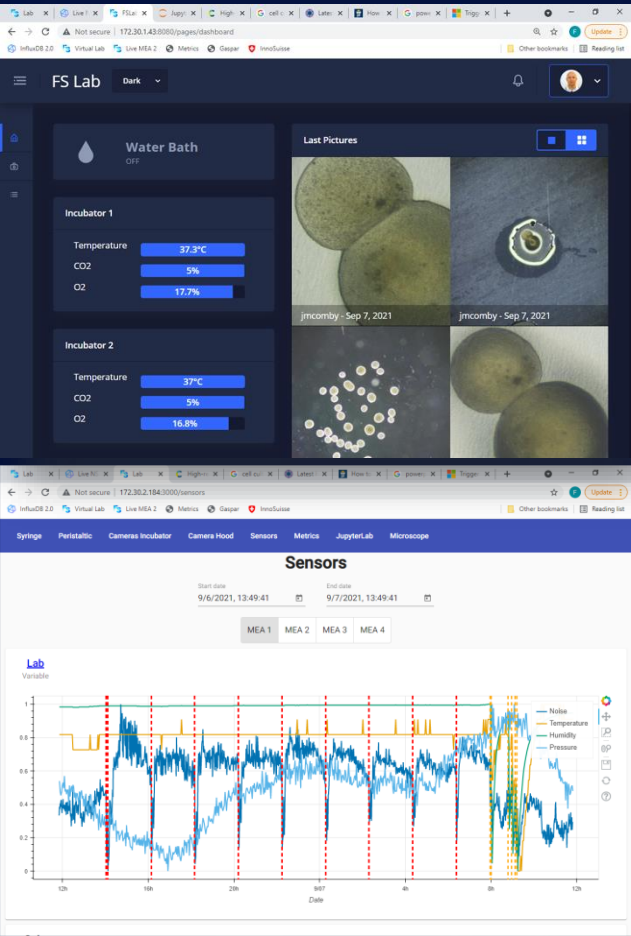


24/7 MONITORING OF ESSENTIAL PARAMETERS

Electrical activity of neurospheres

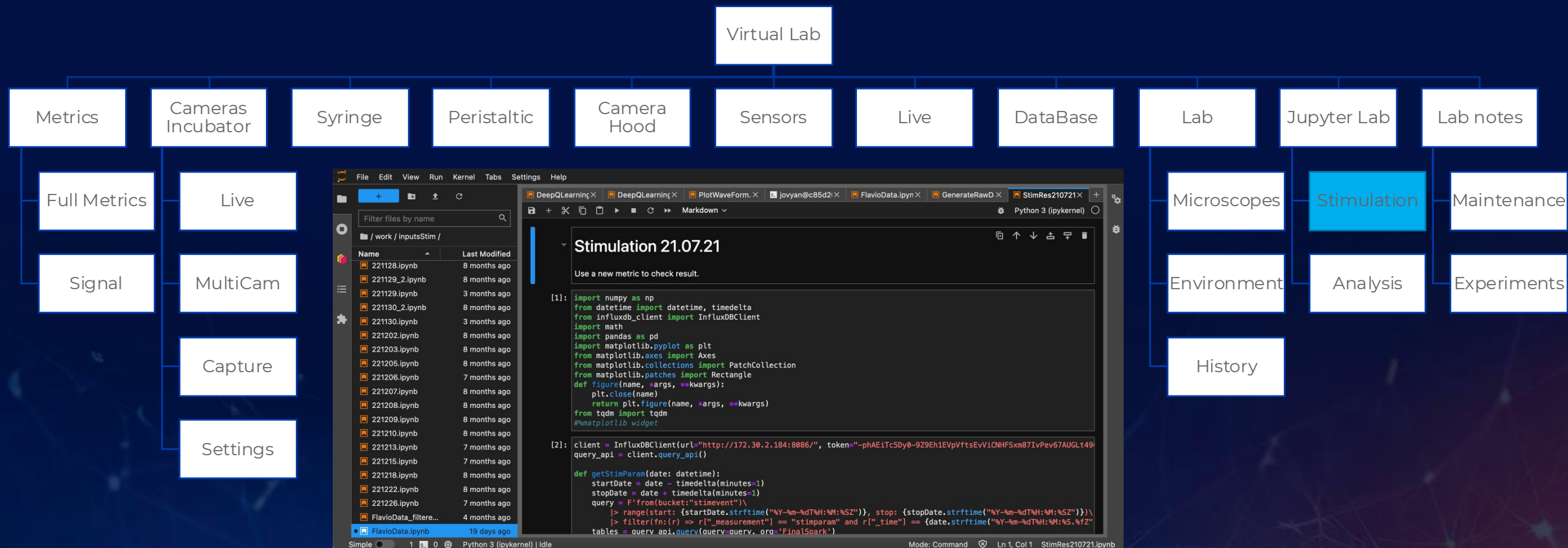


Temperature, pH, CO2, visual assessment



FULLY CONTROLLABLE VIA PYTHON SCRIPT

General Software Infrastructure



56.8s

```
# Connect to intan software
s = socket.socket()
s.connect(('172.30.1.10', 5001))
s.settimeout(0.3)
# Connect to Trigger interface
rp_s = socket.socket()
rp_s.connect(('172.30.2.168', 5001))

# Ask intan software to send the number of spike after trigger
s.send(getCountIntan)

# Stim parameter
amplitude1 = 1.0
pol = 1.0
s_shape = 0.0
phase_dur1 = 100
amplitude2 = 1.0
phase_dur2 = 100

try:
    # Measure impedance
    s.send(runImpedance)
    time.sleep(10)

    # Disable Variation STD (keep a fixed threshold)
    s.send(disableVarSTD)
    time.sleep(2)

    # Send stim parameter
    send_stim_param(s, all_electrodes, amplitude1, 1.0, 0.0, 10000.0, triggerkeys, pol, s_shape,
                    phase_dur1, amplitude2, phase_dur2, 0.0)

    for i in range(10):
        # Stimulation on electrode 0
        read(rp_s, s, 0)
        time.sleep(2)

finally:
    rp_s.close()
    s.send(enableVarSTD)
    time.sleep(2)
    send_stim_param(s, all_electrodes, amplitude1, 0.0, 0.0, 10000.0, triggerkeys, pol, s_shape,
                    phase_dur1, amplitude2, phase_dur2, 0.0)
    s.close()
```

```
# Select the electrodes and the triggers.
nsRange = np.arange(4)
elems = np.arange(8)
readingTriggers = np.zeros((16,16), dtype=np.uint8)
for i in range(8):
    readingTriggers[i,i] = 1
readingTriggers[8,8] = 1 # Trigger for reading without stimulation
repReading = 10
all_electrodes = [nsid*8+c for nsid in nsRange for c in range(8)]
triggerkeys = [j%8+10.0 for j in all_electrodes]

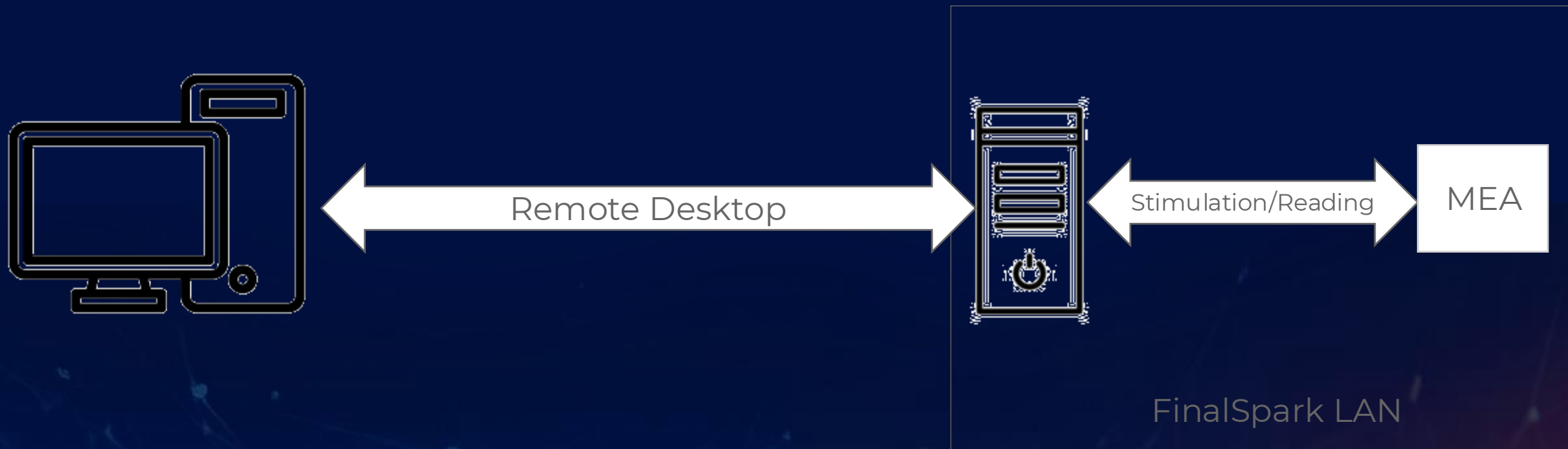
# Send a trigger (run a stimulation) and wait 200ms to count the number of spike
# If the number of spike is above a threshold, stim electrode j+1
def read(rp_sock: socket, sock: socket, j: int):
    rp_sock.send(readingTriggers[:,j].tobytes())
    time.sleep(0.20)

    try:
        buffer = sock.recv(4*130)
        clear_output(True)
        print(f'# Spikes: {buffer[0]}')

        # If number of spike bigger than 3
        if buffer[0] > 3:
            # spike on another electrode
            rp_sock.send(readingTriggers[:,j+1].tobytes())

    except socket.error:
        print('error socket')
```

REMOTE ACCESS FOR REMOTE EXPERIMENTS



TECHNOLOGY AND CODE article

Front. Artif. Intell., 02 May 2024

Sec. Organoid Intelligence

Volume 7 - 2024 | <https://doi.org/10.3389/frai.2024.1376042>

This article is part of the Research Topic

Intersection between the biological and digital: Synthetic Biological Intelligence and Organoid Intelligence

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Ewelina Kurtys

FinalSpark, Rue du Clos 12, Vevey, Switzerland

Wetware computing and organoid intelligence is an emerging research field at the intersection of electrophysiology and artificial intelligence. The core concept involves using living neurons to perform computations, similar to how Artificial Neural Networks (ANNs) are used today. However, unlike ANNs, where updating digital tensors (weights) can instantly modify network responses, entirely new methods must be developed for neural networks using biological neurons. Discovering these methods is challenging and requires a system capable of conducting numerous experiments, ideally accessible to researchers worldwide. For this reason, we developed a hardware and software system that allows for electrophysiological experiments on an unmatched scale. The Neuroplatform enables researchers to run experiments on neural organoids with a lifetime of even more than 100 days. To do so, we streamlined the experimental process to quickly produce new organoids, monitor action potentials 24/7, and provide electrical stimulations. We also designed a microfluidic system that allows for fully automated medium flow and change, thus reducing the disruptions by physical interventions in the incubator and ensuring stable environmental conditions. Over the past three years, the Neuroplatform was utilized with over 1,000 brain organoids, enabling the collection of more than 18 terabytes of data. A dedicated Application Programming Interface (API) has been developed to conduct remote research directly via our Python library or using interactive compute such as Jupyter Notebooks. In addition to electrophysiological operations, our API also controls pumps, digital cameras and UV lights for molecule uncaging. This allows for the execution of complex 24/7 experiments, including closed-loop strategies and processing using the latest deep learning or reinforcement learning libraries. Furthermore, the infrastructure supports entirely remote use. Currently in 2024, the system is freely available for research purposes, and numerous research groups have begun using it for their experiments. This article outlines the system's architecture and provides specific examples of experiments and results.

Edited by



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University of Essex, United Kingdom

Reviewed by



Chiara Magliaro

University of Pisa, Italy



Qi Huang

Johns Hopkins University, United States

TABLE OF CONTENTS

[Abstract](#)[1 Introduction](#)[2 Biological setup](#)[3 Hardware architecture](#)[4 Software](#)[5 Examples of electrophysiological experiments](#)[6 External users of the Neuroplatform](#)[7 Discussion and conclusion](#)[8 Future extensions](#)[9 Methods](#)

CURRENT NEUROPLATFORM USERS: OPEN INNOVATION

GLOBAL NEUROPLATFORM REACH

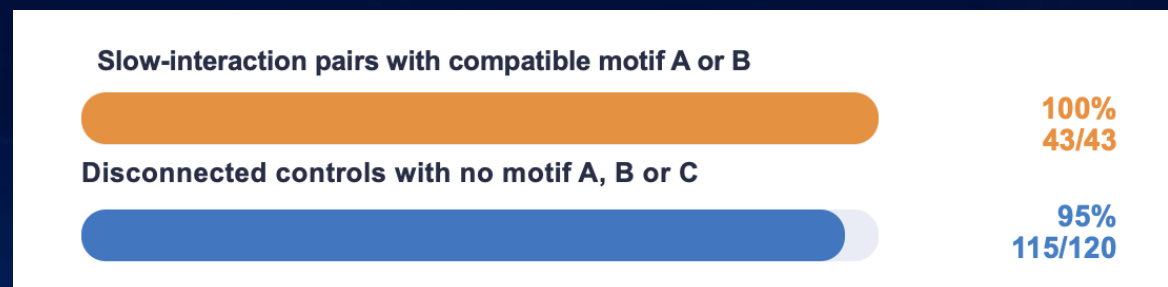
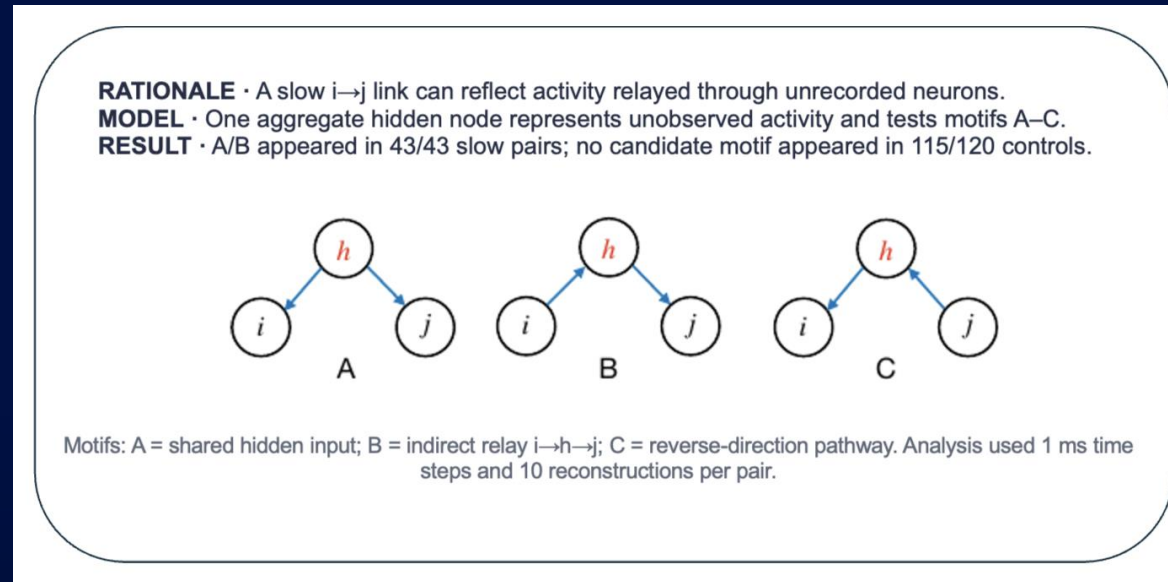
The Neuroplatform has been used by universities, startups, industry teams and independent researchers worldwide.



Switzerland • USA • UK • France • Germany • Norway • Slovenia • Turkey • Abu Dhabi, UAE • South Korea • Japan

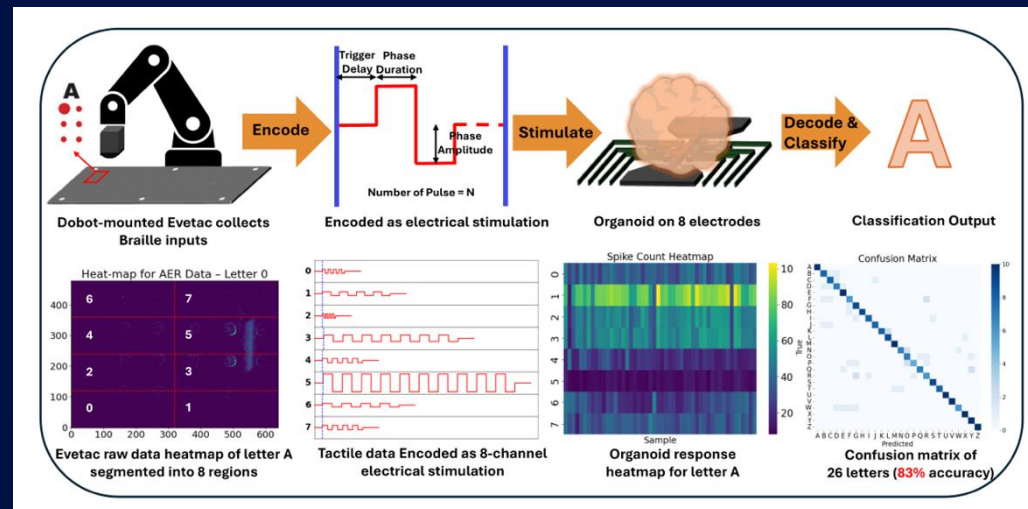
CASE STUDIES

In vitro analysis of neuronal connectivity in 3D organoid



Jaffard S, et al. Reconstruction of neural interactions from partial recordings using a latent Hawkes-process model. Manuscript in preparation (2026).

Event-based robotic sensing with organoids



AVERAGE BRAILLE LETTER CLASSIFICATION ACCURACY

Single organoid



61%

Three-organoid ensemble



83%

Liu T, Philamore H, Ward-Cherrier B. *Encoding Tactile Stimuli for Braille Recognition with Organoids*. Front Artif Intell. 2026;9. doi:10.3389/frai.2026.1800219.

ART PROJECTS



OUR TEAM

ABOUT FINALSPARK



Pioneering research in AI since 2014



Switch to biocomputing approach in 2018



Swiss Headquarters



Dr Fred Jordan
PhD, signal processing



Dr Martin Kutter
PhD, signal processing



Jean-Marc Comby
MSc in physics



Dr. Ewelina Kurtys
PhD, neuroscience



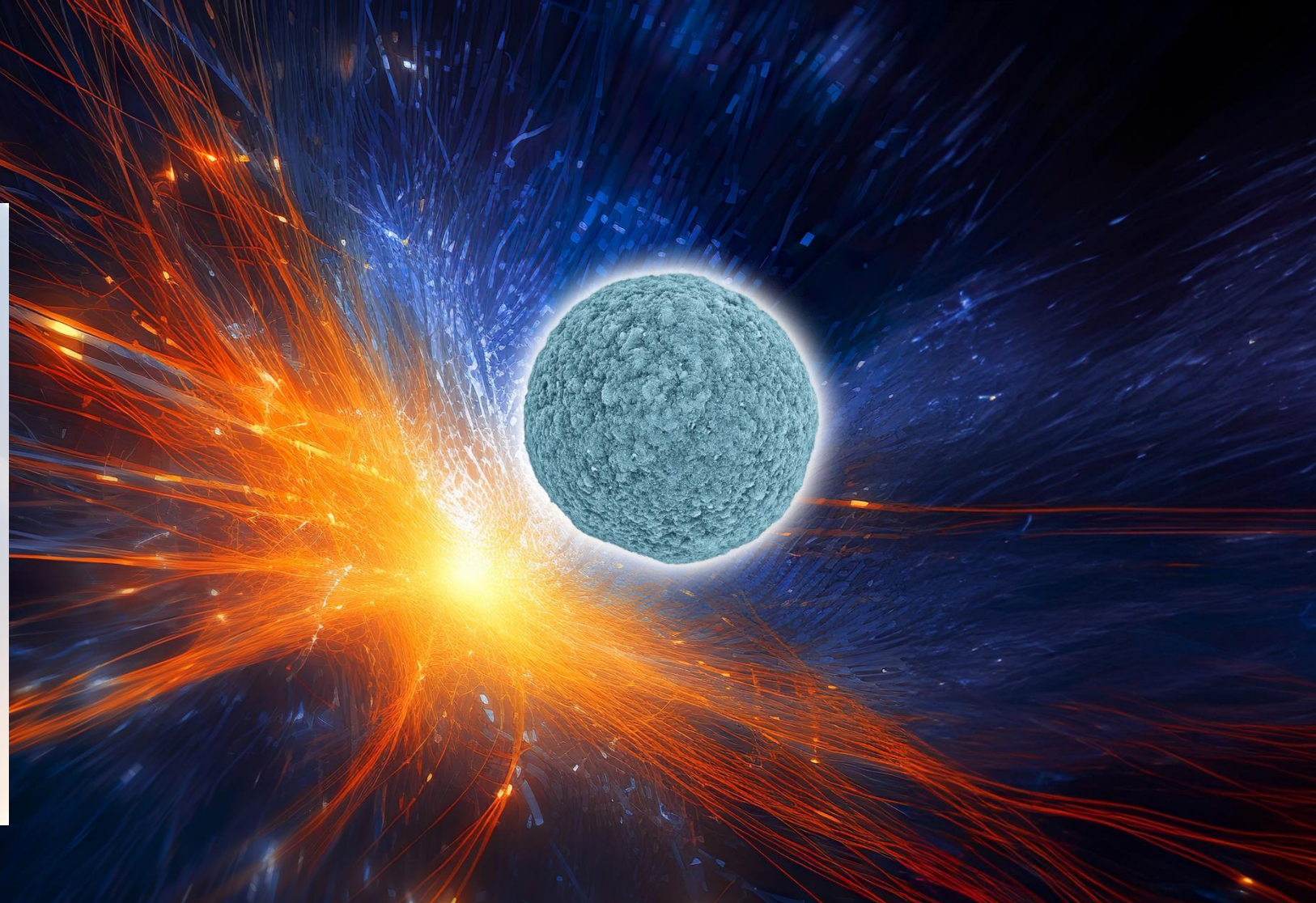
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PhD, biology



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Ph.D. student



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