BRIEFING 01 · DARPA

Computers made of living neurons: DARPA’s O-CIRCUIT

A deep dive into organoid computing: how living neurons compute, what DARPA's O-CIRCUIT program asks for, who else is building 'wetware', and how it could change AI, medicine and defense.

Mohsin Khan Shaik
AI Infrastructure & Site Reliability Engineer · San Francisco · mohsinkhanshaik.com
Edition of 2026-11-22

01 · DARPA

Computers made of living neurons: DARPA's O-CIRCUIT

A deep dive into organoid computing: how living neurons compute, what DARPA's O-CIRCUIT program asks for, who else is building 'wetware', and how it could change AI, medicine and defense.

42 months	~20 W	Mar 2025	800,000
planned program length	power of a human brain	first commercial neuron computer (CL1)	neurons in DishBrain that learned Pong

Key takeaways

- O-CIRCUIT is a 2026 DARPA program to build computers whose computing medium is living neurons and organoid tissue, aimed at low-power AI at the edge.
- It is not trying to build a brain: DARPA says so explicitly, and purely in-silico (silicon-only) proposals are out of scope.
- The field is real but young: Cortical Labs' DishBrain learned Pong in 2022, its CL1 became the first commercial neuron-based computer in 2025, and FinalSpark rents organoid time over the internet.
- The biggest obstacles are engineering, not ideas: keeping tissue alive, reproducible and observable for months.
- Ethics will matter early: as organoids become more complex, questions about sentience and donor consent need clear rules.

Background: why compute with biology?

Modern AI is limited by energy. Training and running large models takes data centers measured in hundreds of megawatts, while the human brain does far more flexible learning on roughly 20 watts. Biological neurons compute with chemistry and electrical spikes, learn continuously, and repair themselves, properties silicon struggles to match.

The term **organoid intelligence** was coined by a Johns Hopkins group including Thomas Hartung to describe using three-dimensional cultures of human brain cells, called *brain organoids*, as a computing substrate [5]. Organoids are grown from stem cells and self-organize into tissue with some of the cell types and layered structure of a developing brain, though they are tiny (millimeters) and far simpler than a real brain.

What O-CIRCUIT asks for

O-CIRCUIT stands for *Organoid Cytomorphic Intelligence Resulting from Convergent Understanding and Information Transfer*. DARPA's solicitation (DARPA-PS-26-28) was published on 1 May 2026 after a proposers workshop on 10 April 2026 [1][2]. Key points:

- **Goal:** power-efficient computers that use living neurons or organoid tissue for AI processing at the tactical edge, where size, weight and power are tight [1][3].

- **Structure:** a 42-month effort with an 18-month first phase, then two 12-month phases, organized around two development approaches, *architecture* and *action* [1].
- **Boundaries:** the FAQ states the program "does not seek to build a brain", and purely in-silico solutions are out of scope [2].
- **Example use:** public coverage describes drones that could "smell" danger such as explosives or chemical agents using olfactory receptor neurons [4].

How organoid computing works

An organoid computer has three layers:

- **The tissue:** neurons (2D cultures or 3D organoids) grown on or around a **multi-electrode array (MEA)**, a chip with many tiny electrodes that can both record spikes and deliver electrical stimulation.
- **The interface:** software encodes inputs as patterns of stimulation (for example, where a ball is in a game) and decodes the network's spiking activity as outputs.
- **The learning loop:** the tissue adapts through synaptic plasticity. In DishBrain, predictable feedback after a "good" action and unpredictable noise after a "bad" one was enough for the culture to improve at Pong [6].

A related approach, **reservoir computing**, treats the living network as a rich, nonlinear "reservoir": you don't train the tissue directly, you train a simple readout on top of its responses. Indiana University's 2023 *Brainoware* used this idea for simple speech tasks, reporting about 78% accuracy at identifying speakers in a narrow test [7].

State of the art in 2026

- **DishBrain (2022):** about 800,000 human and mouse neurons on a CMOS chip learned to play Pong, the field's best-known demonstration [6].
- **Cortical Labs CL1 (March 2025):** launched at Mobile World Congress as the first commercially available computer based on human neurons grown from stem cells, priced at about US$35,000, with remote "wetware-as-a-service" access [6][8].
- **FinalSpark:** a Swiss startup that keeps organoids alive for up to six months and lets researchers run experiments remotely, with a stated goal of AI at a tiny fraction of today's energy [5].
- **DARPA O-CIRCUIT (2026):** the first large defense program to treat organoid tissue as the computing medium itself [1].

Honest caveat: these systems solve toy problems today. Learning Pong is a long way from complex decision-making, and no organoid system rivals a modern neural network on real tasks [7].

How it could change life

- **Edge AI and sensing:** sensors that classify smells, chemicals or signals locally on milliwatts, useful for disaster response, food safety and environmental monitoring.
- **Medicine:** the same platforms are disease models. Organoids from a patient's own cells could show how their neurons respond to a drug, reducing trial and error for epilepsy or neurodegenerative disease.
- **Fewer animal tests:** human neural tissue on a chip can replace some animal experiments in neuroscience and toxicology.

- **Energy:** if hybrid bio-silicon accelerators work for niche tasks, they could cut the energy cost of always-on intelligence.

Future scenarios

2027–2028	2030	2035	2040+
O-CIRCUIT Phase 1 prototypes: tissue that reliably learns simple tasks and talks to electronics; better life-support and longevity.	Field demonstrations of organoid sensing (smell, signal classification) on mobile platforms; standard benchmarks emerge.	Hybrid bio-silicon accelerators for ultra-low-power niches, if reproducibility and lifetime are solved.	Mature biocomputing used alongside silicon for adaptive, always-learning tasks; strong ethical governance in place.

- **Optimistic:** organoid co-processors become a new device class for edge sensing and continual learning.
- **Base case:** biocomputing stays a research and drug-discovery tool, with a few specialized sensing products.
- **Pessimistic:** lifetime, variability and ethics stall the field; neuromorphic silicon captures most of the benefits instead.

Effects and risks

- **Engineering:** tissue needs nutrients, gas exchange, sterile conditions and stable temperature; it ages and varies from batch to batch.
- **Observability:** debugging a living network is far harder than reading a stack trace; new tooling is needed.
- **Ethics:** donor consent, potential for sentience in complex organoids, and how such systems may be used. Clear thresholds and oversight boards will be needed.
- **Dual use:** early applications are military; transparency helps public trust.

What to watch

- O-CIRCUIT award announcements and Phase 1 results.
- Organoid lifetime records (months to years) and batch-to-batch variability.
- Independent benchmarks comparing biological and neuromorphic chips on energy per task.
- Ethics frameworks from bodies such as national academies on organoid research.

Connection to my work

My day job is running AI infrastructure reliably: capacity, power, cooling, observability and incident response. Biocomputing turns every one of those into a biology problem. A "living server" needs health checks (is the tissue alive and responsive?), drift detection (is it still behaving like yesterday?), and graceful degradation when a culture dies. I'd love to see the field borrow SRE practices: SLOs for tissue health, canary cultures, and runbooks.

My take

O-CIRCUIT is a smart bet because it targets a niche where biology has a real edge: low-power, adaptive sensing. I don't expect organoids to replace GPUs. I do expect them to teach us how to build more efficient AI, and to produce useful medical tools along the way. The winners will be the teams that make living computers boringly reliable.

Key players & programs

DARPA O-CIRCUIT	2026 program; organoid tissue as the computing medium for edge AI [1]
Cortical Labs (Australia)	DishBrain (Pong, 2022); CL1 commercial neuron computer (2025) [6][8]
FinalSpark (Switzerland)	Remote-access organoid platform; organoids kept alive up to six months [5]
Indiana University	Brainoware reservoir computing with organoids (Nature Electronics, 2023) [7]
Johns Hopkins	Coined 'organoid intelligence' and set out the research agenda [5]

Frequently asked questions

What is DARPA O-CIRCUIT?
A 2026 DARPA program to build computers that use living neurons and organoid tissue as the computing medium, aimed at power-efficient AI at the tactical edge. It runs for a planned 42 months in three phases.

Is O-CIRCUIT trying to build an artificial brain?
No. DARPA's FAQ states the program does not seek to build a brain. It focuses on harnessing how biological neurons process information efficiently.

Has a biological computer ever learned a task?
Yes. Cortical Labs' DishBrain, about 800,000 neurons on a chip, learned to play Pong in 2022, and its CL1 became the first commercial neuron-based computer in 2025.

Why use living neurons instead of chips?
Energy and adaptability. A human brain runs on about 20 watts and learns continuously, while large AI systems need data centers.

Glossary

Organoid: A small, self-organizing 3D culture of cells grown from stem cells that mimics some features of an organ.

Multi-electrode array (MEA): A chip with many electrodes that records neuron activity and delivers stimulation.

Reservoir computing: Using a complex dynamic system as a fixed 'reservoir' and training only a simple readout layer.

Edge AI: Running AI on devices in the field rather than in a data center.

References

1. DARPA — O-CIRCUIT program page
   https://www.darpa.mil/research/programs/o-circuit
2. DARPA — O-CIRCUIT FAQ (May 2026)
   https://www.darpa.mil/sites/default/files/attachment/2026-05/faq-darpa-program-o-circuit.pdf
3. Military Aerospace — Insect brain-level computing for low-power edge AI
   https://www.militaryaerospace.com/computers/article/55361824/researchers-eye-insect-brain-level-computing-to-bring-low-power-artificial-intelligence-ai-to-the-edge
4. The Sociable — O-CIRCUIT: drones that smell danger
   https://sociable.co/military-technology/darpa-o-circuit-program-drones-smell-danger-biologically-inspired-computer/amp/
5. National Geographic — Scientists want to build 'living' computers powered by brain cells
   https://www.nationalgeographic.com/science/article/brain-cells-organoids-computers-ai-energy

6. IEEE Spectrum — A biological computer for sale (Cortical Labs CL1)
   https://spectrum.ieee.org/biological-computer-for-sale
7. Scientific American — These living computers are made from human neurons
   https://scientificamerican.com/article/these-living-computers-are-made-from-human-neurons
8. Cosmos — First biological computer made from neurons
   https://cosmosmagazine.com/technology/computing/first-biological-computer-neurons
9. arXiv — Brain organoid computing: an overview (2025)
   https://arxiv.org/html/2503.19770v2