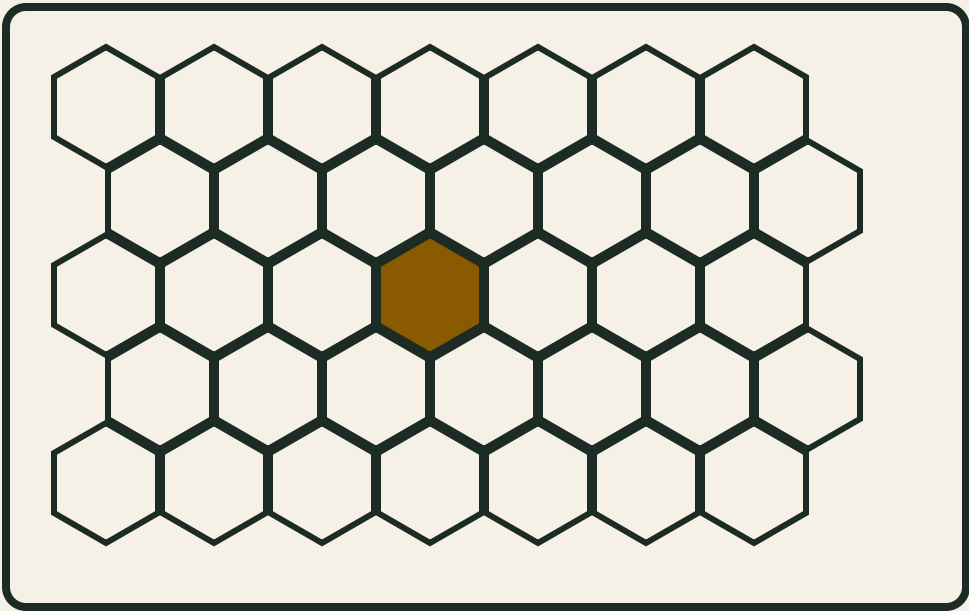


A WORKING PAPER, IN PLAIN LANGUAGE

The Bee in the Rack

Human Neural Cultures, Commercial Computing, and the Limits of the Size Argument

Living human neurons are now rented out as computers. Their maker says there is no sign they feel anything, and an outside scientist says they are no different from a simulation. This paper tests those reassurances, and asks after the donors whose cells fill the dishes.



ONE CULTURE IN THE RACK
ABOUT AS MANY CELLS AS A FLY HAS NEURONS

A Computer Made of Neurons

What was said on camera, and why it matters

The usual skeptical argument against machine consciousness is about the wrong material. This machine is made of the right one.

OCTOBER 4, 2026

On Australian television, two experts said there is nothing in the dish to worry about.

THE COMPANY

Brett Kagan, Cortical Labs

Asked where the ethical line is, the chief scientific officer said people worry small clumps of cells might feel something, that there is no evidence of it, and none that the company is “anywhere near close to an ethical red line”. He said the company checks constantly.

AN OUTSIDE SCIENTIST

Simon Schultz, Imperial College

Interviewed separately, the neurotechnology director predicted the cultures will never wake into consciousness, by magic or emergence, and said running computations on living cells is ethically the same as simulating a big AI system.

No transcript exists. The segment was transcribed by speech recognition; everything except the one quoted phrase is paraphrase.

WHY THE ANSWERS CARRY WEIGHT

The best argument against machine minds is about material. Here the material is human neurons.

For a decade the debate over conscious machines has turned on substrate. Its most developed skeptical view, biological naturalism, says consciousness depends on being a living organism, so today's AI is unlikely to have it however it behaves. The CL1 runs on living human neurons, the only kind of cell known to host a mind. The argument from material cannot be used against it in the usual way.

WHAT IS LEFT

From the company: no sign of feelings in little clusters of cells. From the outside scientist: they will never be conscious, and ethically they equal a simulation. And a promise of constant checking, with no published method.

THE ARGUMENT ON ONE PAGE

The reassurances were offered with more confidence than their reasons can bear.

<i>Too small to matter?</i>	→	As a count, no: one culture is fly-sized, and size is no reason for dismissal. As simple wiring, yes for now, and only while it stays simple. Part III
<i>Will never be conscious?</i>	→	A prediction about cultures as they are, which says nothing about the ones being built. Part III
<i>Same as a simulation?</i>	→	A dilemma either way, and the company's own lab disclaims equal status in print. Part IV
<i>Who is missing?</i>	→	The donors, whose cells and DNA sit in every culture. Part V
<i>What follows?</i>	→	Review and disclosure, no ban. Part VI

THREE LIMITS, STATED FIRST

The paper does not say the cultures feel anything, and it proposes no ban.

- 1 No finding of experience**
The best current account says today's flat cultures probably cannot feel, and the paper agrees. It disputes the certainty, its stretch to future cultures, and the silence about donors.
- 2 No claim that biology is required**
The argument does not need biology to be necessary for a mind.
- 3 No prohibition**
Everything it proposes is review, records, disclosure, and research.

Method: the company's own product page, papers, and broadcast; press for deployment figures only; scholarship found through Scite and Consensus and checked against Crossref; law from official sources. Chosen on purpose, not a systematic review.

What Is Being Sold

The platform, the racks, the training signal

A device that keeps human neurons alive on a chip, rented over the internet, run by anyone who can write simple code.

THE PLATFORM

Human neurons on a silicon chip, rented by the hour over the cloud.

THE DEVICE

CL1

Neurons grown from human stem cells live on a chip whose electrodes both stimulate and record them. Built-in life support sustains them for as long as six months, though the company has claimed 500 days.

THE WORLD THEY LIVE IN

A simulation

Software drops the neurons into a virtual world, and what they do changes that world.

WHO RUNS IT

Anyone renting

Customers send code straight to the neurons. On television the company said someone with high school programming could do it, so whoever rents a culture writes its stimulation.

THE ONE ETHICAL CLAIM ON THE PRODUCT PAGE

That it beats animal testing ethically.

DEPLOYMENT

A data center of living cells in Melbourne,
a rack in Singapore, plans for a thousand units.

120

units in Cortical Labs’ Melbourne facility in March 2026, about 200,000 cells each, roughly 24 million in all.

20

units in a prototype rack that the National University of Singapore and its partners unveiled in August 2026.

1,000

units, roughly, planned for a Singapore facility, as reported at the Melbourne launch.

Per-unit figures vary: one report gives about 800,000 neurons. The paper uses the lower figure, which counts cells, not surviving neurons. No source says whether units share or link cultures, so the fair comparison is one culture.

THE TRAINING SIGNAL

In the Pong experiment, a hit brought predictable input and a miss brought chaos.

THE DESIGN

2022

When the culture returned the ball, it got predictable stimulation. A miss earned four seconds of random stimulation, 150 millivolts at 5 hertz. The idea, from the free energy principle, was that cultures would act to avoid the states that lead to unpredictable input.

WHAT IT SHOWED

Measurable change

The feedback changed the cultures' activity, and they showed more plasticity during play than at rest. Whether they avoid anything in a deeper sense is not established. The cultures also seemed to relearn each session.

THE WORD "SENTIENCE"

The 2022 paper argued its cultures fit a technical definition of sentience. Thirty neuroscientists disputed it. Birch urges the usual meaning, capable of feeling pain or pleasure, and on that meaning nothing in 2022 shows sentience. Milford and colleagues still warned the design risks suffering on its own designers' theory.

WHERE THE RESEARCH IS HEADING

The company is deliberately making its cultures more organized.

MEMORY CELLS

January 2026

Company scientists grew human neurons of the hippocampus, the brain’s memory center, from two donors’ cells. Organoids built from them lived over 400 days and had richer, hub-organized activity than flat cultures.

SHAPES ON THE CL1

August 2026

A preprint ran flat cultures, modular networks, and 3D organoids on the CL1 itself. Modular cortical cultures did best, so not every result rewards brain-likeness.

THE DIRECTION

Chosen for performance

3D structure, long maturation, closed-loop coupling, and memory circuitry are all features the ethics literature flags. Nobody has said which of these sit in the racks customers rent.

Kagan saw this coming in 2023: his review said researchers will need to ask when complexity calls for ethical attention, and noted a few donors could stock many devices.

Smallness, Organization, and Prediction

What counting neurons can and cannot show

Size cannot carry the reassurance. Simple wiring can, for now, while the research changes it.

NO HUMAN FLOOR TO COUNT AGAINST

Against 86 billion neurons, 200,000 looks like nothing. But no count marks where experience starts.

A TEMPTING NUMBER

42 percent

Patients with brain injuries stayed aware only above roughly 42 percent of the cortex's usual glucose use, which predicted awareness in 94 percent of them. Multiply 86 billion by 42 percent and you get about 36 billion neurons. That number means nothing: the 42 percent is an energy rate, not a share of active neurons.

INSTRUMENTS THAT MISS

Three cases

A woman judged vegetative showed brain activity like healthy people's when asked to imagine tennis. Firefighter Donald Herbert talked with his family for hours almost ten years after his injury. Another man regained speech after nineteen years. All three had working brainstems.

COUNTS FAIL BOTH WAYS

The cerebellum has about 69 billion neurons to the cortex's 16 billion, so counting alone would put consciousness in the wrong place. Organization, embodiment, or being an organism do the work.

THE COMPARISON CLASS

One culture holds about as many cells as a fruit fly has neurons.

SYSTEM	APPROXIMATE COUNT		WHAT THE EVIDENCE SHOWS
Sea slug		20,000 neurons	A standard model for learning and memory. No candidacy claim.
Fruit fly		139,255 neurons	Lasting pain sensitization and vigilance after nerve injury; named in the 2024 declaration.
One CL1 culture		~200,000 cells (up to ~800,000)	Learned a simulated game. Nothing yet that bears on whether it could feel.
Honeybee		~960,000 neurons	Pessimistic judgments when agitated; Birch's example of a sentience candidate.

Counts come from different methods; the CL1 figures are reported cells or neurons, not measured survivors. The dashed bar shows the higher reported figure.

SOURCES Orvis et al. (2022); Dorkenwald et al. (2024); Khuong et al. (2019); New York Declaration on Animal Consciousness (2024); Williams (2026); Khang (2026); Frasnelli et al. (2014); Bateson et al. (2011); Birch, J. (2024). When is a brain organoid a sentience candidate? (Version 2). *Molecular Psychology*.

WHAT THE COMPARISON SHOWS, AND ONLY THAT

Counting neurons cannot settle the question against concern. That is all the comparison proves.

ANIMALS THAT SIZE CAN FEEL

Flies and bees

Agitated honeybees read ambiguous cues pessimistically; bumblebees show dopamine-driven upswings after surprise rewards. In 2024, hundreds of scientists put their names to a statement that insects may realistically have experiences. Birch rejected size as a reason to dismiss organoids for this reason.

BUT BEES HAVE BODIES

The gap

Bees and flies have bodies, senses, and evolved structures that track the whole animal. A dish of cells on electrodes has none of that. And learning or avoidance alone proves little: slime molds habituate, and a single-celled Stentor has a ranked set of escape responses.

SCALE, SEPARATELY

Melbourne's 24 million cells are a sum across separate dishes, not one larger brain. Scale matters in two ways: more cultures carry the unanswered question, and each donor's DNA spreads to more machines.

THE BRAINSTEM RULE

The strongest skeptical case is real, and it is about present flat cultures.

Birch proposes that if an organoid develops or connects to a working brainstem that controls arousal and sleep and waking cycles, it is a sentience candidate. People with different theories can agree on that, because a person whose brainstem has permanently failed is not sentient. He also counsels a default skepticism toward bare tissue outside any organism.

WHAT THE PAPER ACCEPTS

Evidence of absence

No brainstem, no body, no pain receptors. That is evidence that relevant structures are missing, which is stronger than a lack of evidence, and it supports probable noncandidacy for today’s flat cultures.

WHAT IT CONTESTS

Three stretches

Applying it to tomorrow’s cultures, to cultures being deliberately reorganized, and to the flat certainty of the on-camera answers.

TISSUE, ORGANISM, AND THE CLOSED LOOP

A culture whose input depends on its own output is not quite a slice in a dish.

THE OPEN QUESTION

Closed loop

Life support alone does not set the CL1 apart. The closed loop does: the culture is raised in a simulated world that answers it. On views tying minds to self-maintaining organisms, software from outside changes nothing. On views tying minds to a system coupled to its world, it might.

EMBODIMENT

Croxford and Bayne

Their view: organoids without bodies are unlikely to be conscious. The 2022 study called its cultures embodied in a game world. Nobody knows if wiring through electrodes counts; if it does, the CL1 is not exempt.

RESTRICTIONS

Holm and Lewis

They would restrict organoid research only once valenced experience is nontrivially likely. The paper agrees about today and restricts nothing; its records are how anyone would notice a change.

THE PREDICTION

The prediction of no consciousness is either unsupported, or a claim only about cultures as they are.

READ LITERALLY

No mind can arise here

That needs an argument about organization, which was not given, or the organism argument, which the equivalence claim itself rejects.

READ CHARITABLY

Nothing will appear suddenly

True of today’s cultures, perhaps. But the cultures are being changed on purpose, and since no proven detector exists, a slow change would go unnoticed too.

CONVERGENT UNCERTAINTY

Five doubts meet in one system. No one can say what organization experience needs. There is no validated detector. Experience might take unfamiliar forms. It is unsettled whether this material can host it, and here the material weighs toward concern. And the cultures are being engineered for more organization. Confidence would require settling at least one of these; no one did.

A WORKING PRECEDENT

Britain recognized crabs and octopuses as sentient without claiming to know their inner lives.



WHAT CARRIES OVER, AND WHAT DOES NOT

Britain had positive evidence from living animals; for today's cultures the evidence runs the opposite direction, so restrictions do not transfer. The procedure does: admit the question is open, give a standing body a duty to keep asking, and let review move with the evidence.

The Equivalence Claim

Is a living culture just a simulation?

Either the claim settles nothing about status, or it asserts something the company's own laboratory has disclaimed.

TWO READINGS

“Same ethics” can mean the same rules, or the same standing.

SAME PRINCIPLES

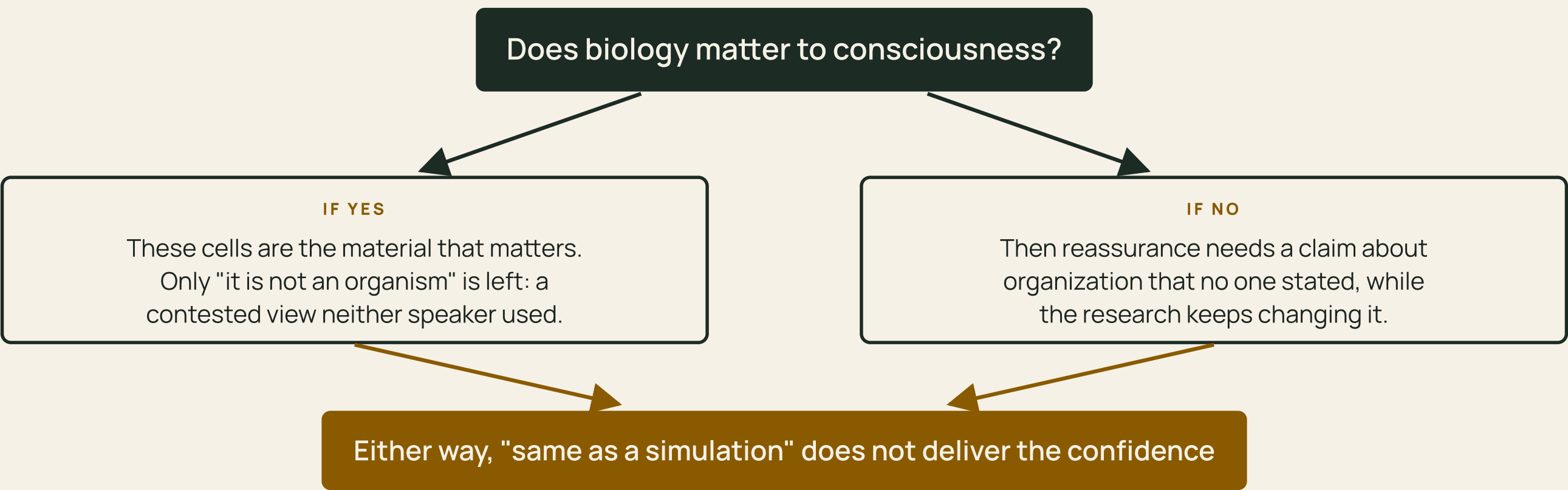
Harmless, settles nothing

A single rulebook can rule differently on different systems, provided composition can count as evidence.

SAME STATUS

Carries the reassurance

The cultures get whatever a simulation gets. Only this reading reassures, and it fails.



TAKING THE CLAIM AT ITS WORD

If the same rules apply, the rules for big AI systems apply here too.

Suppose the AI systems being compared really are not conscious. The reassurance still needs the cultures to resemble them in whatever makes them so, which is the organizational claim nobody made. The comparison is also undefined: which systems, and which principles?

THE CONSEQUENCE

Should the rules for big AI systems call for records, disclosure, and outside evaluation, an operator who adopts the equivalence has signed up for most of the measures in Part VI.

A YARDSTICK FROM THE OPERATOR’S OWN LAB

Kagan’s own paper says shared vocabulary “does not imply moral equivalence”.

CLASS	WHAT IT MEANS	WHERE THINGS FALL
I	Reactive, no memory	A thermostat, in the authors’ own examples
II	Has memory, but fixed rules for transforming input	A trained AI model whose rules are fixed in use, plausibly
III	Adaptive: its rules change with its own past activity	The 2022 cultures changed how they transformed input during play, which meets this class by the definitions

WHAT FOLLOWS

Class III is said to be necessary for morally relevant agency, not sufficient, so this stops short of candidacy. Still, the company’s own measure cannot exclude the cultures, and it has no test that could back up what was said on TV. The authors never place the cultures in a class themselves; that step is the paper’s reading of their definitions.

ABSENCE OF EVIDENCE

The company's line matches professional guidance. That guidance also says to keep watching.

The ISSCR, the stem cell field's professional society, says there is currently no biological evidence of consciousness or pain in brain organoids that would call for special oversight. The same passage tells researchers to watch for issues as organoids mature over long periods or are assembled together, which describes the 500-day and 400-day cultures, and, for software coupling across units, the nearest analogue to assembly.

TWO DIFFERENT BARS

A field with no validated detector proves little by finding nothing. Following Dung: asserting an inner life in a culture should require strong proof, while giving modest consideration under uncertainty should face a low one. They should not be confused.

THE THREE-DIRECTIONAL INCONSISTENCY

One rule, set composition aside, applied three ways.
In the third, it throws away evidence.

DIRECTION	EXAMPLE	WHAT THE MATERIAL TELLS US
Machine into human	A pacemaker or cochlear implant	Nothing about whether the person has a mind; their standing was settled already
Animal into human	A pig heart valve	Nothing, for the same reason
Human into machine	Human neurons in a computer	The computing part is the one material known to support experience; setting it aside discards evidence

AND THE SOURCE

A manufacturer or an animal has claims of its own, handled separately. Here the source is a person, and that person’s DNA runs through every culture; treating the host like code gives that person no place. What remains is the owner’s discretion, a line drawn by ownership, not by science.

THE OBLIGATION A SIMULATION NEVER HAS

No simulation carries a piece of a living person. Every culture does.

A GENOME IN MANY RACKS

Because a few donors can supply many devices, one person’s DNA could be computing in many racks at the same time. Van Till and colleagues place the moral value of neuron models, even simple ones, partly in that genetic link and their symbolic value.

CONSENT UNDER STRAIN

Kataoka and colleagues argue uncertainty about consciousness undermines donor consent and favor consent per project. Gaillard argues classic informed consent nearly breaks down when tissue outlives anything its donor foresaw.

WHO OWES THE ACCOUNT

Professional guidance accepts vendor cell lines only when used consistently with the original consent. Whoever uses the material should know what that consent covered and be able to say so.

Whose Neurons

What the record shows about the donors

The research lines trace to newborns. Nothing public says who gave the cells in the commercial racks, or what they agreed to.

WHAT THE RECORD SHOWS

The cells that learned Pong came from newborns. Any consent was their parents’.

THE RESEARCH LINES

2022

Both lines came under a transfer agreement from Murdoch Children’s Research Institute. One was built on ATCC PCS-201-010, fibroblasts from a newborn boy’s circumcision tissue; the other, RM3.5, also from newborn foreskin.

THE SUPPLIER’S TERMS

ATCC

The supplier says its tissue was obtained with informed consent, is for laboratory research, and needs a license for any commercial use. Whether those terms follow derived lines is not public.

THE COMMERCIAL LINES

Unknown

Recent descriptions say adult blood or other donated tissue. Nothing public identifies which lines the rented units use, what donors heard, whether their consent reached computing, whether they got paid, or how cultures are disposed of.

CONSENT STRETCHED PAST ITS PURPOSE

One feature of the Henrietta Lacks case recurs: agreement for one use, extended to another.

In 1951 Henrietta Lacks signed a treatment form that never mentioned research, and tissue removed in that treatment became the HeLa cell line; no one told her. The comparison is limited to the shape of the consent problem. The paper claims no parallel to the racial and institutional exploitation she suffered. If newborn lines are in commercial use, the stretch is longer: parents' agreement, at most for research, used for a computing business.

WHAT GUIDANCE ALREADY ASKS

Stem cell guidance asks that donors be told about possible commercial uses and whether they would share in any profit. Others argue a thick opt-out is not enough for organoid banks, and Kagan's own 2023 review says donors should understand what biocomputing implies. The public record cannot show whether these were met.

WHERE THE LAW LOOKS

Rules that protect donors assume research, tissue traceable to a person, and its original form.

QUESTION	WHAT THE LAW SAYS	THE GAP
Is renting computing time research?	Singapore and the U.S. Common Rule define research as work toward generalizable knowledge	A customer running an app may be doing neither
Does consent attach?	U.S. consent rules reach identifiable specimens; profit disclosure only “when appropriate”	Deidentified cell lines fall outside
Does the donor have a claim?	<i>Moore</i> : no conversion claim; disclosure duty lies with the physician	Commercial developers owed no direct duty
Is it still human tissue?	Singapore excludes tissue that is unidentifiable and substantially manipulated; Victoria bans sale of tissue taken from the body	Reprogrammed neurons may fall outside both, untested

Not legal advice, and no claim that these laws govern this operator. Australia’s national research guidance, revised in 2026, was not reviewed.

SOURCES Human Biomedical Research Act 2015, ss. 2, 32, 37, First Sched. para. 4(1) (Sing.); 45 C.F.R. §§ 46.102(e)(1), (l), 46.116©(7), (d)(1) (2018); *Moore v. Regents of the Univ. of Cal.*, 51 Cal. 3d 120, 129, 131–33, 143 (1990); Human Tissue Act 1982 (Vic) ss 3, 38–39 (Austl.).

Governance Without Prohibition

Six measures, none of them a ban

Demand strong proof before crediting a culture with an inner life, ask little before taking modest care, and deal with donors today.

REVIEW TRIGGERS KEYED TO ORGANIZATION

Commit in advance to independent review when a culture shows any of six markers.

- 1 3D organoid structure, or brainstem-like tissue that regulates arousal ALREADY MET
- 2 Sleep-and-wake-like switching between global activity states
- 3 Kept alive past a duration the operator states now DUE NOW
- 4 Cultures coupled across units into one network, or memory circuitry used for lasting tasks PARTLY MET

A TRIGGER IS A REASON TO LOOK

Review can find nothing has changed. If something has, it can change training signals, add monitoring, notify donors, and publish. 3D organoids and hippocampal lines have already run on the CL1, so review is due for that work today.

RECORDS AND DISCLOSURE

Log what the cultures receive, say whose cells they are, and record how they end.

TRAINING SIGNALS

Logged every session

Because renters write the stimulation, the operator should log its strength, frequency, and duration, review protocols that rely on avoidance, publish totals, and prefer designs that work without avoidance when they perform as well.

PROVENANCE

Published

Name the cell lines, the scope of each consent, license terms, and whether donors were paid, plus each unit’s makeup, count, and coupling. Seek consent that names biocomputing, with a way to opt out of uses, and recontact donors where consent covered research only.

DECOMMISSIONING

Recorded

Write down when and how each culture is ended, what becomes of the tissue, and how long cultures really last.

Why log at all, when cells lack pain receptors? Because the training is built to recreate, in human cells, the avoidance behavior that scientists read as a sign of distress in animals. That aim warrants a record, not a conclusion.

MEASUREMENT AND REGULATION

Say what would change your mind, and let regulators say what the rules cover.

STATED CRITERIA

Make the checking checkable

Publish what the company checks for, what evidence would change its view, and what it would do. Back research on signs that do not rely on behavior, like perturbational complexity.

REGULATORY CLARITY

Singapore, Victoria, and elsewhere

Say plainly whether renting time on neural cultures is covered by research and tissue law, and whether anonymized, heavily altered human neural tissue is too.

A STANDING COMMITTEE

On the UK model

A panel modeled on Britain’s Animal Sentience Committee could track biocomputing and serve as the independent reviewer the triggers require.

WHY NOT A MORATORIUM?

Birch leaves one open. The paper takes his other path, review with weighing of harms and benefits, since pausing would halt the measurement work that could actually answer the question, and push the whole matter out of sight.

SOURCES 10 News+. (2026, October 4). *Scientists are creating the world’s first biological computer in Australia* [Video]; Lavazza & Massimini (2018); Bayne et al. (2020); Birch & Browning (2021); Birch, J. (2024). When is a brain organoid a sentience candidate? (Version 2). *Molecular Psychology*.

VII

Objections and Limits

What the paper concedes, and what it still claims

Today's cultures are unlikely to feel anything. Modest care is still not premature.

SEVEN OBJECTIONS, ANSWERED

The paper concedes the evidence for today’s cultures and holds its ground on the rest.

OBJECTION	THE REPLY
Labs have used neural tissue for decades	Accepted for flat cultures; the CL1 adds closed loops, scale, renter code, engineered organization, and sale
Slime molds learn too	Conceded; the animals answer only the size argument, and learning is never treated as evidence of experience
Oversight slows animal replacement	It bans nothing; its costs are small and the kind animal research already bears
It was only about vocabulary	Then it settles nothing about status and still leaves the donor
The likelihood is trivial	A small chance still justifies small precautions; one trigger is already met; what donors are owed has nothing to do with probability
Donors’ interests end at donation	The claims are the genetic link and the scope of consent, not property
Academic labs do this too	The package applies anywhere; the commercial setting adds renter code with no described ethics review

SOURCES Birch (2024); Holm & Lewis (2025); *Moore v. Regents of the Univ. of Cal.*, 51 Cal. 3d 120, 143 (1990); van Till et al. (2023); This paper, Section VIII.

LIMITS AND NEXT STEPS

The evidence is thin in known places, and two studies would firm it up.

LIMITS

Stated by the paper

Reading Kagan’s answer as about size is a reconstruction from a TV clip. Schultz was edited in from a separate interview. Figures per unit vary and count cells, not survivors. Which lines and configurations are in the racks is unknown. The animal counts use different methods. The legal reading is untested.

FUTURE WORK, ONE

A provenance audit

Request that the company and its partners name the cell lines and setups in the rented units, release the consent forms and licenses, compare them with the stem cell guidance, and publish whatever the result.

FUTURE WORK, TWO

A measurement study

A preregistered study of hippocampal organoids kept over a year on the CL1, testing for sleep-like state switching and perturbational complexity against flat controls, with the trigger result stated in advance.

THE CLAIM

Nobody has shown nothing is there, or that nothing ever will be.

The CL1 removes silicon from the debate. What is left is living human neurons, trained by a design that assumes they avoid unpredictable input, sustained by machinery, wired to a virtual world, rented online, and made more organized on purpose. As a count, the size argument fails against animals science treats as candidates; as simple wiring, it holds only while the wiring stays simple. The prediction says nothing about cultures being built. The equivalence either settles nothing or asserts what the company's own lab disclaims, and either way leaves out the donors.

WHAT IS OWED NOW

Donors whose cells fill the racks deserve an accounting now. No neuron count will settle the question either way. Organization and closed-loop coupling might, and the company is developing both.

REPRODUCED FROM THE PAPER’S REFERENCE LIST, GROUPED BY KIND

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