BRAINS IN A DISH: ORGANOID INTELLIGENCE AND THE FUTURE OF COMPUTING

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I. INTRODUCTION

Human neurons in a dish are learning to play video games and, for better or worse, those neurons may represent the future of artificial intelligence (AI).[1] These cerebral organoids, also known as mini-brains, are small, lab-grown, three-dimensional structures of neural tissue that can mimic the development and functionality of the human brain. For over a decade, organoids have been instrumental in gathering profound insights into human neurology, leading to breakthroughs in neurological research and drug development.[2] Now, researchers and companies like Cortical Labs, an Australian biotechnology research company, and FinalSpark, a Swedish tech startup, are selling access to its organoids as a subscription service and making strides in transforming human neurons into bioprocessors capable of computation, learning, and analysis.[3]

As traditional AI faces growing concerns over energy consumption and environmental sustainability,[4] the developing field organoid intelligence (OI) has the potential to be a more energy-efficient alternative to today's machine-learning models.[5]

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[1] Brett J. Kagan, Andy C. Kitchen, Nam T. Tran, Farshad Habibollahi, Mohammad Khajehnejad, Benjamin J. Parker, Kagan K. Oghalai, Olivia M. DeMarse, Forough Habibollahi, Moein Khajehnejad, Amitesh Gaurav, Anish S. Dalal, James M. Jun, Alexander D. Wissner-Gross, David B. Grayden, Rod D. Adams, Steve M. Potter, Jon H. Kaas, Karl J. Friston & Adeel Razi, *In Vitro Neurons Learn and Exhibit Sentience When Embodied in a Simulated Gameworld*, 110 NEURON 3952 (2022), https://doi.org/10.1016/j.neuron.2022.09.001.

[2] Hong Chen, Xuan Jin, Tong Li & Zhen Ye, *Brain Organoids: Establishment and Application*, 10 FRONTIERS IN CELL & DEV. BIOLOGY 1029873, 1, 2 (2022), https://doi.org/10.3389/fcell.2022.1029873.

[3] Cortical Labs, https://corticallabs.com/company.html (describing the company as a Melbourne-based biotech firm developing a new generation of biological computers) [https://perma.cc/5RA8-KHVZ]; Alexandre Lacoste, Alexandra Luccioni, Victor Schmidt & Thomas Dandres, *Quantifying the Carbon Emissions of Machine Learning*, ARXIV (2019), https://doi.org/10.48550/arXiv.1910.09700; FinalSpark, *Neuroplatform*, https://finalspark.com/neuroplatform/ (detailing subscription access to living brain organoid processors starting at $1,000 per month) [https://perma.cc/CR3U-XQ6X].

[4] Lacoste et al., *supra* note 3.

[5] Lena Smirnova, Brian S. Caffo, David H. Gracias, Qi Huang, Itzy E. Morales Pantoja, Bohao Tang, Donald J. Zack, Cynthia A. Berlinicke, J. Lomax Boyd, Timothy D. Harris, Erik C. Johnson, Brett J. Kagan, Jeffrey Kahn, Alysson R. Muotri, Barton L. Paulhamus, Jens C. Schwamborn, Jesse Plotkin, Alexander S. Szalay, Joshua T. Vogelstein, Paul F. Worley & Thomas Hartung, *Organoid Intelligence (OI): The New Frontier in Biocomputing and Intelligence-in-a-Dish*, 1 FRONTIERS IN SCI. 1017235, 1, 17 (2023) (discussing OI-based biocomputing systems as enabling faster

Simultaneously, OI raises complex ethical and legal questions about the integration of human brain tissue with computer technology. This Technology Explainer discusses the science behind cerebral organoids, introduces the concept of organoid intelligence, and briefly reviews some of the legal and ethical implications of the field.

II. HOW CEREBRAL ORGANOIDS ARE DEVELOPED

This section outlines the foundational technologies and methodologies used in cerebral organoid development, from cellular reprogramming to three-dimensional cultivation techniques that enable these structures to mimic aspects of human brain tissue.

A. FROM BODY CELLS TO BRAIN CELLS

The creation of cerebral organoids begins with stem cells, which are like multipotent biological building blocks that can differentiate themselves into many kinds of specialized cells.[6] There are several ways to generate stem cells – such as sourcing them from embryonic tissue or by using cloning therapies – however, many researchers now prefer to take somatic cells, like those from skin or blood, and carefully transform them with reprogramming factors until they revert back into their stem cell-like state.[7] This process results in "induced pluripotent stem cells" (iPSCs), and while they take weeks to develop, iPSCs are widely regarded as a more ethical alternative to stem cells sourced from embryos or fetal tissues.[8]

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decision-making, continuous learning, and new insights into cognition and cognitive disorders), https://doi.org/10.3389/fsci.2023.1017235.

[6] *Differentiate,* MERRIAM-WEBSTER DICTIONARY (2025) (biological definition, "the sum of the processes whereby apparently indifferent or unspecialized cells, tissues, and structures attain their adult form and function"), https://www.merriam-webster.com/dictionary/differentiation [https://perma.cc/F8HF-E6CW].

[7] For a definition of "somatic cells," see MERRIAM-WEBSTER DICTIONARY (2025), https://www.merriam-webster.com/dictionary/somatic%20cells [https://perma.cc/F8HF-E6CW] ("[O]ne of the cells of the body that compose the tissues, organs, and parts of that individual other than the germ cells."). For a discussion of stem cell differentiation, see Shaojun Yang, Hao Hu, Hsiao-Tuan Kung, Ruru Zou, Yijun Dai, Yu Hu, Ting Wang, Tian Lv, Jing Yu & Feng Li, *Organoids: The Current Status and Biomedical Applications*, 4(3) MEDCOMM e274, 1, 5 (2023), https://doi.org/10.1002/mco2.274 (explaining that organoids can be established from stem cells, including ESCs, iPSCs, and ASCs, through self-organization similar to natural organ development).

[8] Timothy J. Nelson, Alba Martinez-Fernandez & Andre Terzic, *Induced Pluripotent Stem Cells: Developmental Biology to Regenerative*

The stem cells, once formed, are then guided through another series of developmental cues, prompting them to transform into early-stage brain cells known as "neural progenitor cells."[9] Researchers can either implant these cultivated cells into living organisms (*in vivo*) or, as in the case of OI, grow the cells outside of a living host (*in vitro*). The *in vitro* development process requires placing the neural progenitor cells into a gel-like matrix that functions like scaffolding upon which the cells can grow, multiply, and further differentiate into neurons and other types of brain cells until they ultimately arrange into the three-dimensional tissue structures scientists call "organoids."[10] Since the 1980s, the term organoid – with its root words literally meaning "resembling an organ" – has signified groupings of cells that mimic the function of organs on a much smaller scale.[11] In this context, a cerebral organoid is a small clump of cells that mirrors the qualities of a human brain.

Despite often being called "mini brains" colloquially, it would be a mistake to think of these organoids as complete and functioning human brains due to their limited complexity and shortened lifespan. Cerebral organoids *in vitro* are typically no larger than 4mm in diameter –about the size of a pea – and as such, they pale in comparison to the complexity and neurological denseness of larger structures in the human brain, like the neocortex.[12] Further, without

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Medicine, 7 NAT. REV. CARDIOLOGY 700 (2010), https://doi.org/10.1038/nrcardio.2010.159.

[9] Mutsumi Eiraku, Kazunari Watanabe, Masakazu Matsuo-Takasaki, Masato Kawada, Shigenobu Yonemura, Masahiro Matsumura, Hiroshi Wataya, Satoshi Nishiyama, Kojii Ohtsuka, Kunihiro Ishizaki, Makoto Takahashi, Masaya Sakurada, Naoko Ogura, Takumi Motoyama, Masaya Koyanagi, Yoshiki Yonemitsu, Ryuichi Ishibashi, Nobutaka Kojima, Taisuke Ishii & Yoshiki Sasai, *Self-Organized Formation of Polarized Cortical Tissues from ESCs and Its Active Manipulation by Extrinsic Signals*, 3 CELL STEM CELL 519, 521 (2008) (describing the development of neural progenitor cells and their differentiation into distinct cortical layer cell types), https://www.cell.com/cell-stem-cell/fulltext/S1934-5909(08)00455-4.

[10] Yong Jin Hong, Se Bin Lee, Jihoon Choi, Seok-Ho Yoon & Jeong Tae Do, *A Simple Method for Generating Cerebral Organoids from Human Pluripotent Stem Cells*, 15 INT'L J. STEM CELLS 95, 96 (2022), https://doi.org/10.15283/ijsc21195.

[11] Mina Simian & Mina J. Bissell, *Organoids: A Historical Perspective of Thinking in Three Dimensions*, 216 J. CELL BIOLOGY 31, 32 (2017), https://doi.org/10.1083/jcb.201610056.

[12] Xuyu Qian, Hongjun Song & Guo-li Ming, *Brain Organoids: Advances, Applications and Challenges*, 146 DEVELOPMENT dev166074, 1, 3 (2019) (noting that brain organoids typically grow to 3–4 millimeters in diameter, about the size of a small pea), https://doi.org/10.1242/dev.166074.

a vascular system and a heart to pump and circulate blood, organoids often struggle to sufficiently distribute the oxygen and nutrients needed for the tissue to survive, which greatly limits both their longevity and their developmental potential.[13] Organoids can be engineered to mirror specific regions or qualities of the brain, but, at the time of this publication, researchers cannot grow an entire human brain from iPSCs. Despite this limitation, a myriad of uses already exist for organoid technology in medical research and computational intelligence alike.

B. CURRENT MEDICAL APPLICATIONS

Cerebral organoids have revolutionized neurological research in disease modeling and developmental studies, unlocking potential new regenerative therapies that may be able to help the brain repair itself.[14] Cerebral organoids are also valuable sources of stem cells for personalized medicine and "cell replacement therapies," where healthy cells are transplanted in place of lost or damaged neurons.[15] These organoid-derived therapies are being studied to treat conditions like Parkinson's disease[16] and multiple sclerosis.[17] Organoids are also beginning to reduce the amount of controversial animal testing done in laboratories, as they provide a more accurate representation of human biology than studies done on rats or other animals.[18]

While these medical applications continue to evolve, cerebral organoids have also emerged at the intersection of neuroscience and computer science, potentially revolutionizing how we think about both biological and artificial intelligence.

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[13] *Id.* at 4 (explaining that due to the absence of vascularization and circulation, brain organoids develop a necrotic core with limited viable thickness).

[14] Soo Hyun Kim & Mi Yoe Chang, *Application of Human Brain Organoids—Opportunities and Challenges in Modeling Human Brain Development and Neurodevelopmental Diseases*, 24 INT'L J. MOLECULAR SCI. 12528, 1, 8 (2023), https://doi.org/10.3390/ijms241512528.

[15] *Id.*

[16] *Id.* at 9.

[17] Ling Yang, Si-Cheng Liu, Yi-Yi Liu, Fu-Qi Zhu, Mei-Juan Xiong, Dong-Xia Hu & Wen-Jun Zhang, *Therapeutic Role of Neural Stem Cells in Neurological Diseases*, 12 FRONTIERS IN BIOENGINEERING & BIOTECHNOLOGY 1329712 (2024), https://doi.org/10.3389/fbioe.2024.1329712.

[18] Jack McGovan, *Reimagining Alternatives to Animal Testing*, JOHNS HOPKINS MAGAZINE (Fall 2024), https://hub.jhu.edu/magazine/2024/fall/alternatives-to-animal-testing-advances/ [https://perma.cc/M8KP-XZEG].

III. ORGANOID INTELLIGENCE EXPLAINED

As cerebral organoids grow more sophisticated, researchers are exploring ways to merge the unique, inherent properties of computers and the human brain, attempting to create the first seamlessly integrated artificially intelligent biological computer.[19]

A. THE HUMAN BRAIN'S COMPUTATIONAL POWER

In many ways, the human brain functions like a computer.[20] It receives input in the form of sensory information and produces outputs such as movement, speech, or memory recall, just as a basic computer processes data and generates responses. Moreover, just like a computer's circuitry, the brain relies on electrical impulses to transmit signals across synapses.[21] Neurons process information through graded electrical potentials and complex synaptic interactions, creating a sophisticated signaling system that, while fundamentally different from digital computation, offers compelling parallels that make brain-computer interfaces conceptually viable.[22]

Despite these similarities, there are profound differences in the way brains and computers process information.[23] Standard digital computers work linearly, executing operations in step-by-step sequences and storing their data in fixed, clearly defined locations.[24] Conversely, the brain processes information simultaneously across

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[19] L.R.J. Chakka & Mohammed Maniruzzaman, *Organoid Intelligence: Training Lab-Grown Mini-Brains to Learn and Compute with AI*, 11 AAPS OPEN, 4, 2 (2025) (exploring potential applications of AI-integrated brain organoids in drug development and bio-computing, emphasizing their energy efficiency and adaptability), https://doi.org/10.1186/s41120-025-00109-3.

[20] Univ. of Colo. at Boulder, *Human Brain Region Functions Like Digital Computer*, SCIENCEDAILY (Oct. 6, 2006), https://www.sciencedaily.com/releases/2006/10/061005222628.htm [https://perma.cc/XZ7W-TG72].

[21] Tasnim K. & Liu J., *Emerging Bioelectronics for Brain Organoid Electrophysiology*, 434 J. MOLECULAR BIOLOGY 167165 (2022) (noting that brain organoids can exhibit spontaneous network activity and generate rhythmic oscillations similar to delta and gamma waves in the human brain, though detection is limited by current technology), https://doi.org/10.1016/j.jmb.2021.167165.

[22] *See generally* Alberto E. Pereda, *Electrical Synapses: A Functional Comparison with Chemical Synapses*, 15 NATURE REV. NEUROSCIENCE 250, 250–263 (2014), https://doi.org/10.1038/nrn3708.

[23] Smirnova et al., *supra* note 5.

[24] *See generally* Petter Aaser, Marius Knudsen, Ole Henrik Ramstad, Michael Engelund, Eivind Svanæs, Robert Jenssen & Emre Yaksi, *Towards Making a Cyborg: A Closed-Loop Reservoir-Neuro System*, in Proc. of the 14th Eur. Conf. on Artificial Life (ECAL 2017) 430 (2017), https://doi.org/10.1162/isal_a_072.

billions of neurons and distributes this information along interconnected networks, constantly rewiring itself based on experiences and demonstrating a kind of built-in plasticity that many researchers are eager to replicate.[25]

The brain's efficiency surpasses current computing technologies in several key respects, particularly in terms of energy consumption and learning capabilities. While computers surpass the human brain's capacity for quick, complex, and accurate calculations, the human brain is optimized for efficient learning and problem-solving in ways that computers are not.[26] For example, where a human brain would need approximately 20 watts of energy to think through and solve a problem, the clusters used in machine-learning models typically require *one million* watts of energy to process similar results.[27]

This efficiency extends to the brain's remarkable learning capabilities, which far outpace current machine learning systems in certain contexts.[28] For instance, if you wanted to train a machine-learning model to do a simple "same-versus-different" task, like recognizing images of cats from images without cats, you would need hundreds of training samples before the computer could even begin to determine whether a picture had a cat in it, and *thousands* before the results were reliably accurate.[29] Conversely, it would only take a sample size of around ten photos before a human could accurately identify images of cats.[30] The human brain is also faster at making accurate inferences from what it has learned. For instance, the brain may quickly recognize a tiger as a kind of cat with no additional prompting, whereas a computer model would need a larger and more comprehensive dataset to accurately make that connection.[31]

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[25] Smirnova et al., *supra* note 5, at 17.

[26] *Id.*

[27] *Id.* at 3 (noting that Frontier, the world's most powerful supercomputer as of June 2022, consumes 21 megawatts to reach 1.102 exaFlops, while the human brain is estimated to achieve similar performance at just 20 watts—demonstrating a 10^6-fold power efficiency advantage for biological computation).

[28] *Id*. at 2.

[29] *Id*. at 3 (citing François Fleuret et al., *Comparing Machines and Humans on a Visual Categorization Test*, 108 PROC. NAT'L ACAD. SCI. U.S. 17621 (2011), https://doi.org/10.1073/pnas.1109168108)).

[30] *Id.*

[31] Radoslaw M. Cichy, Martin P. Paul, Joshua C. Peterson, Marvin Rezanejad, Robert M. Bilder, Thomas Naselaris & Joshua B. Tenenbaum, *The Challenge of Representing Visual Relations in Deep Neural Networks*, 8 INTERFACE FOCUS 20180011, 1, 10 (2018), https://doi.org/10.1098/rsfs.2018.0011.

Scientists have already made significant strides in merging brain organoids with digital computers, and the field is increasingly close to harnessing the best of both the brain's energy efficiency and neural plasticity with a computer's raw computational power.[32] This convergence represents an exciting frontier in biocomputing research, and it is why researchers globally are dedicating themselves to further developing organoid intelligence.

B. HOW OI WORKS: NEUROLOGICAL INTERFACES AND MULTIELECTRODE ARRAYS

The integration of brain organoids with computational systems requires sophisticated two-way communication mechanisms between the organoid and the electronic devices. Most commonly, researchers use microelectrode arrays (MEAs) that can both record and stimulate electrical activity within the organoid's neural networks.[33] These arrays consist of dozens to thousands of tiny electrodes embedded in a substrate, either rigid like glass or a flexible polymer, which make contact with various parts of the organoid tissue.[34] When neurons in the organoid fire, the electrodes detect the resulting electrical signals, which are then amplified and processed by a computer system. In response, the electrodes can deliver precise electrical stimuli to specific regions of the organoid, influencing neural activity and creating bidirectional communication.[35]

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[32] Haixia Shi, Andrzej Kowalczewski, Duy Vu, Jianning Li, Hongliang Wang, Wenrui Gu, Yujie Wen, Xiangjian Bai, Honglian Liu, Yong Lu, Zhi Yang & Shuo Lin, *Organoid Intelligence: Integration of Organoid Technology and Artificial Intelligence in the New Era of In Vitro Models*, 21 MED. NOVEL TECH. & DEVICES 100276 (2023), https://doi.org/10.1016/j.medntd.2023.100276.

[33] Brett J. Kagan, Christopher Gyngell, Tanya Lysaght, Cynthia Scholes, Victor Bote, Philip Kennedy, Erik H. Snow, Diana M. Fleischman, Helen Lambert, Julian Savulescu & Adeel Razi, *The Technology, Opportunities, and Challenges of Synthetic Biological Intelligence*, 68 BIOTECHNOLOGY ADVANCES 108233, 3 (2023), https://doi.org/10.1016/j.biotechadv.2023.108233.

[34] Mary E.J. Obien, Konstantinos Deligkaris, Tobias Bullmann, Douglas J. Bakkum & Urs Frey, *Revealing Neuronal Function Through Microelectrode Array Recordings*, 8 FRONTIERS IN NEUROSCI. 423 (2015), https://doi.org/10.3389/fnins.2014.00423.

[35] Stefano L. Giandomenico, Stefan B. Mierau, Grace M. Gibbons, Laura M.D. Wenger, Luca Masullo, Tanya Sit, Matthew Sutcliffe, Julie Boulanger, Marco Tripodi, Emmanuel Derivery, Ole Paulsen, Gabriella Lakatos & Madeline A. Lancaster, *Cerebral Organoids at the Air–Liquid Interface Generate Diverse Nerve Tracts with Functional Output*, 22(4) NATURE NEUROSCI. 669 (2019), https://doi.org/10.1038/s41593-019-0350-2.

The resulting data from MEAs is so enigmatic and complex that researchers rely on machine learning and computational biology to decode the electrical impulses into usable data.[36] Neural activity patterns are inherently intricate, featuring rhythmic oscillations, synchronization events, and seemingly random spiking behaviors.[37] Machine learning's advanced pattern recognition abilities can organize, define, and translate these otherwise indecipherable brain signals into usable information, making machine learning integral to allowing researchers to communicate with organoids in real time.[38] These AI-driven bioinformatics breakthroughs are what make it possible for organoids to respond to simulated virtual environments, receive "training" on desired and undesirable outcomes, and participate in "goal-directed" behavior.[39]

Despite still being in its early stages, the field of OI is no longer a far-fetched, theoretical concept. In fact, at the time of this publication, there are already several companies offering commercially available access to the processing power of proprietary computer-integrated cerebral organoids, and researchers have published groundbreaking findings on both OI's computational capacity and possible sentience. In 2022, Cortical Labs, a biotechnology research company based out of Australia, made headlines with its "DishBrain" study, wherein human brain organoids were trained to perform real-time, goal-directed tasks like playing the video game "Pong" in a simulated virtual environment.[40] The organoids not only learned the rules of the game, but they outperformed the fully digital machine-learning algorithms in both

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[36] *See generally* Vinicius Hernandes, Anouk M. Heuvelmans, Valentina Gualtieri, Dimphna H. Meijer, Geeske M. van Woerden & Eliska Greplova, *autoMEA: Machine Learning-Based Burst Detection for Multi-Electrode Array Datasets*, 18 FRONTIERS IN NEUROSCI. 1446578 (2024), https://doi.org/10.3389/fnins.2024.1446578.

[37] Obien, et al., *supra* note 34.

[38] Cleber A. Trujillo, Rui Gao, Pedro D. Negraes, Jun Gu, James Buchanan, Stephan Preissl, Andrew Wang, Wei Wu, Gabriel G. Haddad, Ian A. Chaim, Anne Domissy, Maxime Vandenberghe, Arnold Devor, Gene W. Yeo, Bradley Voytek & Alysson R. Muotri, *Complex Oscillatory Waves Emerging from Cortical Organoids Model Early Human Brain Network Development*, 25(4) CELL STEM CELL 558 (2019), https://doi.org/10.1016/j.stem.2019.08.002.

[39] Kagan et al., *supra* note 1.

[40] Forough Habibollahi, Moein Khajehnejad, Amitesh Gaurav & Brett Joseph Kagan, *Biological Neurons vs. Deep Reinforcement Learning: Sample Efficiency in a Simulated Game-World* (Oct. 9, 2022) (unpublished manuscript), https://openreview.net/pdf?id=N5qLXpc7HQy, [https://perma.cc/MDU6-URG8].

improvement over time and overall high score.[41] Cortical Lab's organoids also showed indications of sentience by responding to sensory impressions through "adaptive internal processes" that mirror the neuroplasticity of human learning and decision making.[42] FinalSpark, another OI company, has begun training its organoids with dopamine, quite literally rewarding desired behaviors by flooding the organoids with the kind of feel-good chemicals that our embodied brains often crave.[43] Though researchers agree that cerebral organoids lack sensory and pain receptors, meaning they generally cannot "feel" things in a traditional sense, there is an active debate on whether and how the merging of organoids with AI – or similarly connecting organoids to robots with visual processors and ambulatory abilities – may increase the organoids cognitive capacity to a point that necessitates a more evolved ethical framework for OI research and development.[44]

As with any new scientific development, there are more questions than answers regarding the full scope of OI's capabilities. While maintaining living tissues remains a laborious and expensive challenge for researchers, and the practicality and scalability of OI remain to be seen, there have been sufficient advancements to warrant serious conversations on the ethics, applicability, and overall desirability of OI.

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[41] *Id.* at 4 (wherein performance improvement was measured by the number of times the ball was successfully rallied from paddle to paddle. In the initial testing phase, the human cerebral organoids had fewer long rallies compared to the machine-learning control group. In the second phase, the organoids showed a significant increase, outperforming all control groups with a level of statistical certainty that precludes a random improvement by chance).

[42] Kagan et al., *supra* note 1 at 3953.

[43] Loz Blain, *Living Brain-Cell Biocomputers Are Now Training on Dopamine*, NEW ATLAS (May 28, 2024), https://newatlas.com/computers/finalspark-bio-computers-brain-organoids/ [https://perma.cc/MP3Q-76M6].

[44] For an example of an ambulatory OI robot, see Lacy Schley, *Meet the Scientists Connecting Lab-Grown "Mini Brains" to Robots*, DISCOVER MAGAZINE (Nov. 2, 2018), https://www.discovermagazine.com/mind/meet-the-scientists-connecting-lab-grown-mini-brains-to-robots [https://perma.cc/UX64-JEYW]; for a general discussion on how merging organoids with technology may inform OI ethics, see Thomas Hartung, Itzy E. Morales Pantoja & Lena Smirnova, *Brain Organoids and Organoid Intelligence from Ethical, Legal, and Social Points of View*, 6 Front. Artif. Intell. 1307613, 4 (2024), https://doi.org/10.3389/frai.2023.1307613.

IV. ETHICAL AND LEGAL CONSIDERATIONS

Scientists and ethicists have already begun probing issues of sentience,[45] the personhood or moral status of cognitive cells,[46] and concerns stemming from human-animal hybrids produced through organoid transplantations,[47] but as of publication, there are no governance rules in any country dedicated to assuring the ethical development of OI.[48] The existing regulatory approaches that govern human subject research and stem cell research may need to be reevaluated as organoid complexity and ubiquity advance. Further, if left underexamined, the current consent mechanisms for blood and tissue donations may result in individuals unwittingly allowing a small, partial copy of their brain to one day be grown and harvested for computational labor and data.[49] The potential commercialization and militarization of OI is rapidly moving from a theoretical concern to an imminent reality.[50] Moreover, just as AI has raised legal questions of ownership and intellectual property disputes, so too may OI beget novel challenges to our understanding of property law.

Ultimately, one of the core questions central to establishing an ethical framework for OI relies on a better understanding of how sentient and human-like these organoids may become. Sentience is, however, a notoriously inscrutable concept – philosophically, scientifically, and legally – and formulating appropriate ethical and legal guidelines will be contingent on how the technology, and our understanding of it, develops over time.

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[45] Andrea Lavazza & Marcello Massimini, *Cerebral Organoids: Ethical Issues and Consciousness Assessment*, 44 J. MED. ETHICS 606, 609 (2018), https://jme.bmj.com/content/44/9/606.long.

[46] Nita A. Farahany et al., *The Ethics of Experimenting with Human Brain Tissue*, 556 NATURE 429, 432 (2018), https://doi.org/10.1038/d41586-018-04813-x.

[47] Hartung et al., *supra* note 44.

[48] Masanori Kataoka, Takuya Niikawa, Naoya Nagaishi, Tsung-Ling Lee, Alexandre Erler, Julian Savulescu & Tsutomu Sawai, *Beyond Consciousness: Ethical, Legal, and Social Issues in Human Brain Organoid Research and Application*, 104 EUR. J. CELL BIOLOGY 151470, 4 (2025), https://doi.org/10.1016/j.ejcb.2024.151470.

[49] The term "computational labor" refers to the processing work that cerebral organoids do in OI systems. Just as generative AI and advanced machine-learning models have led to the outsourcing of tasks to computers, OI may one day serve as a functional replacement to other kinds of cognitive and computational work that was previously done by humans.

[50] Kataoka et al., *supra* note 48, at 4.

V. CONCLUSION

We are currently at the precipice of organoid intelligence, with its vast but uncertain potential to transform computing, neuroscience, and so much more. This Technology Explainer has sought to elucidate the current state of OI, recognizing that as this field evolves, the legal community must similarly advance its understanding to adequately address the profound ethical and regulatory challenges that inevitably lie ahead.