Toward Global Oversight of Human Neural Organoid and Assembloid Research

REPORT FROM THE 2025 ASILOMAR CONFERENCE

ASILOMAR, CA | NOVEMBER 10-12, 2025

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EXECUTIVE SUMMARY

REPORT FROM THE 2025 ASILOMAR CONFERENCE ON ETHICAL AND SOCIETAL IMPLICATIONS OF NEURAL ORGANOIDS, ASSEMBLOIDS, AND THEIR TRANSPLANTATION

*November 10-12, 2025**

In November 2025, an international group of scientists, ethicists, legal scholars, patient advocates, journalists, and policymakers convened at the Asilomar Conference Grounds to address a pressing question: How should the global community monitor and guide research on human neural organoids and assembloids as the field rapidly expands in scope, scale, and sophistication?

Human neural organoids are self-organizing three-dimensional cellular models derived from human pluripotent stem cells that exhibit structural and functional features of the brain. They can be used to model aspects of brain development, function, and disease. Researchers now create *assembloids* by functionally connecting multiple organoids, transplant neural organoid tissue into animal brains where it integrates and influences behavior, and employ organoids in wide-ranging research applications including drug discovery, disease modeling, evolutionary biology, biocomputing, infectious disease research, and personalized medicine.

The meeting was catalyzed by growing recognition that existing oversight mechanisms, including institution-level review and periodic engagement by national academies and professional societies, cannot keep pace with technological advances that transform research capabilities faster than guidance documents can be updated. These advances raise important ethical questions. Could organoids develop morally relevant capacities such as sentience? Do animals receiving human neural transplants face novel welfare risks? What should donors be told when their cells might be used to create brain-like structures, transplanted into animals, or kept alive for years? How can the field prevent premature clinical applications or misuse while supporting promising research?

* This report was written by Dr. Brie Linkenhoker of Worldview Studio, who also led the design of the conference. The report summarizes and synthesizes the content of presentations, panel discussions, and Q&A sessions that were recorded in audio, as well as working group written outputs and plenary presentations. Please contact Brie with questions at brieann@worldview.studio.

The Asilomar meeting did not attempt to resolve these questions definitively. Instead, participants focused on identifying what core functions an international guidance system would need to perform, including:

- **Horizon scanning:** Systematic monitoring of publications, conferences, and funding trends to identify emerging capabilities and potential tipping points
- **Stakeholder convening**: Regular forums bringing together scientists, ethicists, patient advocates, policymakers, funders, and media professionals for ongoing deliberation
- **Guidance development**: Concrete, actionable standards for review processes, consent practices, animal welfare, and responsible communication
- **Local review support**: Consultation and training for institutional committees (SCROs, IACUCs) addressing novel ethical questions
- **Public engagement:** Research on public attitudes, educational content creation, and dialogue facilitation to promote informed democratic participation

Working groups discussed several possible organizational models without settling on any specific model, but they converged on a set of design principles for a guidance system, including:

- **International and decentered**: Global scope with distributed authority respecting diverse regional perspectives and cultural contexts
- **Interdisciplinary and inclusive**: Seeks input and guidance from scientists, ethicists, social scientists, policymakers, and public audiences across diverse value traditions
- **Transparent and accessible**: Public-facing online presence with guidance processes and deliberations that are comprehensible to multiple audiences
- **Simple and low-burden**: Streamlined processes that support rather than impede research
- **Agile and responsive**: Flexible structures enabling rapid adaptation to scientific advances and emerging ethical questions
- **Comfortable with ambiguity**: Epistemic humility acknowledging uncertainty while enabling ongoing monitoring and iterative guidance
- **Financially sustainable:** Diverse funding sources ensuring long-term capacity for monitoring, convening, and public engagement

EXECUTIVE SUMMARY

The meeting concluded with recognition that significant work remains. Critical questions about governance structure, relationship to existing bodies, funding mechanisms, and operational details will require further development. However, the group achieved consensus on three urgent needs: 1) establishing ongoing monitoring infrastructure, 2) improving communication between researchers and publics, and 3) designing guidance broad and forward-looking enough to anticipate major categories of ethical concern before they arise, reducing how often the field will need to scramble in response to unanticipated developments.

This report synthesizes meeting discussions to inform next steps. It documents the scientific landscape driving calls for enhanced oversight, explores key social and ethical domains requiring continued attention, and presents organizational design principles emerging from participant deliberations. We conclude with a proposal for next steps that builds on this foundation while acknowledging the sustained effort that will be required to establish effective international oversight.

I. THE NEED FOR GUIDANCE

THE ORIGIN AND ACCELERATION OF ORGANOID SCIENCE

Human neural organoid research barely existed fifteen years ago. But today, as one presenter noted in opening remarks, "we're seeing literally hundreds of labs around the world" applying brain organoid technologies. Another speaker noted that until very recently, understanding human brain development required inference from model organisms, examination of postmortem tissue, or neural imaging that cannot capture cellular architecture, molecular signaling, or physiological dynamics. Human induced pluripotent stem cells (hiPSCs) created a new possibility: studying living human neural tissue *in vitro*.

hiPSCs, which can be derived from any individual's somatic cells and reprogrammed to an embryonic-like state, can be guided to differentiate into neural tissue. Remarkably, this tissue self-organizes into organoids that recapitulate key features of human brain development. These organoids follow human-specific developmental patterns and timing even *in vitro*, advancing through stages that reveal increasingly sophisticated properties including functional neural activity with coordinated firing patterns suggesting circuit-level organization.

The Asilomar conference was conducted under modified Chatham House Rule.

Participants understood that no quotes from the meeting would be attributed, but names of participants would be included in the report (see "Meeting Participants" in appendix.)

The field has advanced rapidly along multiple dimensions. Researchers now create neural assembloids by functionally connecting multiple organoids representing different brain regions or organ systems, transplant neural organoid tissue into animal brains where it integrates structurally and functionally with host circuits, maintain organoids in culture for years, and employ them in expanding research applications including disease modeling, drug discovery, personalized medicine, evolutionary biology, biocomputing, and infectious disease research. Each advance amplifies questions about organoid welfare, animal welfare when transplantation occurs, donor consent, and responsible translation to clinical or other applications.

WHY EXISTING OVERSIGHT FALLS SHORT

The rapid development and expansion of organoid and assembloid research has created governance challenges. Current oversight relies primarily on three mechanisms, each with significant limitations for this field:

Institutional review processes include (in US contexts): Institutional Review Boards (IRBs) that evaluate human subjects research and consent procedures; Institutional Animal Care and Use Committees (IACUCs) that oversee animal welfare; and at some institutions, Stem Cell Research Oversight committees (SCROs) that address ethical issues in stem cell research. These committees provide essential oversight for individual protocols, but they function reactively, reviewing proposals that researchers submit. They lack capacity to systematically address field-level questions or to monitor how cumulative advances across many laboratories might raise novel concerns.

Professional society guidelines, particularly the International Society for Stem Cell Research (ISSCR) guidelines, offer valuable frameworks. The 2021 ISSCR guidelines categorize various types of stem cell research according to required review levels, from simple reporting to specialized oversight to outright prohibition. However, as one participant noted, these guidelines are revised only periodically; there have been just three substantial revisions over the past 18 years. Whether ISSCR will revisit neural organoid issues frequently enough to keep pace with rapid changes remains uncertain, and several participants noted that the more brain-specific ethical issues raised by organoid research (e.g., the potential emergence of sentience) may fall outside of ISSCR's expertise.

National academy reports provide authoritative synthesis. The 2021 National Academies of Sciences, Engineering, and Medicine (NASEM) report on human neural organoids offered comprehensive analysis of the ethical and social issues identifiable at the time. But as several participants emphasized, NASEM produces consensus reports only when funded to do so; they may never write another organoid report. One-time assessments, however thorough, cannot provide ongoing guidance for a fast-moving field.

The field thus faces a gap between the pace of scientific change and the tempo of governance response. As one participant observed, "the field is expanding very fast... partly because there is a move away from animal models, partly because there are funders who are supporting this work, partly because it's just fascinating to study the biology of the human brain." But our mechanisms for ensuring this expansion proceeds responsibly operate on much slower timescales.

THE ASILOMAR PRECEDENT AND LESSONS FROM GENOME EDITING

The choice of venue carried symbolic weight. In 1975, scientists gathered at Asilomar to deliberate on the safety of recombinant DNA technology, establishing a model for scientific self-governance that shaped biotechnology oversight for decades. As one participant noted in opening remarks, that meeting addressed a "crisis of confidence" when scientists recognized their work raised questions they could not answer alone.

Neural organoid research faces different questions than recombinant DNA. The 1975 Asilomar focused primarily on biosafety—preventing accidental release of novel organisms. Today's organoid questions center on moral status, animal welfare, consent, and societal implications. But the underlying challenge remains: How can science proceed responsibly when capabilities advance faster than our ethical frameworks can accommodate?

Recent experience with human genome editing offers instructive precedents and cautionary lessons. Starting in 2015, multiple organizations, including the WHO, the National Academies, and other national and international multistakeholder groups, engaged with the ethical dilemmas associated with germline genome editing. These efforts made valuable contributions, building consensus that germline editing remains too risky while refining arguments about what circumstances might eventually justify its use.

Yet as on participant observed, "few, if any, organizations are devoting continuing attention to this topic." Attention shifts to "hotter" topics. Unlike germline editing, where little direct research currently proceeds, neural organoids and assembloids "are going to be used for at least the next several decades in ways that will continue to raise important issues," said one participant. “Continuity in scrutiny is important."

The ethics of genome editing experience revealed challenges of international coordination. Different organizations produced overlapping but not fully aligned guidance. No single body held clear authority or responsibility for ongoing monitoring. One participant suggested that human neural organoid research requires something different: not another ad hoc initiative, but "a continuing international effort—undertaken either by a new entity or one or more existing organizations—committed to, when appropriate, providing guidance for future research," while also monitoring developments, supporting public engagement, and convening regular deliberations.

II. STATE OF THE SCIENCE: CURRENT CAPABILITIES AND NEAR-TERM TRAJECTORIES

Understanding the urgency of oversight requires grasping what has become possible and what lies on the near horizon. This section synthesizes scientific presentations to convey how the field is advancing along three key dimensions: organoid complexity, functional integration through assembloids, and transplantation into living animals.

COMPLEXITY: FROM SIMPLE AGGREGATES TO BRAIN-LIKE STRUCTURES

Today's organoids can contain one to two million neurons—comparable to a bee brain—though still far from the nearly 90 billion neurons in human brains. Meeting presentations illustrated this advancing complexity. Current cortical organoids begin as neural tube-like structures containing neural stem cells. Over time, these stem cells generate diverse neuronal types that self-organize. Critically, the organoids recapitulate human-specific features of brain development.

Organoids cannot grow beyond the distance that oxygen and nutrients can diffuse—typically a few millimeters. But researchers are actively exploring vascularization strategies, and if successful, both size and complexity could increase substantially.

Functional complexity accompanies structural complexity. Researchers have captured recordings from organoids using multi-electrode arrays that demonstrate coordinated patterns of activity that suggest circuit-level organization. Such patterns indicate that neurons within organoids form functional networks, not just loose collections of active cells.

Longevity represents another advancing frontier. Published accounts describe organoids maintained *in vitro* for nearly two years—a period during which human brains undergo profound developmental changes. Extended organoid survival raises questions about what neural features might emerge during comparable timeframes *in vitro*.

Size-related structural limitations remain, primarily due to lack of vascularization. Organoids cannot grow beyond the distance that oxygen and nutrients can diffuse—typically a few millimeters. But researchers are actively exploring vascularization strategies, and if successful, both size and complexity could increase substantially.

ASSEMBLOIDS: FUNCTIONAL INTEGRATION OF MULTIPLE REGIONS

Assembloid technology addresses organoid limitations by connecting multiple structures. Rather than growing a single massive organoid, researchers create specialized organoids containing cell types and organizational structures that mimic different brain regions or other tissues, and then bring them together to form functional connections.

Presenters described assembloids that modeled complex neural pathways, with axons extending from one organoid to another. These assembloids also demonstrate functional connectivity: when researchers apply stimulation to one component, signals propagate sequentially through connected organoids, reconstituting multi-step pathways through which information normally flows in intact nervous systems. This is an important information processing advance across a multi-component system.

By functionally integrating multiple organoids, researchers can create circuits with the combined neuron counts of all constituent structures, which make assembloids much larger and more complex than single organoids. Moreover, complexity may be mutually reinforcing: larger constituent organoids increase overall assembloid complexity, while connections with other organoids might enhance the size and sophistication of each component. This

opens possibilities for emergent features arising from integrated sensory and motor systems or other multi-region interactions.

Current assembloids remain relatively simple, typically connecting two to four organoid types. But presenters emphasized that nothing prevents scaling up to more components representing additional brain regions or integrating neural tissue with organoids modeling other organs to study brain-body interactions. The conceptual and technical foundations for larger and significantly more complex organoids already exists.

TRANSPLANTATION: INTEGRATION WITH LIVING NEURAL SYSTEMS

Transplantation introduces a new dimension to organoid research. When human neural organoids are placed into animal brains, they encounter vascular systems that can support larger structures, host neural circuits that can provide input and receive output, and living bodies that can sense and respond to the world around them.

Evidence increasingly demonstrates functional integration. Researchers described transplants surviving for years, with human neurons extending axons to connect with host neurons and receiving synaptic input from host circuits. In some experiments, transplanted human neurons respond to sensory stimuli presented to the animal, indicating functional incorporation into sensory processing pathways. Most transplantation work uses rodents, though preliminary studies have extended to non-human primates.

III. CORE ETHICAL AND SOCIETAL QUESTIONS ACROSS INTERSECTING DOMAINS

The "state of the science" presentations established what has become, and is becoming, possible. Subsequent panel discussions explored ethical implications and questions in organoid welfare, animal welfare when transplantation occurs, donor consent, and public trust.

ORGANOID WELFARE: COULD THEY BECOME SENTIENT?

Could organoids or assembloids develop morally relevant capacities? Might they suffer, experience pain, or possess some form of sentience or consciousness? How would we know? If we could establish that they had developed higher cognitive capacities, would we have duties toward them?

Based on what is known about the neurobiological underpinnings of consciousness, current organoids appear unlikely to possess such capacities. They lack the thalamocortical connectivity thought to be essential for consciousness in mammals. Unless transplanted, they have no sensory organs to receive input from an external world, no motor systems to act upon that world, and no homeostatic regulation of an internal environment. One participant noted that nervous systems evolved to carry internal representations supporting adaptive behavior—capabilities requiring far more than current organoids possess.

Participants emphasized that consciousness remains scientifically mysterious. We lack definitive markers or measurements. Different theoretical frameworks propose different necessary conditions (e.g., integrated information, global workspace broadcasting, higher-order representations), but without consensus on what consciousness is, it seems impossible to assess organoids and assembloids for consciousness.

However, absence of evidence does not guarantee absence of capacity. Honeybees, whose brains contain fewer neurons than some complex organoids, are increasingly recognized as potentially sentient. This comparison underscores the need for continuous monitoring of how organoid size and complexity track with emerging properties.

Several participants emphasized the importance of systematic monitoring rather than waiting for definitive evidence. Even if current organoids clearly

lack morally relevant capacities, continued growth in size, complexity, longevity, and functional integration might eventually approach concerning

thresholds. Establishing monitoring systems now, while risks remain theoretical, seems more prudent than scrambling to respond after capacities emerge.

What would such monitoring involve? Participants proposed several elements:

- Benchmarking against animal models with known capacities, asking whether organoid complexity approaches that of simple organisms with evident sentience
- Tracking specific capabilities such as sustained oscillatory patterns, responsive behavior to stimuli, or evidence suggesting internal state representations
- Theoretical development of clearer frameworks linking neural organization to morally relevant capacities
- Establishing review triggers defining what combinations of size, complexity, and/or function should prompt mandatory ethical review rather than simple reporting

If human neural tissue functionally incorporates into host circuits, might it alter the animal's experience in ways that create suffering?

These proposals reflect the seriousness with which participants engaged this question, and they point toward two complementary paths forward. Benchmarking organoid complexity against species with known capacities and tracking indicators like sustained oscillatory patterns or signs of internal state representation could be elements of the field monitoring function this report calls for, building the evidence base needed to recognize a meaningful threshold if one is approached. The theoretical work needed to define what those thresholds should be, and what would follow from crossing them, is well suited to the parallel academic deliberation described in this report's recommendations, where it can be developed and refined over time rather than settled before a functional guidance system is launched.

ANIMAL WELFARE: TRANSPLANTED ANIMALS AND HOST ANIMAL WELL-BEING

Transplantation introduces a distinct set of welfare questions focused on animal hosts receiving human neural tissue. Unlike *in vitro* organoid welfare questions, which remain largely theoretical, animal welfare concerns are immediate and concrete

Animals receiving neural transplants can experience pain and harm, and as with all animals used in research, their welfare must be considered legally and ethically. Transplanting human neural organoids into animal nervous systems may intensify these concerns because of the brain's central importance and the difficulty of predicting transplant effects.

Participants highlighted multiple welfare dimensions. Surgical procedures carry inherent risks. Transplanted tissue might not integrate properly, potentially causing inflammation or other pathology. Even successful integration raises questions: If human neural tissue functionally incorporates into host circuits, might it alter the animal's experience in ways that create suffering? Could it enhance cognitive capacities, raising the animal's moral status? Might it produce confusion or distress if human neural organization conflicts with animal neural architecture?

The question of "humanization" generated substantial discussion. Some participants worried that transplants creating more human-like cognition in animals would violate important boundaries. Others argued that capacities matter more than origins—enhancing an animal's cognitive sophistication might be ethically neutral or even positive if it doesn't create suffering, regardless of whether enhancement comes from human neural tissue.

Participants noted additional complexity: perceptions of humanization might diverge from reality. Even if transplants don't meaningfully alter animal cognition, just the *perception* that animals have become "part human" could generate public concern. Managing both actual welfare and perceptions requires careful attention.

Current regulations and guidance provided by Institutional Animal Care and Use Committees (IACUCs) focus primarily on pain, distress, and humane endpoints. Participants observed that

these frameworks assumed animals' fundamental capacities remained stable. IACUCs evaluate whether proposed procedures cause acceptable or unacceptable suffering to animals of a particular species with known capacities. But if transplants might alter those capacities, traditional IACUC criteria may be insufficient.

Some participants suggested that broader consideration, beyond existing animal welfare committee oversight, might be appropriate for certain kinds of transplant work. This expanded review might include evaluation of:

- Whether transplant experiments could change animals' morally relevant capacities
- How to assess animal wellbeing when neural integration might create novel experiences
- What endpoints should trigger experiment termination if behavior suggests distress
- Whether some host species warrant special protection (particularly non-human primates)

Participants emphasized that different regions of the world maintain different animal research infrastructure and are guided by different cultural attitudes, particularly regarding non-human primate research programs. International guidance must accommodate this variation while establishing common ethical floors.

DONOR CONSENT: WHAT SHOULD PEOPLE KNOW ABOUT HOW THEIR CELLS MIGHT BE USED?

Human neural organoids originate from human cells—either embryonic stem cells, induced pluripotent stem cells created from adult tissues, or direct tissue samples. This raises questions about consent: What should donors or their guardians be told about potential uses?

Current consent practices vary by institution and cell source. Embryonic stem cell lines often derive from embryos donated after fertility treatment, with consent obtained from the prospective parents. Induced pluripotent stem cells might come from skin biopsies, blood draws, or other sources, with consent processes similar to those for tissue banking. In general, consent for stem cell research tends to be relatively broad, allowing researchers considerable latitude in how they use donated cells.

Questions arose about whether this broad consent remains adequate. Should donors or their guardians be informed specifically that their cells might be reprogrammed to a pluripotent state and then used to create organoids or assembloids, and/or be transplanted into nonhuman animals? Participants

noted tensions between scientific flexibility and donor autonomy. Requiring highly specific consent for every possible use could become unworkable, potentially hampering valuable research. But broad, vague consent might not adequately respect donor autonomy, particularly for uses that might trouble some donors.

Several specific concerns emerged:

Brain-specific uses: Some donors comfortable with their cells being used for general stem cell research might object specifically to brain organoid research. Participants noted that people who would otherwise consent to cell use for brain-related research could be especially troubled by the creation, and especially the transplantation, of neural organoids and assembloids.

Transplantation: Creating organoids in a dish differs from transplanting them into animals. Even donors willing to provide cells for organoid research might object to their cells being transplanted into animal brains.

Biocomputing: Using neural tissue as computational substrate, especially one that might interact directly with non-biological machine components, represents a particularly novel application that might trouble donors for various reasons. Some might have religious or moral objections to creating "artificial life" or "human-machine hybrids," or they may have concerns about protecting the dignity of human neural tissue.

Identity and memory concerns: Participants discussed challenges in addressing concerns that, while scientifically implausible, may be emotionally resonant to some donors, such as whether an organoid might retain memories or other aspects of a donor's identity. How should consent processes handle such concerns?

Participants emphasized the difficulty of this balance. Good arguments exist on both sides of the consent question, which connects to broader debates about how specific or general consent should be. Too specific, and consent becomes burdensome for donors and restrictive for research. Too general, and it fails to respect autonomy.

No consensus emerged on optimal consent approaches. But participants agreed that consent practices warrant ongoing attention as applications expand, particularly for novel uses like biocomputing that donors might not have imagined when providing samples.

APPLICATIONS AND SOCIETAL IMPLICATIONS

Beyond welfare and consent questions focused on organoids, animals, and donors, participants explored broader societal implications of organoids, assembloids, and their transplantation.

Clinical translation and unregulated therapies: Multiple participants raised concerns about premature clinical use, citing the proliferation of unproved stem cell "treatments" as a cautionary precedent. The field must ensure that organoid-based therapies do not follow the same path toward unregulated, unproven clinical applications.

Participants with experience in both research and clinical translation emphasized the challenge: promising preclinical results create pressure for rapid clinical trials, but moving too quickly risks harming patients and discrediting the broader field, as we saw with early gene therapy treatments.

Unlike conventional drug development, which has well-established regulatory pathways, organoid-based therapies raise novel questions about how to assess safety and efficacy.

Participants discussed whether enhanced oversight of basic research might help prevent inappropriate clinical translation. If review bodies systematically ask "how might this research be misapplied?" during protocol review, might that prompt better safeguards? Others worried that excessive focus on preventing misuse could stifle valuable research.

Patient advocates emphasized the double-edged nature of this concern. Unproven 'organoid therapies' could exploit desperate families, as unregulated stem cell clinics have done. But overly restrictive oversight could also delay legitimate therapeutic development.

Dual-use research: Organoids have important biomedical applications, including understanding disease mechanisms, identifying vulnerabilities, and developing treatments. But they also have dual-use potential, in that they could also serve as platforms for developing bioweapons with the potential to target the human nervous system.

No participants advocated prohibiting pathogen research with organoids. The potential to understand and treat devastating brain infections justifies some risk. But several participants emphasized the need for existing dual-use research oversight policy frameworks to encompass organoid work, ensuring that security implications receive appropriate attention.

If review bodies systematically ask "how might this research be misapplied?" during protocol review, might that prompt better safeguards?

Biocomputing: Using neural tissue as a computing substrate attracted both fascination and concern. Proponents suggest that organoids could enable new, more energy-efficient computing architectures, and that organoids interfacing with machine inputs and outputs could expand research horizons in modeling neurological diseases and potential therapies. Skeptics question whether such applications serve compelling needs or represent technology in search of applications.

Some of the ethical questions raised in biocomputing discussions included: Would biocomputing applications require informed consent beyond that for basic research? If organoid "intelligence" becomes sufficiently sophisticated, especially through organoid-AI interactions, what moral status would the organoids, or hybrid organoid-machine systems, hold? How should we think about creating and destroying neural tissue specifically for computational purposes?

These questions remain largely theoretical, as current organoid intelligence work is highly preliminary. But participants emphasized that governance systems should anticipate emerging applications rather than scrambling to respond after they arrive.

Public perception and trust: Research on human brain tissue does not proceed in isolation from society. Public funding supports the majority of neural organoid research, creating obligations of transparency and accountability to taxpayers and citizens. Public attitudes shape regulatory environments, influence recruitment of research participants, and ultimately determine whether promising research can continue.

But the stakes extend beyond pragmatic concerns about maintaining support. Brain research carries unique cultural and emotional weight across diverse communities. For some, concerns stem from religious or philosophical beliefs about consciousness, the soul, or what makes us human. For others, worries focus on whether organoids might suffer, whether animals receiving transplants become "part human," or whether donors' cells retain some aspect of personal identity or memory. These concerns may not align with current scientific understanding, but they reflect deeply held values about human

dignity, the moral status of different forms of life, and appropriate boundaries for scientific experimentation.

Taking these diverse perspectives seriously represents both an ethical obligation and a practical necessity. As one participant emphasized throughout meeting discussions, scientists must "take seriously the values and experiences of non-scientists in society." This means genuine engagement—not just explaining research or correcting misunderstandings, but listening to what different communities find confusing, troubling, or hopeful, and why, and allowing their concerns to inform how research proceeds and how it is communicated.

Patient advocates highlighted why this engagement matters so urgently. For families living with Rett syndrome, severe autism, Alzheimer's disease, traumatic brain injury, and other devastating neurological conditions, organoid research represents hope where few effective treatments exist. At Asilomar, these advocates made clear they do not want research to slow down. But they also need confidence that it is proceeding responsibly, with oversight robust enough to prevent ethical failures that could derail promising work or erode public support. They underscored that maintaining trust directly affects whether research sustains the funding, social approval, and institutional support necessary to deliver therapeutic breakthroughs.

The consequences of failing to build and maintain this trust—with patient communities, donors, funders, and broader publics—are significant. If substantial portions of the public oppose certain kinds of research or harbor serious concerns about it, that work could lose funding, face regulatory prohibition, or proceed under a cloud of suspicion that undermines both scientific progress and democratic legitimacy. Conversely, proactive engagement that demonstrates responsibility, acknowledges uncertainty, and respects diverse values can create conditions where ethically complex research proceeds with broad social support. For patient advocates hoping for breakthroughs, for researchers pursuing promising questions, and for publics trying to understand rapidly advancing capabilities, building trust serves everyone's long-term interests.

IV. PUBLIC ENGAGEMENT AND COMMUNICATION CHALLENGES

Creating meaningful public engagement with neural organoid research faces distinctive obstacles. The science combines complex concepts from developmental neuroscience, stem cell biotechnology, tissue engineering, and clinical medicine, while simultaneously raising philosophical questions about consciousness, sentience, and moral status that challenge how we think about what makes something worthy of ethical consideration. Uncertainty about what will become possible over the next decade, and about how to frame the moral questions that could arise, creates especially demanding conditions for responsible communication.

Different audiences bring different levels of knowledge and different concerns. For patient advocacy groups focused on psychiatric, neurological, and developmental diseases, neural organoid research inspires hope for

breakthroughs where few treatments exist. Many of these advocates maintain direct connections with researchers and understand the field's trajectory. But for broader public audiences unfamiliar with stem cell research or developmental neuroscience, even basic concepts require substantial explanation. Creating resources that work for both technically sophisticated and general audiences while maintaining accuracy and avoiding condescension poses real challenges.

THE PROBLEM OF HYPE AND SENSATIONALISM

Multiple participants identified problematic media coverage as a recurring challenge undermining effective public engagement. Headlines proclaiming "Scientists Grow Mini-Brains" or speculating about consciousness in organoids grab attention but mislead readers about actual capabilities.

Research on brain-like structures proves particularly vulnerable to journalistic exaggeration, with coverage sometimes invoking "Frankenstein" imagery that distorts public understanding.

The problem doesn't originate solely with journalists. Researchers seeking publicity for funding or career advancement may oversell findings. University press offices, incentivized to generate news coverage, may emphasize dramatic possibilities over technical details. Even scientific institutions sometimes contribute to hype through communications that prioritize attention over accuracy.

When researchers overstate findings—claiming, for instance, to have created sentience in organoids—the resulting coverage damages the entire field's credibility and distorts public debate. Exaggerated claims fuel both unrealistic hope among patient communities and unwarranted fear among those

concerned about ethical boundaries. If public audiences develop excessive fear or unrealistic hope, the consequences harm everyone.

Several participants discussed whether oversight bodies should develop guidance on communication practices. Should there be recommendations for how scientists and institutions describe neural organoid research? What responsibilities do researchers have to correct misrepresentations by others? How can the field balance legitimate excitement about promising research against risks of overselling? What role should journal editors play in reviewing not just scientific content but also how findings are described in abstracts and press releases?

THE ROLE OF JOURNAL EDITORS AND PUBLISHERS

Publishers and journal editors occupy strategic positions in scientific communication. They control what research gets published, how findings are framed, and what press coverage accompanies publication. Several participants emphasized that journals should be considered important stakeholders in any oversight system.

Rather than one-way information provision, deliberative approaches bring diverse people together to learn about a topic, discuss implications, and articulate recommendations.

Major journals already apply editorial judgment about ethically sensitive research. Nature and Science policies prohibit publishing certain types of studies. Similar editorial standards could help guide organoid research through several mechanisms:

- **Ethics review attestation**: Journals could require authors to certify that research underwent appropriate institutional review
- **Editorial assessment**: Editors might refuse publication of research raising serious ethical concerns without adequate justification
- **Press release guidelines**: Journals could provide or require adherence to guidelines ensuring press releases accurately represent findings
- **Post-publication engagement**: When papers attract problematic coverage, journals and authors could actively work to correct misrepresentations

If an oversight body developed communication guidance, journal editors could help implement it through editorial policies and peer review processes.

STRATEGIES FOR EFFECTIVE ENGAGEMENT

Beyond managing media coverage, participants emphasized the need for multidirectional engagement between scientists, patient advocates, ethicists, journalists, and diverse public audiences.

Several approaches emerged:

Research on public attitudes: Empirical work investigating how different people reason about organoids and transplanted animals can identify what worries people, what information they need, and what they consider acceptable. Such research helps ensure that engagement addresses actual concerns rather than assumed ones.

Deliberative forums: Rather than one-way information provision, deliberative approaches bring diverse people together to learn about a topic, discuss implications, and articulate recommendations. The Nuffield Council on Bioethics' work on mitochondrial DNA research provided a model. Such exercises require significant resources but generate rich understanding of diverse perspectives.

Arts and creative media: Theater, visual arts, fiction, or immersive experiences might help people think through complex questions about consciousness, identity, and moral status in ways that technical presentations cannot achieve.

Patient and advocate partnership: People affected by psychiatric and neurological conditions have direct stakes in research outcomes. Including patient advocates not just as audiences but as partners in shaping research priorities and oversight approaches ensures their perspectives inform decisions.

Meeting people where they gather: Rather than expecting public audiences to seek out scientific information, participants suggested bringing engagement to spaces where people already congregate—science museums, patient advocacy gatherings, online platforms, and community spaces including churches and cultural centers.

Creating accessible resources: Most public audiences are not currently seeking information about organoid research. Creating high-quality, accessible resources available when people do become interested—through web searches, news coverage, or personal connection to relevant diseases—helps ensure accurate information reaches those who need it.

The goal across all these strategies should be deliberative dialogue that promotes informed democratic participation in decisions about research that carries both tremendous promise and ethical complexity.

V. TOWARD AN ONGOING INTERNATIONAL PROCESS: ORGANIZATIONAL MODELS AND DESIGN PRINCIPLES

The heart of the Asilomar meeting focused on concrete questions: What kind of system could provide appropriate oversight for neural organoid and assembloid research? What should such a system do? How should it be organized? Who should participate? How should it be funded and governed? Participants explored these questions in panel discussions and then in small working groups.

Participants brought diverse perspectives, as scientists conducting organoid research, ethicists analyzing its implications, legal scholars examining regulatory frameworks, patient advocates representing stakeholder interests, journalists covering the field, funders and editors deciding what research to support and publish, and policymakers considering governance approaches. Working groups developed multiple organizational concepts, but convergence emerged around core principles and essential functions.

This section synthesizes those discussions, emphasizing both shared design principles and unresolved questions requiring further development.

WHY EXISTING MECHANISMS ARE INSUFFICIENT

Before examining proposed solutions, working groups identified gaps in current oversight:

Institution-level review lacks field-level perspective: IACUCs evaluate animal welfare for individual protocols. IRBs assess human subjects protection. SCROs address stem cell research ethics. But these committees operate institution-by-institution, protocol-by-protocol. They typically lack capacity to think about cumulative effects across many laboratories or to monitor field-level trajectories.

As one working group noted: "We don't know how much neural organoid research is being done. There is no central repository." Without systematic monitoring, we cannot track whether the field is approaching concerning thresholds or identify emerging capabilities that warrant ethical attention.

Professional society guidelines update too slowly: ISSCR guidelines provide valuable frameworks, but they are revised only periodically.

The 2021 guidelines did not fully address assembloids, which have advanced substantially since then. Moreover, current ISSCR guidelines require only *reporting* for *in vitro* organoid work, not mandatory review, regardless of complexity.

National academy reports are episodic at best: The 2021 NASEM report offered comprehensive analysis but cannot provide ongoing guidance. NASEM produces reports only when commissioned and funded to do so. One-time assessments, however thorough, cannot keep pace with rapid scientific change.

Current oversight is largely national, but science is global: Research proceeds in many countries with varying regulatory frameworks. Developments in one jurisdiction can influence practices elsewhere. But no international body systematically monitors the global landscape.

CONVERGENT DESIGN PRINCIPLES

Seven working groups explored distinct organizational proposals, but remarkable convergence emerged around core design principles. Any effective oversight system, participants agreed, should embody:

Genuine internationalism requires building governance structures that respect diverse perspectives rather than assuming single "right" answers.

1. International scope with decentered authority

Multiple groups emphasized that oversight must be international. As one group stated, the system should be "international, decentered, and distributive." Another noted that "typically there are particular regions of the world and countries that take the heavier weight and the influence, but this should be very intentionally designed so that there is [more] equal weighting of priorities and perspectives across the world."

This principle reflects both practical and ethical considerations. Practically, organoid research proceeds globally, and developments anywhere can influence practices everywhere. Ethically, Western dominance of bioethics discourse has sometimes imposed frameworks insensitive to other cultural contexts. Genuine internationalism requires building governance structures that respect diverse perspectives rather than assuming single "right" answers.

One participant's comments about non-human primate research highlighted this importance. Such research is a national priority in some regions in the world, while it is being banned in other regions. International governance must accommodate variation while establishing common ethical boundaries.

2. Inclusive multistakeholder composition

Every working group emphasized that scientists alone cannot and should not guide this field. As one group stated, the system must include members who confer legitimacy because they represent professional organizations and disciplines as well as diverse interests and lived experience perspectives.

Proposed stakeholders included:

- Scientists conducting organoid and assembloid research
- Ethicists and philosophers with expertise in consciousness, moral status, and research ethics
- Legal scholars with regulatory framework expertise
- Patient advocates with lived experience and perspectives on what responsible innovation means for families waiting for breakthroughs
- Social scientists studying public attitudes and science communication
- Journal editors and publishers

- Representatives from diverse religious and value traditions
- Animal welfare experts
- Communications and media professionals
- Research funders in government, philanthropy, and private enterprise
- Policymakers from various jurisdictions, including regulatory bodies like the FDA

As one group emphasized, effective oversight requires "epistemic humility"—recognizing that no single perspective holds all relevant knowledge. Complex questions demand diverse expertise and experience.

3. Transparency and accessibility

Multiple groups emphasized transparency. One proposed that the body "should have a public-facing presence, perhaps on the web, with educational content for public audiences." Another emphasized that effectiveness requires the system to be transparent in areas including structure, composition, charge, and processes.

Transparency serves multiple functions. It enables public scrutiny, building trust that oversight proceeds responsibly. It helps researchers understand what is expected. It provides alignment for the scientific ecosystem, including funders, editors, journalists, and institutional review boards. It allows other oversight bodies to learn from deliberations. And it supports democratic accountability, ensuring that governance of publicly funded research reflects public values.

Accessibility complements transparency. If processes are transparent but incomprehensible, transparency serves little purpose. Guidance documents, deliberative summaries, and educational content should be crafted for multiple audiences, with specialized technical content for researchers and accessible summaries for general readers.

4. Simplicity and low burden

Scientists will support oversight if it provides value without excessive burden. One group emphasized that oversight should be "simple, light touch, not bureaucratic, and not difficult for users to explain their research to whatever this body is."

Another identified failure modes: the system "could fail if it is too bureaucratic, onerous, or too broad." If compliance requires extensive paperwork, significant delays, or confusing procedures, researchers will view oversight as an obstacle.

This principle creates design tension. Thorough oversight requires information gathering and deliberation, which takes time and effort. But excessive burden generates resentment and non-compliance. Effective design must balance thoroughness against usability.

Several groups suggested that the system should be "seen as valuable by all stakeholders" and "not be seen as a hurdle to be overcome." This frames aspiration: oversight should help researchers think through ethical implications, connect with relevant expertise, and demonstrate responsibility to funders and publics. Done well, oversight can serve researchers' interests.

5. Agility and responsiveness to rapid scientific change

The field's rapid advancement demands an oversight system that can adapt quickly. One group emphasized that an effective system would "enable an agile response if some kind of tipping point is met. If some kind of ethical issue becomes salient enough to require norm setting, there could be a fast, agile response."

One group proposed "flexible and iterative" processes, "perhaps using a distributed model." Distributed approaches—with oversight capacity in multiple regions rather than centralized in one location—might respond more rapidly to local developments while maintaining global coordination. Other suggestions included ongoing monitoring to identify emerging issues, standing bodies that can convene quickly, flexible guidance that can be updated as needed, and processes for rapid consultation when novel questions arise.

Guidance should acknowledge where consensus exists and where questions remain open. Review processes should make room for deliberation about genuinely difficult cases rather than forcing everything into predetermined categories.

6. Comfort with ambiguity

Several participants noted that we currently do not know whether organoids could develop morally relevant capacities, or when that might occur, or how we would detect it. We cannot predict all possible applications or their implications. Governance must proceed despite this uncertainty.

The principle of "epistemic humility" proposed by one group suggests several practical implications. Guidance should acknowledge where consensus exists and where questions remain open. Review processes should make room for deliberation about difficult cases rather than forcing everything into predetermined categories. Monitoring should track uncertain thresholds even while acknowledging uncertainty about their moral significance. Plans should be made for regular revision to guidelines as new possibilities emerge.

This principle also counsels against premature prohibition. If we cannot be sure what capacities organoids might develop or what risks truly warrant concern, prohibiting research based on speculation seems unwarranted. But epistemic humility cuts both ways—we also cannot be confident that concerning capacities will never emerge. Ongoing monitoring with willingness to impose restrictions if needed balances these uncertainties.

7. Financial sustainability

Every group that addressed practical implementation emphasized funding. The system "could fail if... there's no money to implement and maintain the system." Another noted that failure could result if it "isn't financially sustained."

Sustainable funding matters for several reasons. Field monitoring requires dedicated staff to track publications, attend conferences, and maintain awareness of developments. Convening stakeholder meetings involves travel costs, venue rental, facilitation, and participant support. Developing guidance demands expert time for deliberation, drafting, review, and revision. Public engagement requires resources for research, forum organization, and communication.

But funding sources shape priorities. Government funding may fluctuate with political winds or create pressure to avoid controversial topics. Industry funding raises conflict of interest concerns. Philanthropic funding depends on continued donor interest. Sustainable oversight will likely requires diverse funding sources to buffer against volatility and maintain independence.

CORE FUNCTIONS: WHAT SHOULD AN OVERSIGHT SYSTEM DO?

Working groups proposed different primary emphases—some focused on monitoring, others on guidance development, still others on deliberation or communication. But synthesizing access group outputs reveals overlapping functions that any comprehensive system should perform, including:

1. Horizon scanning and field monitoring

One group proposed a system focused specifically on monitoring: "We envision an oversight system that aims to know what's out there" through "horizon scanning to keep track of progress in the field in a relatively ongoing fashion."

Monitoring would involve:

- Tracking scientific publications to identify new capabilities
- Attending conferences to learn about emerging techniques
- Maintaining relationships with research groups to understand unpublished work
- Analyzing trends in funding to anticipate where the field is heading
- Identifying "tipping points where norm-setting might need to begin"

The goal of horizon scanning is not surveillance but situational awareness. Without systematic monitoring, concerning developments might proceed unnoticed until too advanced to address effectively.

2. Convening forums for stakeholder deliberation

Multiple groups emphasized the need for ongoing deliberation. One proposed "a standing deliberative body/forum" that could "foster, cultivate and maintain" reflection on what's at stake. Another emphasized that an effective system would "inspire deliberative dialogue."

Convening functions could include:

- Regular meetings bringing together scientists, ethicists, policymakers, patient advocates, journal editors, journalists, and other stakeholders
- Workshops focused on specific emerging questions
- Public forums inviting broader engagement
- "Sharing of ethical deliberation" across research groups and jurisdictions

As one group noted, the system would be "most effective if it were collaborative and inclusive." Professional facilitation may also be needed to help navigate discomfort, conflicts, and ambiguity.

3. Developing and disseminating guidance

Several groups focused on guidance development. One proposed a system to "articulate values, define standards building on best practices, and build trust." Another envisioned creating "guidance for scientists" with "continual updates" that "consider multiple stakeholders' values."

Guidance might address:

- What kinds of research require specialized review beyond standard IACUC/IRB processes
- How to assess and minimize risks to animal welfare in transplantation studies
- What consent practices adequately respect donor agency and autonomy for various research applications
- How to communicate research findings responsibly
- What thresholds should trigger heightened scrutiny

Importantly, guidance should be "concrete" and "actionable." One group proposed a system that would "take theoretical insights and provide concrete guidance for reviewing bodies." Abstract ethical principles matter, but researchers and review committees need practical direction.

4. Supporting and connecting local review processes

One group envisioned "a higher level body that advises SCROs and IACUCs on ethical and social issues that ought to be included in research oversight of organoid and assembloid research." Rather than replacing institutional review, this approach would strengthen it.

Functions might include:

- Developing frameworks and questions for institutional committees to consider
- Providing consultation for difficult cases
- Training committee members on relevant ethical issues
- Facilitating knowledge sharing across institutions
- Specifying a core set of baseline standards while allowing local adaptation

As the group noted, this body could "conceive of itself akin to a research ethics consultation service specific to neural organoid research that operates on a continual rather than ad hoc basis."

5. Engaging public audiences and supporting communication

While multiple groups discussed public communication, one group focused on it: "We envision a communication system that aims to be better informed about positive aspects of [organoid and assembloid] research, especially about medicine and diseases." Others emphasized that effective oversight requires "ripple effects into communications [and media] with intent of promoting democratic dialogue."

Communication functions could include:

- Conducting and supporting research on public attitudes
- Creating educational content for diverse audiences
- Facilitating deliberative forums with community groups
- Working with media to improve coverage quality
- Addressing hype and misinformation
- Ensuring "dialogue between multiple groups/ stakeholders"

STRUCTURAL QUESTIONS REQUIRING FURTHER DEVELOPMENT

While groups converged around these design principles, these structural questions remained largely unresolved:

Should this be a new entity or leverage existing organizations?

Several groups noted that existing organizations could offer established reputations, infrastructure, and expertise. including professional societies, WHO, UNESCO's International Bioethics Committee, NASEM, national academies working in coalition, ISSCR, and International Brain Initiative. One group suggested that all of these organizations, and others we may not be aware of, could be leveraged to help inform, design, convene, and/or disseminate guidance.

But existing organizations have limitations. NASEM produces reports only when funded. Professional societies focus primarily on member interests. WHO and UNESCO have global reach but face geopolitical constraints. None may have capacity or inclination to provide sustained monitoring and guidance specifically for organoid research.

A new entity could be dedicated solely to this purpose but might lack established credibility and infrastructure. Creating new international organizations is difficult and time-consuming. Funding might be hard to secure before the organization proves its value.

Participants did not resolve this tension, but some suggested that new and existing organizations might work complementarily rather than competitively. Perhaps an new coordinating body could work with existing organizations to perform specific functions, leveraging their expertise while providing continuity and focus that those organizations cannot offer on their own.

What governance and accountability structures?

How should decision-making authority be distributed? How are members or stakeholders selected? To whom is the body accountable? What recourse exists if guidance proves inadequate or overreaching?

One group emphasized the need for "clarity in its specific purpose and who its guidelines are for" and attention to "questions of legitimacy within and outside the realm of science."

What approach to regulation?

Working groups generally favored guidance over binding regulation. Terms like "light touch," "flexible," and "not bureaucratic" pervaded discussions. But guidance without enforcement relies on voluntary compliance. What incentives might encourage adherence? Several groups suggested roles for journals (requiring ethics review documentation), funders (conditioning grants on compliance), and professional societies (making compliance a membership expectation). But details remained undeveloped.

Some participants suggested that an oversight body should be prepared to recommend regulation when guidance proves insufficient, but should not assume regulatory functions itself. Keeping the body advisory rather than regulatory might maintain flexibility and minimize political pressure.

How to ensure diverse global participation?

Several groups emphasized international scope and avoiding Western dominance, but operationalizing this principle could prove challenging. Language barriers complicate communication. Time zones make synchronous meetings difficult. Resource constraints affect who can participate. Cultural differences shape what questions seem most pressing and how people reason about them.

One group proposed "a decentralized model that might make the convening challenges less difficult." But decentralization creates coordination challenges. How could distributed bodies maintain coherence? How could disagreements be resolved when different regional groups reach different conclusions? Or might a loose overarching structure permit multiple stances?

What temporal cadence?

How often should the body meet? How frequently should guidance be updated? One group asked: "What would be the cadence of meetings? This might depend on the pace of science but also the challenges of making accessible meetings happen."

Annual meetings might suffice for general deliberation, but emerging questions might require rapid response. Perhaps different functions need different cadences—annual summits for broad stakeholder engagement, quarterly meetings for smaller working groups for ongoing monitoring, and ad hoc consultations when specific questions arise.

MODELS OF SUCCESS AND FAILURE

Working groups identified conditions under which oversight would succeed or fail:

Success factors:

- "Leading, respected scientists are involved with promoting it, together with public thought leaders"
- "It inspires deliberative dialogue"
- "Has participation of scientists and generalists"
- "Provides timely feedback"
- "Provides confidence to enable scientific advancement"
- "Inspires ongoing stakeholder support for the research"
- "Supports rich science, transparency, and opportunities for collaboration"
- Creates "accountability" while increasing "public comfort"

Failure modes:

- "Too bureaucratic, onerous, or too broad"
- "Doesn't have scientist or community (stakeholder) buy-in"
- "No one appropriate to manage it"
- "No money to implement and maintain the system"
- "Lacks adequate engagement from either the scientific community or broader stakeholders"
- "Is overly burdensome or confusing"
- "Isn't financially sustained"
- "Slows down progress of ethical science" unnecessarily

These factors suggest criteria for evaluating any proposed structure: Does it engage both scientists and broader stakeholders? Do respected leaders champion it? Does it provide value rather than just imposing burden? Can it be sustained financially? Does it have a clear purpose and appropriate stakeholder involvement?

EXISTING MODELS TO LEARN FROM

Participants referenced several existing models, including:

ISSCR: The ISSCR publishes Guidelines for Stem Cell Research and Clinical Translation. These guidelines "address the international diversity of cultural, political, legal, and ethical issues associated with stem cell research and its translation to medicine," including research integrity, human subject consent, patient welfare, ethical conduct for scientists, and acceptable v. unacceptable uses of stem cell technologies. University-based ESCRO and SCRO ((embryonic) stem cell research oversight) committees use these guidelines for local review of research projects. Grant-making organizations require or encourage compliance with the guidelines, and journals ensure that papers submitted for review adhere to guidelines. The ISSCR collaborates with other organizations for horizon scanning and convenes a diverse group of scientists, ethicists, educators, legal scholars, and philanthropic and business leaders to collaboratively shape its guidance and assist with dissemination.

Human genome editing governance: Multiple organizations have been involved, including NASEM's International Commission, WHO expert committee, national ethics bodies, and the Global Observatory for Genome Editing. They have demonstrated both the value of diverse voices and the challenges of coordination. The proliferation of bodies created some redundancy but also ensured that if one became inactive, others continued.

Mitochondrial DNA transfer and related research: The Nuffield Council on Bioethics' work on public attitudes provided a model for rigorous public engagement.

ARRIGE (Association for Responsible Research in Genome Editing): Mentioned as a professional organization that brings together stakeholders interested in responsible governance.

International Brain Initiative: Global coordination of neuroscience research priorities, demonstrating feasibility of international scientific coordination.

No single precedent offers a perfect template, but each could contribute important lessons and insights for future design.

VI. RECOMMENDATIONS AND NEXT STEPS

» Asilomar generated real, practical momentum toward a functional oversight system. Moving forward, we recommend a deliberately designed multistakeholder process, guided by a small facilitative team and backed by a coalition of funders, carried out over an initial two to three-year period, that would produce:

» **An initial working draft of actionable guidelines**, shaped through human-centered design methods that surface the needs

and contexts of users across the scientific ecosystem. The guidelines should be informed by guidance and processes already in use at research institutions worldwide; specific and reviewable enough to guide decisions on animal welfare in transplantation, donor consent for novel applications, dual-use research risks, responsible communication, and clinical translation; and flexible enough to be adopted across different cultural, regulatory, and research contexts.

» **Field monitoring infrastructure** designed to keep guidance current as the science advances, and to keep the field itself informed as it grows and develops.

» **Communications resources**, including public-facing materials for patient communities and the wider public, that help scientists, funders, journal editors, review boards, and advocacy groups put the guidelines into practice, and that make this fast-moving, innovative field more transparent to those outside it.

» **An expanded stakeholder network**, reaching beyond the groups represented at Asilomar toward broader international, industry, and cultural perspectives, and toward deeper patient advocate participation, including through structured surveys that capture a wider range of voices from around the world as the field grows.

» **A connection to parallel, ongoing academic deliberation** on questions that call for sustained exploration, whether because they anticipate technological capabilities that do not yet exist or because they challenge existing practice in ways worth testing before they inform guidance. Guideline work should not be designed to wait on this deliberation, though it may occasionally need to. What matters most is that the two processes stay connected.

» **A design for the organizational structure** needed to sustain this work afterward, built through a multistakeholder process.

This phase should be multistakeholder by design, not by aspiration, and conducted transparently, with plans and progress shared publicly throughout. It should draw on the people best positioned to inform the guidelines: scientists, ethicists, legal scholars, social scientists, patient advocates, and organizations with deep expertise in research guidance work such as the International Society for Stem Cell Research and the Nuffield Council on Bioethics. It should also draw on the funders, journals, professional societies, and research review bodies whose participation can carry any resulting guidance from paper into everyday practice, shaping how future neural organoid research will be conducted around the world.

VII. CONCLUSION

The November 2025 Asilomar meeting demonstrated that meaningful progress toward international oversight of neural organoid research is both necessary and achievable. Over three days, participants from diverse disciplines and perspectives converged on core design principles for any effective oversight system, identified essential functions that such a system should perform, and developed initial concepts for how monitoring, guidance, and public engagement could proceed. While structural and financial questions remain, the meeting established a shared commitment to a process that respects scientific promise while taking seriously the ethical complexities this research creates. This progress reflects the dedication and expertise that participants brought to deliberations, the quality of facilitation and preparation that made productive dialogue possible, and the vision of the Dana Foundation and the Wu Tsai Neurosciences Institute at Stanford University, whose support made the gathering possible.

The field of neural organoid research cannot wait for perfect governance structures before advancing. Researchers will keep innovating with organoids and assembloids: transplanting human neural

tissue into animal hosts, exploring applications from personalized medicine to biocomputing, and moving toward clinical translation. The question is whether oversight can keep pace, not to constrain that progress, but to ensure it happens with attention to donor consent, animal welfare, dual-use risks, and responsible communication along the way. The convergent principles and proposed next steps outlined in this report provide a foundation for action. Sustaining the momentum generated at Asilomar will require moving deliberately but quickly from principles to practice, from aspiration to implementation, and from dialogue to durable institutions that can guide this remarkable field responsibly into the future.

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Carolyn Johnson is a science reporter at The Washington Post, where she covers biomedical research, health policy, and the business of health care. Previously a science reporter at The Boston Globe, her work has been recognized nationally, including as a finalist for the 2013 Pulitzer Prize in National Reporting. She holds a BA in Physics and English from Amherst College and an MS in Science Writing from the Massachusetts Institute of Technology.

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Tyler Lamb
Tyler Lamb is Director of Policy at the International Society for Stem Cell Research (ISSCR), leading the Society's global advocacy for stem cell research, funding, and ethical regulation. He works to promote evidence-based policymaking and support for scientific advancement worldwide.

Nicole Lav
Nicole Lav is a Ph.D. student in Neurosciences at the University of California, San Diego. She was previously a researcher in the Flanagan Lab at the UC Irvine School of Medicine. Her research involves studying neurodevelopment and neurodegeneration with stem cell-based models and brain imaging techniques.

Dr. Heidi Ledford
Dr. Heidi Ledford is a senior science reporter at Nature, where she covers biomedicine, genetics, and the intersection of science and society. Her reporting explores emerging research in fields such as genomics, drug discovery, and public health, making complex scientific developments accessible to global audiences. Dr. Ledford's work has also appeared in Scientific American, TIME, and other leading publications.

Mitch Leslie
Mitch Leslie is a Contributing Correspondent for Science magazine who writes about molecular and cellular biology. His work also appears in WebMD and RealClear Science, where he delivers accessible explanations of complex studies for scientific and general audiences.

Dr. Brie Linkenhoker
Dr. Brie Linkenhoker is the founder of Worldview Studio, where she leads research, design and media production projects that connect science and society. Brie is a seasoned facilitator, strategist, and foresight expert who has worked with universities, foundations, and NGOs on science engagement strategy. Brie holds a Ph.D. in Neuroscience and an M.A. in International Policy Studies from Stanford University.

Dr. Claudia López Lloreda
Claudia López Lloreda is a reporter for The Transmitter, where she covers neuroinflammation, systems neuroscience, and the neural mechanisms of behavior. Before joining The Transmitter in 2025, she reported for STAT, Science, and The Scientist. She obtained her PhD in neuroscience from the University of Pennsylvania. Her work focuses on translating complex neuroscience research into accessible and compelling stories for broad audiences.

Dr. Kate MacDuffie
Dr. Kate MacDuffie is Assistant Professor in the Department of Pediatrics (Division of Bioethics & Palliative Care) at the University of Washington and an investigator at Seattle Children's Research Institute. Her work examines ethical and social impacts of advances in neuroscience on children and families, using qualitative, quantitative, and conceptual methods to embed stakeholder perspectives in research.

Lea Mann
Lea Mann is a master's student in Cognitive Science at Ruhr University Bochum in Germany. She works as research assistant at the Predictive Brain Lab at Ruhr University Bochum.

Dr. Shruti Marathe
Dr. Shruti Marathe is a postdoctoral research fellow in the Department of Neuroscience at the University of California, San Francisco.

Dr. Mattia Maroso
Dr. Mattia Maroso is a Senior Editor at Science, where he curates neuroscience content. Prior to Science, he was an editor at Science Translational Medicine. He holds a Ph.D. from Istituto Mario Negri in Italy, and he did postdoctoral research at Stanford University and UC Irvine on epilepsy and hippocampal circuitry

Dr. Claire McGovern
Dr. Claire McGovern is a Fellow at Stanford Law School's Center for Law and the Biosciences. She holds an LLB and PhD from Maynooth University. Her research focuses on health law, bioethics, and property law.

Dr. Lucia Melloni
Dr. Lucia Melloni is a Research Professor at Ruhr-University Bochum, a Group Leader at the Max Planck Institute for Empirical Aesthetics and a Research Professor at NYU School of Medicine. Her research combines neuroimaging, electrophysiology, and behavior to uncover the neural mechanisms underlying uniquely human cognitive processes in perception, language, and consciousness.

Dr. Guo-Li Ming
Dr. Guo-Li Ming is the Perelman Professor of Neuroscience and a member of the Institute for Regenerative Medicine at the University of Pennsylvania. Elected to the National Academy of Medicine in 2019, she pioneered the use of patient-derived stem cells to model brain disorders and identify therapeutic strategies.

Megan Molteni
Megan Molteni is a science writer at STAT, covering genomic medicine, neuroscience, and reproductive technology. Formerly a staff writer at WIRED, she received the 2021 AAAS Kavli Science Journalism Award. Her work has appeared in Popular Science, Discover, Undark, and Aeon. She holds a BA from Carleton College and a Master's Degree in Journalism from UC Berkeley.

Dr. Caroline Montojo
Dr. Caroline Montojo is President and CEO of the Dana Foundation, where she leads efforts to advance neuroscience that benefits society and bridges disciplines including ethics, law, policy, and the humanities. Formerly Director of Life Sciences and Brain Initiatives at The Kavli Foundation, she has played a key role in shaping the U.S. and International Brain Initiatives. Dr. Montojo serves on advisory groups for the NIH BRAIN Initiative and the National Academies and is a member of the Council on Foreign Relations.

Dr. Jonathan D. Moreno

Dr. Jonathan D. Moreno is the David and Lyn Silfen University Professor Emeritus at the University of Pennsylvania and an advisor to the Center for Health, Ethics and Society at the University of Hamburg. A member of the National Academy of Medicine and a longtime advisor to U.S. presidential commissions and international bioethics bodies, he is recognized for shaping modern discussions on science, policy, and ethics in government and global health. His latest book is *Absolutely Essential: Bioethics and the Rules-Based International Order*.

Benedetta Muda

Benedetta Muda is a Ph.D. student in Experimental Medicine at the University of Milan. Her research within the European NeuroCOV consortium explores the sociotechnical construction of "NeuroCOVID" through omics analysis and qualitative methods.

Dr. Emily Murphy

Dr. Emily Murphy examines the intersection of neuroscience, behavioral science, and law, exploring how brain and behavioral evidence shape legal reasoning and public policy. She earned her A.B. magna cum laude in Psychology from Harvard, her Ph.D. in Behavioral Neuroscience and Psychopharmacology from Cambridge (Trinity College) as a Gates Cambridge Scholar, and her J.D. from Stanford Law School. Her research, published in leading journals, informs emerging ethical and legal frameworks for neuroscience and biomedical innovation.

Dr. William T. Newsome

Dr. William T. Newsome, PhD, is the Harman Family Provostial Professor of Neurobiology at the Stanford University School of Medicine and Founding Director of the Wu Tsai Neurosciences Institute. A pioneer in systems and cognitive neuroscience, he has made landmark contributions to understanding the neural basis of perception and decision-making. Dr. Newsome is a member of the National Academy of Sciences and the American Philosophical Society. He co-chaired the NIH BRAIN Initiative working group that shaped the nation's neuroscience research strategy.

Dr. John J. Ngai

Dr. John J. Ngai is Director of the NIH BRAIN Initiative, where he leads national efforts to accelerate innovative neurotechnologies for understanding the human brain. A neuroscientist and longtime faculty member at the University of California, Berkeley, Dr. Ngai's research and mentorship have advanced molecular neuroscience and trained a generation of leaders in the field. He brings more than 25 years of scientific and academic leadership to guiding the BRAIN Initiative's long-term strategy and operations.

Dr. Abhishek Pandeya

Dr. Abhishek Pandeya is a Research Associate at the Central Research Facility of Santosh Deemed to be University in Ghaziabad, India. A biotechnologist specializing in molecular biology, virology, and neurotoxicity, his research explores viral miRNA regulation, stem-cell models of neurodegeneration, and autophagy pathways in human disease. Dr. Pandeya has authored numerous peer-reviewed studies on neurotoxicology, apoptosis, and cellular stress published in leading international journals.

Dr. Sergiu P. Pasca

Dr. Sergiu P. Pasca is Professor of Psychiatry and Behavioral Sciences at Stanford University. His lab has pioneered human brain organoids and assembloids to model neural development and disease. A New York Times Visionary in Medicine, he has received the Vilcek Prize, the IBRO-Kemali Award, and the Knight of the Order of Merit distinction.

Kristine Pashin

Kristine Pashin is a researcher in the Heilshorn Group at Stanford University, where she led the 2025 Bio-X Undergraduate Summer Research Program cohort. Her work focuses on neural organoid engineering and the ethical dimensions of stem cell-based therapies. She has been recognized as a TIME Initiative Fellow, two-time Stanford Bio-X Grant recipient, and Hume Honors Fellow for her interdisciplinary research bridging neural engineering, ethics, and policy.

Dr. Meenakshi Prabhune

Dr. Meenakshi Prabhune is Editor-in-Chief of The Scientist. A biophysicist turned editor, she leads coverage that translates complex research for broad scientific audiences. She has held roles across journalism, podcasting, and content strategy. She earned her PhD in biophysics from the University of Göttingen.

Dr. Khara Ramos

Dr. Khara Ramos is Vice President of Neuroscience & Society at the Dana Foundation, where she directs programs that bridge neuroscience, ethics, and public engagement. Formerly the inaugural Director of Neuroethics at the NIH's National Institute of Neurological Disorders and Stroke, she helped establish the field's growth within the BRAIN Initiative and across federal research programs. A neuroscientist by training, Dr. Ramos earned her PhD from UC San Diego and her BA with honors in Symbolic Systems from Stanford University.

Dr. Brian Rummell

Dr. Brian Rummell is a postdoctoral researcher at the Ernst Strüngmann Institute for Neuroscience in Frankfurt, in collaboration with the Max Planck Society.

Juli Sherry

Juli Sherry is Director of Design at Worldview Studio, where she leads design across learning experiences, communications, and digital strategy. Formerly with Worldview Stanford, she holds a BS in Computer Graphics and Animation from DePaul University and an MBA in Design Strategy from California College of the Arts.

Alison Singer

Alison Singer is the President and Co-Founder of the Autism Science Foundation. A leading patient advocate driven by her experience as a parent and guardian to two autistic adults, she has served on the federal Interagency Autism Coordinating Committee and numerous advisory boards for leading research centers. Her honors include the AAP "Autism Champion" and INSAR Outstanding Research Advocate awards.

Dr. Jeremy Sugarman

Dr. Jeremy Sugarman is the Harvey M. Meyerhoff Professor of Bioethics and Medicine at the Johns Hopkins Berman Institute of Bioethics. An international leader in bioethics, he applies empirical and conceptual methods to examine ethical issues related to topics such as informed consent, stem cell research, and global health. He has authored more than 400 publications and advises national and international bodies on ethical standards in biomedical research and policy. He is a member of the International Society for Stem Cell Research's Ethics and Public Policy Committees.

Dr. Giuseppe Testa

Dr. Giuseppe Testa is Professor of Molecular Biology at Università Statale di Milano and Director of the High Definition Disease Modeling Lab at the European Institute of Oncology. At Human Technopole, he leads the Neurogenomics Centre, studying stem cell and organoid epigenetics to understand intellectual disabilities and autism.

Dr. Isha Verma

Dr. Isha Verma is a stem cell biologist and neuroscientist at the University of Michigan, where her research models neurological and neurodegenerative disorders using human stem cell systems. Her work bridges neurodevelopmental biology and regenerative medicine to identify mechanisms of disease and develop stem cell–based therapeutic strategies. Dr. Verma is also an active advocate for science communication and education.

Dr. Linda O. Wadiche

Dr. Linda O. Wadiche is a professor and Vice Chair for Faculty Affairs and Development at the University of Alabama at Birmingham. Her research focuses on neurodevelopment, synaptic plasticity, and the molecular mechanisms underlying learning and memory. She is a Senior Editor at the Journal for Neuroscience.

Lisa Weaklim

Lisa Weaklim is a multimedia producer at Worldview Studio specializing in research-based storytelling. With a background in creative production and over 15 years of project management experience, she has produced films for universities, foundations, and science organizations. She holds a BBA in Marketing Management from Stetson University.

Dr. Nicholas Weiler

Dr. Nicholas Weiler is Associate Director of Communications for Stanford's Wu Tsai Neurosciences Institute and the Knight Initiative for Brain Resilience. An Oakland-based science communicator, he holds a PhD in neuroscience from Stanford University and a Science Communication certificate from UC Santa Cruz. Prior roles include Public Information Officer at UCSF and contributor to Science.

Dr. Jill Wentzell

Dr. Jill Wentzell is Executive Director of the Wu Tsai Neurosciences Institute at Stanford University. A neuroscientist with expertise in molecular and cell biology, she earned her Ph.D. in Neuroscience from Oregon Health & Science University. She has held academic and administrative roles at Stanford, Duke, and UNC Chapel Hill.

Dr. Anthony M. Zador

Dr. Anthony M. Zador is the Alle Davis Harris Professor of Biology and Chair of Neuroscience at Cold Spring Harbor Laboratory. A co-founder of COSYNE and NAISYS, he has pioneered molecular approaches to large-scale connectome mapping and works on NeuroAI, at the intersection of neuroscience and AI.

Dr. Mariela Zirlinger

Dr. Mariela Zirlinger is the Editor-in-Chief of Neuron at Cell Press, where she oversees the publication of leading neuroscience research. Trained in mouse genetics, behavior, and molecular and developmental neurobiology, she earned her Ph.D. at Caltech and completed postdoctoral work at Harvard.

AGENDA

MONDAY, NOVEMBER 10

AFTERNOON

4:00 - 6:00pm	Check in to event and rooms: *Hearst Social Hall*
6:00 - 6:45	Dinner: *Crocker Dining Hall*
7:00 - 8:00	Welcome and overview: *Kiln Meeting Room* Brie Linkenhoker, Sergiu Pasca, Hank Greely, Phil Campbell.
8:00 - 10:00	Optional drinks and informal social gathering: *Hearth Living Room*

TUESDAY, NOVEMBER 11

MORNING

7:30 - 8:15am	Breakfast: *Crocker Dining Hall*
8:30 - 8:45	Welcome: *Kiln Meeting Room*
8:45 - 10:00	**Session I: State of the Science.** *Kiln Meeting Room* Guo-li Ming, Sergiu Pasca, Jeremy Sugarman, Giuseppe Testa
10:00 - 10:30	30 Minute Break
10:30 - 12:00	**Session II: Organoid and Assembloid Research in Society.** *Kiln Meeting Room* John Evans, Nita Farahany (video), Hank Greely, John Ngai, Alison Singer

AFTERNOON

12:15 - 1:00pm	Lunch: *Crocker Dining Hall*
1:15 - 2:45	**Session III: Emergent Properties of Organoids and Assembloids.** *Kiln Meeting Room.* Stanislas Dehaene, Peter Godfrey-Smith, Sergiu Pasca, Lucia Melloni, Anthony Zador.
2:45 - 3:00	Break
3:00 - 4:00	**Session IV: Transplantation and Novel Uses.** *Kiln Meeting Room* Peter Godfrey-Smith, Insoo Hyun, Kazuto Kato, Jonathan Moreno, Sergiu Pasca
4:00 - 4:15	Break
4:15 - 5:15	**Session V: Public Communication.** *Kiln Meeting Room* Phil Campbell, Noah Gray, Jonathan Hamilton, Mattia Maroso, Megan Molteni, Mariela Zirlinger
5:15 - 5:30	Wrap-up: *Kiln Meeting Room*
6:00 - 7:00	Dinner: *Crocker Dining Hall*
7:00 - 10:00	*Optional drinks and informal social gathering: Hearth Living Room*

WEDNESDAY, NOVEMBER 12

MORNING

Please check out before the session begins at 8:30.
Luggage can be stored in the Oak Shelter.

7:30 - 8:15am	Breakfast: *Crocker Dining Hall*
8:30 - 9:45	**Session VI: The Path Forward.** *Kiln Meeting Room.* Alta Charo, Ben Hurlbut, Tyler Lamb, Caroline Montojo, Linda Wadiche
9:45 - 10:00	Break
10:00 - 11:30	**Session VII: Designing an international guidance system.** *Breakout sessions in Kiln Meeting Room and nearby rooms TBD.*
11:30 - 12:00	Next steps and closing remarks: *Kiln Meeting Room.*

AFTERNOON

12:15 - 1:00pm	Lunch: *Crocker Dining Hall*
1:00	Conference ends

APPENDIX C: REFERENCES AND RESOURCES

Foundational reference documents:

Pasca, S.P., Arlotta, P., Campbell, P., Charo, A., Evans, J.H., Farahany, N., Gage, F.H., Godfrey-Smith, P., Hyun, I., Kriegstein, A.R., Melloni, L., Ming, G.L., Moreno, J.D., Sugarman, J., Temple, S., Testa, G., Greely, H.T. (2025). The need for a global effort to attend to human neural organoid and assembloid research. *Science*, 6 November 2025.

National Academies of Sciences, Engineering, and Medicine. (2021). *The Emerging Field of Human Neural Organoids, Transplants, and Chimeras: Science, Ethics, and Governance*. Washington, DC: The National Academies Press.

International Society for Stem Cell Research, Version 1.2. (2025). *Guidelines for Stem Cell Research and Clinical Translation*. https://www.isscr.org/guidelines

Nuffield Council on Bioethics. (2024). *Research Using Neural Organoids: Ethical Considerations*. https://www.nuffieldbioethics.org/publication/research-using-neural-organoids-ethical-considerations/