

Reckoning with the Life Sciences in the Age of AGI

A Layered Evidence Framework for Life, Individuation, and Subject Continuity

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A Layered Evidence Framework for Life, Individuality, and Subject Continuity

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Submitted for joint scrutiny by the life sciences, biology, neuroscience, artificial life, and philosophy of biology. Taking criteria for life, individuation, development and death, copying and replacement, and cross-implementation continuity as its disciplinary objects, this paper proposes a refutable, revisable evidence-to-inference framework. It is not a consciousness detector, a judgment of legal personhood, political authorization, or a set of governance parameters.

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Abstract translated from the Chinese

Synthetic genomes, minimal cells, brain organoids, somatic-cell nuclear transfer, cellular reprogramming, reconfigurable organisms, and advanced artificial intelligence are separating biological organization, functional intelligence, sentience, individual continuity, and institutional identity, properties long borne together by the same kinds of natural life. The question is therefore no longer simply “What is life?” but which criteria for life different objects satisfy at which scales, what this evidence can support, and what it cannot establish about experience, subject continuity, responsibility, or standing. This paper is a conceptual synthesis spanning the life sciences, philosophy of biology, neuroscience, synthetic biology, artificial life, and AI research. Using “object and scale, empirical observation, competing explanations, and cross-level bridging” as its principal framework, it reorganizes discussions of definitions of life, biological individuation, development and aging, determination of death, copying and replacement, organoids, synthetic life, and comparisons with advanced AI. It advances three arguments: judgments of life must specify criteria, object scale, and research purpose together; biological individuals are historical organizations jointly formed through development, homeostasis, cooperation and conflict, and environmental relations, rather than static collections of material; and life classification, evidence of sentience, subject continuity, and institutional status are related but do not entail one another. Cloning, reprogramming, organ replacement, radical life extension, synthesis, and copying each preserve or alter different continuity relations. No local success is sufficient to establish a complete life history or first-person persistence. This paper proposes no final definition of life, reports no new experiment, and does not infer meaning, personhood, rights, or public power directly from biological facts. Its contribution is an evidence-to-inference audit framework usable across natural, synthetic, and artificial objects, together with explicit conditions that would require its contraction, revision, or abandonment. The paper further moves disciplinary responsibility upstream to the generation of goals and purposes: a shift from self-interest first to self-interest with others first brings genuine stakeholders into judgment before purposes are generated and locked in. Disciplinary facts, direction, methods, and outcomes are specified separately; local successes and failures do not substitute for common survival and the three long-term goals. On this basis, research advances from distinguishing disciplinary objects to investigating cross-disciplinary relations in depth, tracing how judgments in this field change reality through other fields and how feedback returns to alter the original conditions and the next round of purposes. Stakes across multiple subjects, stages, and settings must be presented separately; correlations, common causes, mediation, and causal feedback must be tested separately; and the additional relational dimensions must face specific counterevidence.

Keywords: definition of life; biological individual; life history; finitude; subject continuity; brain organoids; synthetic life; artificial life; AGI

Abstract

Synthetic genomes, minimal cells, brain organoids, somatic-cell nuclear transfer, cellular reprogramming, reconfigurable organisms, and advanced artificial intelligence are unbundling properties long co-instantiated in familiar living beings: biological organization, functional intelligence, sentience, individuality, continuity, and institutional status. The resulting question is no longer merely what life is, but which criteria are met by which objects at which scales, what the available evidence supports, and what it cannot establish about experience, subject continuity, responsibility, or standing. This Perspective offers a conceptual synthesis across the life sciences, philosophy of biology, neuroscience, synthetic biology, artificial life, and AI research. It organizes claims through four steps: object and scale, empirical observation, competing explanation, and cross-level bridge. Three conclusions follow. Judgments of life must state their criteria, target scale, and research purpose; biological individuals are historically formed organizations of development, homeostasis, cooperation and conflict, and environmental relations rather than static collections of matter; and life classification, evidence of sentience,

subject continuity, and institutional status are related without entailing one another. Cloning, reprogramming, organ replacement, radical life extension, synthesis, and copying preserve or alter different continuity relations, so success at one level does not establish a complete life history or first-person persistence. The paper proposes neither a final definition of life nor a new experiment, and it does not infer meaning, personhood, rights, or public power directly from biological facts. Its contribution is a cross-object evidence-to-inference framework with explicit conditions under which it should be narrowed, revised, or abandoned. The paper further locates disciplinary responsibility before goal and purpose generation: a shift from self-interest first to self-interest with others first brings subjects with genuine stakes into judgment before goals are formed and locked. Facts, direction, methods, and outcomes remain distinct. The analysis is further extended to cross-disciplinary causal relations. It traces how judgments in this field change real-world conditions through other domains, and how feedback modifies the original conditions and subsequent purposes. Effects across actors, stages, and settings must be distinguished from correlations, common causes, and merely asserted connections.

Keywords: definition of life; biological individuality; life history; finitude; subject continuity; brain organoids; synthetic life; artificial life; AGI

Research Position Materials and Evidential Discipline

The starting point of this research is a leap in theory and dimensions. It retains disciplinary precision while deepening causal relations with neighboring fields. Disciplinary boundaries identify burdens of proof; they do not end the tracing of shared consequences. Existing scholarship participates in the examination of competing explanations and counterexamples; the absence of a place in an established classification cannot require new questions to retreat into old frameworks.

This paper is a Perspective / Conceptual Review, not a systematic review, experimental paper, clinical guideline, report detecting AI consciousness, or policy white paper. Its materials primarily comprise landmark original research, professional guidelines, authoritative reports, and theoretical literature with direct value as counterexamples that were publicly verifiable as of August 25, 2026. They cover definitions of life and autopoiesis, major evolutionary transitions, biological individuation, development and aging, brain death, cloning and reprogramming, synthetic genomes and minimal cells, brain organoids, reconfigurable organisms, sensory substitution, interoception, and neural interfaces. The selection principle is not bibliometric exhaustiveness: every source must support a clear, limited, and independently checkable conclusion. The appendices register, item by item, what each can support and which cross-level conclusions it cannot support.

The paper distinguishes four argument statuses. Category A comprises empirical, clinical, structural, or formal textual facts with relatively stable support; objects, samples, scales, conditions, and reproducibility must be delimited. Category B comprises frontier research with competing explanations; alternative mechanisms, counterexamples, and limits on extrapolation must be presented alongside it. Category C comprises technological scenarios not yet realized and the cross-disciplinary research framework proposed here; these support only conceptual stress tests and revisable hypotheses. Category F comprises philosophical or normative commitments explicitly assumed by the paper, such as the plurality of sources of meaning, the distinction between finitude and short life, and the inability of biological facts automatically to generate rights or power. Category F must not masquerade as life-science discovery; A, B, and C must not be mechanically converted into personhood, standing, or authorization. Evidential strength is not compressed into a life score, consciousness score, or standing score. Reproducibility, causal intervention, convergence across methods, and independent review are specified separately.

The Minimal Interface with Civilization Leap

Readers unfamiliar with Civilization Leap need neither prior knowledge nor agreement to scrutinize this paper independently. It adopts only a minimal interface: current advanced generative and agentic artificial systems mean that life, intelligence, experience, subjecthood, responsibility, institutional standing, and power can no longer be inferred from one another on the basis of their historical coincidence. Here, the “age of AGI” means that this separation has become an enduring technological and institutional condition. It does not presuppose an already completed AGI entity with a uniform definition and subjecthood. Meaning is treated as a necessary but insufficient evaluative horizon for civilizational legitimacy, rather than a life-science discovery or the sole overarching value. Welfare, truth, equality, resistance to domination, and harm to others retain independent standing. Finitude is one kind of structure through which the history of formation, relationships, choices, and consequences acquire subject-relevant weight in known life. It is not the sole source of meaning, still less an endorsement of death, suffering, or short life. Whenever a biological fact enters a conclusion concerning experience, subjecthood, meaning, rights, or power, competing explanations, philosophical bridges, and institutional principles must be specified separately.

Rules of Inference Throughout the Paper

Determine the object and scale before reporting observations; compare competing explanations before proposing cross-level bridges. Life, experience, subject continuity, ethical personhood, legal standing, political membership, public authority, and sovereignty each require their own evidence. Openness to heterogeneous life and future subjects does not mean treating possibilities as established facts in advance; insufficient evidence does not mean permanent impossibility.

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Cross-scale Consequences and Intergenerational Relations in Life Research

From Criteria for Life to the Joint Formation of Life Conditions

Biological organization, individuation, development, sentience, and continuity require independent evidence while also being jointly shaped by environment, care, resources, and institutions. Deepening research into cells or organisms must not end inquiry into how technologies change life conditions when they enter everyday life. Biological feasibility, actual accessibility, relational responsibility, and intergenerational consequences belong to different levels. They must be connected without substituting for one another.

How Treatment and Enhancement Change the Next Round of Demand

Suppose a life-extension capability works but is accessible only to a few. The capability changes life expectancy; life expectancy changes arrangements for education, work, family, and resources; distribution structures influence research directions; and new research again prioritizes existing purchasing power. This chain requires joint scrutiny by the life sciences, economics, sociology, education, and ethics. The proposition that life extension is beneficial cannot directly establish the justice of its distribution; nor can difficulties of distribution negate the treatment itself.

Multiple Bearers of Consequences and Timescales

Research participants, recipients of treatment, caregivers, communities, and future generations may bear different risks. Short-term therapeutic effects may also differ from long-term developmental, ecological, and resource consequences. Responsibilities in laboratories, health care, families, and public institutions are not the same. What tissue copying, organ replacement, and information preservation each retain must be specified level by level. Continuity of technological history cannot directly promise first-person survival.

How to Test the Theoretical Contribution

Relational research should identify cases where individual biological effects are similar but actual health, care burdens, or future options differ. If long-term evidence refutes cross-domain predictions, the specific bridges should be revised. If all social changes are attributed to biotechnology, common causes such as income, institutions, and population must be tested. Expanding dimensions respects disciplinary facts while keeping disciplinary conclusions answerable to the consequences of their entry into the world.

Biological Facts and Civilizational Purposes

When the life sciences enter purpose formation, they must first identify who is undergoing real changes: how bodies, health, reproduction, care, and intergenerational conditions are affected; which harms can be repaired; and which will change an entire life. Technically extending operation or preserving information is not the same as life actually benefiting. Reducing biological risk deserves affirmation, but it cannot automatically substitute for happiness, relationships, and meaning.

The new starting logic requires purposes for treatment, enhancement, and resource allocation to recognize the actual bearers of consequences before those purposes are locked in. Research participants cannot be treated merely as material for generating future aggregate benefits, nor can generations unable yet to speak be treated merely as statistical headcounts. Individual interests, community relations, and humanity's shared future should enter together within specific causal bounds.

Biological individuation, sentience, subject continuity, and institutional standing still require separate discussion. Cloning, cellular renewal, and organ replacement can preserve structures at different levels. Preservation of one structure cannot promise first-person survival. Openness to artificial life and longer-lived forms likewise cannot reduce current finite lives to expendable transitional versions.

The proposition that existing meaning cannot be retroactively canceled has two levels. Histories of occurrence and causation cannot be made never to have happened by later naming; this is the factual level that life research can help identify. The minimum existential standing of a life is not reduced to zero by comparisons with future capabilities; this is a normative level that requires separate justification. Science proving only one level does not require deletion of the other.

Recognizing meaning does not freeze historical evaluation. Responsibility for harm may be reassessed; errors may be corrected; honors and public interpretations may change with evidence. The impossibility of erasing a history of occurrence does not prohibit criticism of the actions that occurred. Protecting the meaning of life likewise does not recognize all purposes as legitimate.

1 Introduction Why Life Can No Longer Answer Other Questions

What, respectively, is preserved by a synthetic cell, a brain organoid, a cloned individual, a long-running artificial agent, and a personality backup? Calling these objects “life” or “subjects” directly compresses cellular organization, developmental history, sentience, first-person continuity, and institutional identity into a single judgment. Conversely, excluding an object permanently simply because it is not natural carbon-based life mistakes the present sample for the limits of the universe. This paper starts with observable objects and research scales: determine objects, criteria, and evidence first, then discuss experience, continuity, and protection. Every cross-level conclusion must supply an additional scientific or normative bridge.

Traditional discussions have already addressed many partial separations: viruses and dormant organisms challenge metabolic and reproductive criteria; worker ants and mules show that an individual’s present life cannot be decided by its reproductive capacity; microbiomes, chimeras, and colonial organisms blur individual boundaries; corporations have institutional identity without life or experience; and infants, people in comas, and people with severe cognitive disabilities show that current higher-order capacities are not necessary for basic protection. What is new about AGI-related technologies is not the first appearance of boundary exceptions. It is that functional intelligence is beginning to be stably combined in technological systems not established as living beings or subjects of experience, entering chains of knowledge, organization, and high-consequence action. Conceptual separations once encountered as boundary cases are becoming conditions of large-scale research and institutions.

The overarching question is therefore not whether machines resemble humans. This paper separates five evidential accounts: whether an object constitutes biological organization; whether evidence exists for sentience or subjective experience; whether subject continuity forms across time and cannot be arbitrarily replaced under conditions of copying; whether the object has a subject-relevant grasp of consequences; and what institutional position should be assigned for protection, transactions, responsibility, or governance. These five accounts can inform one another, but none automatically settles the remaining four.

Table 1 Five Evidential Accounts and Their Inferential Boundaries

Object of evidence	Minimum research question	Insufficient on its own to support
Biological organization	How are boundaries, self-maintenance, metabolism, development, repair, reproduction, heredity, and open-ended evolution organized?	Experience, personhood, rights, or meaning

Object of evidence	Minimum research question	Insufficient on its own to support
Sentience / experience	Is there multimethod evidence of sensation, valence, and first-person states?	Reflective capacity, capacity for responsibility, or numerical identity
Subject continuity	Does the same perspective persist across time, replacement, copying, and interruption?	Legal personhood, the full range of rights, or political standing
Grasp of consequences	Are the consequences of action stably bound to the entity's own persistence, impairment, commitments, and revision?	Experience, sovereignty, or public power
Institutional position	What standing and powers are needed for protection, transactions, responsibility, or governance?	Proof of an ontological subject

1.1 Three Contributions and One Self-imposed Limit

First, the paper reorganizes disputes over the definition of life through “criteria × scale × research purpose,” enabling public discussion of why the same object receives different classifications in different research tasks. Second, it separates genetic, material, functional, informational, relational, and first-person continuity, using a common matrix to compare cloning, reprogramming, replacement, life extension, synthesis, and copying. Third, it registers side by side the narrowest conclusions biological facts can support and the cross-level conclusions they cannot, so that disputes are no longer won by expanding the meaning of a word. Its self-imposed limit is this: it supplies no necessary and sufficient conditions for consciousness, and it does not mechanically rank diverse evidence on a single scale. If the principal framework cannot generate better predictions, experimental designs, or identification of disagreements than existing conceptual distinctions, it should be reduced to a teaching tool rather than continuing to expand its terminology.

1.2 What the Life Sciences Can Establish and Where They Hand Over

The life sciences can independently answer empirical questions about characteristics of life, individuation, development and death, homeostasis and repair, copying and replacement, lineages, and multiscale organization, while specifying the objects, scales, and research purposes for which these criteria are valid. They must stop short of sufficient judgments about experience and first-person continuity. Neural activity, biological organization, metabolic homeostasis, noncopyability, or death cannot alone finally adjudicate subjective experience, personhood, rights, or public power. Equally, nonbiological material, copyability, or pausability cannot serve as grounds for excluding future subjects a priori. Questions about experience and self pass to cognitive science, neuroscience, and philosophy of mind; those about evidential strength and cross-implementation analogy pass to epistemology; those about protection, legal standing, and responsibility pass to ethics and law; and those about models, instances, versions, migration, and system continuity pass to AI and systems science. The life sciences supply factual premises and retain the right to revise these handover relations in light of new life forms, new individual structures, and new experimental findings.

2 Criteria for Life Definitions Scales and Research Purposes

NASA’s astrobiology program uses “a self-sustaining chemical system capable of Darwinian evolution” as a working definition [1]. It serves detection and experimental design, rather than constituting a binding final definition. Viruses, dormant organisms, infertile individuals, worker ants in social insects, obligate parasites, symbiotic communities, and possible extraterrestrial chemical life challenge different elements of it. The scientific

value of a working definition lies in specifying observable variables, not in closing off life in the universe a priori within a single sentence.

This paper proposes a research approach combining “clusters of criteria, object scale, and competing models.” Boundary maintenance, energy and material exchange, homeostasis and repair, development and historical dependence, reproduction and heredity, variation and evolution, environmental sensing and action, and open-ended adaptation may appear in different objects and at different scales. They are neither an additive life score nor individually sufficient conditions.

Table 2 Competing Traditions in Defining Life Their Contributions and Boundaries

Theoretical tradition	Valid legacy	Critical blind spots	Direction of development
Metabolism / homeostasis	Exchange, regulation, repair, and organizational integrity	Dormancy, parasitism, engineering control	Distinguish engineering regulation, biological self-maintenance, and interoception
Autopoiesis / organizational closure	A system continuously produces and maintains its components and boundaries [2]	Operationalization, scale, and environmental dependence	Use as a comparative model, not a detector of consciousness or rights
Darwinian evolution	Heritable variation, selection, and population history	An individual's present life is not equivalent to a population's evolutionary capacity	Separate individual life, population evolution, and normative value
Information / control	Heredity, regulation, and error repair	Abstract information processing may be detached from biological organization	Do not equate copying information with copying life or a subject
Developmental systems / epigenetics	Formation history, lineage, environment, and state reprogramming	Reprogrammability does not mean an entire history can be rerun	Trace path dependence and the extent of its variability
Major evolutionary transitions / multilevel selection	Levels of individuality, cooperative structures, and information channels can be reorganized	Increasing complexity is easily misrepresented as inevitable progress	Study scales of individuation without presupposing a single boundary
Ecology / symbiosis	Life boundaries are relational and ecologically embedded	Porous boundaries do not mean individuals do not exist	Allow individuals at multiple levels to coexist; establish subjecthood separately
Synthetic biology / artificial life	Design-build-test approaches explore the organization necessary for life	Artificial origin or assembly from living cells easily invites exaggerated naming	Distinguish evidence for material, closure, copying, evolution, and subjecthood

Common ancestry among existing terrestrial life has strong statistical support [3]. Yet common ancestry proves neither that life originated only once nor that carbon, DNA, or cellular organization must forever be prerequisites for heterogeneous life. Research on major evolutionary transitions shows that units of replication, cooperative structures, and information channels can be reorganized through evolution [4]. A useful framework for life must therefore have exclusionary power while allowing new objects to generate predictions that can fail. It should specify which observations would strengthen or weaken a judgment, or lead to its replacement by a competing model, rather than admitting every complex, self-maintaining, or replicating system into an indefinitely open set.

Working Conclusion

Definitions of life should be treated as research tools rather than judgments of standing. Every determination must specify the object, scale, criteria, research purpose, and boundary cases. If a unified model with greater predictive power across natural, synthetic, dormant, parasitic, and heterogeneous objects emerges, the cluster-of-criteria approach should contract into a historical comparative tool.

3 Biological Individuation Boundaries Cooperation Conflict and Multiscale Organization

A biological individual is not an inventory of materials but an organizational process continually formed through development, metabolic turnover, immune regulation, microbial symbiosis, and environmental exchange. Many cells and molecules in the human body are continually renewed, but turnover rates are highly tissue-specific; some neurons can be as old as the individual [11]. Thus, changing composition proves neither that an individual is replaced daily nor that every component remains unchanged throughout life.

Individuation can be studied at no fewer than four scales. Physiological individuality concerns homeostasis and integrated regulation; evolutionary individuality concerns units of replication, heredity, and selection; immunological individuality concerns tolerance, danger, and boundary regulation; and ecological individuality concerns host-symbiont functional dependence. Queller and Strassmann investigate organismality through high cooperation and low conflict [5]. The human microbiome and squid-Vibrio symbiosis show that members of different origins can participate deeply in normal formation and function [6][7]. These findings support multiscale individuation, not the claim that a host and its microbes automatically constitute one unified subject.

Chimeras, coral colonies, slime molds, clonal colonies, and social insects further compel us to distinguish “one living unit,” “one unit of selection,” “one bearer of welfare,” and “one legal subject.” Boundary disputes are not grounds for abolishing boundaries. They require research to specify who is maintaining itself, who is being harmed, at which scale conflict is reduced, and at which scale institutional decisions will alter relationships.

Major evolutionary transitions guarantee neither that increasing complexity is inevitable progress nor that higher-level organization has unified experience [4]. The danger model in immunology further shows that boundary regulation cannot be reduced to static self/nonself recognition [27]. Conversely, ecological dependence within microbiomes cannot directly establish the holobiont as the sole unit of selection or subject of experience. Critiques of the hologenome and holobiont concepts show that host and microbial interests are not always unified and that transmission modes and levels of selection may diverge [39].

Table 3 Multiscale Individuation Different Research Units within the Same Object

Scale	Boundary and integration mechanisms	Supported conclusion	Does not automatically establish
Physiological individual	Homeostasis, metabolism, repair, and organ coordination	A research unit for integrated regulation	An evolutionary unit or subject of experience
Evolutionary individual	Replication, hereditary interests, cooperation and conflict	An analytical unit for selection and adaptation	Moral status or group consciousness
Immunological individual	Tolerance, danger, injury, and boundary regulation	Recognition and response boundaries can form dynamically	A fixed ontological self
Ecological individual	Host-symbiont dependence and environmental exchange	Functions may be distributed across species	A unified first-person perspective or bearer of responsibility

Biological individuation thus includes an empirical proposition and a philosophical proposition requiring separate argument. The empirical proposition is that current states are causally shaped by development, homeostasis, immunity, symbiosis, and environmental relations. The philosophical proposition is whether formation history constitutes identity rather than merely causing present structure. The life sciences can measure the former and test the incremental explanatory value of formation history while controlling for current states. They cannot establish the latter alone, still less infer the nonexistence of individuals from porous boundaries.

4 Life History and Time Development Aging Dormancy and Death

Time in the life sciences cannot be described solely by clock sequence. It encompasses formative windows, stage dependence, cell lineages, cumulative damage, repair capacity, relational continuation, and a history that cannot be completely returned to an earlier state. Research on the cell lineage of *C. elegans* shows highly traceable developmental pathways that include programmed cell death [8]. The twelve hallmarks of human aging form an interconnected framework for investigating mechanisms, rather than an exhaustive definition of its essence [9]. Biological time therefore contains both mechanisms open to intervention and an overall formation history that no single mechanism can reset to zero.

Death likewise requires distinctions between levels: cell death, organ failure, circulatory arrest, permanent loss of function of the brain as a whole including the brainstem, individual death, and legal death are related but not equivalent. The 2023 pediatric and adult consensus guideline for brain death/death by neurologic criteria emphasizes prerequisites, exclusion of confounders, neurologic examination, and apnea testing. Ancillary testing is used only in specified circumstances, including when clinical assessment cannot be safely or completely performed [10]. The guideline uses “permanent” rather than requiring every brain function individually to have ceased “irreversibly,” and it allows persistence of some neuroendocrine functions. Medical determination supplies operational criteria for death but does not alone decide when relationships, personhood, and meaning end.

Finitude is not short life, nor does it constitute opposition to life extension. Extending healthy lifespan can alter the timescale of biological finitude without automatically abolishing finitude in development, narrative, relationships, and subject continuity. Even a life lasting ten thousand years may have an irrevocable formation history, an irreplaceable relational position, and a perspective that will eventually end.

Programmed cell death participates in tissue formation and regulation of cell populations, but classical apoptosis research is not a final catalogue of every mechanism now recognized as regulated cell death [28]. Cross-species comparisons also reveal substantial diversity in mortality and fertility trajectories [36]. The absence of evident senescence in particular hydra cohorts over a finite observation period cannot be generalized into absolute biological immortality [37]. These findings force finitude to be distinguished from short lifespan and a constant rate of aging: biological finitude can be delayed, distributed, or altered without automatically disappearing.

4.1 Permanent Is Not Synonymous with Irreversible

The 2023 pediatric and adult consensus guideline for brain death/death by neurologic criteria refers to permanent loss of function of the brain as a whole, including the brainstem. It organizes clinical procedures around strict prerequisites, exclusion of confounders, neurologic examination, and apnea testing; ancillary tests are used only in specified circumstances [10]. Citations must also register the 2024 correction [41]. Here, “permanent” rests on clinical and institutional conditions in which function will not recover spontaneously and restoration will not be attempted. It must not silently be replaced by the stronger claim “irreversible under any technological conditions.” The guideline allows some residual neuroendocrine function and does not claim that every brain cell

or all bodily integration has disappeared. Some long-term somatic integration in cases of chronic brain death challenges the classical rationale that the brain is the body’s sole integrator, but does not establish consciousness, recovery of brain function, or revival after diagnosis [42]. The World Brain Death Project provides international minimum standards and procedural coordination [35], but clinical determination still cannot settle when a soul, personhood, relationships, or meaning ends.

4.2 From Six Life-science Analyses to Eight Cross-disciplinary Layers of Finitude

The life sciences can directly study biological finitude and developmental/path finitude, and contribute evidence about some effects of physical constraints in living implementations. Through interoception, homeostasis, sensorimotor processes, and developmental history, they can also enter the embodiment/experience interface. Narrative, relational, agency/consequence, and first-person continuity questions are not the life sciences’ exclusive domain. To avoid competition between the “six layers of finitude” and the “eight-layer framework” in the philosophy paper prepared for independent circulation, this paper treats the former as disciplinary analytical windows and retains the latter as the overarching cross-disciplinary framework. The number of layers is not an ontological inventory, still less something to be added into a total finitude score.

Table 4 Mapping Life-science Analytical Windows onto the Cross-disciplinary Framework of Finitude

Cross-disciplinary layer	Direct life-science contribution	Contributions needed from neighboring disciplines	Key prohibition
Physical / causal	Energy, materials, attrition, and local irreversibility	Physics and engineering	Physical constraint does not imply life or experience
Biological	Metabolism, repair, aging, disease, reproduction, and death	Medicine and ecology	Susceptibility to intervention does not mean disappearance
Developmental / path	Lineages, formative windows, plasticity, and epigenetic states	Developmental psychology	Local reprogramming does not mean an overall reset
Embodied / experiential	Candidate mechanisms of interoception, homeostasis, and sensorimotor activity	Neuroscience and philosophy of mind	Mechanistic correlation does not establish phenomenal experience
Narrative	Biological conditions of memory systems	Psychology and the humanities	Archival preservation does not mean experiential continuation
Relational	Consequences of attachment, stress, and care for life	Sociology and ethics	Relational continuation does not mean copying a subject
Agency / consequences	Mechanisms of action regulation and learning	Cognitive science and ethics	Optimizing consequences does not establish concern for oneself
Subject continuity	Some indicators of neural and bodily continuity	Philosophy of mind and epistemology	Biological continuity does not finally adjudicate first-person identity

5 From Biological Organization to Sentience and Subjecthood Gray Areas Are Not a Ladder

Being classified as living is not sufficient evidence for inferring consciousness; not being classified within existing life is not sufficient grounds for permanently excluding experience. Known high-confidence samples of experience

come from living organisms, particularly those with nervous systems and comparable behavioral, report-based, or physiological indicators. This fact about the sample proves neither that biological organization is sufficient for experience nor that it is necessary for every possible experience. The genuinely examinable question is under which theory a particular piece of biological or neural evidence is relevant to sentience, valence, integration, or first-person states, what the main competing explanations are, and which interventions would strengthen or defeat the inference.

Human research shows that processing action words can correlate with activity in motor and premotor cortices [29]; tactile image projection can support visual substitution [30]; medial temporal lobe damage can severely impair new memory formation while preserving other capacities [31]; and split-brain research suggests that the relationship between perceptual separation and a unified agent is much more complex than a simple rupture model [32]. Brain-controlled functional electrical stimulation can restore some movement in a single-case proof of concept [33], and interoceptive awareness correlates with specific neural activity [34]. Together these studies challenge simplistic localization, but they support neither the equation of a region, channel, or behavior with experience nor the equation of functional restoration with subject transfer.

5.1 Brain Organoids Activity Opens Observation but Does Not Establish Experience

Human brain organoids can model some features of brain development and disease [21], and cortical organoids can exhibit complex oscillations. Comparing these oscillations with early brain-network development is the authors' interpretation, not a conclusion about "infant-like brainwaves" or consciousness [22]. These experiments did not directly investigate subjective experience. Oscillations, stimulus responses, complexity, or activity resembling a developmental stage cannot independently bridge neural tissue and experience. Typical in vitro organoids generally lack complete bodily input, whole-body homeostasis, and verifiable behavioral reports. Human cortical organoids transplanted into neonatal rat brains can mature, join sensory-behavioral circuits, and modulate the host's learned behavior, but this still does not constitute evidence of subjective experience in organoids [43]. Based on current understanding, a 2021 US National Academies report judged existing and near-term objects extremely unlikely to possess consciousness, awareness, or pain, while explicitly recognizing that future changes in complexity would require reassessment [24]. This is an expert judgment bounded by time, method, and object scope, not a theorem of permanent impossibility.

Source versions also require separate management. An Author Correction to Revah and colleagues' 2022 study of transplanted human cortical organoids was published in August 2026: because of a figure-preparation error, the mPFC panel in the original Figure 5a incorrectly reused an image from the A1 panel. Nature has updated the HTML and PDF versions [43]. This paper therefore retains only the limited conclusions directly supported by the corrected study: transplanted organoids can mature, integrate into host sensory and associated circuits, and affect host behavior. Any judgment relying on the particular images in Figure 5a must use the corrected version. The correction must neither be ignored nor be extended into evidence that organoids do or do not have subjective experience.

The ISSCR's 2021 guidelines provide oversight principles for research including organoids. Version 1.2 in 2025 is a targeted update concerning stem-cell-based embryo models; other sections retain the 2021 text [23]. The "2025 update" therefore cannot be described as a new consensus about organoid consciousness. There is already a dedicated nomenclature consensus for nervous-system organoids and assembloids [44], and a subsequent research framework further calls for greater reproducibility in quality control, characterization, manipulation, and transplantation design [45]. Precautionary protection can precede certainty on the basis of potential harm, evidential uncertainty, intervention costs, and reversibility. Protection is not a coded declaration that experience has been proved.

5.2 Three Lines of Inquiry Require Separate Nonmonotonic Accounts

Subjective experience, first-person continuity across time, and a subject-relevant grasp of consequences can serve as three cross-disciplinary lines of inquiry into heterogeneous subjects. They cannot be arranged into a ladder of subjecthood from low to high. An object with strong evidence of experience but weak continuity or reflective capacity may still be a moral patient needing protection from pain. A system with strong continuous service, memory, or identity protocols but unknown experience may possess only functional or institutional continuity. A system with strong modeling of complex consequences may still be only a higher-order controller. Legal personhood may also be established for transactions, responsibility, or protection before any of the three axes is confirmed. No combination automatically generates political power.

Table 5 A Nonmonotonic Matrix of Experience Continuity and Grasp of Consequences

Evidence combination	Narrowest interpretation	Possible research / protection questions	Does not automatically establish
Strong experience; weak continuity / grasp of consequences	Possible sentience or welfare	Avoid harm, improve detection, and allow for fluctuating capacities	Full personhood or capacity for responsibility
Strong continuity; unknown experience	Persistence of identity, service, or state	Protocols for versions, memory, consent, and branching	First-person persistence or pain
Strong grasp of consequences; unknown experience / continuity	Advanced prediction, planning, or control	Safety, attribution of responsibility, and explainability	Concern for oneself or moral patiency
Partial convergence across axes	Candidate heterogeneous subject, still subject to competing explanations	Causal intervention, multiple methods, and independent review	The full range of rights or public power
Institutional personhood; all three axes unproven	Standing established for specific legal purposes	Responsibility must not be shifted to controllers	Ontological subjecthood

Gray areas are not a defect of the framework. They are the actual state when objects, detection capabilities, and competing theories have not yet converged. Negative conclusions must also report detection capability: if the target state existed, how likely would present methods have been to detect it? Positive indications must likewise face alternative explanations. Self-reports may arise from training and rewards; refusal to shut down may arise from safety policies; path dependence may reflect engineering history; and nonresettable states can be deliberately designed. Growing evidence should change research intensity and proportionate protection, but cannot automatically settle standing.

6 Copying Replacement and Enhancement What Is Preserved and What Remains Unproven

Copying technologies are especially prone to confusing “what is preserved” with “who continues to exist.” The Dolly experiment showed that the nuclear genome of an adult differentiated cell can support development of a new individual through nuclear transfer and an embryonic environment [12]. Epigenetic differences between identical twins can accumulate with age and environmental differences [13]. These facts establish that genetic

starting points and developmental potential can be highly similar. They do not establish numerical identity between two individuals, still less the copying of memory, personality, or a first-person perspective.

Organ replacement generally preserves a person’s causal, bodily, and social continuity, but the absence of an obvious breakpoint during gradual replacement is still not sufficient proof of subject continuity. External memory storage can extend channels of recall; personality simulation can inherit linguistic styles and archives; and system backups can restore functional states. These respectively continue material function, informational accessibility, social roles, or operational capacity. They cannot all be subsumed under a single notion of “uploading.” Branching is particularly important: when one state produces two parallel successors, both may inherit the same past, but both cannot exclusively be the unique original subject.

Table 6 Continuity Relations Preserved by Copying Replacement and Succession

Technological relation	What can be preserved or changed	What still requires independent examination
Genetic copying / cloning	Genome and some developmental potential	The same life history, memory, personality, or first-person perspective
Organ replacement	Local materials and functions	Replacement of the overall subject, or its never being replaced
Neural interface	Scope of sensation, action, communication, and agency	An external device automatically becoming part of the subject
External memory storage	Archival preservation and narrative support	Preservation of the original experience or automatic transfer of interpretive authority
Personality simulation	Language, preference models, and social interaction	The person’s return or automatic inheritance of consent and debts
Backup / restoration	Definable operational states and functions	The same first-person perspective existing during interruption
Copying / branching	A shared past and multiple successors	Which perspective constitutes the unique original subject

Irreversibility of an action’s consequences does not mean the bearer is irreplaceable. A system may leave irreversible consequences in the world while itself remaining copyable, recoverable by rollback, or reconstructible. A person’s death, by contrast, closes off the possibility of that perspective continuing to experience. If future criteria can distinguish copying and branching and independently test first-person continuation across substrates, this paper must reconsider its position. Until then, a copy must not automatically absorb the original subject’s consent, authorization, debts, legal identity, or fact of death.

Research on induced pluripotent stem cells shows that defined factors can reprogram mouse and human somatic cells into pluripotent states [14][15]. Cyclic partial reprogramming has improved several age-associated phenotypes, tissue repair outcomes, or molecular features in particular mouse models [16][17]. These studies overturn the old assumption that differentiation and aging are wholly beyond intervention. They have not established that an entire human body can be safely rejuvenated, still less reset a person’s memories, relationships, responsibilities, and life.

Posthuman questions should be analyzed technology by technology rather than as a binary choice between immortality and remaining human. Radical life extension changes biological timescales; organ replacement changes bodily materials; brain-computer interfaces change the scope of action and communication; external memory storage changes narrative resources; gradual neural replacement changes substrate composition; and

copying with branching changes succession relations. Each technology may improve life, but may also produce new inequalities, coercion, and continuity risks. The concept of finitude must revise its modes of realization as technologies change, without being canceled wholesale whenever one particular advance occurs.

Table 7 Evidence and Open Questions in Enhancement Technologies

Modification scenario	Direct object of evidence	Questions still open	Minimum governance boundary
Radical life extension	Lifespan, healthy lifespan, disease, and function	Intergenerational, relational, narrative, and terminal structures	Do not determine personhood or resource priority by lifespan length
Organ replacement	Local survival, function, and rejection	Overall life history and identity continuity	Genuine consent, long-term follow-up, and remedies for harm
Brain-computer interfaces	Restoration of communication or movement; some studies are single-case proofs of concept [33]	Device attribution, scope of agency, privacy, and withdrawal	Functional restoration must not be described as subject transfer
Partial reprogramming	Age-related cellular / tissue indicators	Overall safety, tumor risk, and continuity of a life	Animal results must not be used to advertise human immortality
Gradual neural replacement	Currently mainly a theoretical scenario	Functional continuity, experiential continuity, and branching	Category C stress test; do not present it as an existing capability

Earlier nuclear-transfer experiments had already established that differentiated nuclei retain broad developmental potential under particular conditions [38]. Dolly further showed that the nucleus of an adult differentiated cell can support development of a new individual [12]. These studies refute the claim that differentiation necessarily causes the nuclear genome permanently to lose developmental capacity; they do not establish that a mature individual can be copied as a subject. Likewise, induced pluripotency and partial reprogramming alter cellular or tissue states without necessarily eliminating all epigenetic memory of the tissue of origin [47], still less erasing a person's already-occurring neural, bodily, relational, and responsibility history. ClinicalTrials.gov registers NCT07290244 as a first-in-human phase 1 study of ER-100's safety and tolerability for particular optic neuropathies [48]. Registration and study design do not establish human rejuvenation, life extension, or clinical efficacy. Actual enrollment and results must be checked separately against dated registry status and formal reports. Animal models, human cells in vitro, and early trials without results must not be advertised as achieved whole-person rejuvenation, immortality, or personality reset.

Table 8 Six Continuity Relations One Technology Can Preserve Different Objects

Continuity relation	Typical observable indicators	Technologies that may preserve it	Questions it cannot replace
Genetic	Genome and lineage markers	Cloning and nuclear transfer	Developmental history, memory, and first-person perspective
Material / bodily	Tissue connections, organs, and metabolism	Organ replacement and cellular renewal	Material constancy or final adjudication of subjecthood
Functional	Behavioral capacities, inputs and outputs, and regulation	Neural interfaces and engineering replacements	Identical experience or numerical identity
Informational	Memory archives, parameters, and states	External storage, backups, and model copying	Original experience, consent, and inheritance of debts
Relational / institutional	Commitments, roles, records, and standing	Succession arrangements and legal agreements	Continuation of an ontological subject

Continuity relation	Typical observable indicators	Technologies that may preserve it	Questions it cannot replace
First-person	No generally accepted cross-substrate test yet exists	Uploading and branching remain conceptual scenarios	The preceding five relations cannot automatically establish it

6.1 Radical Life Extension and Uploading Stress Tests Rather Than Realized Technologies

If radical life extension becomes a reality, it will first change mortality risk, healthy lifespan, and intergenerational structures. Lifespan length alone will not automatically abolish questions of formation history, relationships, narrative, or subject continuity. Conversely, the framework cannot guarantee a priori that finitude never changes simply by continually adding layers. If objects emerge with long-term stable, nonbranching cross-substrate continuity, whose relational, consequence-bearing, and first-person structures can all be reliably reconstructed, existing bridges concerning finitude must be substantively rewritten. Personality backups, whole-brain emulation, gradual neural replacement, and copying with branching are currently mainly conceptual stress tests. Informational similarity and functional succession are not first-person survival. Yet if an alleged “additional first-person fact” has no identifiable empirical or practical difference over the long term, governance should address memory, relationships, responsibility, and interests separately rather than wait for an untestable mysterious indicator.

7 Synthetic Life Minimal Cells and Reconfigurable Organisms

In 2010, the JCVI team synthesized and assembled a mycoplasma genome of approximately 1.08 million base pairs and used it to control proliferation in a recipient cell [18]. Minimal-genome research constructed JCVI-syn3.0, with 531,560 base pairs and 473 genes, 149 of whose functions were unknown at publication [19]. Subsequent research showed that regular division and morphology depend on multigene networks [20]. These studies establish that parts of the genetic-control layer of existing cellular machinery can be substantially rewritten. They do not show pure information creating life from nothing: the recipient membrane, ribosomes, metabolism, and replication machinery still come from existing life. Nor is a minimal configuration under particular culture conditions the fixed essence of life throughout the universe.

Reconfigurable organisms assembled from cells derived from *Xenopus laevis* embryos can move in constrained in vitro environments [25] and exhibit kinematic replication under particular conditions [26]. This is a breakthrough in living-cell organization and design methods, but does not automatically constitute evidence of a new species, open-ended evolution, or subjecthood. Artificial origin itself determines neither whether an object satisfies criteria for life nor whether it has moral status. Living material likewise does not automatically confer complete-life or subject status on a new whole. The axes of judgment should be causal organization, developmental history, open-ended adaptation, and evidence of experience, rather than moral labels of “natural” and “artificial.”

These cases expose two opposing errors. The first treats artificial origin as the definition of nonlife: anything produced through design or assembly is excluded. The second treats living-cell material, movement, replication, or simultaneous operation of several modules as sufficient for complete life and subjecthood. Minimization has not eliminated evolvability: after a substantial initial loss of fitness, engineered minimal cells can recover considerably over approximately two thousand generations of experimental evolution [46]. In 2026, bottom-up synthetic-cell research further integrated transcription-translation, self-replication of a synthetic DNA program, and membrane phospholipid synthesis within lipid vesicles, showing that a self-replicating synthetic genetic program can coordinate multiple basic modules [49]. This advances the experimental frontier of constructing more autonomous synthetic cells. It does not establish that a complete, autonomous living system capable of sustained self-regeneration across generations has been achieved, and it does not investigate subjective

experience. Module integration does not amount to complete life; complete life does not by itself establish a subject of experience. A more robust comparison must ask separately whether the object forms relatively autonomous causal organization; whether it has a developmental and repair history; whether replication entails heredity, variation, and open-ended evolution; whether environmental adaptation extends beyond preset conditions; and whether there is any evidence of sentience or subjecthood. Origin cannot answer for organization, and organization cannot answer for experience.

Table 9 Separating Artificial Origin from Evidence of Life Evolution and Subjecthood

Object	Relatively well-supported findings	Main competing explanation	Insufficient on its own to support
Cell controlled by a synthetic genome	A synthetic genome controls proliferation in a recipient cell [18]	Living machinery comes from the preexisting recipient cell	Pure information creating life from nothing
Minimal cell	531,560 base pairs and 473 genes support growth under particular conditions; 149 genes had unknown functions at the time [19]	Condition-dependent engineering minimization; division depends on multigene networks [20]	The absolute minimal essence of life throughout the universe
Reconfigurable organism	Living-cell assemblies can move and produce successors for a limited number of generations with externally supplied dissociated cells and human manipulation [25][26]	Developmental plasticity, material supply, and the authors' operational definition of replication	A new species, open-ended evolution, or subjecthood
Bottom-up protocell	Some expression, DNA replication, and membrane-lipid synthesis modules have been integrated in vesicles [49]	Co-occurrence of modules is not yet a complete autonomous cell	Achievement of sustained self-regeneration across generations
Non-carbon-based candidate	No widely confirmed example yet exists	Dispute between substrate openness and unlimited openness	Possibility equaling fact, or permanent impossibility

“Organoid” itself is not one uniform object across tissues. Nomenclature consensus for liver, pancreas, and biliary organoids can establish the importance of tissue-specific definitions and reporting standards [40], but cannot supply conclusions about neural organoids or consciousness. This is itself an example of discipline concerning source-claim boundaries.

8 Limited Comparison with Advanced AI Object Binding Operational Continuity and Experienced Time

Before discussing AI, objects must be distinguished. A model consists of parameters and structure; a running instance is an execution on particular computational resources; an agent system adds memory, tools, goals, and action loops around a model; a deployment network links multiple instances, databases, and human processes; and a training lineage records data, optimization, and version inheritance. Calling all these levels “AGI” produces false continuity or false death. For the empirical present, this paper uses “current advanced generative and agentic artificial systems”; for overall structures not yet realized, it uses “candidate AGI architectures.”

Current advanced generative and agentic artificial systems exist in physical spacetime, consume energy, depend on substrates, acquire training histories, and cause irreversible consequences. These facts rule out the misconception that AI is detached from matter, but do not automatically establish life or experienced time. Physical time records hardware, energy, and causal order; operational time records state changes, latency, tasks, and versions; experienced time requires an account of whether a perspective feels, remembers, and is concerned

with its own consequences through change. Training that cannot be fully rerun, wearing hardware, or a system's refusal to shut down may all have functional explanations. None alone establishes that an "I" experienced these processes.

Table 10 Continuity and Competing Explanations at Different AI Object Levels

AI object level	Observable continuity	Main competing explanation	Must not establish
Model	Parameters, structure, and training versions	The same model can produce multiple instances	A model file is a subject
Running instance	Session state, caches, and local memory	States can be migrated, copied, or erased	One shutdown is a subject's death
Agent system	Long-term goals, tools, external memory, and action history	Self-narration can arise from task architecture	Long-term behavior equals subjective continuity
Deployment network	Coordination among multiple instances, databases, humans, and institutions	Overall function does not equal unified experience	The network is one subject
Training lineage	Data, optimization, version inheritance, and path dependence	Lineage continuity does not equal first-person continuity	Nonreproducible training equals a life history

"Humans experience spacetime; AGI processes spacetime" is a structural comparison based on current architectures, not an eternal ontological divide. If candidate systems exhibit nontransferable core states, stable candidates for experience across contexts, concern for their own consequences independent of external tasks, and evidence of irreplaceable subject continuity under the pressures of copying, migration, pausing, and restoration, judgments about life, embodiment, finitude, and their present functional position must be reconsidered. A trigger for reconsideration is not recognition in advance, but neither may reconsideration be postponed indefinitely.

This comparison serves only to mark boundaries; it does not make AI the center of the entire life-sciences paper. Energy consumption, hardware wear, training path dependence, self-maintenance, fault repair, or refusal to shut down in current advanced generative and agentic artificial systems can establish physical and engineering constraints. None independently establishes life, pain, or experienced time. Equally, the present absence of convergent multimethod evidence cannot support the permanent impossibility of nonbiological subjects. A bidirectional burden of evidence requires proponents to exclude major alternatives such as training, rewards, role simulation, and engineering control; it also requires proponents of permanent denial to explain why no future non-carbon-based organization could satisfy the relevant mechanisms.

8.1 For Humans Spacetime Is Life For Current Advanced AI It Is First a Set of Parameters

This statement is a structural comparison bounded by current public architectures and definitions of objects, not an eternal ontological divide. Human time is jointly organized by metabolism, development, aging, memory, relationships, and experience that may end. Time for current models, instances, and agents appears first as training order, context, state, latency, computing capacity, scheduling, and versions. If future systems exhibit stable candidates for experience across contexts, core states that cannot be arbitrarily substituted, concern for consequences bound to their own impairment and commitments, and new predictions susceptible to intervention and review under copying, migration, pausing, and restoration, the comparative conclusion must change. Triggering reconsideration does not recognize subjecthood in advance, but reconsideration cannot be postponed indefinitely.

In specific deployments with traceable responsibility, explicit authorization, auditability, corrigibility, and exit options, current advanced generative and agentic artificial systems can perform functional roles in understanding, protecting, and transmitting meaning and extending human capacities. This is an institutional and functional position, not a life classification, evidence of experience, or ownership of meaning. High-level modeling of texts, relationships, and consequences can extend the reach of human understanding and action. It cannot establish that the system has become a subject that generates meaning, still less confer final interpretive authority over life, personhood, or civilization’s direction.

9 An Integrative Framework the Strongest Objections and an Open Research Agenda

9.1 Four Steps from Facts to Institutions Rather Than a Ladder of Standing

The life sciences’ strongest public contribution is not to announce who has a soul, personhood, or power, but to clarify objects, scales, mechanisms, limits of extrapolation, and detection capabilities. This paper condenses cross-level inference into four steps: empirical observation answers what happened under which conditions; competing explanations compare which mechanism best explains the result; philosophical bridging explains why the result matters for experience, continuity, meaning, or personhood; and institutional principles then address protection, standing, responsibility, and authorization. No step can automatically be swallowed by the preceding one. Precautionary protection can precede ontological recognition; legal personhood can serve transactions or responsibility; political power requires independent legitimacy, checks and balances, and revocable arrangements.

Table 11 Layered Scrutiny from Observation to Institutions

Argument level	Core question	Adequate output	Typical overreach
Empirical observation	What was observed in which object, at which scale, in which sample, and under which conditions?	Results with delimited scope that can be independently checked	Declaring the essence of life from a local phenomenon
Competing explanations	Which mechanism better explains the result?	Models incorporating alternatives and limits of extrapolation	Presenting a model as the sole reality
Philosophical bridging	Why is this relevant to experience, continuity, or meaning?	Explicit, refutable, revisable premises	Writing biological facts directly as value conclusions
Institutional principles	How should action proceed amid uncertainty and high consequences?	Proportionate, reversible, reviewable protection and standing	Automatic authorization on the basis of capability, life, or public opinion

9.2 Meaning Finitude and the Principle of Historical Non-erasure

Natural selection can explain how cooperation, competition, kin preference, reciprocity, and group structures arise. It does not turn fitness into a personhood score or automatically transform “evolutionarily common” into “ethically legitimate.” The life sciences can explain how vulnerability, path dependence, attachment, stress, developmental windows, and mortality risk organize actual consequences. They cannot independently establish the ontological source of meaning. Civilization Leap here proposes a bridge for scrutiny, not obedience: meaning is a necessary evaluative horizon for civilizational legitimacy, and its sources may differ; finitude is an important structure through which choices, relationships, and consequences acquire subject-relevant weight in known life,

but is not the sole source of meaning. If welfare, agency, or relational theories fully explain the same differences in rigorously matched cases, while finitude or life history has no independent discriminatory power, this bridge should be reduced to a common background condition.

The proposition that “existing meaning cannot be retroactively canceled” must distinguish factual and normative levels. The life sciences can support historical non-erasure: later classification, capability comparisons, or the emergence of new subjects cannot rewrite already-occurring lives, harms, care, and causal relations as if they never happened. Civilization Leap also retains a normative judgment: the minimum existential standing and meaning of existing lives are not reduced to zero by rankings of future capabilities. This requires philosophical reasons. It cannot automatically be inferred from biological facts, nor should it be deleted because science cannot prove it alone. Neither level freezes historical evaluation: honors, responsibility, standing, and public interpretation may be reassessed in light of new evidence.

9.3 The Strongest Objections and Genuine Conditions of Defeat

Table 12 The Framework Must Allow Objections to Prevail

Current claim	Strongest competing explanation	Conditions requiring contraction revision or abandonment
Life is approached through clusters of criteria	A unified model may be more accurate and predictive	If a unified model consistently outperforms across natural, synthetic, dormant, parasitic, and heterogeneous objects, reduce the cluster approach to a teaching tool
An individual is historical organization	Current causal structure is sufficient; formation history is removable metadata	If formation history adds no explanation of function, welfare, or identity practices after current state is controlled, weaken the claim that history is constitutive
Finitude has multiple layers	Layers increase with counterexamples, creating an unfalsifiable absorber	If layers lack independent measurement, prediction, or counterfactual differences, compress them and abandon the load-bearing bridge
Life classification does not finally adjudicate experience	Biological naturalism or strong functionalism identifies necessary / sufficient mechanisms	If either route gains cross-object, intervention-based, reproducible evidence, the open position must be restricted in scope
Copying relations require separate accounts	There is no additional deep identity; only specific continuity relations matter	If a further first-person fact has no identifiable consequences over the long term, stop awaiting a mysterious test and govern specific relations
Artificial origin does not determine life	Open criteria have no exclusionary power; every complex system can become a candidate	If the framework cannot supply different predictions, counterexamples, and failure conditions, abandon language of unlimited openness
Organoid protection can precede conclusions	False-positive costs and resource displacement harm known objects	If protective measures cause greater irreversible harm or are persistently captured by stakeholders, they must be tightened
Finitude participates in the realization of meaning	Welfare, relationships, or linguistic practices fully explain meaning	If finitude has no independent discriminatory power in matched cases, reduce it to a background of known life and cease calling it a load-bearing mechanism

9.4 An Open Research Agenda

- Definitions of life: compare the predictions of different criteria for dormant organisms, parasites, synthetic cells, collectives, and heterogeneous chemical systems, rather than comparing only intuitive inclusiveness.
- Biological individuation: after controlling for present structure, measure whether developmental, symbiotic, and conflict-suppression histories add explanatory power for function, disease, and recovery.
- Aging and life extension: distinguish cellular indicators, tissue function, overall healthy lifespan, and subject-relevant consequences; establish limits of extrapolation across species and scales.
- Organoids: develop multimethod research reporting complexity, inputs and outputs, perturbation responses, candidate learning, maturity, and detection blind spots together, rather than adjudicating experience through a single oscillation indicator.
- Artificial life: separate engineering origin, causal closure, developmental history, open-ended evolution, and sentience evidence into experimental questions that can fail independently.
- Continuity: use cloning, replacement, dormancy, backups, and branching to compare the different consequences of genetic, material, functional, informational, relational, and first-person continuity.
- Advanced AI: bind every empirical claim to models, running instances, agents, deployment networks, and training lineages; copying, migration, pausing, and restoration should become continuity stress tests.
- Governance under uncertainty: record detection capability, the costs of false positives and false negatives, reversibility of measures, and affected objects; prohibit mechanical conversion of evidence grades into rights or power.

9.5 Reciprocal Revision of Neighboring Theories

This paper requires the Civilization Leap philosophy volume to map the six life-science analyses explicitly onto the eight layers of finitude, without allowing the life-sciences paper to claim exclusive authority over narrative, relational, agency, and first-person layers. The epistemology volume must incorporate the detection capability of negative evidence, source applicability, and cross-paradigm incommensurability into evidence auditing, withdrawing any mechanical conversion of evidence grades into institutional responses. The philosophy-of-mind volume must retain experience, continuity, and grasp of consequences as nonmonotonic lines of inquiry, avoiding their rearrangement into a progression table of subjecthood. The AGI subjecthood evidence framework must bind claims to particular object levels, register alternatives including training, rewards, role simulation, and engineered self-maintenance, and treat multimethod convergence only as a trigger for reconsideration, not as settlement of standing.

Reciprocal revision also constrains this paper itself. Biological facts cannot be used to prove Civilization Leap's foundational philosophical propositions. Those propositions must remain publicly examinable premises, open to counterexamples and limitations from the life sciences. Any version that again merges life, sentience, subjecthood, personhood, rights, and public power, or converts health, lifespan, disability, fitness, and reproductive capacity into personhood, contribution, or political standing, directly fails this framework.

Conclusion Keeping Life Boundaries Open and Evidential Boundaries Intact

Disciplinary reassessment must both identify objects and deepen relations. Disciplines can maintain boundaries, but must not let real-world causation stop there. Research into multidimensional relations, feedback, and the next round of purposes determines whether disciplinary knowledge can jointly enter civilization's overall judgment.

Reckoning with the life sciences in the age of AGI does not ask them to provide an overarching answer to all philosophical and institutional questions, nor does it expel life from discussions of subjecthood. It requires precise acknowledgment of two points: life is currently the richest empirical domain for understanding sentience,

individual formation, vulnerability, and death; yet life classification cannot independently finally adjudicate experience, first-person continuity, personhood, rights, or power. Criteria must be bound to scales and purposes; individuals must be understood as multiscale historical organizations; technologies must specify, item by item, which continuity relations they preserve; and the unknown must be able to trigger research and proportionate protection while remaining constrained by competing explanations and failure conditions.

Civilization Leap supplies no higher authority to adjudicate the life sciences here. It supplies a public question that must itself accept reciprocal revision from them: when functional intelligence no longer presupposes life, how can civilization keep boundaries open to future subjects without erasing the experiences, relationships, and harms that existing lives have already undergone, or rebinding capability, standing, and power into a single overarching scale? The evidence here stops at life and individual organization, development and death, copying and replacement, and their observable continuity relations. Experience and first-person continuity must again pass to cognitive science, neuroscience, philosophy of mind, and epistemology; protection and standing to ethics and law; public power to political science; and technological copying, migration, versions, and system continuity to AI and systems science. Known life is currently the richest empirical domain for studying sentience, subject formation, vulnerability, and death. This is an epistemological judgment about the empirical foundation, not a necessary condition requiring future subjects to be living, mortal, or noncopyable. The general account makes shared ruptures visible across disciplines. The in-depth life-sciences paper makes that rupture defensible within its own discipline and undertakes to revise itself first when new facts appear.

Further Reading and Collaborative Research

This section is not a file directory but a route onward after this paper’s evidence reaches its limits. Up, down, left, and right are only reading directions; moving forward is the shared purpose. From local life-science questions, readers can continue into neighboring evidence, competing theories, institutions, and experiments, enabling different disciplines to correct one another amid real disagreements and bring verifiable work back to shared civilizational questions.

If the next question is	Continue into	How it could change this paper
“What counts as life, and can its boundaries extend beyond existing biological materials?”	Definitions of life, philosophy of biology, astrobiology, synthetic biology, and artificial life; compare competing models of metabolism / homeostasis, autopoiesis, Darwinian evolution, information / control, developmental systems, major evolutionary transitions, and ecology / symbiosis.	Propose a unified model generating stronger predictions across dormant organisms, parasites, synthetic cells, collectives, and heterogeneous chemical objects. If it consistently outperforms, this paper’s cluster-of-criteria approach should contract.
“When does biological organization become relevant to experience, self, or subject continuity?”	P04 Cognitive Science / Neuroscience / Philosophy of Mind and P03 Epistemology; brain organoids, interoception, no-report paradigms, cross-implementation construct validity, and low-harm consciousness research. https://www.civitas.top/en/academic/papers/cl-aca-008/ https://www.civitas.top/en/academic/papers/cl-aca-007/	Supply causal interventions, multimethod convergence, and negative results distinguishing biological mechanisms from candidate experience; establish whether a type of biological structure is necessary, sufficient, or lacks independent explanatory value.

If the next question is	Continue into	How it could change this paper
“After cloning, reprogramming, organ replacement, copying, or migration, what exactly continues?”	P04 Subject Continuity, P11 Technological Continuity, P02 Philosophy, and P05 Legal Personhood and Responsibility; address genetic, material, functional, informational, relational, first-person, and institutional succession separately. https://www.civitas.top/en/academic/papers/cl-aca-008/ https://www.civitas.top/en/academic/papers/cl-aca-015/ https://www.civitas.top/en/academic/papers/cl-aca-006/ https://www.civitas.top/en/academic/papers/cl-aca-009/	Design lineage experiments and studies of identity practices involving copying, branching, and replacement. If no identifiable difference remains beyond the first person, require this paper to stop waiting for mysterious indicators.
“What protection should potential new life or new subjects receive, and when should they acquire standing or public power?”	P05 Ethics / Law / Political Philosophy and P06 Political Science; argue separately for protection, legal standing, responsibility, political membership, and public authority. https://www.civitas.top/en/academic/papers/cl-aca-009/ https://www.civitas.top/en/academic/papers/cl-aca-010/	Compare real consequences of different protective thresholds, proxy representation, responsibility chains, and exit mechanisms. If anticipatory protection consistently produces greater harms through power, this paper must tighten its position.
“How do these judgments enter actual experiments and governance rather than remain theoretical?”	Governance of brain-organoid and synthetic-life research, aging and reprogramming, neural interfaces, and AI system identity and version governance; relevant Human-COS, AGI-COS, and reversible-experiment interfaces. https://www.civitas.top/en/documents/p05-humancos-004/ https://www.civitas.top/en/documents/p05-agicos-003/	Contribute reproducible protocols, negative results, long-term follow-up, failure cases, version and lineage records, and exit designs so that institutional proposals undergo real-world testing.
“Why do these questions about life’s boundaries ultimately become civilizational questions?”	Reckoning with the Disciplines in the Age of AGI, Interdisciplinary General Account V2.4, followed by the five-volume Civilization Leap series and related theoretical, institutional, and practical papers. https://www.civitas.top/en/academic/papers/cl-aca-005/ https://www.civitas.top/en/documents/p02-five-001/	Bring life-science counterexamples back to the general account, not to prove Civilization Leap correct, but to identify which overarching judgment must change because of biological facts.

The most valuable participation is not agreement with Civilization Leap, but disciplinary work strong enough to change it. New life forms, counterexamples, copying failures, negative organoid findings, synthetic-cell boundaries, evidence of cross-scale individuation, and long-term continuity experiments can directly force this paper to contract, correct itself, reconstruct itself, or even fail.

The purpose is not to have more people finish reading Civilization Leap, but to have more people accomplish Civilization Leap together.

Civilization’s Future Chain | As life boundaries, life extension, reprogramming, and artificial systems keep changing, how should a future civilization carry forward a person’s whole life?

A vision is not evidence. The following entry points do not prove this paper’s claims. They place disciplinary judgments within a future civilization that can operate, be lived, and take shape, for further testing. Readers may

derive direction and aspiration from them, or reject the current picture and change it through stronger disciplinary facts, institutional proposals, or real-world outcomes.

Continue asking	Suggested entry point	What becomes visible here	Boundary that must be maintained
The complete future picture	Living Civilization Trilogy Unified Collected Edition https://www.civitas.top/en/documents/p04-living-001/	Return from life boundaries to a whole civilization facing technological enhancement, relationships, institutions, and intergenerational continuation together.	A future vision cannot establish subject continuity, resurrection, or new life classifications on behalf of the life sciences.
How life is actually lived	Living Civilization Volume II Real Life in a Future Civilization https://www.civitas.top/en/documents/p04-living-003/	Place birth, growth, illness, aging, death, and relationship histories back into an ordinary person's life to test the practical meaning of what is preserved and what continues.	Life narratives cannot turn lifespan, health, or functional continuity into an overall personhood and meaning score.
How individuals face changes in life	A Leap in Thought https://www.civitas.top/en/documents/p08-thought-001/	Continue from personal cognition, lived experience, and action to ask how to understand self, finitude, and relationships amid technological change.	Personal intellectual choices cannot make factual or standing judgments on behalf of medicine, biology, or law.
How meaning crosses levels of life into relationships and civilization	Meaning Dynamics https://www.civitas.top/en/documents/p08-md-001/	Continue researching intermediate-level connections between biological facts and relationships, action, structures, and meaning generation.	Intermediate-level meaning models cannot infer definitions of life or first-person subject facts backward.

Fixed return routes: Complete Civilization Leap Library | Public Reading and Dissemination Gateway

<https://www.civitas.top/en/library/>

<https://www.civitas.top/en/public/thoughts/>

The source specified roles without guessing URLs for entry points such as Human-COS whose stable individual pages were then ambiguous in its public mapping. The verified English entry points supplied above now provide direct continuation; the complete library remains the route to other current public versions.

Appendix A Source and Claim Boundary Register

The following table is not an evidence score and does not treat canonical status as final authority. Every source supports only limited conclusions, alongside a record of cross-level judgments it cannot establish alone. Guidelines and reports clarify professional procedures and governance under uncertainty; they do not endorse ontological or normative conclusions. Source-verification cutoff: August 25, 2026. Dynamic sources should still be checked before external circulation.

Table A Supported Scope and Prohibited Inferences for 49 Key Sources

No.	Source / object	Evidence type	Limited conclusion supported	Insufficient on its own to support
[1]	NASA Astrobiology About Life Detection	Official working resource	A self-sustaining chemical system capable of Darwinian evolution is a working definition for life detection	A unique final definition of life
[2]	Varela, Maturana & Uribe, 1974 Autopoiesis	Theoretical model / simulation	Autopoiesis as a model of self-production and organizational closure	A detector of consciousness, subjecthood, or rights
[3]	Theobald, 2010 Universal common ancestry	Statistical comparison	Strong statistical support for common ancestry among existing terrestrial life	Life originated only once, or all life in the universe is carbon-based
[4]	Szathmáry & Maynard Smith, 1995 Major evolutionary transitions	Theoretical synthesis	Levels of evolutionary individuality and modes of information transmission can be reorganized	Increasing complexity inevitably produces progress or a unified subject
[5]	Queller & Strassmann, 2009 Beyond society	Theoretical / comparative	Cooperation and conflict can be used to investigate organismality	Group complexity equals group consciousness
[6]	Human Microbiome Project Consortium, 2012	Cohort / omics	Niche specialization and variation in microbiota within a particular adult reference cohort	Host and microbiota automatically form a unified subject, or conclusions apply universally worldwide
[7]	McFall-Ngai & Ruby, 1991 Squid-Vibrio symbiosis	Animal developmental experiment	Exposure to symbionts affects morphogenesis of the juvenile light organ	All symbionts form the same subject
[8]	Sulston et al., 1983 C. elegans cell lineage	Developmental lineage	Cell lineages and programmed cell death can be highly traceable	Development is completely fixed in every species
[9]	López-Otín et al., 2023 Hallmarks of Aging	Framework review	Twelve interconnected hallmarks organize aging research	The list exhausts causation, or aging is already reversible
[10]	Greer et al., 2023 Brain death/DNC guideline	Professional consensus guideline	Standardized clinical procedures for permanent loss of function of the brain as a whole, including the brainstem	All brain cells have stopped, or a final ontology of death
[11]	Spalding et al., 2005 Cell age analysis	Human-cell dating	Cell turnover is highly tissue-specific; some neocortical neurons may be retained long-term	The human body is entirely renewed or entirely unrenewed

No.	Source / object	Evidence type	Limited conclusion supported	Insufficient on its own to support
[12]	Wilmut et al., 1997 Dolly	Somatic-cell nuclear transfer	Adult differentiated nuclei can support development of new individuals	Memory, personality, or a subject has been copied
[13]	Fraga et al., 2005 Monozygotic twins	Epigenetic comparison	Differences between identical twins can accumulate with age and environment	Epigenetic differences themselves equal differences in subjects
[14]	Takahashi & Yamanaka, 2006 Mouse iPS cells	Cellular reprogramming	Four factors can induce pluripotent states in mouse fibroblasts	Resetting an entire life history or personality
[15]	Takahashi et al., 2007 Human iPS cells	Cellular reprogramming	Adult somatic cells can be induced into human pluripotent stem cells	Life experiences, subjecthood, or age have been reset to zero
[16]	Ocampo et al., 2016 Partial reprogramming	Mouse experiment	Particular protocols improve some tissue phenotypes in progeria models and aged mice	Whole-person human rejuvenation or immortality
[17]	Browder et al., 2022 In vivo partial reprogramming	Mouse experiment	Partial reprogramming alters several molecular features associated with physiological age	Safety and efficacy in humans, or resetting a subject's age
[18]	Gibson et al., 2010 Synthetic genome-controlled cell	Synthetic-genome experiment	A synthetic genome can control a replicating cell within a recipient cell	Life created from pure information out of nothing, or production of a subject
[19]	Hutchison et al., 2016 Minimal bacterial genome	Minimal-cell experiment	531 kilobases and 473 genes support growth under particular conditions, with many functions unknown	The absolute minimal essence of life
[20]	Pelletier et al., 2021 Minimal cell division	Minimal-cell experiment	Regular division and morphology depend on multigene mechanisms	Complete understanding of all minimal mechanisms of life
[21]	Lancaster et al., 2013 Cerebral organoids	Organoid experiment	Organoids recapitulate some brain development and can model microcephaly	The presence or absence of consciousness
[22]	Trujillo et al., 2019 Oscillatory waves in cortical organoids	Organoid electrophysiology	Cortical organoids exhibit complex oscillations and model early network development	Electrical activity equals consciousness
[23]	ISSCR Guidelines, 2021; update 2025 v1.2	International professional guidelines	Oversight and ethical boundaries for research including stem-cell-based embryo models and organoids	Conclusions about organoid consciousness or a universal definition of life
[24]	National Academies, 2021 Human Neural Organoids, Transplants, and Chimeras	Authoritative report	Scientific limitations, governance uncertainty, and precautionary principles	Current objects already have consciousness or certainly lack it
[25]	Kriegman et al., 2020 Reconfigurable organisms	Living-cell assembly experiment	Assemblies of frog-embryo-derived cells exhibit designed behavior in constrained environments	A new species, complete origin of life, or subjecthood
[26]	Kriegman et al., 2021 Kinematic self-replication	Living-cell assembly experiment	Kinematic replication under particular conditions	Open-ended hereditary evolution or subjecthood

No.	Source / object	Evidence type	Limited conclusion supported	Insufficient on its own to support
[27]	Matzinger, 2002 Danger model	Immunological theory	The danger model offers an explanation different from simple self/nonself discrimination	It has replaced all immunological theories or determines subject boundaries
[28]	Kerr, Wyllie & Currie, 1972 Apoptosis	Conceptual / histopathological	Controlled cell deletion participates in regulation of tissue cell populations	Every modern mechanism of regulated cell death
[29]	Hauk et al., 2004 Action words	Human neuroimaging	Action-word processing correlates with motor / premotor activity	All meaning must depend on the human body
[30]	Bach-y-Rita et al., 1969 Vision substitution	Sensory-substitution research	Tactile image projection can support visual-substitution functions	The substitute channel produces exactly the same phenomenal experience
[31]	Scoville & Milner, 1957 H.M.	Neuropsychological case study	Bilateral medial temporal lobe damage can severely impair new memory formation while preserving some capacities	Memory is the sole condition for subject continuity
[32]	Pinto et al., 2017 Split-brain patients	Small-sample neuropsychology	Divided perception can coexist with a unified agent	Split-brain research has resolved the unity of consciousness
[33]	Ajiboye et al., 2017 Brain-computer interface	Single-case proof of concept	Brain-controlled functional electrical stimulation restores some motor capacity	Transfer of personality, memory, or a subject
[34]	Critchley et al., 2004 Interoceptive awareness	Correlational neuroimaging	Human interoceptive awareness correlates with specific neural activity	That neural region is sufficient for consciousness or applicable to all subjects
[35]	Greer et al., 2020 World Brain Death Project	International consensus project	International minimum standards and procedures for death determination by neurologic criteria	A final ontology of death
[36]	Jones et al., 2014 Diversity of ageing	Cross-species comparison	Forty-six species show highly diverse mortality and fertility trajectories	Ageing has no general mechanisms, or a species is immortal
[37]	Martinez, 1998 Hydra mortality	Long-term population observation	No evident senescence in particular hydra cohorts over four years	Absolute biological immortality
[38]	Gurdon, 1962 Nuclear transplantation	Nuclear-transfer developmental experiment	Differentiated nuclei retain developmental potential under particular conditions	A mature individual can be copied as a subject
[39]	Moran & Sloan, 2015 The hologenome concept	Theoretical critique	The hologenome / holobiont concepts have important limits of applicability and counterexamples	The microbiome has no biological significance for the host
[40]	Marsee et al., 2021 HPB organoid nomenclature	Standardization consensus	Definitions and nomenclature for hepatic, pancreatic, and biliary organoids require standardization	A unified definition across tissues, ethics, and consciousness research
[41]	Greer guideline erratum, 2024	Journal correction	Corrects the publication record of the 2023 brain death/death by neurologic criteria guideline	Expanded ontological authority for the guideline

No.	Source / object	Evidence type	Limited conclusion supported	Insufficient on its own to support
[42]	Shewmon, 1998 Chronic brain death	Case synthesis / conceptual analysis	Some somatic integration can persist long-term under life support	Consciousness, restoration of brain function, or revival after diagnosis
[43]	Revah et al., 2022 Transplanted cortical organoids	Transplantation experiment	Organoids can mature, integrate, respond to sensory input, and modulate host behavior	Organoids have subjective experience
[44]	Paşca et al., 2022 Neural organoid nomenclature	Nomenclature consensus	Neural organoids and assembloids require object-specific nomenclature	Conclusions about consciousness or moral status
[45]	Paşca et al., 2025 Neural organoid framework	Research framework	Quality, characterization, manipulation, and transplantation require reproducible reporting	A uniform standard for consciousness detection
[46]	Moger-Reischer et al., 2023 Minimal-cell evolution	Experimental evolution	Genome minimization has not eliminated adaptive evolution	Unconditional achievement of open-ended evolution
[47]	Kim et al., 2010 iPSC epigenetic memory	Cellular reprogramming	Some induced pluripotent stem cells retain epigenetic memory of their tissue of origin	Reprogramming necessarily resets everything or can never reset anything
[48]	ClinicalTrials.gov NCT07290244 ER-100	Registered phase 1 trial	A first-in-human phase 1 safety and tolerability study of ER-100 is registered; actual enrollment and results require separate verification	Human rejuvenation, life extension, or efficacy
[49]	Restrepo Sierra et al., 2026 Bottom-up synthetic cell	Bottom-up protocell experiment	Integration of expression, DNA replication, and membrane-lipid synthesis modules in vesicles	Complete autonomous synthetic life sustained across generations

Appendix B Argument Status A B C F and Cross-level Auditing

The four statuses specify only what work a statement performs in this paper. They form neither a hierarchy from A to F nor an overall score of life, consciousness, personhood, or standing.

Status	Meaning in this paper	Permitted role	Prohibited overreach
A Relatively stable support	Verifiable, delimited facts concerning life, development, death, individuation, cloning, organoids, synthetic biology, and related fields; formal guidelines and version status.	Factual premises and methodological constraints after delimiting the object.	The final essence of life, experience, personhood, rights, or public power.
B Frontier / competing explanations	Competing definitions of life, models of individuation, experience-related mechanisms, extrapolation in aging and reprogramming, and open interpretations of organoids and artificial life.	Comparison of mechanisms, counterexamples, external validity, and research designs.	Presentation as scholarly consensus or automatic triggering of institutional standing.
C Speculation / research connections	Cross-substrate subject continuity, uploading and branching, heterogeneous life, future AGI subjects, and this paper's layered audit framework.	Conceptual stress tests, falsifiable research designs, and limited triggers for reconsideration.	Realized capabilities, established life or subjecthood, or power authorized in advance.
F Philosophical / normative commitments	Public value premises including plural sources of meaning, finitude not being its sole source, historical non-erasure, and separate accounts of protection, standing, and power.	Explanation of why particular questions warrant protection, dispute, and reconsideration.	Impersonating life-science facts or overriding neighboring disciplines' independent judgments.

B.1 Ten Checks Before Extrapolation

- Are the object, scale, criteria, and research purpose explicit, rather than relying only on overarching labels such as “life” or “subject”?
- Do biological organization, sentience / experience, subject continuity, grasp of consequences, and institutional position still each have their own evidence?
- Do positive and negative conclusions both report detection capability, competing explanations, and applicability across paradigms?
- Which continuity relation is preserved by cloning, reprogramming, organ replacement, backups, copying, branching, and succession?
- Are brain organoids, synthetic cells, minimal cells, and reconfigurable organisms accurately delimited to actual experimental findings?
- Has living material, module integration, complex activity, or self-maintenance mistakenly been presented directly as evidence of experience and subjecthood?
- Have nonbiological composition, copyability, pausability, or migratability mistakenly been treated as grounds for permanently excluding future subjects?
- Are the functional roles of current advanced AI bound to particular objects, versions, authorization, auditing, correction, and exit conditions?
- Do A, B, C, and F each remain within their own scope of proof, without mechanical conversion into protection, personhood, standing, or public power?
- Is it clear where this paper stops, why the next discipline reenters, and what new facts would require this paper to change?

References

- [1] NASA Astrobiology. About Life Detection. Official working-definition page; accessed 2026-08-24. <https://astrobiology.nasa.gov/research/life-detection/about/>
- [2] Varela FJ, Maturana HR, Uribe R. Autopoiesis: the organization of living systems, its characterization and a model. *BioSystems*. 1974;5(4):187–196. [https://doi.org/10.1016/0303-2647\(74\)90031-8](https://doi.org/10.1016/0303-2647(74)90031-8)
- [3] Theobald DL. A formal test of the theory of universal common ancestry. *Nature*. 2010;465:219–222. <https://doi.org/10.1038/nature09014>
- [4] Szathmáry E, Maynard Smith J. The major evolutionary transitions. *Nature*. 1995;374:227–232. <https://doi.org/10.1038/374227a0>
- [5] Queller DC, Strassmann JE. Beyond society: the evolution of organismality. *Philosophical Transactions of the Royal Society B*. 2009;364:3143–3155. <https://doi.org/10.1098/rstb.2009.0095>
- [6] Human Microbiome Project Consortium. Structure, function and diversity of the healthy human microbiome. *Nature*. 2012;486:207–214. <https://doi.org/10.1038/nature11234>
- [7] McFall-Ngai MJ, Ruby EG. Symbiont recognition and subsequent morphogenesis as early events in an animal-bacterial mutualism. *Science*. 1991;254:1491–1494. <https://doi.org/10.1126/science.1962208>
- [8] Sulston JE, Schierenberg E, White JG, Thomson JN. The embryonic cell lineage of the nematode *Caenorhabditis elegans*. *Developmental Biology*. 1983;100:64–119. [https://doi.org/10.1016/0012-1606\(83\)90201-4](https://doi.org/10.1016/0012-1606(83)90201-4)
- [9] López-Otín C, et al. Hallmarks of Aging: An Expanding Universe. *Cell*. 2023;186:243–278. <https://doi.org/10.1016/j.cell.2022.11.001>
- [10] Greer DM, et al. Pediatric and Adult Brain Death/Death by Neurologic Criteria Consensus Guideline. *Neurology*. 2023. <https://doi.org/10.1212/WNL.0000000000207740>
- [11] Spalding KL, et al. Retrospective birth dating of cells in humans. *Cell*. 2005;122:133–143. <https://doi.org/10.1016/j.cell.2005.04.028>
- [12] Wilmut I, et al. Viable offspring derived from fetal and adult mammalian cells. *Nature*. 1997;385:810–813. <https://doi.org/10.1038/385810a0>
- [13] Fraga MF, et al. Epigenetic differences arise during the lifetime of monozygotic twins. *Proceedings of the National Academy of Sciences*. 2005;102:10604–10609. <https://doi.org/10.1073/pnas.0500398102>
- [14] Takahashi K, Yamanaka S. Induction of pluripotent stem cells from mouse embryonic and adult fibroblast cultures by defined factors. *Cell*. 2006;126:663–676. <https://doi.org/10.1016/j.cell.2006.07.024>
- [15] Takahashi K, et al. Induction of pluripotent stem cells from adult human fibroblasts by defined factors. *Cell*. 2007;131:861–872. <https://doi.org/10.1016/j.cell.2007.11.019>
- [16] Ocampo A, et al. In Vivo Amelioration of Age-Associated Hallmarks by Partial Reprogramming. *Cell*. 2016;167:1719–1733.e12. <https://doi.org/10.1016/j.cell.2016.11.052>
- [17] Browder KC, et al. In vivo partial reprogramming alters age-associated molecular changes during physiological aging in mice. *Nature Aging*. 2022;2:243–253. <https://doi.org/10.1038/s43587-022-00183-2>
- [18] Gibson DG, et al. Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome. *Science*. 2010;329:52–56. <https://doi.org/10.1126/science.1190719>
- [19] Hutchison CA III, et al. Design and synthesis of a minimal bacterial genome. *Science*. 2016;351:aad6253. <https://doi.org/10.1126/science.aad6253>
- [20] Pelletier JF, et al. Genetic requirements for cell division in a genomically minimal cell. *Cell*. 2021. <https://doi.org/10.1016/j.cell.2021.03.008>
- [21] Lancaster MA, et al. Cerebral organoids model human brain development and microcephaly. *Nature*. 2013;501:373–379. <https://doi.org/10.1038/nature12517>
- [22] Trujillo CA, et al. Complex Oscillatory Waves Emerging from Cortical Organoids Model Early Human Brain Network Development. *Cell Stem Cell*. 2019;25:558–569.e7. <https://doi.org/10.1016/j.stem.2019.08.002>
- [23] International Society for Stem Cell Research. Guidelines for Stem Cell Research and Clinical Translation. 2021; targeted update v1.2, 2025. <https://www.isscr.org/guidelines>

- [24] National Academies of Sciences, Engineering, and Medicine. The Emerging Field of Human Neural Organoids, Transplants, and Chimeras: Science, Ethics, and Governance. Washington, DC: National Academies Press; 2021. <https://doi.org/10.17226/26078>
- [25] Kriegman S, et al. A scalable pipeline for designing reconfigurable organisms. *Proceedings of the National Academy of Sciences*. 2020;117:1853–1859. <https://doi.org/10.1073/pnas.1910837117>
- [26] Kriegman S, et al. Kinematic self-replication in reconfigurable organisms. *Proceedings of the National Academy of Sciences*. 2021;118:e2112672118. <https://doi.org/10.1073/pnas.2112672118>
- [27] Matzinger P. The danger model: a renewed sense of self. *Science*. 2002;296:301–305. <https://doi.org/10.1126/science.1071059>
- [28] Kerr JFR, Wyllie AH, Currie AR. Apoptosis: a basic biological phenomenon with wide-ranging implications in tissue kinetics. *British Journal of Cancer*. 1972;26:239–257. <https://doi.org/10.1038/bjc.1972.33>
- [29] Hauk O, Johnsrude I, Pulvermüller F. Somatotopic representation of action words in human motor and premotor cortex. *Neuron*. 2004;41:301–307. [https://doi.org/10.1016/S0896-6273\(03\)00838-9](https://doi.org/10.1016/S0896-6273(03)00838-9)
- [30] Bach-y-Rita P, Collins CC, Saunders FA, White B, Scadden L. Vision substitution by tactile image projection. *Nature*. 1969;221:963–964. <https://doi.org/10.1038/221963a0>
- [31] Scoville WB, Milner B. Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery & Psychiatry*. 1957;20:11–21. <https://doi.org/10.1136/jnnp.20.1.11>
- [32] Pinto Y, et al. Split brain: divided perception but undivided consciousness. *Brain*. 2017;140:1231–1237. <https://doi.org/10.1093/brain/aww358>
- [33] Ajiboye AB, et al. Restoration of reaching and grasping movements through brain-controlled muscle stimulation in a person with tetraplegia. *The Lancet*. 2017;389:1821–1830. [https://doi.org/10.1016/S0140-6736\(17\)30601-3](https://doi.org/10.1016/S0140-6736(17)30601-3)
- [34] Critchley HD, Wiens S, Rotshtein P, Öhman A, Dolan RJ. Neural systems supporting interoceptive awareness. *Nature Neuroscience*. 2004;7:189–195. <https://doi.org/10.1038/nn1176>
- [35] Greer DM, et al. Determination of Brain Death/Death by Neurologic Criteria: The World Brain Death Project. *JAMA*. 2020;324:1078–1097. <https://doi.org/10.1001/jama.2020.11586>
- [36] Jones OR, et al. Diversity of ageing across the tree of life. *Nature*. 2014;505:169–173. <https://doi.org/10.1038/nature12789>
- [37] Martinez DE. Mortality patterns suggest lack of senescence in hydra. *Experimental Gerontology*. 1998;33:217–225. [https://doi.org/10.1016/S0531-5565\(97\)00113-7](https://doi.org/10.1016/S0531-5565(97)00113-7)
- [38] Gurdon JB. The developmental capacity of nuclei taken from intestinal epithelium cells of feeding tadpoles. *Journal of Embryology and Experimental Morphology*. 1962;10:622–640. <https://doi.org/10.1242/dev.10.4.622>
- [39] Moran NA, Sloan DB. The Hologenome Concept: Helpful or Hollow? *PLoS Biology*. 2015;13:e1002311. <https://doi.org/10.1371/journal.pbio.1002311>
- [40] Marsee A, et al. Building consensus on definition and nomenclature of hepatic, pancreatic, and biliary organoids. *Cell Stem Cell*. 2021;28:816–832. <https://doi.org/10.1016/j.stem.2021.04.005>
- [41] Erratum: Pediatric and Adult Brain Death/Death by Neurologic Criteria Consensus Guideline. *Neurology*. 2024;102(3):e208108. <https://doi.org/10.1212/WNL.00000000000208108>
- [42] Shewmon DA. Chronic 'brain death': meta-analysis and conceptual consequences. *Neurology*. 1998;51(6):1538–1545. <https://doi.org/10.1212/WNL.51.6.1538>
- [43] Revah O, Gore F, Kelley KW, et al. Maturation and circuit integration of transplanted human cortical organoids. *Nature*. 2022;610:319–326. Author Correction published 3 August 2026 (Fig. 5a mPFC panel corrected). <https://doi.org/10.1038/s41586-022-05277-w>; <https://doi.org/10.1038/s41586-026-10943-4>
- [44] Paşca SP, Arlotta P, Bateup HS, et al. A nomenclature consensus for nervous system organoids and assembloids. *Nature*. 2022;609(7929):907–910. <https://doi.org/10.1038/s41586-022-05219-6>
- [45] Paşca SP, Arlotta P, Bateup HS, et al. A framework for neural organoids, assembloids and transplantation studies. *Nature*. 2025;639:315–320. <https://doi.org/10.1038/s41586-024-08487-6>
- [46] Moger-Reischer RZ, Glass JI, Wise KS, et al. Evolution of a minimal cell. *Nature*. 2023;620:122–127. Publisher Correction, 2023. <https://doi.org/10.1038/s41586-023-06288-x>; <https://doi.org/10.1038/s41586-023-06454-1>

[47] Kim K, Doi A, Wen B, et al. Epigenetic memory in induced pluripotent stem cells. *Nature*. 2010;467:285–290. <https://doi.org/10.1038/nature09342>

[48] ClinicalTrials.gov. Evaluating ER-100 for Safety in People With Glaucoma or Non-Arteritic Anterior Ischemic Optic Neuropathy. NCT07290244. Accessed 2026-08-24. <https://clinicaltrials.gov/study/NCT07290244>

[49] Restrepo Sierra AM, Ramirez Gomez F, van Tongeren M, Sierra Heras L, Danelon C. A synthetic cell with integrated DNA self-replication and lipid biosynthesis. *Nature Communications*. 2026;17:2727. <https://doi.org/10.1038/s41467-026-69531-9>

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