2025; 1-1 | pp.1-8

Academians Journal of Biology

ISSN: XXXX-XXXX

Volume 1, Issue 1, July-September 2025

(An Academians Publishers of Research & Academic Resources)

Original Research Article

Received: 27-07-2025 **Accepted**: 18-08-2025 **Published**: 22-09-2025

The Ontological Imperative: Synthetic Biology and the Disciplining of Life as a Postmodern Care Paradigm

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Abstract: The emergence of synthetic biology marks a significant paradigm shift in humanity's engagement with the natural world, transitioning from exploitation and conservation to deliberate ontological redesign. This review builds on the concept of synthetic biology as a "postmodern technology of care" by critically examining its philosophical foundations, operational mechanisms, and ethical ramifications. We contend that synthetic biology enacts a form of ontological care, aiming to address suffering and existential threats not by modifying environments or behaviors, but by re-engineering the biological essence of organisms to enhance their fitness within human-altered contexts. Drawing on literature from bioethics, science and technology studies (STS), environmental philosophy, and molecular biology, this review analyzes three principal mechanisms of ontological care: (1) Metabolic Gatekeeping, where organisms are engineered for hyper-efficiency in controlled bioproduction systems; (2) Predetermined Ecologies, where gene drives and genetic biocontrol establish human-designed population dynamics in wild systems; and (3) Evolutionary Triage, where assisted evolution and de-extinction projects prioritize genetic malleability over ecological resilience. We identify the central ethical dilemma as the "Care-Control Paradox," in which benevolent objectives such as species preservation or disease eradication are pursued through extensive biological control and simplification. The review concludes by considering alternative frameworks, including "relational care" and "prosthetic biology," that may foster more collaborative and less imperialistic approaches to the more-than-human world. Ultimately, we argue that the most profound impact of synthetic biology may reside not in the organisms it produces, but in the new, technologically mediated ontology of life it establishes.

Keywords: *synthetic biology, postmodernism, ethics of care, more-than-human, ontology, genetic engineering, biocontrol, bioethics*

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1. Introduction

The 21st century is witnessing a technological revolution that challenges the very categories of nature, life, and agency. Among the most disruptive of these technologies is synthetic biology, a field dedicated to the design and construction of new biological parts, devices, and systems, and the re-design of existing, natural biological systems for useful purposes (Khalil & Collins, 2010). While often discussed in terms of its potential applicationsâ€”from sustainable biofuels to novel therapeuticsâ€”its deeper philosophical implications are only beginning to be understood. Fulvi (2025) provides a crucial intervention by framing synthetic biology not merely as a toolkit but as a "postmodern

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technology of care." This characterization moves the debate beyond utilitarian applications and into the realm of fundamental ontology, suggesting that the field is driven by a desire to refashion biology itself to improve the condition of both human and more-than-human beings.

This review accepts this foundational premise and seeks to expand it into a comprehensive critical framework. Fulvi correctly identifies the core tenet: life, in its current evolutionary state, is deemed unsatisfactory and in need of human-led optimization to meet contemporary crises. This perceived insufficiency is not merely functional but ontological; it resides in the very nature of biological systemsâ€"their complexity, unpredictability, and contingent evolutionary history (Boldt, 2018). If modern medicine sought to heal the body, and modern conservation sought to protect the environment, postmodern synthetic biology seeks to re-code both the body and the environment. This is care not as remediation or stewardship, but as ontological replacementâ€"a substitution of "unruly" natural systems with "docile," simplified, and controllable bio-engineered ones.

This paper reviews and synthesizes the principal dimensions of this paradigm shift in four sections. First, we elaborate on the philosophical foundations of the new care paradigm, drawing on postmodern theory, Foucault's concept of biopower, and more-than-human ethics to establish a comprehensive theoretical framework. Second, we analyze the mechanisms of ontological disciplining, extending beyond Fulvi's examples to categorize and examine the distinct modes of interventionâ€"Metabolic Gatekeeping, Predetermined Ecologies, and Evolutionary Triageâ€"through which this form of care is implemented. Third, we critically discuss the implications, focusing on the "Care-Control Paradox," the redefinition of biological normality, and the emergence of a potential new biological colonialism. Finally, we explore future perspectives and alternative frameworks, such as "relational care" and "humble design," that may guide synthetic biology toward a more ethically nuanced and less imperialistic trajectory. The aim is to provide an interdisciplinary review that clarifies how synthetic biology is transforming not only our capabilities, but also our fundamental understanding of life's purpose.

2. Philosophical Foundations

To understand synthetic biology as a technology of care, one must first grasp the postmodern condition of technology itself. Postmodern technologies, as opposed to their modern predecessors, are characterized by their blurring of foundational boundariesâ€"between organism and machine, nature and artifact, the real and the constructed (Lyotard, 1984).

2.1. From Biopower to Ontopower

Foucault's (1978) concept of biopowerâ€"the power to "make live and let die" through the administration of life at the level of populationsâ€"provides a critical starting point. Modern technologies of care, such as public health initiatives and welfare systems, are classic instruments of biopower; they manage and optimize biological processes (birth rates, health, longevity) within a human population. However, synthetic biology represents a radical intensification of this power. As noted by authors like Cooper (2008), we are witnessing a shift from biopower to what might be termed "ontopower"â€"the power to define, design, and instigate new forms of life itself. It is no longer sufficient to manage the life a body has ; the ambition is to redesign the life a body is . This is power exercised at the ontological level, determining the very conditions of being for biological entities.

2.2. The Engineering Mindset and the "Unsatisfactory" Natural World

The field is underpinned by an engineering mindset that views biology as a potentially perfectible, but currently flawed, technology. Drew Endy, a prominent synthetic biologist, famously stated, "Biology is too important to be left to biologists" (as cited in Specter, 2009, p. 24), encapsulating the field's drive to import the principles of standardization, abstraction, and modularity from electrical engineering into biological research (Endy, 2005). In this view, natural selection is a "tinkerer," producing inefficient and messy systems (Jacob, 1977). Synthetic biology, in contrast, aims for rational design. This creates a fundamental dissatisfaction with evolved life, framing its complexity not as a marvel of adaptation but as an obstacle to functionality and control (Calvert, 2010). The "care" that synthetic biology provides is thus predicated on a diagnosis of inherent biological deficiency.

2.3. Care as a More-than-Human Political Practice

Traditional ethics of care, pioneered by theorists like Gilligan (1982) and Noddings (1984), focus on interpersonal relationships and the moral imperative to respond to the needs of concrete others. This review, following Fulvi (2025) and thinkers like Puig de la Bellacasa (2017), expands this notion into the more-than-human realm. A postmodern technology of care must consider its relationships with and impacts on animals, plants, microbes, and ecosystems. However, as Tronto (1993) notes, care is inherently a political practice involving power dynamics. The critical question becomes: who defines the "need" of the other, and by what right? In synthetic biology, the "need" of the more-than-humanâ€"a mosquito, a yeast cell, a sea turtleâ€"is unilaterally defined by human actors. Its need is deemed to be a different biology, one that serves human or human-defined ecological purposes. This constitutes a form of paternalistic care that operates through ontological disciplining rather than empathetic engagement.

3. Mechanisms of Ontological Disciplining in Practice

The theoretical framework of ontological care manifests through specific, tangible technological mechanisms. These are not merely applications but are the very instruments through which the disciplining logic of synthetic biology is enacted.

3.1. Metabolic Gatekeeping: The Factory as a Paradigm of Care

The production of semi-synthetic artemisinin in engineered yeast (Saccharomyces cerevisiae) is a canonical example that illustrates the principle of Metabolic Gatekeeping(Paddon & Keasling, 2014). This process involves inserting plant-derived genes into yeast, effectively reprogramming its metabolism to produce artemisinic acid, a precursor to the potent antimalarial drug artemisinin.

This goes beyond creating a more efficient drug manufacturing process. It represents a broader ontological shift. The inherent, evolved complexity of the sweet wormwood plant (Artemisia annua)â€"its slow growth, its dependence on specific climatic conditions, its variable yieldâ€"is framed as a barrier to care (the need for reliable, affordable malaria treatment). The solution is not to work with this complexity but to bypass it entirely by gatekeeping the desired metabolic output within a simplified, genetically enclosed, and industrially managed microbial chassis. The engineered yeast is ontologically disciplined: its biological purpose is reduced to a single, hyper-efficient function. Its "care" for the human malaria patient is achieved through its own metabolic subjugation. This establishes a paradigm where the most "caring" organism is the one with the most constrained, predictable, and controllable biology, transforming the factory bioreactor into the ideal model for a caring relationship with nature.

3.2. Predetermined Ecologies: Imposing Order on Wild Systems

The application of gene drives for eradicating disease vectors like malaria mosquitoes (Anopheles spp.) or invasive rodents exemplifies a second, more radical mechanism: the creation of Predetermined Ecologies(Esvelt et al., 2014). Gene drives are genetic systems that bypass the rules of Mendelian inheritance, ensuring a particular gene is passed to nearly all offspring, thereby spreading it rapidly through a population.

While Fulvi (2025) notes this as disciplining, we can further analyze it as a form of ecological programming . Traditional public health and conservation manage ecosystems through external interventionsâ€”insecticide spraying, trapping, habitat manipulation. Synthetic biology, through gene drives, internalizes this management within the genome of the target species itself. The "care" for human communities or endemic species is achieved by writing a self-executing eradication algorithm directly into the DNA of the threat (Webber et al., 2015). The wild, stochastic population dynamics of the mosquito are overwritten with a human-designed, deterministic code for population collapse.

This represents the ultimate extension of the engineering mindset into the heart of ecology. The ecosystem's "problem" is defined as a flawed genetic code in a key species, and the "care" is the deployment of a genetic patch. The profound risk, of course, is that this code is executed irreversibly across an entire population and potentially across national borders. The discipline is absolute and self-propagating, with emergent properties and unintended ecological consequencesâ€”such as the removal of a food source for other species or the rise of secondary pestsâ€—that our computational models, for all their sophistication, cannot fully predict (National Academies of Sciences, Engineering, and Medicine, 2016).

3.3. Evolutionary Triage and the Aesthetics of "Save-ability"

The hypothetical case of engineering sea turtles like Chelonia mydas to survive warming-induced feminization introduces a third, poignant mechanism: Evolutionary Triage(Wodak, 2021). In this scenario, care is directed at the species itself, but it is a care that demands ontological alteration as the price for survival. Rising global temperatures cause incubating turtle eggs to develop almost exclusively as females, threatening the species with reproductive collapse (Jensen et al., 2018). A synthetic biology "solution" would involve using gene drives or other methods to alter the temperature-dependent sex determination genes, making the species resilient to human-caused warming.

This creates a new, unsettling form of triage. The question is no longer just "which species can we save with the resources we have?" but "which species are genetically malleable and well-understood enough to be saved through our interventions?" This privileges a certain aesthetic of "save-ability." Species with simple, monogenic, or well-characterized traits become prime candidates for care. Those with complex, polygenic, or poorly understood adaptations may be deemed "unsaveable" and left to extinction (Preston, 2018). The "care" becomes conditional upon the organism's compatibility with synthetic biology's tools and the human capacity to understand and re-write its core functions. This risks creating a new biological hierarchy, where the "cared for" are those who can be most easily disciplined and redesigned, fundamentally altering the meaning of conservation from preserving what is to creating what can be in a human-engineered future.

4. Discussion

The unifying thread across these three mechanisms is what we term the Care-Control Paradox. This is the inextricable and deeply problematic link between the benevolent, often urgent, aim of care and the profound, ontological-level control required to achieve it within the synthetic biology paradigm.

4.1. The Inescapable Tension

On one hand, the promise of care is compelling. Proponents argue that in the face of existential threats like pandemic diseases, rapid climate change, and the sixth mass extinction, the slow, "messy," and contingent processes of natural evolution are a luxury we can no longer afford (Church & Regis, 2012). The urgent need to care for vulnerable human and more-than-human communities justifies a radical, direct intervention at the genetic level. From this perspective, it is unethical not to use every tool at our disposal, including synthetic biology, to prevent immense suffering and loss (Savulescu et al., 2020).

On the other hand, the reality of this care is operationalized as control. It is the control over metabolic pathways, over reproductive futures, over evolutionary trajectories. It simplifies complex, co-evolved systems into manageable, linear functions, replacing ecological relationality with engineered determinism. This control is not a side effect; it is the essential mechanism of the care being offered. The paradox lies in the fact that the very act of "saving" a species or "curing" an ecosystem may require its fundamental alteration, effectively replacing the autonomous entity with a human-directed simulacrum. This raises the philosophical question: are we saving the sea turtle, or are we replacing it with a patented, climate-resilient model that carries the turtle's name?

4.2. Redefining "Normality" and Pathologizing Wildness

A significant consequence of this paradigm is the redefinition of biological normality. Within the logic of synthetic biology, the "normal" or "healthy" state of an organism or ecosystem is one that is predictable, efficient, and controllable. Conversely, wildness, complexity, and evolutionary contingency are increasingly pathologized as states of dysfunction and risk (Bhattachary et al., 2020). A forest that burns in a wildfire is "unhealthy"; a mosquito that transmits disease is "flawed"; a yeast that doesn't overproduce a desired compound is "deficient." This technological framing of biological problems inevitably leads to technological solutions that further entrench the control paradigm, creating a feedback loop that marginalizes non-technological, relational, or precautionary approaches to care.

4.3. The Risk of a New Biological Colonialism

The power to redesign life is not distributed equally. The development and deployment of synthetic biology technologies are concentrated in wealthy nations, corporations, and research institutions (Zhang et al., 2021). This raises the specter of a new form of biological colonialism, where the genetic fabric of the Global South's biodiversity, agricultural systems, and even human populations becomes a resource for intervention and optimization by powerful external actors (Benjamin, 2016). Who decides that a mosquito population in sub-Saharan Africa should be driven to extinction? Who owns the intellectual property on the climate-resilient sea turtle? The disciplining power of synthetic biology could thus extend beyond non-human organisms to discipline entire human communities and nations, determining their ecological and health futures without their meaningful consent or participation.

5. Future Perspectives: Towards a Relational and "Humble" Synthetic Biology?

The critique of synthetic biology as ontological disciplining is not necessarily a call for its wholesale abandonment. The genie is, in many ways, out of the bottle. The challenge is to navigate its development with ethical foresight. Rather than rejecting the field, we can explore pathways toward a more reflexive and ethically nuanced practice that tempers the drive for control with a philosophy of relation and humility.

5.1. Prosthetic vs. Replaceive Biology

A promising direction is a shift from replacive to prosthetic biology. The current paradigm often seeks to replace a natural system with a synthetic one (e.g., replacing the Artemisia plant with engineered yeast). A prosthetic model, in contrast, would aim to create temporary, supportive interventions that augment an organism's or ecosystem's inherent capacities without seeking to permanently overwrite them (Budd et al., 2023). For example, instead of engineering a blight-resistant chestnut tree, one could engineer a benign soil microbiome that temporarily provides the tree with blight-fighting compounds during an outbreak. This approach is more reversible, localized, and respects the autonomy and evolved resilience of the recipient organism.

5.2. The Principle of "Humble Care" and Precaution

Drawing from the environmental precautionary principle and virtues of epistemic humility, a principle of "Humble Care" would guide research and deployment (Sandler, 2019). This would prioritize interventions that are:

Reversible:Where possible, built with genetic "kill switches" or other fail-safes.

Localized:Designed to minimize ecological spread and impact beyond the target area.

Polyphonic:Developed through transparent, inclusive processes that incorporate ecological knowledge, indigenous wisdom, and public values, not just technical expertise (Stilgoe et al., 2013).

Needs-Based:Focused on addressing clear and present harms rather than pursuing technological possibilities for their own sake.

5.3. Reframing the Goal: Fostering Resilience over Imposing Control

Ultimately, the most significant shift would be to reframe the goal of synthetic biology from imposing control to fostering resilience . This would mean designing not for optimal function in a controlled environment, but for adaptive capacity within a complex, changing ecosystem. It would require synthetic biologists to see themselves not as architects of a new nature, but as participants in a dynamic, more-than-human community, with all the responsibility and restraint that such a role entails (Haraway, 2016).

6. Conclusion

Synthetic biology, understood as a postmodern technology of care, represents a fundamental crossroads in the human story. It offers powerful, even seductive, tools to address some of the most pressing challenges of our time. However, as this review has argued, its power is predicated on a logic of ontological disciplining that reduces biological complexity to engineered function and replaces evolutionary contingency with human design. The mechanisms of Metabolic Gatekeeping, Predetermined Ecologies, and Evolutionary Triage illustrate how care in the Anthropocene is becoming synonymous with control at the most fundamental level of existence.

The future of this field will depend on its ability to consciously and courageously grapple with the Care-Control Paradox. Will it mature into a discipline that, with benevolent intent, imposes a single, human-designed order onto the biosphere, thereby completing the project of modernity by dissolving the last vestiges of independent nature? Or can it evolve into a practice of "humble care" and "prosthetic" support that fosters relationality, respects autonomy, and supports the vibrant, unpredictable, and autonomous flourishing of the more-than-human world? The answer to this question will determine not just which species we save from extinction or which diseases we eradicate, but what kind of worldâ€”and what kind of relationship with life itselfâ€”we ultimately choose to build and inhabit. The most profound product of synthetic biology may not be any single organism, but the new ontology it writes into the fabric of our planet.

References

Benjamin, R. (2016). Informed refusal: Toward a justice-based bioethics. Science, Technology, & Human Values , 41 (6), 967â€“990. https://doi.org/10.1177/0162243916656059

Bhattachary, D., Calitz, J. P., & Hunter, A. (2020). Synthetic biology dialogue . https://www.bbsrc.ac.uk/documents/2000-synthetic-biology-dialogue-pdf/

Boldt, J. (2018). Machine metaphors and ethics in synthetic biology. Life Sciences, Society and Policy , 14 (1), 12. https://doi.org/10.1186/s40504-018-0077-y

Budd, A. M., Beisel, C. L., & Dymond, J. S. (2023). Synthetic biology for therapeutic applications. Molecular Therapy , 31 (3), 1-15. https://doi.org/10.1016/j.ymthe.2023.01.016

Calvert, J. (2010). Synthetic biology: Constructing nature. The Sociological Review , 58 (1_suppl), 95â€“112. https://doi.org/10.1111/j.1467-954X.2010.01913.x

Church, G. M., & Regis, E. (2012). Regenesis: How synthetic biology will reinvent nature and ourselves . Basic Books.

Cooper, M. (2008). Life as surplus: Biotechnology and capitalism in the neoliberal era . University of Washington Press.

Endy, D. (2005). Foundations for engineering biology. Nature , 438 (7067), 449â€“453. https://doi.org/10.1038/nature04342

Esvelt, K. M., Smidler, A. L., Catteruccia, F., & Church, G. M. (2014). Concerning RNA-guided gene drives for the alteration of wild populations. eLife , 3 , e03401. https://doi.org/10.7554/eLife.03401

Foucault, M. (1978). The history of sexuality, Vol. 1: An introduction . (R. Hurley, Trans.). Pantheon Books.

Fulvi, D. (2025). Synthetic biology as a postmodern technology of care. NanoEthics , 19 , 11. https://doi.org/10.1007/s11569-025-00479-8

Gilligan, C. (1982). In a different voice: Psychological theory and women's development . Harvard University Press.

Haraway, D. J. (2016). Staying with the trouble: Making kin in the Chthulucene . Duke University Press.

Jacob, F. (1977). Evolution and tinkering. Science , 196 (4295), 1161â€“1166. https://doi.org/10.1126/science.860134

Jensen, M. P., Allen, C. D., Eguchi, T., Bell, I. P., LaCasella, E. L., Hilton, W. A., Hof, C. A. M., & Dutton, P. H. (2018). Environmental warming and feminization of one of the largest sea turtle populations in the world. Current Biology , 28 (1), 154â€“159.e4. https://doi.org/10.1016/j.cub.2017.11.057

Khalil, A. S., & Collins, J. J. (2010). Synthetic biology: Applications come of age. Nature Reviews Genetics , 11 (5), 367â€“379. https://doi.org/10.1038/nrg2775

Lyotard, J. F. (1984). The postmodern condition: A report on knowledge . (G. Bennington & B. Massumi, Trans.). University of Minnesota Press.

National Academies of Sciences, Engineering, and Medicine. (2016). Gene drives on the horizon: Advancing science, navigating uncertainty, and aligning research with public values . The National Academies Press. https://doi.org/10.17226/23405

Noddings, N. (1984). Caring: A feminine approach to ethics and moral education . University of California Press.

Paddon, C. J., & Keasling, J. D. (2014). Semi-synthetic artemisinin: A model for the use of synthetic biology in pharmaceutical development. Nature Reviews Microbiology , 12 (5), 355â€“367. https://doi.org/10.1038/nrmicro3240

Preston, C. J. (2018). The synthetic age: Outdesigning evolution, resurrecting species, and reengineering our world . MIT Press.

Puig de la Bellacasa, M. (2017). Matters of care: Speculative ethics in more than human worlds . University of Minnesota Press.

Sandler, R. L. (2019). The ethics of genetic engineering and gene drives in conservation. Conservation Biology , 34 (2), 1-11. https://doi.org/10.1111/cobi.13407

Savulescu, J., Persson, I., & Wilkinson, D. (2020). Utilitarianism and the pandemic. Bioethics , 34 (6), 620â€“632. https://doi.org/10.1111/bioe.12771

Specter, M. (2009, September 28). A life of its own. The New Yorker . https://www.newyorker.com/magazine/2009/09/28/a-life-of-its-own

Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. Research Policy , 42 (9), 1568â€“1580. https://doi.org/10.1016/j.respol.2013.05.008

Tronto, J. C. (1993). Moral boundaries: A political argument for an ethic of care . Routledge.

Webber, B. L., Raghu, S., & Edwards, O. R. (2015). Is CRISPR-based gene drive a biocontrol silver bullet or global conservation threat? Proceedings of the National Academy of Sciences , 112 (34), 10565â€“10567. https://doi.org/10.1073/pnas.1514258112

Wodak, J. (2021). Drawing a line in the sand: Bioengineering as conservation in the face of extinction debt. Queensland Review , 28 (2), 169â€“182.
https://doi.org/10.1017/qre.2022.14

Zhang, J. Y., Marris, C., & Rose, N. (2021). The transnational governance of synthetic biology: Scientific uncertainty, cross-borderness and the 'art' of governance. BIOS Centre Working Paper . London School of Economics and Political Science.