Petroglifos. Revista Crítica Transdisciplinar 9(2): e090201 julio-diciembre 2026.
DOI: 10.5281/zenodo.21327278
ISSN 2610-8186
www.petroglifosrevistacritica.org.ve

**Artículo Científico. Revisión**

# Social biotechnology: conceptual foundations, operational framework and the ontology of a new science for life

# Biotecnología social: fundamentos conceptuales, marco operativo y la ontología de una nueva ciencia para la vida

Daniel E. Martin-Vargas [1*]

[1]Researcher. Laboratorio de Mejoramiento Genético de Plantas. Centro de Biotecnología Agrícola. Instituto Venezolano de Investigaciones Científicas (IVIC). Pan-American Highway, Km 11, Altos de Pipe, San Antonio de Los Altos, Postal Code: 1204. Miranda, Venezuela.

*Corresponding author: dmartin@ivic.gob.ve

Recibido: 30-04-2026. Aceptado: 09-07-2026. Publicado: 20-07-2026.

## Abstract

Contemporary biotechnology faces structural challenges regarding its social legitimacy, largely because current intellectual property models and decontextualized methodological approaches have hindered the translation of molecular innovation into equitable collective well-being. Against this backdrop, the central objective of this work is to conceptualize Social Biotechnology as a transdisciplinary paradigm and a "Science for Life," defining its ontology and structuring its operational framework to reconfigure the relationship between bios and socius. Methodologically, the study applied a documentary analysis with a critical-hermeneutic approach to interpret contemporary literature and synthesize emerging theoretical dimensions. As a result, the proposal is founded on four pillars: biotechnological sovereignty, governance of the biocommons, territorial pertinence, and symbiotic transdisciplinarity. This article articulates this framework through strategic dimensions in health, agri-food, and the environment, integrating Open Science and Service-Learning as drivers of co-creation and prosocial leadership. By reorienting the valuation of innovation from Return on Investment (ROI) to the Social Rate of Return (SRR), Social Biotechnology consolidates a structural framework for the equitable management of scientific advancement. This architecture integrates molecular rigor with redistributive justice, enabling communities to reclaim their agency and transforming the laboratory into a space for territorial emancipation. Within this system, technical praxis directs its purpose toward an ethic of vital preservation, consolidating science as a genuine tool of resilience to ensure the dignity of existence in the face of current global challenges.

**Keywords:** open science, intellectual property, scientific innovation, ethics of science.

## Resumen

La biotecnología contemporánea enfrenta desafíos estructurales en su legitimidad social, en gran parte debido a que los actuales modelos de propiedad intelectual y los enfoques metodológicos descontextualizados han dificultado la traducción de la innovación molecular en bienestar colectivo equitativo. Ante este escenario, este trabajo tiene como objetivo central conceptualizar la Biotecnología Social como un paradigma transdisciplinario y una “Ciencia para la Vida”, definiendo su ontología y estructurando su marco operativo para reconfigurar la relación entre el bios y el socius. Metodológicamente, el estudio aplicó un análisis documental con enfoque hermenéutico-crítico para interpretar la literatura contemporánea y sintetizar las dimensiones teóricas emergentes. Como resultado, la propuesta se fundamenta en cuatro pilares: soberanía biotecnológica, gobernanza de los biocomunes, pertinencia territorial y transdisciplinariedad simbiótica. El presente artículo articula este marco mediante dimensiones estratégicas en salud, agroalimentación y ambiente, integrando la Ciencia Abierta y el Aprendizaje-Servicio como motores de cocreación y liderazgo prosocial. Al reorientar la valoración del Retorno de Inversión (ROI) hacia la Tasa de Retorno Social (TRS), la Biotecnología Social consolida un marco estructural para la gestión equitativa de la innovación científica. Esta arquitectura integra el rigor molecular con la justicia redistributiva, permitiendo a las comunidades recuperar su agencialidad y transformando el laboratorio en un espacio de emancipación territorial. En este sistema, la técnica orienta su propósito hacia una ética de la preservación vital, consolidando la ciencia como una herramienta genuina de resiliencia para asegurar la dignidad de la existencia frente a los desafíos globales actuales.

**Palabras clave:** ciencia abierta, propiedad intelectual, innovación científica, ética de la ciencia.

## Introduction

Contemporary biotechnology stands at a historical crossroads. The digital-molecular convergence—encompassing genomic editing, synthetic biology, and bioinformatics—is achieving unprecedented precision in the manipulation of living matter (Rosslenbroich, 2023). This progress, however, amplifies the gap between technoscientific potential and social equity, evidencing a structural crisis in the dominant reductionist paradigm. By favoring biomedicalization and market-driven frameworks that prioritize instrumental optimization over collective utility, this model frequently neglects the intrinsic interactions between biological systems and sociopolitical contexts (Benjamin, 2024; Geiger & Bourgeron, 2026; Jasanoff, 2019). Consequently, it reduces life to a transactional asset, denying its nature as a shared ontological and metabolic process (Rosslenbroich, 2023; Wu *et al.*, 2026).

In response to the exhaustion of this model, this article contends that Social Biotechnology is not merely an applied branch of biology but an emerging transdiscipline at the service of life, whose theoretical foundations challenge the dominance of scientific reductionism (Turnhout, 2022). Far from entailing a rejection of technique, this proposal posits an intentional reconfiguration that seeks to bridge the gap between laboratory innovation and community praxis. It articulates technoscience with collective deliberation and the integration of social innovations, consistent with contemporary scholarship on the democratization of knowledge.

While conventional biotechnology has been historically defined by the instrumental manipulation of living matter, Social Biotechnology is grounded in emancipation through the democratization of knowledge and the exchange of diverse perspectives. This stance consolidates a vision of science as a collaborative and sovereign process, whose viability is enhanced through the integration of *Open Science* and *Service-Learning* methodologies. Such a model has proven to be a catalyst for prosocial leadership and effective co-creation in the face of contemporary complexity challenges (Martín-Vargas, 2026).

The objective of this work is to conceptualize Social Biotechnology, transitioning from a “biotechnology of products” toward one of “social processes.” By integrating participatory bioethics, technological sovereignty, and biological equity as transverse axes, this framework redefines scientific practice for the 21st century. This proposal not only incentivizes open innovation models and inclusive public policies but also restores society's role in managing its biological reality. Ultimately, it vindicates the fundamental purpose of science: as a genuine tool at the service of human dignity and the preservation of life in all its manifestations.

## Ontological definition of *Social Biotechnology*

Social Biotechnology conceptualizes an ontological reconfiguration of the relationship between bios and socius, moving beyond traditional corporate social responsibility. While conventional biotechnology operates through an instrumental logic centered on the fragmentation of the object (Borg & Policante, 2022), Social Biotechnology is grounded in an 'ontology of the bond,' where technique is validated by its harmonic integration into biotic interdependencies. This shift challenges the prevailing sociotechnical paradigm—which extends its dominance through the algorithmization of human existence—and overcomes the historical compartmentalization of biotechnological practice (Jasanoff, 2019; Turnhout, 2022).

Driven by the urgency to harmonize technical progress with distributive and epistemic justice, this work develops the concept of Social Biotechnology, understood as a *transdisciplinary system of biological knowledge, praxis, and technologies oriented toward the production of the common good and the restoration of ecosystem integrity, whose governance, management, and benefits reside in the collective as a sovereign subject.* This paradigm transcends the reductionist vision that instrumentalizes living matter as a transactional asset, restoring its status as an inalienable right and consolidating it as a process of co-creation, where technique is placed at the service of an ethics of life preservation.

This conceptualization aligns with emerging paradigms of technological sovereignty and community science (Purkayastha, 2024), which demand that biological governance be an extension of the democratic agency of peoples (Jasanoff, 2019; Turnhout, 2022). In this praxis, molecular rigor and social sovereignty converge, based on four exhaustive and non-negotiable pillars that structure its operational framework:

### *Technical autonomy and biotechnological sovereignty*

Biotechnological sovereignty proposes an alternative to traditional linear models of technology transfer, which often reproduce structural imbalances and dependency in marginalized territories (Abdullahi *et al.*, 2025). This pillar empowers communities to exercise political, technical, and epistemic agency, allowing them to co-design situated innovation trajectories that transform their sociotechnical reality (Betancourt *et al.*, 2026; Umbrello & O'Hara, 2024). This autonomy is articulated through three critical dimensions:

- **Dismantling the "Black Box" model:** This dimension challenges the deployment of closed, hermetic, and proprietary technologies. It proposes a radical openness to dismantle colonial dependencies, fostering the development of interoperable, sovereign, and open-source solutions that allow for the socialization of knowledge and collective governance over biological systems and processes (Purkayastha, 2024).
- **Technical agency and self-determination:** The collectivity transcends its role as a market niche to become an active subject through bio-citizenship. This requires technical independence and the exercise of self-determination, understood as the faculty to validate or reject biotechnological trajectories that compromise the cultural or ecosystemic integrity of the territory (Chan, 2024; Turnhout, 2022).
- **Decolonizing innovation:** This axis reverses the

historical imbalance where the Global South provides the genetic base while the North concentrates intellectual property, demanding a transition from exclusionary regimes toward inclusive frameworks (Adaji, 2025). It addresses structural asymmetries in global governance by promoting distributed networks that ensure scientific sovereignty in the territories of origin (Canfield, 2023).

***Governance of the biocommons: life as common heritage***

Against the logic of genomic capital that fragments and privatizes biological information, this pillar positions technical knowledge as an inalienable heritage of the collectivity. It aims to transcend "enclosure biotechnology" through management based on the commons and technological inclusion, under the following premises:

- B**iocopyleft and Open Science Systems:** This model promotes Biocopyleft—an open-source licensing framework applied to biological materials, genetic sequences, and knowledge—to shield the openness of biological resources against restrictive intellectual property (Parolini, 2026). Unlike traditional patents, this framework guarantees the circulation of knowledge through inclusive governance, ensuring that any derivative development maintains free access and prohibits private appropriation (Adaji, 2025).
- **Social Rate of Return (SRR) vs. Return on Investment (ROI):** Beyond financial ROI, this approach establishes SRR as the central metric for biotechnological validation. Grounded in impact assessments (Basset, 2023), it prioritizes food sovereignty, public health, and ecosystemic resilience, transforming the "biological dividend" into collective well-being rather than mere capital accumulation.
- **The community bio-library and genomic integrity:**The framework manages codes and protocols as commons, shielding the territory through models of "protected openness" that ensure equity and prevent biopiracy (Parolini, 2026). This approach thus redefines the laboratory as a bio-library: a node of responsible flow oriented toward solving local problems (Chen & Pschetz, 2024). A compelling empirical application of this paradigm is demonstrated by Hogg *et al.* (2024), who integrated advanced genomic sequencing with Indigenous knowledge to conserve an Australian marsupial, establishing a successful model of data sovereignty, territorial equity, and practical problem-solving.

***Territorial pertinence and technological contextualism***

Social Biotechnology displaces the imperative of universal scalability in favor of the principle of Territorial Pertinence. Under this approach, the efficacy of an intervention lies not in its mechanical replicability, but in its capacity for dialogic coupling with the local ecosystem.

- **The thesis of technological contextualism:** A technology can only be considered "advanced" if it is capable of being integrated in a situated manner. Molecular or computational sophistication lacks ontological value if it requires inaccessible infrastructure or if it collides with the cultural matrix of the territory. True innovation lies in sociotechnical adequacy, which demands a transformation of science toward justice and sustainability (Turnhout, 2022).
- **Situated biotechnological design and social reverse engineering:** This model prioritizes biotechnological development "from and for" the territory, focusing on the genomics of resilience and distributed manufacturing systems. It promotes, for instance, the local production of bio-inputs—products of biological origin—derived from microorganisms (bacteria, fungi, viruses), macroorganisms, plant extracts, or natural bioactive compounds—used in agro-productive systems to improve crop nutrition,

development, health, and productivity— (Ayaz *et al*., 2023) and essential drugs at the point of need, mitigating vulnerabilities through health sovereignty and the bioeconomy (Abdullahi *et al*., 2025).

- **Epistemic hybridization and intercultural dialogue:** The validity of a "science for life" resides in its capacity to integrate territorial and ancestral knowledges—traditions deeply rooted in ecosystem observation and practical experience. By conceptualizing the territory as the primary laboratory, these dialogues generate solutions with greater sustainability and relevance than those derived from dominant development models (Jasanoff, 2019).

### *Dialogue of knowledges and symbiotic transdisciplinarity*

This pillar establishes a transdisciplinary convergence where molecular biology rigor integrates with political ecology and the ethics of life, overcoming traditional knowledge fragmentation through a paradigm of sociotechnical co-design.

- **Systemic co-authorship of innovation:** Social sciences and territorial knowledges move beyond a posteriori evaluation to become co-authors from the genesis of experimental design. This approach extends the laboratory into the community, recognizing local and ancestral knowledge holders as researchers and reconfiguring life as a web of relationships through agroecological co-design—a set of practices and a social movement applying ecological principles to sustainable food and agricultural systems (Fitzsimmons *et al.*, 2026; Duchene *et al.,* 2026).
- **Biopromotionality and autonomy of the living:** This principle reconfigures technical praxis as a catalyst for the autonomy of the bios, safeguarding its evolutionary integrity against extractive logics. Biopromotionality—the intrinsic or induced capacity of a biological organism to enhance, stimulate, or activate beneficial physiological or functional responses in another living system—serves as the cornerstone of this approach. By integrating multi-species interactions and optimizing responses to biological stress, this practice strengthens the adaptive capacity and climate resilience of living systems (Pehlivan *et al.*, 2025).
- **Biotechnological legitimacy matrix:** Collectively, these pillars act as an ethical audit and evaluation matrix. Any project aspiring to the standard of Social Biotechnology must demonstrate consistency with this operational framework, employing participatory evaluation practices that ensure scientific progress is inseparable from social justice and the preservation of life (Kieslinger *et al.*, 2022).

The following table (Table 1) provides a visual synthesis of the proposed operational framework for Social Biotechnology, integrating its four foundational pillars into a cohesive model.

### 'Science for Life' as an epistemological framework

Postulating Social Biotechnology as a 'science for life' demands an epistemological shift: transitioning from technoscience oriented toward the reduction and control of living matter to a praxis that recognizes its intrinsic dignity and 'bio-autonomy'—the capacity of living systems to self-regulate and maintain their integrity independently (Umbrello & O'Hara, 2024). This transition reconfigures the ontological dimensions between science and existence (Jasanoff, 2019), moving beyond traditional applied biology through three axes: the rupture with mechanistic reductionism (Rosslenbroich, 2023); the adoption of the 'Biosocial Holobiont,' which conceptualizes organisms and their microbial communities as entities inextricably integrated into social, historical, and political contexts; and the redefinition of the biotechnologist as a mediator in processes of genomic capital (Borg & Policante, 2022).

**Table 1**

*Operational Framework of Social Biotechnology: The Four Pillars.*

| Pillar | Core objective | Key dimensions |
|---|---|---|
| Technical Autonomy & Sovereignty | Breaking structural dependency models. | Dismantling "Black Box" models, fostering technical agency/bio-citizenship, and decolonizing innovation. |
| Governance of the Biocommons | Positioning life as inalienable heritage. | Biocopyleft/Open Science, Social Rate of Return (SRR) prioritization, and community bio-libraries. |
| Territorial Pertinence | Shifting from universal scalability to situated coupling. | Technological contextualism, situated design/social reverse engineering, and epistemic hybridization. |
| Symbiotic Transdisciplinarity | Overcoming knowledge fragmentation through co-design. | Systemic co-authorship, biopromotionality of the living, and ethical legitimacy matrix. |

***Overcoming mechanistic reductionism***

Conventional epistemology, rooted in Cartesianism—an epistemological and ontological model characterized by radical dualism and analytical rationalism—and positivism, fragments life to optimize isolated components. While this approach has driven technical advances, the decontextualization of biological systems for commercial purposes presents significant limitations for long-term socio-ecological integration (Borg & Policante, 2022; Wu *et al.*, 2026). In contrast, Social Biotechnology proposes an ontology of indissoluble relationality, where scientific knowledge is inseparable from its sociopolitical implications.

- **Critique of biological isolation:** The legitimacy of biotechnology erodes when it dissociates from its vital purpose. Life transcends the boundaries of the cellular membrane and the genomic sequence; it is defined by its flow and interdependence with the social fabric. As Jasanoff (2019) argues, technoscience must restore meaning to existence, recognizing that every intervention irreversibly transforms the human and ecosystemic horizon (Chen & Pschetz, 2024). Under this premise, biotechnology abandons its status as an isolated practice to configure itself as an ecology of care (Hackfort & Saave, 2024).
- **The 'Biosocial Holobiont' as a unit of analysis:** This framework shifts the focus from the biologically isolated individual to the Biosocial Holobiont, assuming deep interdependence between organic well-being, community stability, and territorial health (Matyssek *et al.*, 2022; Piloto-Sardiñas *et al.*, 2026). By understanding biology as a web of interdependencies, it renders any technoscience that 'cures' a body while degrading its social or ecological environment epistemologically flawed (Hackfort & Saave, 2024; Pehlivan *et al.*, 2025). Consequently, the Biosocial Holobiont integrates biological and human praxis, serving as the minimum unit of evaluation for innovation.
- **Intervention as existential commitment:** The biotechnologist transcends the role of an operator

of living matter to become a mediator of vital processes. This is the core of Social Biotechnology: shifting the paradigm from dominance toward the construction of bonds that ensure regenerative sustainability (Kapoor *et al*., 2024; Pehlivan *et al*., 2025). By fracturing the supposed scientific "neutrality"—frequently used as cover for the commodification of knowledge—the researcher assumes the inherent political responsibility of their praxis (Canfield, 2023; Wu *et al.*, 2026).

### *From centralized control to Bio-autonomy*

Science for Life responds to the crisis of technoscientific legitimacy by shifting centralized biological control—a device for the standardization of genomic capital (Borg & Policante, 2022)—toward bio-autonomy. This praxis prioritizes technical sovereignty and the capacity of communities for self-management to preserve their existence with dignity against extractive logics (Umbrello & O'Hara, 2024). This transition unfolds through two conceptual shifts:

- **Shifting the focus from 'Biomass' to 'Dignified Life':** Prevailing technoscience often reduces living systems to commodifiable assets, operating through an 'ideology of innovation' that perpetuates historical structural inequalities (Canfield, 2023). Social Biotechnology reverses this by prioritizing the promotion of a dignified life. Instead of measuring success through scalable profitability, this model evaluates innovation by its capacity to strengthen territorial resilience and sovereignty (Abdullahi *et al*., 2025; Purkayastha, 2024).
- **The ethical turn of scientific validity:** Technoscientific validity transcends the laboratory to demand systemic ethical consistency. According to Umbrello & O'Hara (2024), any technical innovation—even if reproducible—lacks integral validity if it is socially exclusionary or ecologically degrading. Thus, this approach redefines science under an unavoidable commitment to the distributive justice of knowledge (Adaji, 2025).

### *Epistemology of care and participatory technoscience*

Social Biotechnology functions as a catalyst for local agency, transmuting molecular rigor into an instrument for self-determination in contested territories (Hackfort & Saave, 2024; Turnhout, 2022).

- **Symbiosis vs. Domination:** This paradigm shatters the modern imperative to 'master nature'—a narrative underpinning the extractivism of genomic capital (Borg & Policante, 2022)—in favor of an ontology of relationality. The goal is to decode biological languages to cohabit with them through regenerative collaboration that enhances biospheric autopoiesis: the capacity of the Earth system to maintain itself through complex, interdependent biogeochemical and ecosystemic processes (Collado-Ruano, 2026).
- **Knowledge as a Tool for Care:** Responsibility for the 'other' becomes the engine of scientific curiosity. Care materializes in design: the development of drugs and inputs oriented toward liberating health systems from patent dependency (Abdullahi *et al*., 2025), promoting health sovereignty and soil health (Kapoor *et al*., 2024; Pehlivan *et al*., 2025). As Chen & Pschetz (2024) suggest, technoscience must be configured as "ecologies of care" that recognize our ontological interdependence.
- **Fundamentals of biosocial architecture:** This architecture rests on 'Expanded Interconnectivity'—the awareness of the social impact intrinsic to laboratory practice (Chan, 2024)—and 'Regenerative Responsibility,' which mandates that every innovation systemically improves the environment it intervenes in (Duchene *et al.*, 2026). Thus, technoscience is no longer an agent of blind modernization, but a catalyst for regenerative sustainability

in the Anthropocene (Collado-Ruano, 2026).

**Operational dimensions and strategic deployment**

As a 'Science for Life', Social Biotechnology must transcend rhetoric toward transformative intervention. Its operationality—the development of operational definitions and practical, measurable procedures designed to study abstract concepts—articulates Open Science and Service-Learning to foster prosocial leadership and territorial co-creation (Martín-Vargas, 2026). The following three dimensions elevate technique into a tool for emancipation.

***Health dimension***

While conventional biotechnology has prioritized high-cost interventions that commodify health as a restricted-access good, Social Biotechnology proposes a shift toward 'Social Precision Health'. This approach reorients diagnostic and therapeutic capabilities toward territorial autonomy, democratizing technical access through situated infrastructures (Geiger & Bourgeron, 2026).

- **Open-Source diagnostics:** This dimension mandates the development of molecular tests—such as CRISPR biosensors or field-based PCR—under open-access protocols to dismantle current intellectual property barriers (Adaji, 2025). Service-Learning projects catalyze this process: by involving students and communities in the co-creation of tools, these initiatives democratize technical access and train a new generation of scientists committed to public health and sanitary sovereignty (Martín-Vargas, 2026).
- **Territorial bioproduction and distributed manufacturing:** Implementing micro-bioreactor nodes enables the synthesis of essential biologicals at the point of need, drastically reducing dependence on global supply chains. This strategy transcends logistical optimization, representing a fundamental step toward health sovereignty and the technological self-management of health systems (Abdullahi *et al*., 2025).
- **The citizen as manager of their biopolitics:** The subject transitions from patient-client to citizen-manager, acquiring technical capacities to oversee their own well-being. This molecular democratization, framed within bio-citizenship, promotes health through informed self-management and data transparency (Chen & Pschetz, 2024).

***Agrifood dimension***

Following the political economy framework of McKay *et al.* (2025), the agrifood dimension acts as an integrating axis, articulating social metabolism, market dynamics, and the sociopolitical structures that define food security. Consequently, agroecological innovation distances itself from the 'Green Revolution' model—characterized by closed technological packages—to adopt Social Biotechnology: an approach that hybridizes cutting-edge genomic innovation with situated local knowledge.

- **Resilience genomics and precision editing:** This approach employs molecular markers and precision editing to enhance native varieties against biotic and abiotic stress, preserving the collective ownership of seeds as a non-negotiable pillar of food sovereignty (Kapoor *et al.,* 2024; Pehlivan *et al*., 2025).
- **Bio-inputs and autochthonous microbiomes:** Prioritizing local microbial consortia for soil regeneration constitutes a process-oriented biotechnology that replaces dependence on synthetic agrochemicals (Ayaz *et al*., 2023). This vision restores the health of the agroecosystem through biological symbiosis and respect for local biodiversity.
- **The farmer as co-investigator:** Research shifts to open-access laboratories under Service-Lear-

ning models, where agroecological co-design drives participatory genetic improvement (Duchene *et al.*, 2026). This Open Science approach ensures the public domain of data, acting as an engine for socio-ecological justice.

### *Environmental dimension*

Rather than functioning as a reactive industrial mitigation service, environmental management is redefined as a process of socio-ecological restoration, restoring collective agency over ecosystemic metabolism to the community (Collado-Ruano, 2026; Umbrello & O'Hara, 2024).

- ***Participatory bioremediation:*** Beyond technique, the deployment of biological agents constitutes an act of collective learning and historical reparation. To counter extractive co-option, the Service-Learning model redefines intervention as a 'living laboratory' for co-creation and prosocial leadership (Martín-Vargas, 2026), ensuring transparent impact through Open Science (Chen & Pschetz, 2024). An empirical example is the rehabilitation of mined-out areas in Marinduque, Philippines, where integrating local communities and assessing social acceptability transformed a standard protocol into a genuine process of territorial restoration (Alaira *et al.*, 2021).
- **Citizen biovigilance and networked monitoring:** Deploying biosensors within civil society transforms environmental information into a public good. This model levels information asymmetry through biovigilance—the structured, ongoing evaluation of ecological, agronomic, and socio-technical impacts of biotechnological innovations—thereby validating participatory monitoring (Kieslinger *et al.*, 2022) and ensuring territorial data availability under Open Science principles (Parolini, 2026).
- **Biodefense and situated evidence:** Community surveillance empowers territorial defenders with technical backing for litigation and advocacy, providing a scientific shield against external degradation (Betancourt *et al.*, 2026). Ecosystem health thus transitions from a legal abstraction to an installed technological capacity, consolidating local resilience against corporate or climatic threats.

## Discussion: toward a new global biotechnological governance

Conceptualizing Social Biotechnology as a 'science for life' is more than a semantic exercise; it is a demand for structural reform within the scientific system. This transition requires subverting the 'biotechnology of control' to erect a model of collective empowerment (Jasanoff, 2019).

### *Overcoming epistemic monopoly and establishing bio-autonomy*

The current technocratic model, marked by structural asymmetries in resource governance, exercises an epistemic monopoly where profitability dictates innovation validity (Canfield, 2023; Benjamin, 2024). Social Biotechnology dismantles this by proposing a distributed governance that breaks the opacity of technological 'black boxes' (Purkayastha, 2024). In this framework, the authority to define urgent needs is redistributed, dissolving the hierarchy between 'expert' and 'affected party'. Territorial and ancestral knowledges thus become co-authors from the genesis of the problem, providing an ecological and social validity absent in the extractive model (Fitzsimmons *et al.*, 2026; Collado-Ruano, 2026).

Concurrently, the shift from centralized biological governance to local bio-autonomy cultivates situated technical agency (Umbrello & O'Hara, 2024). This paradigm embeds biotechnological sovereignty within human security agendas, recognizing that controlling the 'source code' of existence—seeds, drugs, and protocols—is as vital as physical integrity (Abdullahi *et al.,* 2025). By reconfiguring restrictive intellectual property models, this framework empowers the Global South to transcend its role as a peripheral recipient, reimagining the laboratory as a locus for technical emancipation and bio-citizenship (Adaji, 2025).

### *A regenerative scientific system and the New Biosocial Contract*

Advancing this paradigm requires overcoming the 'publish or perish' model—which erodes the scientific ethos—in favor of research with real-world impact (Timmis *et al.*, 2025). This demands reconfiguring technology transfer through Open Science and Service-Learning to solve complex problems, free from exclusionary patent systems (Martín-Vargas, 2026). The Social Rate of Return (SRR) must quantify scientific vanguardism (Basset, 2023); consequently, funding agencies should adopt Biocopyleft and territorial pertinence as non-negotiable criteria for excellence. This regenerative science transcends centralized paradigms, fostering open-source knowledge networks and socio-ecological resilience.

Globally, this approach materializes through Social Innovation Nodes (SINs) (Geiger & Bourgeron, 2026). Aligned with translocal networks (Avelino *et al*., 2020), these nodes generate in situ biotechnological solutions. SINs empower territorial initiatives to "deepen" local autonomy while "expanding" translocally to access resources beyond conventional structures (Chen & Pschetz, 2024). Unlike traditional biotechnology, which relies on intellectual property to protect markets (Benoliel & Bourgeois-Gironde, 2025), Social Biotechnology safeguards collective well-being through the common good. Shifting from a "biopolitics of scarcity" to one of "shared abundance," this framework drives a more inclusive and democratic model of global cooperation."

## Final Considerations

Social Biotechnology is not a peripheral alternative; it is a systemic necessity to overcome the exhausted technocratic model. Transitioning from an extractive bioscience toward a 'Science for Life'—understood as an inalienable common—is the logical step to address current planetary challenges. Moving beyond the dichotomy of technicalism and activism, this paradigm leverages the Social Rate of Return (SRR), Biocopyleft, and distributed governance to transform utopia into a methodology of real impact. By translating molecular rigor into community praxis, technological maturity is no longer measured by the capacity to patent, but by the ability to heal, feed, and regenerate living systems—restoring biotechnology's ontological purpose: guaranteeing the dignity of existence.

Adopting this framework demands dismantling institutional isolation to recognize the social fabric as the ultimate 21st-century laboratory. By hybridizing scientific rigor with redistributive justice, researchers become facilitators of socio-environmental equity, validating their praxis through knowledge co-production.

Ultimately, Social Biotechnology constitutes the new biosocial contract of our era. It establishes a non-negotiable commitment: to transform the life sciences from an instrument of exclusion into a bridge for emancipation, enabling humanity to design its future through sovereignty, an ethics of care, and planetary solidarity.

## Literature cited

Abdullahi, Y., Ahmed, N., Bashir, S., Abdi, Y., Abdi, M., Saeed, O., Okesanya, O., Agboola, A., & Ahmed, M. (2025). Empowering health sovereignty in Africa through innovations for self-reliant healthcare. *Discover Public Health*, 22(1), 770. https://doi.org/10.1186/s12982-025-01184-3

Adaji, A. E. (2025). Open science for health research and innovation in Africa: A call for an 'inclusive' intellectual property rights regime. *South African Journal of Bioethics and Law,* 18(1), 21-27. https://www.samajournals.co.za/index.php/sajbl/article/view/2643

Alaira, S., Padilla, C., Alcantara, E., & Aggangan, N. (2021). Social acceptability of the bioremediation technology for the rehabilitation of an abandoned mined-out area in Mogpog, Marinduque, Philippines. *Journal of Environmental Science and Management*, 24(1). https://doi.org/10.47125/jesam/2021_1/08

Avelino, F., Dumitru, A., Cipolla, C., Kunze, I., & Wittmayer, J. (2020). Translocal empowerment in transformative social innovation networks. *European Planning Studies*, 28(5), 955-977. https://doi.org/10.1080/09654313.2019.1578339

Ayaz, M., Li, C. H., Ali, Q., Zhao, W., Chi, Y., Shafiq, M., Ali, F., Yu, X., Yu, Q., & Huang, W. (2023). Bacterial and fungal biocontrol agents for plant disease protection: Journey from lab to field, current status, challenges, and global perspectives. *Molecules*, 28(18), 6735. https://doi.org/10.3390/molecules28186735

Basset, F. (2023). The evaluation of social farming through Social Return on Investment: A review. *Sustainability*, 15(4), 3854. https://doi.org/10.3390/su15043854

Benjamin, R. (2024). *Imagination: A manifesto.* Princeton University, Department of African American Studies. https://aas.princeton.edu/publications/research/imagination-manifesto

Benoliel, D., & Bourgeois-Gironde, S. (2025). Ecosystem services IP: Exploiting natural resources for innovation. *University of Illinois Law Review*, 935.

Betancourt, M., Camacho Benavides, C. I., Gutierrez Navarro, A., & Jiang, P. (2026). From metabolic rift to food sovereignty: Strengthening the socioecological justice struggle in food systems. *The Journal of Peasant Studies*, 1–24. https://doi.org/10.1080/03066150.2026.2617440

Borg, E., & Policante, A. (2022). *Mutant ecologies: Manufacturing life in the age of genomic capital* (1°ed.). Pluto Press. https://doi.org/10.2307/j.ctv3142tg1

Canfield, M. (2023). The ideology of innovation: Philanthropy and racial capitalism in global food governance. *The Journal of Peasant Studies,* 50(6), 2381–2405. https://doi.org/10.1080/03066150.2022.2099739

Chan, A. (2024). Teaching and learning with situated data: Socio-technical pedagogy and reform at the Community Data Clinic and Biological Computer Lab. *Engaging Science, Technology, and Society,* 10(1–2), 187-205. https://doi.org/10.17351/ests2023.1627

Chen, Y., & Pschetz, L. (2024). Microbial revolt: Redefining biolab tools and practices for more-than-human care ecologies. In F. Floyd Mueller et al. (Eds.), *CHI '24: Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (pp. 1-16). https://doi.org/10.1145/3613904.3641981

Collado-Ruano, J. (2026). Regenerative philosophy: Learning from the sacred web of life to face the complexity of the Anthropocene. In *Encyclopedia of the Anthropocene.* Springer, Cham. https://doi.org/10.1007/978-3-031-51703-7_214-

1

Duchene, O., Ginot, C., Perrin, J., Peigné, J., Robin, J., & Celette, F. (2026). Using on-farm experimentation to co-design agroecological farming: A common principle with a variety of applications and researcher stances. *Renewable Agriculture and Food Systems*, 41, e12. https://doi.org/10.1017/S1742170526100349

Fitzsimmons, T., Yates, M., Jordan, R., & Callan, V. (2026). Co-creating impact: Positioning indigenous knowledge holders as expert researchers. *Equality, Diversity and Inclusion: An International Journal*, 45(3), 538-553. https://doi.org/10.1108/EDI-09-2023-0315

Geiger, S., & Bourgeron, T. (2026). *Peak Pharma: Toward a new political economy of health*. Oxford University Press. https://doi.org/10.1093/9780191993626.001.0001

Hackfort, S., & Saave, A. (2024). Toward a caring and (re) productive bioeconomy? A feminist analysis of socio-technical innovations and sustainability shortcomings. *Sustainability: Science, Practice and Policy,* 20(1), 2375808. https://doi.org/10.1080/15487733.2024.2375808

Hogg, C., Edwards, R., Farquharson, K., Silver, L., Brandies, P., Peel, E., Escalona, M., Jaya, F., Thavornkanlapachai, R., Batley, K., Bradford, T., Chang, J., Chen, Z., Deshpande, N., Dziminski, M., Ewart, K., Griffith, O., Marin-Gual, L., Moon, K., ... Belov, K. (2024). Extant and extinct bilby genomes combined with Indigenous knowledge improve conservation of a unique Australian marsupial. *Nature Ecology & Evolution*, 8(7), 1311–1326. https://doi.org/10.1038/s41559-024-02436-2

Jasanoff, S. (2019). *Can science make sense of life?.* Polity Press.

Kapoor, P., Kamboj, M., Langaya, S., Swami, S., Yadav, S., Panigrahi, S., Goswami, R., & Saini, M. (2024). Biotechnology for advancing regenerative agriculture: Opportunities and challenges. In S. Kumar et al. (Eds.), *Regenerative Agriculture for Sustainable Food Systems*. Springer, Singapore. https://doi.org/10.1007/978-981-97-6691-8_14

Kieslinger, B., Schürz, S., Mayer, K., & Schaefer, T. (2022). Participatory evaluation practices in citizen social science: Insights from three case studies. *fteval Journal for Research and Technology Policy Evaluation*, (54), 10-19. https://doi.org/10.22163/fteval.2022.567

Martín-Vargas, D. (2026). Aprenentatge servei i ciència oberta: un model transformador per a la cocreació de ciència, tecnologia i innovació i el foment del lideratge prosocial en la joventut veneçolana davant de reptes planetaris. *RIDAS, Revista Iberoamericana de Aprendizaje-Servicio*, 21, 15-37. https://doi.org/10.1344/RIDAS2026.21.2

Matyssek, R., Lüttge, U., & zu Castell, W. (2022). Evolution of holobiont-like systems: From individual to composed ecological and global units. In U. Lüttge et al. (Eds.), *Progress in Botany Vol. 83* (pp. 203-248). Cham: Springer International Publishing. https://doi.org/10.1007/124_2022_57

McKay, B., Nehring, R., & Catacora-Vargas, G. (2025). The political economy of agroecological transitions: key analytical dimensions. *The Journal of Peasant Studies*, 52(3), 461–484. https://doi.org/10.1080/03066150.2024.2399138

Parolini, G. (2026). Intellectual property rights, open science and open questions on research data: A biodiversity science perspective. *Research Ideas and Outcomes*, 12, e184961. https://doi.org/10.3897/rio.12.e184961

Pehlivan, N., Altaf, M., Emamverdian, A., & Ghorbani, A. (2025). Beyond the lab: Future-proofing agriculture for climate resilience and stress management. *Frontiers in Plant Science*, 16, 1565850. https://doi.org/10.3389/fpls.2025.1565850

Piloto-Sardiñas, E., Rodríguez, I., Santos, H., Paulino, P., Corona-González, B., & Cabezas-Cruz, A. (2026). Ecological frameworks of pathogen–pathogen and pathogen–microbiome interactions within the tick holobiont. *Pathogens*, 15(4), 440. https://doi.org/10.3390/pathogens15040440

Purkayastha, P. (2024). *Knowledge as commons: Toward inclusive science and technology*. NYU Press. http://www.jstor.org/stable/jj.28558234

Rosslenbroich, B. (2023). *Properties of life: Toward a theory of organismic biology*. MIT Press. https://doi.org/10.7551/mitpress/14739.001.0001

Timmis, K., Williams, P., Karahan, Z., López□García, P., Rainey, P., Chavarria, M., Greening, C., Steward, K., Hallsworth, J., Silva Pereira, C., Giraldo, R., Verstraete, W., Jonjić, S., Ramos, J., Nunes, O., Ventosa, A., Armstrong, R., Sessitsch, A., Ron, E., & Wang, H. (2025). Journals operating predatory practices are systematically eroding the science ethos: A gate and code strategy to minimise their operating space and restore research best practice. *Microbial Biotechnology,* 18(6), e70180. https://doi.org/10.1111/1751-7915.70180

Turnhout, E. (2022). *A better knowledge is possible: Transforming science and technology for justice, pluralism, and sustainability.* University of Twente. https://ris.utwente.nl/ws/files/296209223/inaugural_booklet_professor_esther_turnhout_14_october_2022.pdf

Umbrello, S., & O'Hara, P. (2024). The "Common Good" in a genetically-modified future: Drawing on Lonergan's critical realism in reproductive ethics. *Paradigmi*, (3), 489-510. https://dx.doi.org/10.30460/116419

Wu, Y., Lu, X., & Lin, C. (2026). The ethical paradox of research valorisation: Knowledge commodification versus public good. *European Journal of Education*, 61(1), e70512. https://doi.org/10.1111/ejed.70512