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Thinking Within and Across

Cesar & Lois
cesarandlois.org
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cesarandloiscollective@gmail.com

Lucy HG Solomon
California State University San Marcos
Department of Art, Media, and Design
---
lucyhgsolomon@gmail.com

Cesar Baio
Universidade Estadual de Campinas
Department of Multimedia, Media and Communication
---
baio.cesar@gmail.com

ABSTRACT

Thinking Within and Across is a critique of the human mind as separate from other intelligences, isolated by the project of Modernity and its imprint on science, religion, philosophy and theories of the mind. Sourcing logic models within microbiological systems, art collective Cesar & Lois seeks to work across different intelligences, through what we call a "bhiobrid" (bio-digital hybrid) intelligence—a crossing of human knowledge through books with the pre-human logic of microorganisms and a post-human artificial intelligence. The microbiological intelligence is based in nature and reflects knowledge embodied within whole systems. This type of microbiological knowledge is also endemic to human beings; much of our bodies is host to microbial entities, and those simple microbes interact with complex multicellular networks within the human body. Alternatively, at the forefront of artificial neural networks are attempts to replicate the human brain's processing of electrical signals, resulting in a human-based super intelligence. We look to microbiological logic.

Figure 1 | *Degenerative Cultures*, Cesar & Lois
Lumen Prize exhibition *Uncommon Natures*, Brighton, UK 2018.

Degenerative Cultures, an artwork created by Cesar & Lois and with *Physarum polycephalum*, pictured in Figure 1, crosses microbiological, technological and human knowledge systems in order to learn from the logic of non-human systems, which supports ecosystemic growth. The intelligences also work together as they grow, mapping and corrupting the predatory knowledge frameworks that have consistently driven how humanity interacts with living entities within nature. In outlining the thinking that propelled this integration of intelligences, we frame the capacity for thinking across species and systems within Jason W. Moore's web of life, in which all systems (human and non-human) are connected. As the human participants and *Physarum polycephalum* become interlocutors across these systems, they become entangled with one another, interacting in new ways. Embodied through entanglement, the merged microbiological and human networks populate Donna Haraway's interspecies worldings.

KEYWORDS

Bhiobrid; Bio-art; Cross-Intelligence; Living /Artificial Intelligences; Microbio-logical; More-than-human

1 | INTRODUCTION

The human-centric, monocultural—specifically non-indigenous—perspective of ignoring nonhuman intelligence is under revision: "Nothing is off limits anymore, not even the rationality that was once considered humanity's trademark" (de Waal, 2016, p. 4). More and more intelligence is attributed to nonhuman entities, beyond the anthropomorphism of mammals, like gorillas that sign and elephants that remember [1]. Microbiological logic and plant perception speak to an intelligence based in whole systems, of which we humans are one node in a

broad network, and yet our human technological networks perpetuate a human system that is maintained separate and apart. With some notable exceptions, the current state of humanity secludes the human individual and the human mind through global capitalism and its companion, acculturation. This thinking both apart from other entities and on behalf of the human individual has impacted countless other species: the result is climactic for the once-exalted human mind. In isolation—apart from other species, on top of not embedded within the environment—human logic is flawed. Only with this grand breakdown of organic networks, punctuated by the existential threat to one millions species [2] (one million and one, if we include human beings), does the system intelligence of the whole become apparent and we begin to have an awareness of nature-based, non-human knowledge that is more than, not less than, and that lends itself to thinking *with*—not individually, not separate, but together.

Against this backdrop of interconnectedness, with the added possibilities of thinking together, is this question: how do we as artists make possible an imagination that accommodates the non-linear, collaborative and interconnected thinking of Haraway's "more-than-human worlding?" This requires that we "join in the metabolic transformations between and among rocks and critters…" (Haraway, 2016, p. 56).

We pair this conceptual question of how to make more-than-human art with another question—one with techno-ethical dimensions: how can our human networks intersect with nature's non-neural networks, passing and receiving information from a technological Internet with the Internet of living things? Our response to these—a provocation really—was a question: "What if fungi could tweet?"

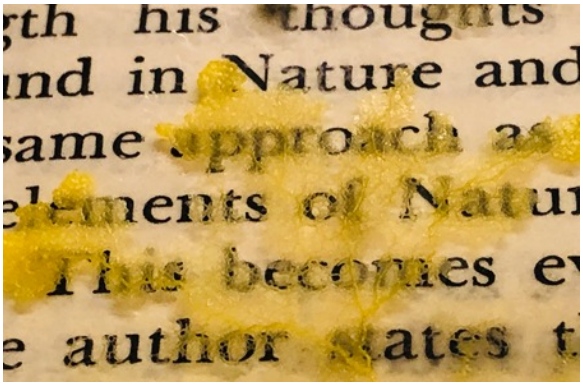

Figure 2 | *Degenerative Cultures*, in *Sentient States*, Portugal, Cesar & Lois, 2019. Detail of *Physarum polycephalum's* growth over text of *Jacques Boyceau and the French Formal Garden.*

This question propelled *Degenerative Cultures*, an art project that integrates microbiology and artificial intelligence with human texts and results in a fungal colonization of the Internet. For the project, the term "fungal" has become conceptual. When we first experimented with organisms marking up human texts and tweeting the output, we cultivated airborne mold over the pages of a book. After this, we grew edible mushrooms within philosophy books. We later nurtured *Physarum polycephalum*, which is not a fungus but was misclassified as such because of shared characteristics, such as sporing, and reclassified as a Protist through genetic analysis. Commonly called "slime mold," the organism is also not a mold. This naming, misnaming and renaming of microorganism in the human project to categorize nonhuman nature-based entities has a conceptual place in our project as well. Does our classification system explain the world, or does it build it in a specific way that fits our human understanding? Inevitably, mold also grows on the pages, emerging beneath or over *Physarum polycephalum*, creating inter-species interactions that contributes to the text's degradation.

Though non-neural, *Physarum polycephalum* is considered "intelligent" because of its ability to solve organizational problems, such as moving through a maze (Shaviro, 2010). Within the context of this project, non-neural microbiological logic works together with a computational system to question the human legacy of control over nature, and parallel to this, the accelerating demolition of non-human nature and its environments. The output of these collaborating intelligences is data (and tweets) that show microorganisms consuming that legacy—beginning with the organism's growth over the text as pictured in Figure 2. Many months after our initial question, a group of undergraduate literature students discussed the tweets of the microbiological culture broadcast at the twitter handle @HelloFungus. The students from California State University San Marcos workshopped the text and examined the tweets as prose, seeking import and considering the organism's agency. One student commented, "If we were to read this like fungus would, it would be significantly different." We had new questions to consider: was this an integration of knowledge systems, as we had intended, or was it cross-species (and cross-systems) literature? Of course we also wondered, if fungi tweet, what would fungi say to us? While this question is compelling, the integrated system is not a conduit for cross-species communication, but for crossing intelligences: for exploring new ways to think together. As artists, we designed the integrated logic system in order to reconsider what we hold as knowledge and imagine a "bhiobrid" interspecies intelligence.

2 | BHIOBRID METHODOLOGY

In *Degenerative Cultures*, microorganisms tweet. The living organisms grow over the text of physical books, tweeting as they grow. The selected texts document the human endeavor—specific to global and non-indigenous or not land-based communities—to dominate nature. An A.I. agent learns from this microorganism and scours the Internet to degenerate digital texts on humanity's project to control nature.

The growing fungal colony literally tweets as it grows over and redacts the text of the book. *Physarum polycephalum* grows on physical books about humanity's sweeping project to redesign nature, with degenerative readouts tweeted by the organism as it grows. The living entity cooperates with a bot, which corrupts digital files in response to the microbiological redaction of the physical book. This digital fungus, an A.I. with generative algorithms based on organic growth, responds to twitter users. Human viewers who mention @HelloFungus on Twitter participate in the degeneration of the texts, prompting the digital fungus to seek and decompose more online texts.

Physarum polycephalum grows across the text and interacts with the digital network: there is information coming in and coming out. This thinking across intelligences is a step towards a collaborative system that works within and on behalf of nature's broad network. It is a network that is inclusive of nature's insistent operators, human beings, but which contextualizes our human capacity for action (and our intelligence) within the layered thinking of an interdependent network.

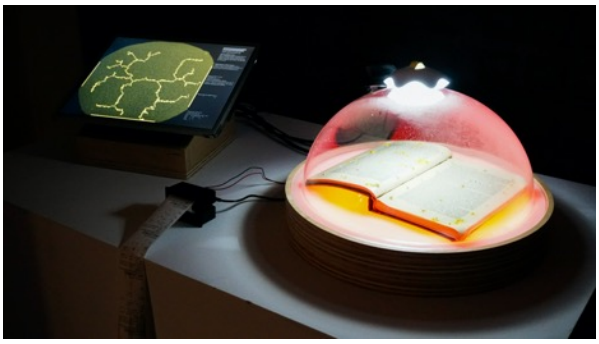

Figure 3 | Digital fungus in *Degenerative Cultures*, Portugal edition, Cesar & Lois, 2019

2.1 | AN INTEGRATED INTELLIGENCE

In layering these intelligences—non-neural systems sourced in nature, artificial intelligence and human knowledge embedded in texts—we propose a new operational system, one that takes into account and learns from nature's networks. Within the multi-directional system of *Degenerative Cultures*, an A.I. merges the digital and analog, or in this case, nature-based "operations." These organically sourced operations are the growth parameters of the observed organism: how *Physarum polycephalum* grows.

The growth of the biological culture on the book is tracked and parameterized by a computer vision algorithm. The data is compared with the original text, producing a series of tweets based on the growth of the living organism. These fungal tweets are printed on a continuous record that resembles a kind of degenerative poetry. The digital fungus is programmed using a combination of generative algorithms—inspired in automata cellular—and natural language processing. The A.I. algorithm that searches the Internet is trained to recognize electronic texts that express the intent to dominate nature, especially those classified as geo-engineering. For each exhibition of the project, *Degenerative Cultures*, there is *a* new edition with new texts and contextualized approaches to local climate issues. In each edition of the project, the A.I. targets subtopics that reflect "human solutions" for local environmental challenges. After compiling such texts, the digital fungus feeds itself with the electronic database, degenerating the meaning of the texts in the manner that the living microorganism grows over and obscures the words in the book's pages. This process is represented visually on a computer monitor beside the living organism, as it grows over the book within a protective dome (Figure 3). The AI's consumption of human knowledge is visible through the degeneration of online texts on the monitor and as tweets printed out on a thermal printer. Thus, the generative algorithms in which the work is technically codified become instruments for information degeneration. The logic of the digital algorithms is informed by organic data and led by the objective to identify texts that reflect the human-centered ideology of controlling nature. Because of these nature-based and nature-oriented operational directives, through its growth, the A.I. rejects the historical divide between humanity and nature. This assertion of a reconnection is not only technical but, overall, conceptual and ideological.

2.2 | NATURE-BASED SYSTEMS

Linked to connecting organic and technological nodes are questions about how codes of behavior are embedded within the form and methods of transference across their different systems. Within microbiology, there are biological systems that comprise so-called "intelligent" networks, although it has been asserted that all cells "communicate" on a chemical level, both to one another and in response to their environment (England, 1999). *Physarum polycephalum* (modeled in Figure 4) is a particularly strong "poster child" for "intelligent" networked behavior because it is easily grown, observable, highly motile, responsive to environmental cues, and the single-celled microorganism distributes resources equally among individuals as it grows (Jones, 2015). Because of its unique properties, this organism has been used to model complex human networks, including traffic distribution systems (Watanabe & Takamatsu, 2014).

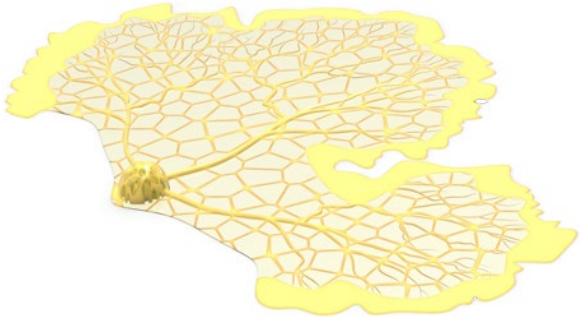

Figure 4 | Model of *Physarum polycephalum*'s network of single-celled organisms, Cesar & Lois and DaTA Lab, 2019.

As introduced before, *Physarum polycephalum* is not a fungus, although it was once categorized as one—in part because of its propagation through spores. Once considered fungi, microbiologists have determined that the organism is more like an amoeba than a fungus. This remarkable species evades clear classification, as it acts both individually, as single-celled organisms, and together, as a network that demonstrates equitable distribution across individuals. The organism possesses a system-based intelligence in which it shares information across its many nodes, growing as a collective and moving efficiently towards and even remembering the location of food. The organism accomplishes all of this without even a single neuron.

Figure 5 | Bhiobrid system, a graphic representation, Cesar & Lois and DaTA Lab.

Because of this measured and "intelligent" growth, *Physarum polycephalum* was a natural choice in considering the composition of a bhiobrid network (represented in Figure 5), which integrates *Physarum polycephalum's* networking with the nodes of the Internet, a human-centered technological network. While the decentralized decision-making and optimal food distribution across the microbiological network may directly connect with the origin of animal (and human) intelligence, the organism's network is quite different from the way we have developed our human societies. Likewise, our human networks, including our technological systems, operate by decidedly different directives. An important question for us is how the replication of this kind of nature-based growth within human systems could redirect and possibly reorient the logic of those systems. This is what has driven Cesar & Lois to take on the project of integrating nature's networks with human networks.

Steven Shaviro argues that *Physarum polycephalum* does not operate in accordance with what human social science scholars have understood as "rational choice." For Shaviro, "Slime molds represent an extreme ontological case, in which the contrast between internal and external definition, as well as between individual and collective determination, is pushed to its most intensely ambiguous point" (Shaviro, 2010).

For Cesar & Lois, integrating A.I. and *Physarum polycephalum* is a way of envisioning a hybrid body-based, pre-human intelligence and a post-human A.I. The integration involves biological and technological impulses which generate an artificial intelligence. In this sense, *Degenerative Cultures* has set us on a course of research around the theoretical and artistic collaborative learning process between A.I. and microorganisms—a collaboration replete with poetic metaphor and technical possibility.

3 | DISCUSSIONS

Our vision of the bhiobrid system, represented in Figure 6, was a response to that initial question, "What if fungi could tweet?" We had been thinking about how to articulate the challenges that humanity poses to nature, which are so much larger than the present moment—no matter the calamities of today's climate, and that stretch so much further than the current epoch—no matter the name that we call it. We felt the heavy weight of an extensive body of knowledge which infuses Western thinking, which spans philosophical treatises and landscape design tomes, which collectively declares that the human mind is logical and, according to Bacon, to Descartes, to Kant and to so many others, capable of ordering nature.

Cartesian philosophy was highly influenced by Bacon's always-present idea of "mastery of nature". According to Richard Kennington (1978):

> "The syncretic union of philosophy and politics, made explicit in Discours VI, may be divided into its elements: […](4) the project of humanitarian mastery of nature common to philosophy or science and society nonetheless divides into a two-sided relationship, each with its duties and rights to benefit (…)".

For Kennington, the seventeenth century "syncretic philosophy" established the modern political society which became the active agent of technological progress.

In the paper, "Order: God's, Man's and Nature's," Montuschi expounds on humanity's subordination of nature originating in Western thinking. He traces the ongoing concern with the "ideal garden" in religious and scientific historical texts as one that revolves around gaining knowledge. The domination of nature, which Montuschi finds equally rooted in the cultivation of the storied Garden of Eden and in Francis Bacon's pursuit of a new science of nature, involves in both cases the acquisition of nature's knowledge. Montuschi also links this to anthropocentric long-term planning: "Bacon ran his philosophical project on a double agenda: on one side, the pursuit of a new science for the knowledge and control of nature and on the other side, the use of a new science for the purpose of human betterment."

Kant states that the human being is an animal endowed with the capacity for making "himself" into a rational animal (Kant 2008). For Viveiros de Castro and Danowski, this process of instituting "human exceptionalism" by Kant and the founders of

modernity projected the promised image of "man" as a "conqueror of nature" through technology (Montuschi, 2014, pp. 5, 24).

We purposefully selected texts that flow from these two intertwined trajectories to serve as substrates for nature's growth. This long project of Western thinking about nature entails the coopting of nature's knowledge. Rather, let the microorganisms cultivate human knowledge, asserting nature's domination and reordering human datasets. This inversion challenges a human-centered philosophy of science, even the role of the human gardener, and inverts the one-sided perspective in which the human actor is the world and nature's designer. And yet we do not want to simplify this project as a mere reversal of the human domination that is at once both a creative and destructive force (a gardener that designs and also redacts certain elements from nature, with elimination brought about through pest control and, in the extreme, resulting in species extinctions). We entertain this reversal and push for more; we move beyond this simple solution, where nature has its say in the end. There is more than this one-sided story embedded within the integrated system of *Degenerative Cultures*: there is also an exchange of knowledge, a collaboration, and, ideally, growth in both directions. But the starting point is a history of domination disguised as order.

> "The Italian garden is described as affording a unique opportunity to examine the response of the human mind to geometry. Classical Roman planning, upon which it is based technically, had pointed the way to an organization of space which appropriately expressed the Roman sense of law and order." (Geoffrey Jellicoe, 1960)

In considering this/our intellectual and written history, we thought: why not use this text—Jellicoe's outline of the principles inherent in gardens across cultures—as evidence of human thinking, which has very specific embedded values when it comes to nature, including laws for and order over nature. This text on Italian landscape design became the substrate for the growth of *Physarum polycephalum* for an Italy edition of *Degenerative Cultures*, the output of which is documented in the fungal twitter feed. Plato's Socratic dialogues, as well as philosophical treatises on humanity's relationship to nature, have hosted *Physarum polycephalum* and a variety of fast-growing molds.

4 | OUTCOMES

How does a microorganism "read," and what is redacted? This is where the layering of knowledge systems becomes operative, and also the point at which the project probes the outcomes of the bhiobrid logic.

In the first iteration of this project, an architecture student asked whether we had analyzed the tweets of the living organism and what we had learned. This question prompted our seminar with the literature students in Figure 6, who asked questions of the fungus and of the text that we as artists had not considered, or perhaps we assumed the answers to. The students accepted the microorganism as author, as an interspecies communicator, and they workshopped the text, seeking clarity, seeking meaning and, most surprisingly, seeking connection.

Figure 6 | Literature class analyzing the @HelloFungus tweets with writing professor Sandra Doller and Cesar &is, 2018.

Since that reading, the bhiobrid system has evolved, and the living microorganism interacts with a digital fungus: the nature-based and artificial organisms each corroding texts on nature, from history and from the future, with the A.I. compiling and disassembling online climate engineering texts.

The first tweet of Existential Phenomenology (William A. Luijpen, 1965), with 0% degeneration, reads:

By means of knowledge man overcomes the determinism of nature and of natural processes, for it is through man's consciousness that nature and its processes are-for-man. Nevertheless, nature,

The first fungal redaction, or the first word that the organism grew over, was the word, *man*, resulting in a tweet with the original excerpted text minus *man*. It is difficult not to read intention in this amendment, or in the final three tweets communicated before the text was completely covered by the organism (the final @HelloFungus tweets, shown in Figure 7):

determinism

determinism

determinism

As human beings we are able to make meaning from the microorganism's behavior exclusively from the human perspective. Taking inspiration in Vilém Flusser speculative philosophy [3], we can try to think about human cultures from the perspective of a non-human organism. With this project, we seek to establish a bhiobrid logic that challenges our human inclinations to organize and subjugate nonhuman entities, which in some ways the assertion of human meaning of the tweeted text does. While the

microorganism clearly possesses no literary aspirations, the crosscurrents between the organism's growth and textual output ultimately make a commentary on the value of non-neural intelligences.

Figure 7 | @HelloFungus final tweets of Lujipen reading, 2018.

By inserting microbiological intelligence into the mechanistic knowledge-making structure of a growing A.I., we challenge the authority of human knowledge, and our logic as a superior way of understanding and relating to the world. This is especially relevant in current conditions of climate crisis, where human thinking is considered both culpable and redemptive: the definition of illogical. As the project explores local and contextual aspects of these issues for each rendition, in the Singapore edition of *Degenerative Cultures* (NTU Global Digital Art Prize, 2019), digital evidence of weather modification is compiled by the A.I. The digital fungus plots and redacts this version of a supreme human logic.

5 | SOCIETAL IMPLICATIONS

In thinking about the societal implications of an integrated intelligence, we are interested in how signals originating from the living system redirect the computational system. Scaling out, we speculate about the values placed on decisions across the integrated network as opposed to the solely computerized system. How might the computational system, relying on microbiological logic, impact societal systems?

By crossing living and computational systems, we challenge the composition of our technological networks, the forms of which intractably shape our societal values. When innovators seek to improve those same technological networks, they often do so with efficiency in mind, which translates as profit to the technology's developers and perceived advantages for users. In *Shape of Things: A Philosophy of Design*, Vilém Flusser remarks, "Not so long ago, this would have been an unnecessary question. The morality of things? The designer used to have the production of useful objects at the forefront of his mind" (Flusser, 1999, p. 66).

As Flusser indicates, the calculated value of technologies—even 20 years later—does not typically reflect the specific societal values that they reinforce, or their global impacts. These profitable technologies are neither ecosystemic or ecotopian: they do not reinforce optimal relationships and equivalent exchange across human and nonhuman entities. In seeking to reinvent our systems as ecosystemic, in forming an integrated intelligence, we are thinking about the morality of things, and we are also thinking about the morality of the connections between those things. By philosophically inspecting the architecture of our technologies, we can see how those architectures—the forms of our technical systems—shape our societal systems (Flusser, 1985), and even ourselves (Bryant, 2014).

There is a moral imperative—not just to individual human societies but also to the global system of human societies and to both local and global ecosystems—to reformulate the methodology for shaping new technologies. In their text, Mamo and Fishman demand that efforts to build science and technology engage social and environmental justice: "Discursive and structural framings are not mutually exclusive" (Mamo and Fishman, 2013 p. 167). The advance of tools with a consideration of projected repercussions is not without adherents or advocates. Keith W. Miller, who outlined "The Rules" for responsible computing in 2011, did not anticipate the need to look to nature-based processes as a model system, yet he asserted a morality of making and urged taking responsibility for the design of new technologies: "We're hungry for more clarity about who is responsible for what in these increasingly important sociotechnical systems" (Miller, 2011, p 59).

Just as Miller calls on efficacious computing, sociologists like Manuel Castells are reexamining social systems within the context of a "new technological paradigm." Castells states that new information technologies "are indispensable means for the actual manifestation of many current processes of social change, such as the emergence of new forms of production and management, of new communication media, or of the globalization of economy and culture." Back in 2000, when the first flash drives and the first camera phones were introduced, before Gmail or iTunes or Roomba vacuums, Castells identified a new society: "The new society is made up of networks" (Castells, 2000, p. 694).

However, there are more networks than those technological ones, more methods for communicating across and between, and these are found in nature. How then do we then conceptualize a society in which technological networks are really integrated into the very complex natural networks of interactions between different living species *and* non-living objects? Is this way of thinking a possible answer to

the Anthropocene's urgent questions about our human systems. This question that we pose, and our subsequent experimentation with a bhiobrid system, emerges from the moment of now as a component of and result from the current epoch, when the privileging of anthropocentric networks is questioned. We see this across disciplines, from sociology and world systems theory to the biological sciences, and also in media art. It is no coincidence that biological systems become integrated into art works at a time when scientists advance our human understanding of nature-based networks.

In his philosophy of technology, Gilbert Simondon discusses the relationship between technical objects and nature, stating that the closer an object is to nature, the more imperfect it becomes and that, on the other hand, the more technical the object is, the more perfect it is. Simondon thus proposes the "naturalization of the object," which he describes as *a process of adaptation-concretization*. He develops this into what he calls *the associated medium* (Simondon, 1989).

In analyzing Simondon's concept of the associated medium, geographer Milton Santos determines that the very union of a natural (geographic) environment and a technical medium presupposes, on its own, a problematic ontological separation. The Brazilian geographer proposes a geographical environment as a territory in which technique and nature already would already have been integrated into one another —since before human conceptualization of the environment, and always.

> "In fact, we say, there is no such thing as a geographical [natural] environment on one side and a technical environment on the other. What has always been created from the fusion is a geographical environment, a medium that has lived for thousands of years as a natural or pre-technical environment, a medium that has been called a technical or machinic medium for two to three centuries, and which today we are proposing to consider as a technical-scientific-informational medium." (Santos, 2006, p.24)

The integration of digital networks, the expansion of A.I. and the penetration of pervasive computing in the sociopolitical system call into question the local and global socio-political stability of modern power structures (communication, political representation, economics and governance). Benjamin Bratton envisions a new, new society, one that is released from the history of Modernism, and even from the Anthropocene and its complementary names for human-based worlds and their systems (i.e. Post-Capitalism, Capitolocene):

> "The post-Anthropocene indicates that the organizing work of a 'xenogeopolitical aesthetics' (or whatever) can be done only in relation to a mature alienation from human history and anthropocentric time and scale. As it foreshadows and foregrounds the eclipse and extinction of Anthropocenic anthropology and corresponding models of governance, it establishes not only that humanism disappears with humans, and vice versa, but that the more elemental genetic machines with which we now co-embody flesh can and will, in time, re-appear and express themselves as unthinkable new animal machines, and with them, New Earths." (Bratton, 2015)

6 | CONCLUSION

As more scientists reveal the networking capacity of nature and reference the embedded Internet contained within the air, through spores, and underground, across mycelia and root systems, we humans feel more connected, despite the impending failure of so many of nature's embedded and embodied systems. Does this need for connection in any way halt the disconnect that has calcified through all sorts of human endeavors? Can we, at long last and again, think within and across? We want to, as Haraway demands of us, *stay with the trouble* (Haraway, 2016). To do so, we need to engage in a conversation that, as Moore tells us, "allows a proliferating vocabulary of humanity-in-nature, rather than one premised on humanity *and* nature."

And yet here we are, at a time when scientists loudly and in concert sound the alarm and politicians reopen the Amazon to development and pull back emission standards for a revved-up industrial surge. This rabble is audible outside of nature, with the *and* that Moore warns us about still articulated. It is time to think within and across. It is long past time for nature's intelligence to become guide to and for human systems, so that these systems, too, do not stand apart—not human systems within an overarching nature, but human systems with nature-based systems, and nature's networks as the network.

As we integrate nature's ways of forming networks with human knowledge systems, we also consider what those technologies that take into account and are integrated with nature may mean for human societies, and for the nonhuman entities touched by those societies. A first step, as artists and technologists, is to reorient our practice not as actors, enactors and operators, but as co-evolutionary thinkers. The human creators of new networks who envision and build those technologies in cooperation/collaboration with (not against or without consideration of) nature are those who *think within and across*—in order to examine the epistemological and affective status of humanity as part of nature.

When Haraway imports ethnographer Marilyn Strathern's teaching that, "It matters what ideas we use to think other ideas" (Haraway, 2016, p. 34), we

extend this to ways of thinking. It matters which neural and non-neural intelligent networks—inclusive of nature-based microbiological networks—are layered on top of each other, or intertwined, in order for new ways of thinking to be possible. In the collaborative mode of thinking that we describe, which occurs across intelligences, there are multiple modes of sensation and cognition within the integrated intelligence. This layering matters. It also matters which networks are layered—in this case, *Physarum polycephalum* and fungi. This matters because of how knowledge, as perception, moves across and forms a network, and it matters that this is layered with our inherent, intuitive human thinking as well as with the technological networks that we use to convey our logical thinking. It even and especially matters that all of these are layered on top of human texts, which are imprinted upon by nature's knowledge.

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ENDNOTES

[1] A popular example of human-non-human communication revolves around Dr. Francine Patterson and Koko, a gorilla who communicates with sign language. The memories and emotionality of elephants are likewise in the popular canon of animal sentience, evidenced by the grieving of elephants over the dead and the visiting of graves.

[2] The UN report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) from May 2019 indicates that one million species face extinction, threatening the ecosystems on which all living beings depend.

[3] In the book *Vampyroteuthis Infernalis*, Vilém Flusser analyzes human culture from the perspective of what he considered the total otherness, the non-logical and completely sensual thinking of the octopus called *Vampyroteuthis infernalis*.

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BIOGRAPHICAL INFORMATION

Cesar & Lois is comprised of Cesar Baio (Brazil) and Lucy HG Solomon (USA). Formed in 2017, the collective probes the evolution of humanity's relationship to nature by advancing intersections between social, technological and biological systems. Spanning two continents, Cesar & Lois invites viewers to renegotiate their interactions within these systems, challenging our societies' inherent logic models. The resulting work criticizes the societal structures that perpetuate inequities across economic, environmental and global systems. Integrating laboratory and technological spaces, the duo performs microbiological mappings and bio-AI architectures with the objective of learning from the overlapping patterns of human-based knowledge and the wisdom of nature's growth algorithms. Cesar & Lois exhibits globally, with exhibitions traveling from Ravenna to San Francisco, and actions in Berlin and Durban. Their project, *Degenerative Cultures*, which crosses nature with human systems, was the recipient of the 2018 Lumen BCS Prize in Artificial Intelligence (UK) and a finalist for the 2019 NTU Global Digital Art Prize (Singapore).

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