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In Latin America, the convergence of art, technology, and activism, alongside the environmental impact of globalization, has led to works addressing ecological themes. While constituting a new focus of digital art practices in the region, these works are best understood as critiques of, and as interventions into, the politics of technology—specifically, of the corporate control of technology, and the conjunction of digital technologies and transnational capital that has reshaped social, political, and cultural discourses in the region (and, of course, globally).

An analysis of such projects demands a frame of reference that is at once scientific, social, and artistic. As it happens, such an agglomeration of disciplines is of a piece with cybernetics, a transdisciplinary approach to the study of communication in hybrid biological and artificial systems. Popularly associated with Norbert Weiner, the MIT mathematician who pioneered the study of feedback in self-regulating systems, cybernetics was developed, in part, by Latin American scientists. As a conceptual framework, it is particularly applicable to discussions of art in Latin America that builds on these past practices in the histories of science.

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Two environmentally-informed works—*Plantas Nómadas* (2008–ongoing), a robotic work by the Mexican artist Gilberto Esparza, and *Algas Verdes* (2010–ongoing), a bio-art installation by the Colombian artist Hamilton Mestizo Reyes—offer a prism through which we can refract the relevance of cybernetic concepts to present practices.[1] *Plantas Nómadas* is a small, mobile robot encasing a microbial engine and living, native plants. *Algas Verdes* takes the form of microbial cultures growing on algae contained in transparent tubes, which are affixed to, or suspended from, built structures.

Designed to enable adaptation and integration into local environments, these participatory, long-term projects are conceived as interventions into the dominant discourses of technology and evolution. Conceptually, formally, and technically, they reflect and expand upon the notion of autopoiesis, a concept related to cybernetics. Because Latin American contributions to cybernetics are not well understood in art theory, a discussion of the concept of autopoiesis, a term coined in 1972 by the Chilean biologists Francisco Varela and Humberto Maturana, is in order.[2]

The Foundations of Autopoiesis

Autopoiesis, from the Greek, *auto*, meaning self, and *poiesis*, production or creation, refers to a system characterized by a network topology and capable of reproducing and maintaining itself through feedback processes (feedback loops that enable its parts to act in concert, and the system as a whole to interact with its environment).[3] According to the literary critic and scientist N. Katherine Hayles, Varela and Maturana's concept of autopoiesis originated in their shared interest in embodied cognition, and marked the culmination of "second-order" cybernetics, which can be traced to the work of the American anthropologists Margaret Mead and Gregory Bateson and the German/American philosopher and physicist Heinz von Foerster, who coined the term in 1960.[4]

"Second-order" cybernetics is extrapolated from "first-order" cybernetics, an interdisciplinary science that emerged from collaborations, during WWII, between Wiener, the engineer Julian Bigelow, and the Mexican physician and physiologist Arturo Rosenbleuth Stearns, then working at Harvard on research pertaining to chemical transmission in the nervous system. In 1943, they jointly wrote "Behavior, Purpose and Teleology," a paper that extended the idea of feedback to more complicated biological and technological systems, establishing the theoretical basis for cybernetics.[5] Wiener defined cybernetics, a term he coined in 1948 from the Greek *kybernetike* or "governance," as "the scientific study of control and communication in the animal and the machine."[6]

The question of embodiment is a key difference between first- and second-order cybernetics. As Hayles notes, first-order cybernetics assumes, following scientific/rationalist dogma, that the observer is "outside of the system observed," and in so doing stresses the separation of the human from

[1] These works can be seen as heirs to Latin American art engaging cybernetics, a discussion of which is beyond the scope of this essay.

[2] Francisco Varela and Humberto Maturana, *Autopoiesis and Cognition: The Realization of the Living* (Dordrecht, The Netherlands: D. Reidel, 1980).

[3] Varela and Maturana, *Autopoiesis and Cognition*, 78.

[4] N. Katherine Hayles, *How We Became Posthuman* (Chicago and London: The University of Chicago, 1999), 10.

[5] Norbert Wiener, *Cybernetics or Control and Communication in the Animal and the Machine* (Canbridge, MA: MIT Press, 1948), 8.

[6] Wiener, *Cybernetics*, 11.

the machine; as Hayles puts it, the machine is understood "as an object of control rather than an intrinsic part of the self."[7] In contrast, second-order cybernetics, beginning with von Foerster and continuing with Varela and Maturana, implicates the observer, emphasizing that cognition or knowledge cannot be understood as a disembodied process. In other words, "the world is not out there," but is made "by ourselves by living it," as Hayles writes, paraphrasing Varela and Maturana.[8] From this perspective, technology and science are seen as intrinsic parts of the human being, and thus are understood as foundational components in the production of social relationships.

This view is evidenced by Varela and Maturana's concept of autopoietic machines, which they contrast with what they call "allopoietic machines."[9] Autopoietic machines are autonomous, in the sense that they produce their own organization (a network form of production). By contrast, allopoietic machines are produced or "produce other things than themselves" and are therefore defined by their purpose (e.g., a car, which is produced by "processes" other than the organization of the car and its operations).[10] Autopoietic machines possess individuality, since "their behavior is determined by their operations" as opposed to allopoietic machines, whose goal is the production of "something other than the production of themselves."[11] Autopoietic machines are also "unities," in that "their operations specify the boundaries in the process of self-production" and thus have "no inputs or outputs," contrary to allopoietic machines, whose behavior depends on the "boundaries" specified by the input of "the observer."[12] Put succinctly, autopoietic machines represent "bottom-up" systems; allopoietic machines embody the "top-down" or hierarchical way of organizing systems. Underlying these views is the presumption that the organization of the means of production also produces distinct forms of social relationships.

On this note, Varela and Maturana's privileging of "embodiment" isn't just an intellectual preoccupation, but is equally a lived reality, embedded in their support of Chile's social and political transformation at the beginning of the 1970s. Leading this transformation was Salvador Allende, Chile's new president, who was elected in 1970 and who set the nation on a socialist course (*La vía chilena al socialismo* [the Chilean path to socialism]).[13] Cybernetics was an integral component of Allende's vision, as evidenced by the Cybersyn project (Proyecto Synco), a collaborative endeavor between Allende, Fernando Flores, a cabinet minister in charge of nationalizing Chile's industrial sectors, and a British management theorist, Stafford Beer. The project involved the design of a transitional program for implementing democratic socialist economic planning, and was thus envisioned as a network system designed to connect the various nodes of production, including government officials, administrators, and factory workers, in order to enable cooperation between them. As the historian Eden Medina notes, Varela and Maturana's emerging notion of

[7] Hayles, *How We Became Posthuman,* 5.

[8] Hayles, *How We Became Posthuman,* 158.

[9] Varela and Maturana, *Autopoiesis and Cognition*, 80.

[10] Varela and Maturana, *Autopoiesis and Cognition*, 79–80.

[11] Varela and Maturana, *Autopoiesis and Cognition*, 80.

[12] Varela and Maturana, *Autopoiesis and Cognition*, 80.

[13] See Eden Medina, *Cybernetic Revolutionaries: Technology and Politics in Allende's Chile* (Cambridge, MA: MIT Press, 2011).

autopoiesis was a key influence on Beer's vision of the system, a utopian exercise in applied cybernetics cut short in 1973 when the U.S.-backed military coup overthrew Allende and brought General Augusto Pinochet to power.[14]

[14] Medina, *Cybernetic Revolutionaries*, 194. Beer wrote the preface to the 1973 English translation of *Autopoiesis and Cognition.*

Varela and Maturana's anti-capitalist politics inflected their social and political understanding of technologies, and was a cornerstone of their notion of autopoiesis, with its emphasis on non-hierarchical production and organization, whether in cybernetic systems or human relations. It is in light of these ideas that autopoiesis is central to an analysis of the artworks at hand.

Self-Production

Plantas Nómadas, a robot "living" on contaminated river waters, and *Algas Verdes*, a bacterial culture thriving on algae, are designed as technologies whose behavior is not pre-determined (by a central program) but is contingent on the interactions between their components and between the system and the environments in which they "live." This self-organizing, network-like design—autopoietic at its heart—is integral to the projects' roles as participatory, long-term interventions designed to counter environmental degradation in their respective sites: a heavily polluted river in a rural, industrial area in Mexico, and the exhaust-choked environs of Bogotá, Colombia.

Plantas Nómadas (2008–ongoing) grew out of Esparza's earlier urban intervention involving robotics, *Parásitos Urbanos* (2005–2007), a series of works similarly designed to interact with their habitat.[15] *Parásitos Urbanos* consisted of small robots made of recycled techno-waste (small motors from cellphones and toys, electronic controllers, computer parts, sensors, and PVC tubes) that roamed Mexico City's urban environments. Over two years, from 2005 to 2007, Esparza created a profusion of robotic parasites that residents of the city sometimes met in chance encounters. The project spanned six different robotic creatures, ranging from extremely simple constructions propelled by small batteries to more complex forms designed to search for sources of energy they can feed on. Some of the most basic creatures in the series included *Ppndr-s* or *pepenadores*, a group of small, spider-like robotic structures constructed from wires and micro-controllers embedded in PVC tubes, which took their name from the slang term for people who survive by salvaging trash in Mexico City. Like their namesakes, groups of *Ppndr-s* rummaged through heaps of trash on the city's streets, drawing a range of reactions from passersby, from surprised stares to amused double-takes.[16] Other, more complex robots like *dblt* were intended as ironic imitations of Mexico City's street vendors, who tap into the power grid illegally. Well out of reach from passersby, the *dblt* "lived" suspended on the city power lines, from which it collected energy, all the while drawing attention to

[15] See http://www.parasitosurbanos.com/parasitos/proyecto.html.

[16] See http://www.parasitosurbanos.com/parasitos/ppndrs.html.

itself through the loud sounds it emitted—samples of the urban soundscape around it.

Plantas Nómadas (2008–ongoing) marks a shift in Esparza's focus on urbanity and illegality, turning from Mexico City's megasprawl to peripheral (rural) areas; from allegorical and parasitic machines that illegally jack into the grid to autonomous (self-powered) robots.[17] A literal expression of Gilles Deleuze and Félix Guattari's concept of nomadology, Esparza's art is, in Deleuzean terms, "rhizomatic" (i.e., non-hierarchical). *Plantas nómadas* is an "anti-body," says Esparza, whereby "distinct forms of intelligence" can potentially contravene "environmental damage on a small scale."[18] The robot, a mobile structure encasing a microbial fuel cell and a plant, could be spotted in the wild, roaming the contaminated banks of the Santiago river at El Salto and Juanacatlán, in the state of Jalisco, one of the sites where Esparza tested and developed it (Fig. 1).[19] The unsupervised disposal of highly toxic waste by a variety of industries along the El-Salto-Ocotlan industrial corridor (a free-trade industrial park long contested by local residents and environmental activists) makes this site an ideal area for intervention.[20] The robot feeds on the bacterial colonies forming in the contaminated waters of the river, which it then "digests" through processes catalyzed within its microbial fuel cell, transforming the bacteria into the electricity that propels it. (Microbial fuel cells are devices that convert chemical energy into electrical energy by the catalytic or metabolic reactions of microorganisms, such as bacteria and algae). Through this feedback dynamic, the water is filtered and the plants living in the body of the robot are supplied with clean water, in

[17] See http://www.plantasnomadas.com.

[18] Quoted from the artist's statement. See http://www.plantasnomadas.com.

[19] See the documentary online at https://www.youtube.com/watch?v=bHF0MHousfM.

[20] Centro Documentazioni Conflitti Ambientali, http://www.cdca.it/spip.php?article1671&lang=it.

Fig. 1. Gilberto Esparza, *Plantas Nómadas* (2008–ongoing). Courtesy of the artist.

turn returning energy to the environment through the release of oxygen. (The plants used are native to the area.)

Because the bacterial components generate little energy, the robot moves very slowly—just enough to continue to function—thus preventing rapid mechanical wear. The integration of a self-generating mechanism, and the emphasis on slowing down movement in favor of expanding the life cycle of the robot, stand in contrast to the normative framing of robotics within the requisites of speed and efficiency of capital-driven, allopoietic technology. *Plantas Nómadas* suggests a model for developing technology in tune with the non-linear processes that characterize organic life, a metaphor that Esparza also extends into his artistic practice, which includes Makerspace-style workshops designed to share the processes and tools used in the project. ("Makerspaces" are community-operated workspaces, typically run by people with shared interests in art and technology. They're associated with the Maker movement, a grassroots phenomenon devoted to DIY technology and the politics of technoliteracy.)

Similarly, Mestizo's *Algas Verdes* is conceived as a self-sustaining system, albeit one designed for urban environments. The project had its origins in research Mestizo conducted at the University Javeriana in Bogotá, where he obtained his MFA in 2006. There he collaborated as a docent in the v*i*d*a lab (2005–2008), an experimental workshop for industrial design students founded by fellow Colombian artist Alejandro Tamayo. This workshop took as its focal point the investigation of urban life through the lens of "critical design" practice, which draws on product design, industrial design, architecture, biology, human computer interaction, and art.[21] Students were encouraged to question the emphasis on functionality in industrial design; to explore the tenuous borders between the natural and the artificial in the environments of one of the most polluted cities in the world, Bogotá; and to engage in transdisciplinary research in other departments at the university.[22]

A main reference point for members of the v*i*d*a lab collaborating with faculty and students at the biology department was the work of the biologist Lynn Margulis. Contrary to Darwinian orthodoxy, Margulis's theory of evolution, which draws on the concept of autopoiesis, emphasizes symbiosis as the key mechanism of life's uniqueness and diversity. Thus, she suggests that symbiogenesis—a process in which separate organisms (e.g., mitochondria) fuse into a cell, thereby generating an entity with significantly increased metabolism and capacity for adaptation—is the key to evolutionary processes.[23] This view resonates with Mestizo's work, which combines biology, design, physical computing (the creation of artificial systems that are responsive to their environment), and, in the experimental and collective vein of the now-defunct v*i*d*a lab, DIY culture.

Like *Plantas Nómadas*, *Algas Verdes* (Fig. 2) is conceived as an interspecies system that functions through cooperative behaviors, or as Mestizo

[21] See Anthony Dunne and Fiona Raby, *Design Noir: The Secret Life of Electronic Objects* (Basel: Birkhauser, 2001).

[22] Alejandro Tamayo, "v*i*d*a Lab: Rethinking Objects for Everyday Life," in *Design Education* 26 (2009); available online at http://tdd.elisava.net/coleccion/26/tamayo-en/view?set_language=en.

[23] See Lynn Margulis and Dorian Sagan, *What Is Life?* (Oakland, CA: University of California Press, 2000).

Fig. 2. Hamilton Mestizo Reyes, *Algas Verdes* (2010–ongoing). Courtesy of the artist.

puts it, "symbiosis."[24] The project is part of a series of works delving into issues arising from ecology, technology, and collective knowledge.[25] These projects include *Electricium Vitum* (2007), *Ba-c-teria* (2008), and *Bioelectronics* (2013), which are functional microbial fuel cells charged by various forms of bacteria thriving in human and household bio-waste. First conceived at the Media-Lab Prado Madrid, a Makerspace, *Algas Verdes* investigates the possibility of using various types of local green algae to create biodiesel and generate electricity.[26] Mestizo and his collaborators built various prototypes, including wall-mounted installations made of local recycled materials such as clear PVC fittings designed to be integrated into domestic and urban architectures as sources of oxygen and energy. In line with the artist's focus on collective, open models of production and distribution, Mestizo, like Esparza, conducts public workshops and releases the research undertaken for the project onto the Internet, so that it can be replicated and developed by the broader community.[27]

As collaborative projects, *Plantas Nómadas* and *Algas Verdes* are themselves rooted in, and contribute to the development of, models of production and distribution of technology and technical knowledge based on a collectivist ethos—an ethos that contrasts sharply with the competition-driven ethos that binds technology to industry and industrial models of production. Contrary to the homogenization of these allopoietic processes, *Plantas Nómadas* and *Algas Verdes*' collaborative models invite the rethinking of theories of technology, arguing against speed, progress, and productivity for their own sake; in their stead, Esparza and Mestizo

[24] Hamilton Mestizo, "Bioelectric," in *Balance-Unbalance Conference Proceedings*, May 31–June 2, 2013, Noosa, Australia, 16; available online at http://www.balanceunbalance2013.org/uploads/1/3/2/6/13266267/balance-unbalance_proceedings_abstracts.pdf.

[25] See http://librepensante.org.

[26] The Media-Lab Prado is financed by governmental and private institutions, including Telefónica, a Spain-based telecommunications corporation.

[27] For documentation of *Algas Verdes*, see http://medialab-prado.es/mmedia/5073/view.

emphasize environment-specific sustainability, symbiogenesis, self-production, and collective knowledge. Then, too, as interdisciplinary interventions, their works challenge ingrained notions about the separation of art and science.

Beyond the Two Cultures

In the context of Mexico and Colombia, the recent emergence of digital arts with ecological themes involves a new generation of artists embracing "environmentally-engaged media art practice" or "tactical eco-art," as the artist Arcangel Constantini puts it.[28] Constantini is one of a group of artists who occasionally collaborate with Esparza, including the Mexican artists Marcela Armas and Ivan Puig, all of whom have developed environmentally-themed projects of their own. While sharing similar concerns and strategies with activist, techno-literate, environmentally engaged artwork elsewhere, these projects constitute, at the same time, unique responses to ecological pressures in their respective regions. For instance, the Chilean collective Chimbalab (Constanza Piña and Claudia González) devised a portable radio station that draws on potatoes for energy, and broadcasts at the Vega market, the central market of fruits and vegetables in Santiago. (The station was built after Chile's earthquake in 2010, which exposed the limitations of new communication systems, such as standard telephonic and cellular infrastructure; in contrast, radio is a more stable and accessible medium).[29] Similarly, *Plantas Nómadas* and *Algas Verdes* are conceived in response to ecological imbalances resulting in their sites from the aftermath of rapid cultural and economic transformation connected to globalization processes. On the one hand, this includes the displacement of rural populations in the service of macroeconomic policies in Mexico, which includes the creation of free-trade industrial parks such as the El-Salto-Ocotlan industrial corridor, and on the other, the explosive growth of cities like Bogotá, ill-equipped for the rapid influx of displaced rural populations. Taken together, these works refute the purist logic of homogenization, favoring instead inclusion and difference, as suggested by their conceptual embrace of the in-between: they operate in the post-disciplinary interstices of art, science, and social activism.

From this perspective, Esparza's and Mestizo's integration of sources in robotics and biology that draw on autopoiesis, itself a concept embedded in the interdisciplinary legacy of cybernetics, interknits traditions that are often assumed to be separate, yet share common points of reference. The notion of what the U.S. performance collective Critical Art Ensemble calls "tactical biopolitics" and the concept of autopoiesis (as envisioned by Varela and Maturana), while emerging out of distinct practices and circumstances, can be seen as related critiques of positivism and instrumentalism as the bases from which to conceptualize,

[28] See http://nanodrizas.org/index.php?/english-version/presentation/; and http://artedigitalamm.blogspot.com/2012/10/plantas-nomadas-de-gilberto-esparza.html.

[29] Valentina Montero Peña and Pedro Donoso, "Dissent and Utopia: Rethinking Art and Technology in Latin America," in *Red Art: New Utopias in Data Capitalism: Leonardo Electronic Almanac* 20, no. 1 (London: Goldsmiths, University of London, 2014), 145.

shape, and deploy technology. Esparza's and Mestizo's projects share a focus on the use of technologies as a means of cooperation and participation, while stressing symbiotic relations as central premises of change and adaptation.

The convergence of art, science, technology, and activism that these projects exemplify has found fertile ground in renewed resistance to the control of technologies by economic and political interests, and has helped foster alliances between local and global civil communities of artists, scientists, and technologists sharing similar ecological concerns. The complexity of these projects invites critical analysis based both on a historical knowledge of art and, as important, science. Contrary to historical assumptions on both sides of the conceptual wall dividing what C.P. Snow called the "two cultures" of science and the humanities, these strands are not only historically intertwined, but also share affinities in their conceptual orientation toward socio-political transformation.

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