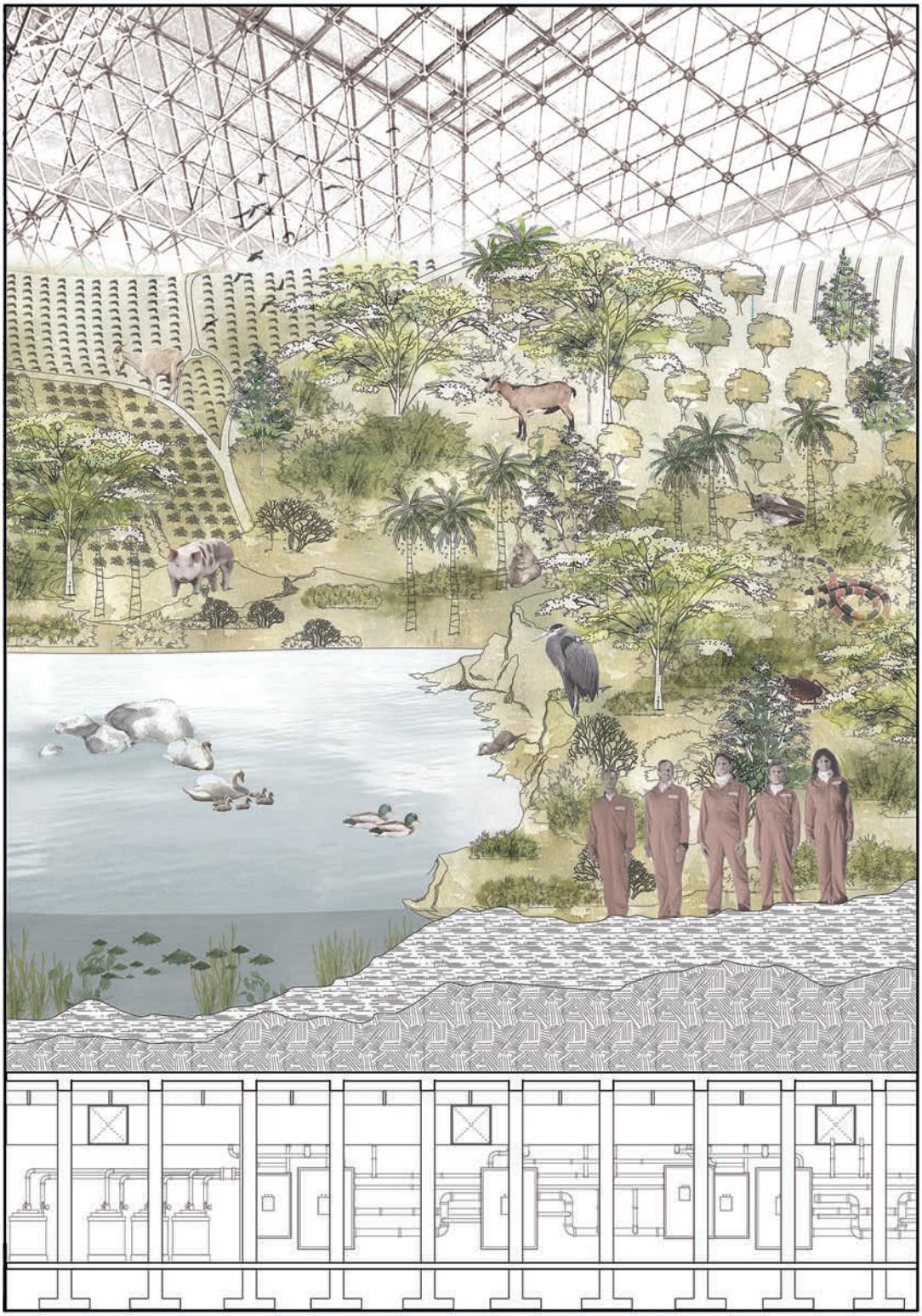


Lydia Kallipoliti
& Andreas Theodoridis

Field Notes on Plants and Pipes

One August night in 2018, while proofreading the manuscript I* had just submitted for my book *The Architecture of Closed Worlds*, I realized that inside me was another closed world, a vibrant one waiting to burst out. Looking at my pregnant belly, I could not imagine the features of the life about to be born. Instead, I was thinking about Biosphere 2, in Arizona, which I had written about for the book just a few days before. I had left this case study for last because I was dreading putting the pieces of its long literature and controversy together. It is the most famous closed ecological system ever built, and it failed, in 1993, publicly and spectacularly. The Biosphere's inability to breathe and metabolize, despite the massive pneumatic artificial lungs it was equipped with, made me think of it as a giant stomach digesting and then producing excrements that needed to be purged. In the wave of August heat, my thoughts grew darker to the point that I rewatched Peter Greenaway's *The Belly of an Architect*, revisiting the obsession of the male protagonist – architect Stourley Kracklite – with the diseased contents of his belly. In preparing an exhibition on the work of Étienne-Louis Boullée, Kracklite imagined that he had swallowed Boullée's Cenotaph for Isaac Newton and it was growing inside his belly as an asymmetrical malformation. Similar fears of malformation ran wild in my head. Did I ingest the Biosphere? A failed experiment in reproducing life anew? With many inconsistent, hormone-driven thoughts at play, I decided to visit Biosphere 2 one week before my pregnancy cutoff travel date. While traveling, I read Barbara Maria Stafford's *Body Criticism*, her history of body metaphors as sometimes aligned with amorphous ideas and evil in the Enlightenment. André Félibien, she writes, "declared that the greatest obstacle an artist could encounter was a malformed idea."[1] I imagined Biosphere 2 as a kind of malformity of the modern world depicted as a luscious tropical setting under glass, safeguarded against the barren Arizona desert. What were the unseeable aspects of this world, its underground secrets?

Upon arrival, I was greeted by a volunteer biologist holding a sealed round glass bottle containing a soup of algae,

* The authors, a couple in life, use the pronoun *I* in this narrative. They shared this trip, the belly, and the experience of pregnancy and of new life together.

1. Barbara Maria Stafford, *Body Criticism: Imaging the Unseen in Enlightenment Art and Medicine* (Cambridge: MIT Press, 1991), 248.

Opposite page: Lydia Kallipoliti and Youngbin Shin, Drawing of Biosphere 2. All images courtesy the authors.

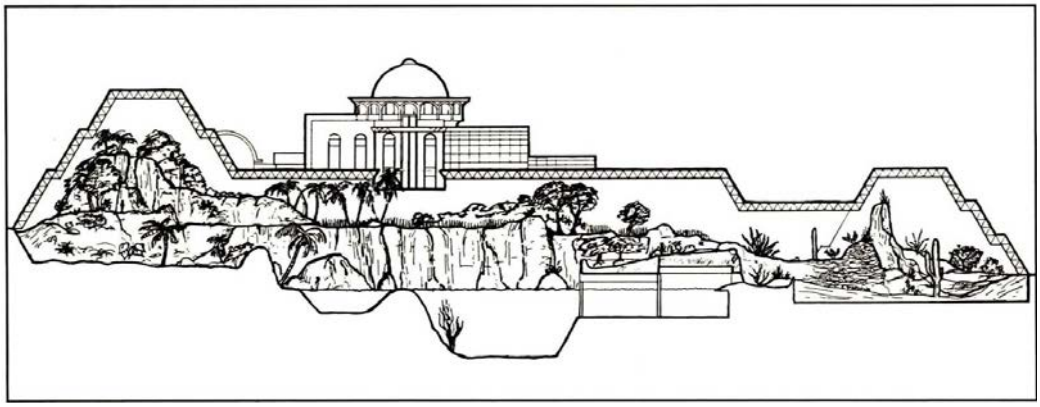
The tour guide at Biosphere 2, in Oracle, Arizona, with an "ecosphere" to represent Clair Edwin Folsome's bottle experiments in the 1960s, upon which the concept of Biosphere 2 was based. Photo: Andreas Theodoridis, August 2018.

microbes, and other microorganisms, which, she said, were happily coexisting and exchanging nutrients in a form of ecosystemic balance. She was keen to explain how Biosphere 2 was inspired by the bottle experiments of microbiologist Clair Edwin Folsome at the University of Hawaii, who, in the 1960s, went to the beach and scooped up seawater and sediment from the Pacific Ocean into a large glass jar.[2] Folsome's jar was blown up to monumental proportions with the living experiment of Biosphere 2, questioning whether certain biological systems can exist only at certain scales. As systems are made larger to emulate Biosphere 1 – that is, the Earth – new challenges arise with the large increase in the flow of data, which makes balancing the organic composition of an atmosphere a more demanding, complex, and unpredictable process.

After moving through the space-frame enclosure – a multi-hinge "nodeless joint" system specifically designed (and patented) by Peter J. Pearce to make Biosphere 2 the world's most airtight building – I entered Biosphere 2. The facility, spanning 3.14 acres and enclosing five ecosystem regions known as biomes, was impressive. Even more impressive was the sensorial immersion into a desert, a marsh (mangrove wetlands), an ocean, a rainforest, and savannah grasslands amid areas for agricultural cultivation and spaces for human habitation, including a kitchen and living quarters. What was sublime, however, was leaving the curated "natural" stage sets and passing through an airlock to descend into the underworld, called the "technosphere" – the underground maze of mechanical infrastructure that sustains the biomes above.

The technosphere is absent from the architectural section of Biosphere 2. There are excellent accounts by various scientists and authors, as well as the crew itself and people who were intimately involved in the experiment in its many facets, narrating the aspiration to reimagine life and make the world anew.[3] Nevertheless, the role of the section that distinctly separates the natural biomes above from the mechanical world below remains unexplained. This clear dissection reveals a consistent design fantasy to maintain the natural-artificial divide in the built world – that is, to separate the world of pipes from that of plants. I argue that the astonishing separation of a mechanical underworld that supports and enables the world above – the world of manufactured, naturalized wilderness – is not exclusive to Biosphere 2 and its idiosyncrasies. Rather, the section is an

2. See Sabine Höhler, "Ecospheres: Model and Laboratory for Earth's Environment," *Technosphere Magazine*, June 20, 2018, https://technosphere-magazine.hkw.de/p/Ecospheres-Model-and-Laboratory-for-Earths-Environment-qfrCXdpGUyenDt224wXyjV.
3. See William J. Broad, "Paradise lost: Biosphere retooled as atmospheric nightmare," *New York Times*, November 19, 1996; Reed Karaim, "World in a bottle: Once the punch line of a bad joke," *Preservation: The Magazine of the National Trust for Historic Preservation* 59, no. 3 (2008): 48–54; and Kevin Kelly, *Out of Control: The Rise of Neo-biological Civilization* (New York: Basic Books, 1994).



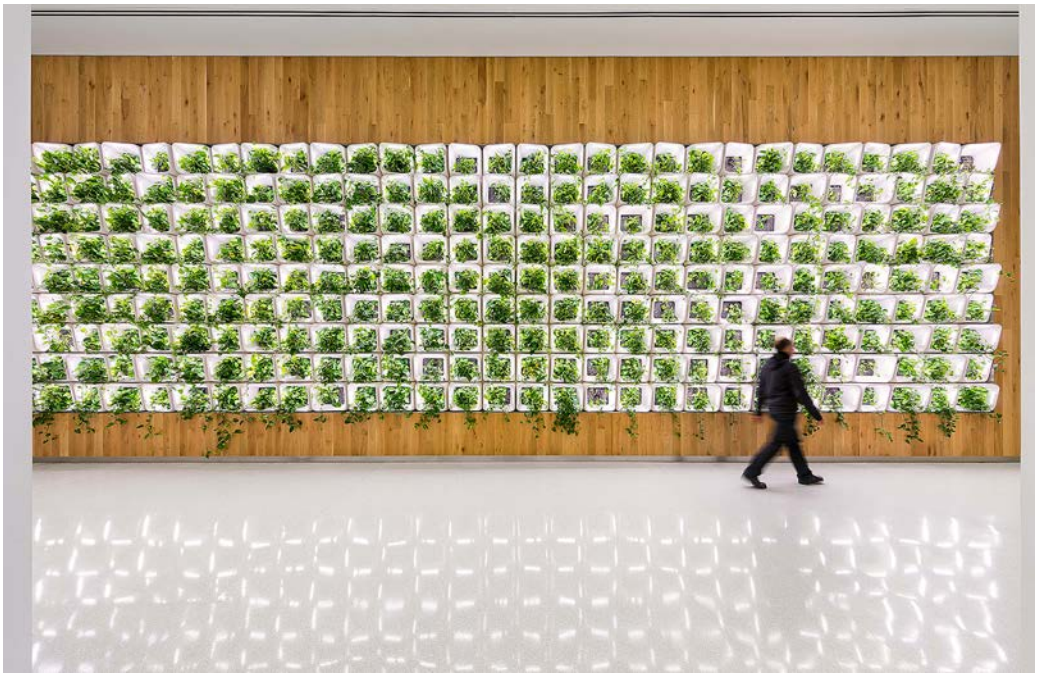
Longitudinal section of Biosphere 2 through the rainforest, desert, and transitional biomes, from "Biosphere II: A Project to Create a Biosphere," *SSI Space Studies Institute Newsletter* 12, no. 3 (May-June 1986).

architectural tool of territorial sovereignty. In the case of Biosphere 2, it represents a modality of building and a view of the world to sustain our lost idea of untamed land, independent of what it takes to manufacture the image of wilderness.

Biosphere 2's subterranean technosphere includes 50 miles of color-coded pipes, huge ductworks, switchboxes, dials, vacuum blowers, and more than 200 motors, 100 pumps, and 60 fans. In the nerve center – the computer room – every valve, pipe, and motor is simulated in a software network. Chemical compounds are continuously monitored in the soil, air, and water, making Space Biosphere Ventures' environmental-monitoring techniques some of its most prominent and marketable spinoff products.[4] The plants above, including the biomes and marshes as well as the leaves on which the animals feed, are actually supported by pipes and tubes, resulting in an architecture of disorientation in a chthonic maze of plumbing that is not registered in the public eye. The Biosphere's mechanical underworld is thus not only unseen but also denied representation. A parallel and more recent case is the digital cloud and its grounding on Earth, which propelled media scholars and architects to ask what "the cloud" is made of. What is the physical infrastructure that sustains our digital data and distributes it, and where is it geographically located?[5] Equivalently, it is critical to ask, What are the artificial biomes made of? If they are made of invisible technospheres, what is the architecture of their pipes and underbellies?

The plant-pipe diagram of Biosphere 2's technosphere is not alone in separating the mechanical and the natural world. In New York City's Public Safety Answering Center II (PSAC II), designed by SOM, a green wall, containing 288 plant modules, filters indoor air to maintain air quality (IAQ). The wall's plants would not survive for a week were it not for the pipes that provide water and nutrients to this major

4. Kelly, 166.
5. See Shannon Mattern, "Infrastructural Tourism," *Places*, July 2013, https://placesjournal.org/article/infrastructural-tourism/; Lisa Parks, *Cultures in Orbit: Satellites and the Televisual* (Durham: Duke University Press, 2005); Niklas Maak, *Server Manifesto: Data Center Architecture and the Future of Democracy* (Berlin: Hatje Cantz, 2022).



An HVAC-integrated Active Modular Phytoremediation System (AMPS) "green wall" installed at the Public Safety Answering Center II (PSAC II), designed by SOM, Bronx, New York. AMPS developed by Center for Architecture, Science and Technology (CASE), 2017, led by Anna Dyson, with J. Vollen, A. Aydogan, M. Gindlesparger, Ph. Mankiewicz, Pa. Mankiewicz, C. Ciardullo, A. Theodoridis, et al.

hydroponic venture. The section of the unbuilt Tsuruhama Rain Forest Pavilion in Osaka, by CambridgeSeven Associates, is almost identical in its logic of partitioning two worlds; so are the recent biosphere headquarters of Amazon, designed by NBBJ and built in downtown Seattle. The section, therefore, demarcates an idea of a "return" to the Earth, an architecture of disappearance, maybe not a return to nature but our lost sense of nature: a regression, which is paradoxical. These green worlds are quite the opposite of the natural. They are conditioned, perfectly calibrated, and measured as simulated pieces of nature; they showcase a constructed worldview, a soothing fantasy of a promiscuous green universe that has crumbled.

In *The Machine in the Garden*, Leo Marx discusses how our deeply rooted yearning to return to a simpler, harmonious existence is delivered, through complicated technology, as the "spontaneous fruits of an Edenic tree."[6] Citing philosopher José Ortega y Gasset, Marx calls this regression an international form of primitivism, with humans thinking that the civilization around them is the result of a spontaneous force. Ortega y Gasset argues that, in the depths of their souls, humans are unaware of the artificial character of civilization and do not extend their enthusiasm for the technological instruments to the principles that make them possible. This curious state of mind is also described by Freud as a collective neurosis and the very epitome of fantasy making.

6. Leo Marx, *The Machine in the Garden* (Oxford: Oxford University Press, 1964), 8.

In this sense, the technosphere, which ostensibly exemplifies technological instrumentation, speaks on many fronts of architecture's return to the idea of the first house and the so-called primitive, innocent state. Biosphere 2, which leaked less air per annum than a space shuttle does,[7] recorded unforeseen biotic interactions. The proliferation of cockroaches and crazy ants paralleled the flourishing of a rare species of amoeba in Biosphere 2's ocean. This giant amoeba from the Caribbean was so unevolved that it still relied on symbiotic bacteria instead of mitochondria to generate metabolic energy under lower irradiation conditions. Curiously, the ocean biome reverted to a primitive state. Scientists of the Landscape Evolution Observatory (LEO) assumed that the hyperinsulated artificial ecosystems of Biosphere 2 indicated a regression in geological history, pointing to a time when the sun was younger and dimmer than it is today.

However, Biosphere 2, along with similar large-scale facilities, is not a naive Edenic fantasy. In a heightened combination of entertainment and ecology within a controlled environment, biospheres and closed-loop nature-based systems emerged, reflecting the hubris of late-modern capitalism. Critically, these worlds are not only key sites of engineering and environmental production, they also continue to revive the fantasy of regression while heavily capitalizing on its execution. They temper and fabricate a controlled wilderness as a commodity of architectural production. In particular, Amazon's biosphere-like headquarters was inspired by a 2013 study concluding that workspaces that include plants lead to a 47-percent boost in employee well-being, a 45-percent boost in creativity, and 38-percent boost in productivity.[8] Amazon hired a full-time horticulturalist named Ron Gagliardo to develop a plan for and then safeguard the biodiversity and well-being of its plants. Gagliardo and his team selected 3,400 plant specimens, from coffee and cacao trees to smelling corpse flowers originating from over 30 countries (including some plants in danger of extinction). The objective was to create tree canopies growing about three stories above the ground level, meeting rooms enclosed by walls of vines, a creek, and a waterfall. Plants and trees were envisioned to grow and interweave with meeting rooms called "treehouses," as well as open public areas, where Amazon employees could enjoy their lunch-breaks. The company is also investing in augmented brain development along with the presence of vegetal life. According to many studies, improved air quality provided by vegetal

7. Naturalist Daniel Botkin, one of Biosphere 2's original advisors, claimed that Biosphere 2 leaked just 10 percent of its oxygen a year. In comparison, a space shuttle leaks two percent a day. See W. F. Dempster, "Methods for measurement and control of leakage in CELSS and their application and performance in the Biosphere 2 facility," *Advances in Space Research* 14, no.11 (November 1994): 331–35.
8. Dan Kedmey, "A Leafy Office is a Happier Office, Study Finds," *Time*, September 1, 2014, https://time.com/3247391/a-leafy-office-is-a-happier-office-study-finds/.

systems has a significant effect on cognitive functions.[9] Therefore, a green wall, such as the one at PSAC II, is a major investment for a facility where decision-making under pressure is of utmost significance.

These curated natural stage sets are evidence that major corporations like Amazon not only acknowledge our alienation from the land but also capitalize on it. Such investments are based on the premise of repair, or on the capitalization of repair, with the intention to restore our severed connections with the Earth and its physical forces. Yet, this imagined restoration can only happen via the world of pipes. Imagining the codependency of living systems and machines, Kevin Kelly wrote about Biosphere 2 that "life is a technology. Life is the ultimate technology."[10] He recalled the so-called heretical arguments, in the 1920s, of geologist Vladimir Vernadsky, who conceived of the biosphere of living creatures as a large chemical factory. Then, if Biosphere 2 is a factory for life, is it not based on the architecture of codependency between the world above and the world below? Is there such a thing as a plant in an interior world that is not merged with pipes? Why can't plants and pipes form new alliances and spatial typologies?

The alienation of peoples and cultures from the soil of the Earth is powerfully narrated by Donna Haraway, who calls for the rise of the Chthulucene, the dynamic ongoing symchthonic forces and powers of which people are a part. "I am a compost-ist," she argues; "not a posthuman-ist: we are all compost, not posthuman."[11] Yet, if the Chthulucene is always below, never ethereal like the digital cloud, one would expect to find dirt, soil, and shit in Haraway's story: a concoction of abject matter as a reminder that we are still part of a locale in this world with a material and visceral presence – a reminder that we are located somewhere as living bodies. In Biosphere 2, the basement is full of pipes carrying energy and nutrients. The soil is elevated, and down below one finds in the Chthulucene the maze of machines linked to the soil and its malformations.

Biosphere 2 originated in the counterculture of Synergia Ranch, which was spurred by systems ecologist and environmentalist John Allen.[12] In due course, it has come to validate planetary interiors in the corporate world, like Amazon's biospheres in Seattle or Apple's headquarters in Cupertino, California. These biomes reveal a deeply rooted desire to live inside a simulation: the virtual environment of a naturalized bucolic landscape detached from the technosphere that

9. See Usha Satish et al., "Is CO_2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO_2 Concentrations on Human Decision-Making Performance," *Environmental Health Perspectives* 120, no. 12 (December 2012).
10. Kelly, *Out of Control*, 165.
11. Donna Haraway, "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," *Environmental Humanities* 6 (2015): 161.
12. See the documentary *Spaceship Earth*, directed by Matt Wolf and released in 2020.

sustains it. The absence of infrastructure in the drawings of biospheres, as well as in our perception of them, indicates the need to provide an image of a world unharmed, or – at the other extreme – of survival after catastrophe. Narrative and instrumentality do not collide in architectural representations. They are registered in separate drawings: the former in pictorial representations of the natural kingdom, the latter in engineering drawings of invisible, hidden, and unwanted systems. As Emilio Ambasz once said, "If a building is sustainable and LEED-approved [it is] an edifice, not architecture. To do a building, you need technology, to do architecture you need art."[13]

In many ways, it can be argued that plants and green carpets are a type of visual fiction, perhaps the only type of viable visual fiction that is linked to ecological architecture. Yet, considering that plants and green surfaces are only possible because of the technosphere, is there such a thing as a green world, one that is not tied – with an umbilical cord – to the world of machines?

The evolution of living systems supported by technological infrastructure reveals a largely unexplored mutualism in architectural production that deserves further study. What new forms of design agency and politics emerge from the bond of plants and pipes? As built environments integrate more bioregenerative systems, building materials are no longer the inert interfaces or passive receptors of spaces that may be sized up with no repercussions. Possibly new metrics need to be invented to scale hybrid inhabitable systems – analogous to the architectural metrics of area and volume – metrics that would link geometry with the fragile vacillations of living systems.

All things considered, the failures of Biosphere 2 were instructive and illuminating. This is meant neither to valorize failure nor to promote the positivist ethic that equilibrium will follow disarray. It is simply to indicate that the ambitious goal to return to the Earth illustrates devolution in time in all its material and social complexity. Biosphere 2 helped observe, identify, and substantiate unforeseen material and psychic formations in a new, yet primitive world: one that has arisen only through live experimentation.

13. Emilio Ambasz, "The Environments of Emilio Ambasz," interview by Cynthia Davidson, *Log* 52 (Summer 2021): 99.

Lydia Kallipoliti is an architect, engineer, scholar, and an associate professor at The Cooper Union in New York. Andreas Theodoridis is an architect, engineer, building scientist, and an assistant professor at the New York Institute of Technology.