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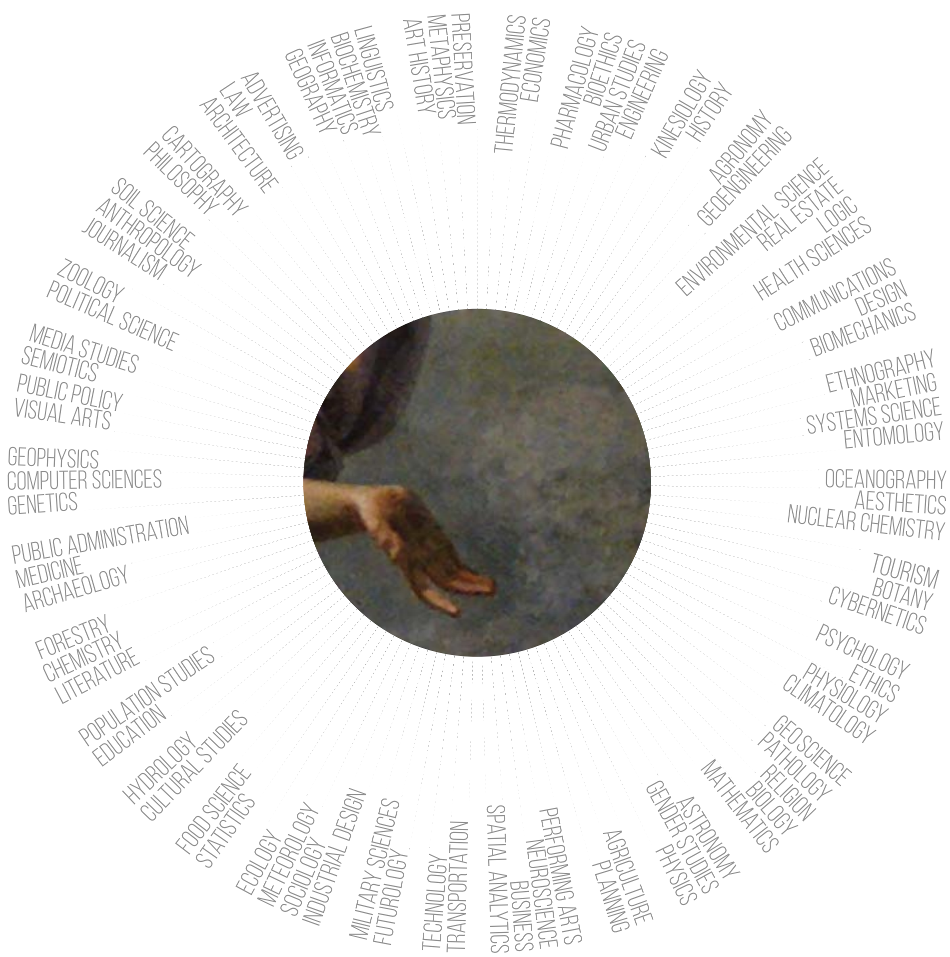

RICHARD WELLER

TERRARIUM

THE ULTIMATE DESIGN EXPERIMENT

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+ TECHNOLOGY, DESIGN

At some point in their education most kids will make a terrarium. An article in the US National Science Teachers Association's journal, *Science and Children*, states that while a failed terrarium is a disappointment for the children, it is nonetheless "a good point of departure for discussion."[1] The 1975 article I am referring to doesn't prescribe what that discussion should be, but we can infer that the failed terrarium lends itself to a cautionary tale about human manipulation of the environment. By contrast, the successful terrarium is a take-home trophy of getting at least some basic biological relationships right.

But by imprisoning, and eventually killing that which it appears to protect, the terrarium has a dark side. In the terrarium, nature is simultaneously reified by and cut off from culture. The terrarium lures the unsuspecting child into the conceptual framework of Cartesian dualism, a way of knowing the world that few will ever be able to escape. In this sense, making a terrarium rehearses in miniature the ominous environmental narrative of adulthood in the Anthropocene – an age where that ultimate terrarium, the Earth, is now fixed in the gaze of a thousand satellites. And like the child looking down upon their little world, the adults too are uncertain if the experiment they are conducting with theirs, will succeed or fail.

Seen through the contemporary filter of an atmosphere now overloaded with greenhouse gases, it is fitting that terrariums have their origin in and were inspired by a desire to protect delicate plants, not only from winter, but also from the heavily polluted atmosphere of Victorian London. There, the surgeon and amateur horticulturalist Nathaniel Bagshaw Ward accidentally "discovered" what would become known as Wardian cases: enclosed glass containers that permitted plants to thrive without external inputs.[2] Wardian cases became popular when in 1834 J.C. Louden, the editor of *The Gardeners' Magazine*, enthusiastically presented them to his readership. Through miniaturization, the Wardian case made accessible and domestic what had hitherto been the aristocratic and scientific domain of large glasshouses. Ward also speculated that his cases could have therapeutic benefit, as well as the capacity for food production to improve the diet of the urban poor, both of which have now been proven to some extent true.

However, as is the case with all human modifications of the environment, benefits are shadowed by problems. For example, the Wardian case enabled the globalization of agriculture by distribution of specimens throughout the British Empire, but also unwittingly facilitated the transplantation of species that would later be cursed as "invasives." Additionally, from a postcolonial perspective, Louden's premonition of the efficacy of Ward's invention reads as insidious when he extrapolates that "perhaps the time may arrive when such artificial climates will not only be stocked with appropriate birds, fishes, and harmless animals, but with examples of the human species from the different countries imitated...who may serve as gardeners or curators of the different productions. But this subject is too new and strange to admit of discussion, without incurring the ridicule of general readers."[3] With the World's Exhibition of 1851 set inside Joseph Paxton's Crystal Palace—itself a mammoth terrarium—Louden's vision of the world's ecoregions and cultures as a theme park moved closer to reality. Notably, among the exotica of empire on display was one of Ward's own curiosities – a bottle sealed and unopened for 18 years containing a specimen of living moss.

Far more than a Victorian curiosity, the architectural typology of the terrarium and its latent fantasies of total environmental control refracts through the 20th century in iconic projects such as Buckminster Fuller's Dome over Manhattan (1960) and his US Pavilion in Montréal (1967), Walt Disney's Experimental Prototypical Community of Tomorrow (EPCOT) (1982) in Orlando, and, most infamously, Biosphere II in Arizona (1991). In this article, we will briefly revisit these precedents, but to truly understand the portent of the terrarium we will also follow its manifest destiny beyond the bubble of our own atmosphere, out into space.

Experiments on Earth

The most famous 20th-century architect of the terrarium was, of course, Buckminster Fuller. Fuller conceptualized and, through his Dymaxion cartography, unpacked the whole planet as a kind of geodesic dome and put it back together again as an architectural kit. Fuller advocated the use of geodesic domes from the scale of (affordable) housing to that of whole cities. While unsuccessful as mass housing, and often derided in terms of architectural aesthetics, the domes were and still are utilized by the military and other agencies as cost-effective, lightweight structures. More than this, the geodesic dome came to signify Fuller's particular brand of techno-utopian optimism, adopted by the ecological sub-culture of the 1960s and 1970s.

THE VIVARIUM; OR, INSECT-HOME.

FOR OBSERVING THE TRANSFORMATIONS OF BUTTERFLIES, MOTHS, AND OTHER INSECTS.

Fuller's lifelong engagement with the typology of the terrarium is best expressed by two iconic projects: the unbuilt Dome over Manhattan (1960) and the US Pavilion built for the 1967 Expo in Montréal. The two-mile-wide Dome over Manhattan, conceived in association with the architect Shoji Sadao, was intended to be a climate controlled and energy efficient bubble floating above the ground plane. How Fuller took this idea seriously is something of a mystery, as the incongruity of the dome with the surrounding grid raises awkward and unresolved questions of the relationship between the two. Covering a conventional exhibition building, the geodesic dome of the US Pavilion at the 1967 Expo in Montréal is a miniature version of the Manhattan concept. Here the architectural double entendre of placing a building inside a building performs the same "world within a world" trick as the terrarium; but instead of encasing nature, Fuller's utopia (the dome) and America's cornucopia (the exhibition) are brought into alignment. After the Expo, the dome briefly housed botanical displays before a fire in 1976 melted its plastic skin, spewing plumes of thick black smoke into the sky. Renamed and redeemed as "the Biosphere," it now houses exhibitions about the environment and climate change.

By this time, Fuller's technological cathedrals had caught the eye of that eternal American optimist, Walt Disney. Six years after Fuller and Sadao had sketched their Dome over Manhattan, Disney set about making the vision a reality, only now on a 50-acre tabula rasa in Orlando, Florida. Titled the "Experimental Prototype Community of Tomorrow" (EPCOT), the dome was intended to house a community free of urban blight, congestion, and pollution. According to the propaganda, EPCOT would be "protected day and night from rain, heat and cold, and humidity" and offer "employment for all."[4] As Andrew Hurbner describes it, through the "benevolent control of downtown spaces, homes, transportation, and greenways" EPCOT would "stave off slum formation, poverty, and blight, and with them, urban riots like those that had rocked Los Angeles in 1965 and several other major cities in 1966."[5]

Soon after pitching the project, however, Disney died, leaving EPCOT to become the tragicomedy one might expect when entrusting utopia to theme park executives. When it opened in 1982, EPCOT's most prominent feature was a vast carpark, and the all-encompassing dome had contracted into what looked like a giant golf ball. Named "Spaceship Earth" in deference to Fuller's eponymous book, the dome now houses an audio-animatronic ride designed by the science fiction writer Ray Bradbury.[6] As Bradbury explained to journalists in 1977, guests are taken on a 15-minute tour of the entirety of universal history, shown how to "clean the air, unpollute [sic] the seas and save the whales." At the end of the tour guests are asked "what is our future?" Bradbury's answer: "we have to go into space."[7]

Spurred on by the Cold War, serious preparation for this apparent inevitability gained momentum internationally around the same time that Fuller's geodesic domes, and his metaphor of "Spaceship Earth" entered popular culture. In fits and starts both the Russian and American space programs developed closed-system simulation programs involving plants, animals, and humans.[8] The first, in 1965, was the Russian Bios-1 experiment where the atmosphere necessary to sustain one person in a 12 m3 enclosure was generated by an algal cultivator containing *Chlorerra vulgarus*. Bios-1 achieved 20% self-sufficiency. To improve upon this, in 1968 Bios-2 expanded the experiment's territory to include an additional 8.3 m3 area containing a diversity of edible plants. Then, built entirely underground, at a capacious 315 m3, Bios-3 attempted to simulate off-planet conditions for up to three people; the best it could achieve was to sustain two people for a maximum of five months.[9] Because additional nutrition in the form of animal products and electric energy to power xenon lamps for plant growth were supplied from outside, these experiments failed to achieve self-sufficiency in conditions of absolute isolation. What these closed-system experiments underscore is how complex and difficult it is to create bioregenerative systems, and by extension just how much of our daily biochemical existence in the open system of the Earth we take for granted. NASA, too, had been experimenting with similar prototypes to the Russians during the 1960s and '70s but it was the privately funded and designed Biosphere II in Oracle, Arizona that turned the science of bioregenerative life support systems into a public spectacle. Replete with simulations of the world's major biomes and spanning 1,900 m2, Biosphere II (Biosphere I being the actual Earth) was the McMansion of closed systems or, as Roy Walford put it, "the Garden of Eden on top of an aircraft carrier."[10] On September 26, 1991, eight "biospherians" or "terranauts" as they were variously called, including Walford, entered the enclosure and didn't come out until two years later. By the time they emerged, the ecosystem had virtually collapsed, all pollenating insects had died, cockroaches had overtaken, oxygen levels were diminished, and the crew had broken into warring factions. However, there were some positive findings: individuals recorded some health improvements, 83% food self-sufficiency was achieved, and much was learned about our capacity (or rather, incapacity) to design and manage ecosystems.[11]

Experiments in Space

As a container isolating and protecting plant life, the terrarium has a crucial role to play both metabolically and psychologically for humans undertaking long duration flights and living for extended periods in space stations and off-planet settlements. However, as the scientific literature attests, growing a humble lettuce in space is no simple thing: it means light, water, oxygen, carbon dioxide, temperature, and nutrition need to be precisely, and constantly, controlled.

The first terrarium containing a variety of plants in space was the "Oasis" greenhouse on Salyut 1, the first space station launched in 1971 by the USSR. Since then, terraria of one sort or another have been included in all space stations to study the potential of plants in micro-gravity conditions to supplement space traveler diets, filter air, cleanse waste water, and provide medicinal treatments. In 1975, Salyut 4 took the honor of hosting the first vegetable garden in space, and in 1982 aboard Salyut 7 the first flower in space was cultivated.[12] The Salyut missions also produced the first space-farmers of note, in particular Valentin Lebedev who, during his 211 days onboard Salyut 7, cultivated peas, lettuces, tomatoes, coriander, and onions. The first work of what we might call landscape architecture in space–that is, a garden designed "for the sole purpose of ornamental plant culture to provide psychological comfort to the cosmonauts"–was a terrarium built into the structure of Salyut 6 as a small picture window.[13] The current International Space Station has a fully automated micro-gravity garden the size of a suitcase, which contains more than 180 sensors relaying real-time information back to NASA's Kennedy Space Center.[14]

What all this research points toward is the prospect of building controlled, ecological life-support systems, replete with fertile soil, insects, animals, and plants, which could sustain large numbers of people indefinitely; in short, the colonization of other planets. Taking Mars as an example, however, the challenges are significant. On Mars, gravity is 1/100th of what it is on Earth, there is no readily available water, no nitrogen, the regolith contains aluminum (which is toxic to plants), and, in comparison to Earth, the climate is extreme. Furthermore, since it currently costs about $10,000 to put a pound of payload into Earth's orbit, launching even a modest pot-plant into space is prohibitively expensive.[15] But instead of hauling organic materials into space, NASA is asking if we could just grow them there. Just as life was once seeded on Earth, if the initial conditions could be sparked on other planets, then life's self-generative capacity could be harnessed.

Lynn Rothschild from the Ames Research Center is confident that biological engineering can overcome the challenges of creating life-support systems for humans in space.[16] It all begins with what she refers to as a "PowerCell." These designer cells would use solar radiation to convert carbon dioxide, nitrogen, water, and minerals into organic compounds such as sugars and proteins. Thus, she claims, "by the end of the decade, we will have taken the first steps towards realizing the vision of a synthetic biology enabled future off planet…Using organisms as feedstock, additive manufacturing through bioprinting will make possible the dream of producing bespoke tools, food, smart fabrics, and even replacement organs on demand."[17]

Beginning with the Wardian cases that enabled the British Empire to relocate tea production from China to India, to the creation of entirely new ecosystems in space, the seemingly innocent terrarium contains some of our wildest dreams and delusions. Today's equivalent to the classroom terrarium experiment with which this article began is a commercially available product known as the "Space Garden." The Space Garden is described by its manufacturers as "a ground-based version of the vegetable growth system designed for the International Space Station."[18] As advertised, the "Space Garden comes with all the materials needed to conduct biological agricultural and life science investigations, just like the astronauts. Each kit includes an expandable growth chamber, seeds, watering syringe, growth medium, and educational activities to introduce the science of plants in space in a fun – even an edible way!" And as it was in 1975 with school kids innocently fumbling over their terraria, when a Space Garden fails in today's classroom we can assume it will also trigger useful discussion. Only now, the teacher might have to explain that the terrarium experiment is not just a little symbol of the world, it is the world.

Acknowledgment
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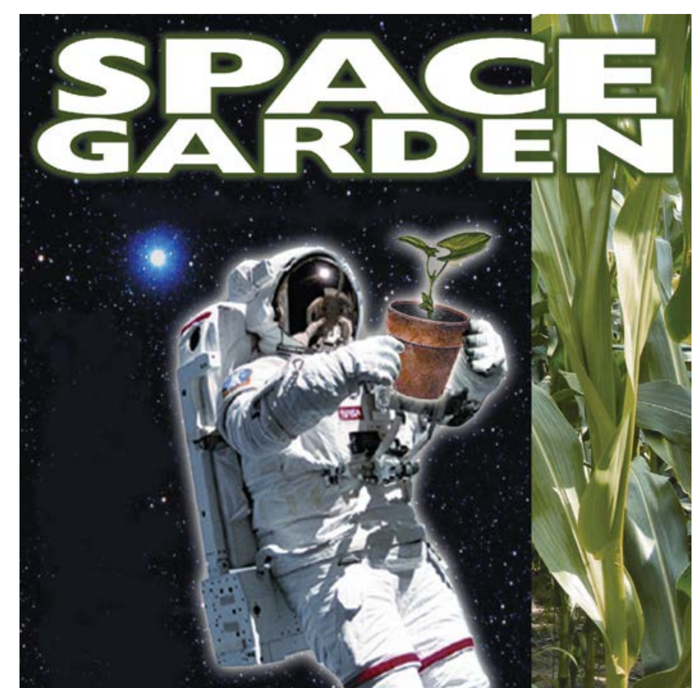

1 V. Daniel Ochs & Mary R. Brock "Bottle Biology," *Science and Children* 13, no. 2 (1975): 15–17.

2 David R. Hershey, "Doctor Ward's Accidental Terrarium," *The American Biology Teacher* 58, no. 5 (1996): 276-81. As for Ward's "discovery" there is evidence to suggest that the ancient Greeks and Romans had enclosed plants with rudimentary forms of glass to force growth.

3 John Claudius Loudon, *Remarks on the Construction of Hot-Houses* (London, 1817), 4 quoted in William Taylor, "The Cultivation of Reason: Functionalism and the Management of Nature" *Studies in the History of Gardens & Designed Landscapes* 18, no. 2 (1998): 130.

4 Andrew J. Huebner, "The Conditional Optimist: Walt Disney's Postwar Futurism," *The Sixties* 2, no.2 (2009): 227–44.

5 Ibid.

6 Buckminster Fuller, *Operating Manual for Spaceship Earth* (New York: Pocket Books, 1968).

7 John C. Tibbetts, "Ray Bradbury's EPCOT Adventure," *Storytelling* (2006): 57, at 60.

8 Frank B. Salisbury, Josef I. Gitelson & Genry M. Lisovsky, "Bios-3: Siberian Experiments in Bioregenerative Life Support," *BioScience* 47, no. 9 (1997): 575–85.

9 Ibid., 578.

10 Jordan Fisher Smith, "Life Under the Bubble," *Discovery Magazine* (October 2010) http://discovermagazine.com/2010/oct/20-life-under-the-bubble (accessed July 22, 2018).

11 Now owned and managed by the University of Arizona, Biosphere II is part tourist attraction, part white elephant, and part Landscape Evolution Observatory (LEO). In what appears to be an experiment relevant to terraforming alien environments or repairing those we have denuded here on earth the LEO consists of three artificial landscapes made up of as little preexisting organic material as possible. These are rigged with 1800 sensors monitoring how biomass changes over time: Luke A. Pangle, et al., "The Landscape Evolution Observatory: A Large-Scale Controllable Infrastructure to Study Coupled Earth-Surface Processes," *Geomorphology* 244 (2015) 190–203.

12 Sandra Haeuplik-Meusburger, et al., "Greenhouses and their Humanizing Synergies," *Acta Astronautica* 96 (2014): 148–50.

13 Robert Zimmerman, "Growing Pains: It's the One Area of Space Science in Which You Get to Eat the Experiment, *Air & Space Magazine* (September 1, 2003).

14 NASA, "Orbiting Agriculture," https://www.nasa.gov/missions/science/f_lada.html (accessed July 22, 2018).

15 Lynn J. Rothschild, "Synthetic Biology Meets Bioprinting: Enabling Technologies for Humans on Mars (and Earth)" *Biochemical Society Transactions* 44, no. 4 (2016): 1158–64.

16 Ibid.

17 Ibid.

18 Space Garden, http://www.spacegarden.net (accessed July 22, 2018).

Top: BIOS-3, Krasnoyarsk, 1972.

Middle: Biosphere II, 2008.

Bottom: Space Garden, Orbital Technologies Corporation.

Previous page: Montréal Biosphère, May 1976.

IMAGE CREDITS

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The Evolving Design of Our Life

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