



NO BUBBLE IS SEALED.

The Engineered Breathable Interior, from the Imperial
Glasshouse to the Terraformed Planet

I. Introduction: The Autonomous Interior

Three enclosures, two centuries, three scales. In 1844 Decimus Burton and Richard Turner began a house of glass and wrought iron at Kew to keep a tropical plant collection alive in a temperate country. In 1970 Ant Farm inflated a forty-by-forty-foot polyethylene bubble on a plaza at Berkeley and announced over a loudspeaker that the outside air had failed. Between 2015 and 2018 Foster + Partners designed a settlement to be printed from Martian soil by robots that would arrive, excavate, and finish the interior before any crew was admitted to it. The three share no program, period, or material. They share an operation: each manufactures a breathable interior by declaring an outside hostile and a boundary sufficient. I call that figure the autonomous interior.

The autonomous interior is a serviced interior that has learned to hide its servicing. Banham’s account of the well-tempered environment sets the terms: the modern interior is less enclosed than supplied, produced continuously by plant, fuel, water, and labour, and the discipline’s habit has been to treat that apparatus as something to be got out of sight.¹ Sloterdijk supplies the stakes. Once air itself becomes a design target explicated, conditioned, withheld enclosure stops being a question of shelter and becomes a question of who is permitted to breathe. ²Bennett supplies the cast: the coal, the tinted glass, the polyethylene, the circulating water, and the regolith are not instruments serving an autonomous interior but actants producing it, and the interior has no existence apart from them. ³ Latour supplies the diagnosis: the sealed interior is a Global that believes it has detached from the Terrestrial, when the Terrestrial is both what it is made of and where it discharges. ⁴Kallipoliti supplies the history: the closed world is a recurring twentieth-century project, and its recurrence is a record of its failures.

The three cases are read at ascending scale rather than in chronological order - body, ground, terrestrial - because the argument concerns what each enclosure must externalize in order to appear closed, and that quantity grows with the frame. The Clean Air Pod encloses a crowd for an afternoon; the Palm House encloses a climate in perpetuity; the Mars Habitat encloses a planet’s worth of absence.

An autonomous interior would have to refuse two things at once: any input from its environment, and any discharge into it. None of the three can. Each promises more environmental control than the last and conceals more dependence in the promising, and the outside each externalizes always returns: carbon dioxide in the bubble, soot on the glass, the Earth in every gram of the Martian shell. What separates them is not whether the seal holds, because **it never does**, but what each does with the fiction: the Pod confesses it, the Palm House conceals it, the Mars Habitat abandons the Earth in earnest on the strength of it. The sealed interior is therefore a political technology before it is a technical one. It privatizes survival, deciding what stays inside the frame, and who is left outside to breathe what is vented back.

II. Confessing the Fiction, The Clean Air Pod, Ant Farm (1970)

In spring 1970, the San Francisco collective Ant Farm, founded in 1968 by Chip Lord and Doug Michels, who called themselves “underground architects”⁶ staged Air Emergency on lower Sproul Plaza at the University of California, Berkeley, as part of a three-day environmental teach-in. Its instrument was the Clean Air Pod (CAP 1500), a forty-by-forty-foot polyethylene bubble inflated by salvaged fans. An air-raid siren drew a crowd; a loudspeaker announced that the outside air had failed and that anyone who could not reach shelter would die within fifteen minutes; gas-masked, white-coated members ushered onlookers into the pod and handed death-consent forms to those who refused. ⁷

The Pod literalizes the figure my research pursues: the sealed conditioned interior as a membrane dividing a breathable inside from a lethal outside (bubble habitat). Yet Ant Farm builds the contradiction into the object. Its “clean air” is not autonomous; it is produced by used fans, backed by generators, and held inside a skin of petroleum (chain of non-human actors). Ant Farm’s own manual is candid about this dependence, it advises that worn polyethylene is best disposed of by burning, releasing carbon dioxide and black smoke, and defends the membrane as a better use of oil than the internal-combustion engine. ⁸The refuge from pollution is itself a petroleum artifact, conditioned by the same industrial metabolism it indicts. Environmental autonomy here is not achieved but performed.

This is what separates the Pod from the earnest sealed interiors of the other case studies: it knows the autonomy is fiction and says so. The Inflatocookbook describes the inflatable interior as becoming, by turns, “a temple, a funhouse, a suffocation torture device, a pleasure dome.” ⁹ The same membrane that shelters can asphyxiate; refuge and confinement share one skin. The Pod stages exactly this ambivalence, survival made conditional on enclosure.

The project survives chiefly as media (fig. 2). The image is not a photograph of the event but an Ant Farm–designed front page a fabricated Oakland Tribune, its masthead fictively dated 1972, that reports the performance as news under the headline “Breathing-That’s Their Bag.” The mirrored ranks of white-coated figures, the deadpan caption, the official byline: the document does not record the work so much as extend it, collapsing the line between event, evidence, and advertisement. The Pod is communicated as a press release for a catastrophe, and in making the disaster a media object, Ant Farm shows how completely the promise of a conditioned interior is, even as protest, a thing produced, framed, and sold. **No Bubble is sealed.**



Figure 1. Ant Farm, compiled pages and a performance photograph from the Ant Farm Timeline, 1968–78; the Air Emergency material documents the Clean Air Pod at lower Sproul Plaza, University of California, Berkeley, 1970. Source: Felicity D. Scott, Ant Farm: Living Archive 7 (Barcelona: Actar, 2008).



Figure 2. Ant Farm, “Breathing-That’s Their Bag,” newspaper facsimile documenting the Clean Air Pod (“Air Emergency”), Berkeley, California, 1970. Source: Felicity D. Scott, Ant Farm: Living Archive 7 (Barcelona: Actar, 2008).

¹ Reyner Banham, *The Architecture of the Well-Tempered Environment* (London: Architectural Press, 1969).
² Peter Sloterdijk, *Terror from the Air*, trans. Amy Patton and Steve Corcoran (Los Angeles: Semiotext(e), 2009).
³ Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham, NC: Duke University Press, 2010).
⁴ Bruno Latour, *Down to Earth: Politics in the New Climatic Regime*, trans. Catherine Porter (Cambridge: Polity Press, 2018).
⁵ Lydia Kallipoliti, *The Architecture of Closed Worlds, or, What Is the Power of Shi?* (Zurich: Lars Müller Publishers, 2018).
⁶ Felicity D. Scott, *Ant Farm: Living Archive 7* (Barcelona: Actar, 2008).
⁷ Ant Farm, “Breathing-That’s Their Bag,” newspaper facsimile documenting the Clean Air Pod (“Air Emergency”), Berkeley, 1970, reproduced in Scott, *Ant Farm: Living Archive 7*.
⁸ Ant Farm, *Inflatocookbook* (San Francisco: Ant Farm, 1973), “Materials: Recycling.”
⁹ Ant Farm, *Inflatocookbook*, “A Course in Getting Acquainted with Inflatables.”

III. Hiding the Furnace, The Palm House at Kew (1844–48)

If the Pod admits its debts, the glasshouse spends its engineering on hiding them. It also works one scale up: not a crowd sheltered for an afternoon, but a climate held in perpetuity. The Palm House at the Royal Botanic Gardens, Kew, designed by the architect Decimus Burton with the Dublin iron-founder Richard Turner, who was responsible for its structure, heating, and glazing (1844–48), was built to keep alive a tropical plant collection (non-human actor) that England’s temperate climate could not sustain.¹⁰ It is less a building for people than a machine for plants. When the botanist John Lindley and the physicist Robert Hunt warned that clear glass would scorch tropical foliage, Kew commissioned Hunt to run experiments on light and plant growth and to specify a green glass, tinted with copper oxide, that filtered the scorching rays while passing the light the plants needed to build woody fibre.¹¹ The intended occupants were the palms; the interior light itself was engineered for tropical bodies. What the building set out to make (a self-sustaining tropical world under glass) is an autonomous interior, sealed off from the temperate English weather around it.

Turner’s aim for the glass was that it be so clear “you won’t see that glass is there,”¹² and heat, humidity, and rain were supplied on command by twelve boilers, hot-water tanks, and a lattice of perforated pipes.¹³ The tropical climate was an assembly of working parts (boiler, coal, wrought iron, tinted glass, circulating water, and filtered light) each an actor in producing an interior that presented itself as an untended paradise.¹⁴

The autonomy of that interior depended on machinery the design took great care to hide. The boilers were sunk in vaults beneath the floor, and their smoke was carried through an underground tunnel roughly five hundred feet east to a chimney that Burton dressed as an Italian Romanesque campanile, which also held the water tank feeding the sprinklers inside.¹⁵ The furnace that kept the paradise warm was buried and disguised as ornament. What the house contained was not only a tropical climate but the botanical wealth of empire: Kew sat at the centre of a colonial network that moved economic plants (cinchona, rubber, oil palm) between territories, and the Palm House put the living capital of that traffic on display.¹⁶ Posed as an artificial paradise against the smoke of the industrial city, the glasshouse kept out of sight the coal economy that warmed it and the imperial extraction that stocked it, both pushed past the frame it offered the visitor.¹⁷

The seal did not hold. From the 1880s the coal smoke of the very industrial city the glasshouse defined itself against drifted over Kew and settled on the roof, and the combination of atmospheric soot and the tinted glass cut the transmitted light so far that plants could no longer be grown; by the 1930s the green glazing was given up altogether.¹⁸ A visitor had once seen the emerald glass “glowing like a mass of gigantic fiery opals”; within decades the same panes had blackened with the city’s exhaust.¹⁹ The autonomy the Palm House manufactured was never real. It was produced by, and finally undone by, the earthbound world it claimed to shut out: the coal it burned, and the polluted air that coal sent back through its roof. The paradise had no outside it could do without: **No Bubble is Sealed.**



Figure 3. Frederick York, Interior of the Palm House, Kew Gardens; stereoview photograph, Royal Botanic Gardens, Kew, 1860s. Public domain. Source: Wikimedia Commons.

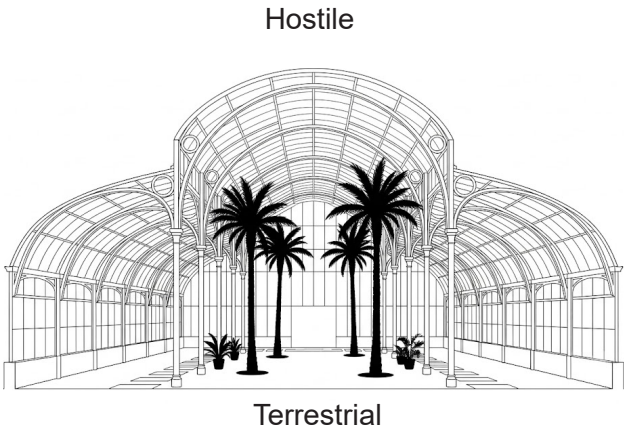


Diagram 1



Figure 4. Adrian Pingstone, Palm House, Royal Botanic Gardens, Kew (Decimus Burton, architect, and Richard Turner, engineer, 1844–48); colour photograph, exterior, 2004. Public domain. Source: Wikimedia Commons.

IV. Leaving the Ground, The Mars Habitat, Foster + Partners (2015–18)

Foster + Partners’ Mars Habitat, developed between 2015 and 2018 for the NASA / America Makes 3D-Printed Habitat Challenge, proposes a settlement for up to four astronauts printed from regolith, the loose soil and rock lying on the surface of Mars. It is a habitat for people that no person builds. The practice’s own account sets out the sequence: pre-programmed, semi-autonomous robots arrive first, select the site, and excavate a crater a metre and a half deep; a second delivery lowers inflatable modules into that crater to form the core of the settlement; the machines then print the shell over them.²⁰ The astronauts land into a finished interior. Where the Palm House was rebuilt around palms that had already outgrown it, and the Clean Air Pod was inflated around the bodies queuing to get inside, the Mars Habitat is sealed before anything living is admitted to it. Its first inhabitants are its builders, and they are not human. The domes belong to a lineage: the gridded shells in the construction diagram are descendants of Fuller’s geodesic enclosures, and they inherit his premise that a world can be made whole by giving it a hull.²¹ They inherit the economics of that lineage along with its forms.²²



Figure 5. Foster + Partners, Mars Habitat, exterior rendering of the regolith-printed settlement (NASA / America Makes 3D-Printed Habitat Challenge); digital rendering, London, 2015. © Foster + Partners. Source: Foster + Partners, fosterandpartners.com/projects/mars-habitat.

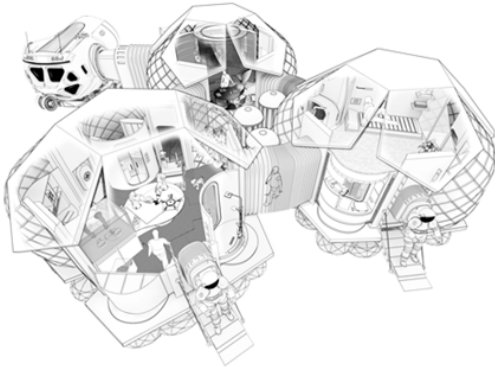


Figure 6. Foster + Partners, Mars Habitat, diagram of the semi-autonomous construction robots and the Regolith Additive Construction (RAC) process; digital rendering, London, 2015. © Foster + Partners. Source: Dezeen, “Foster + Partners reveals concept for 3D-printed Mars habitat built by robots,” 25 September 2015, dezeen.com/2015/09/25/foster-partners-concept-3d-printed-mars-habitat-robots-regolith.

¹⁰ Edward J. Diestelkamp, “Richard Turner and the Palm House at Kew Gardens,” in *Structural Iron, 1750–1850*, ed. R. J. M. Sutherland (Aldershot: Ashgate, 1997), 77; Henrik Schoenefeldt, “The Use of Scientific Experimentation in Developing the Glazing for the Palm House at Kew,” *Construction History* 26 (2011): 19.
¹¹ Schoenefeldt, “Scientific Experimentation,” 28–33.
¹² Schoenefeldt, “Scientific Experimentation,” 20, quoting Turner’s project correspondence.
¹³ Schoenefeldt, “Scientific Experimentation,” 30–33.
¹⁴ Bennett, *Vibrant Matter*.
¹⁵ Diestelkamp, “Richard Turner.”
¹⁶ Richard Drayton, *Nature’s Government: Science, Imperial Britain, and the “Improvement” of the World* (New Haven, CT: Yale University Press, 2000).
¹⁷ Drayton, *Nature’s Government*.
¹⁸ Schoenefeldt, “Scientific Experimentation.”
¹⁹ Gardener’s *Chronicle* (1848), quoted in Schoenefeldt, “Scientific Experimentation,” 34.
²⁰ Foster + Partners, “Mars Habitat,” project description, accessed July 23, 2026, <https://www.fosterandpartners.com/projects/mars-habitat>.
²¹ R. Buckminster Fuller, *Operating Manual for Spaceship Earth* (Carbondale: Southern Illinois University Press, 1969).

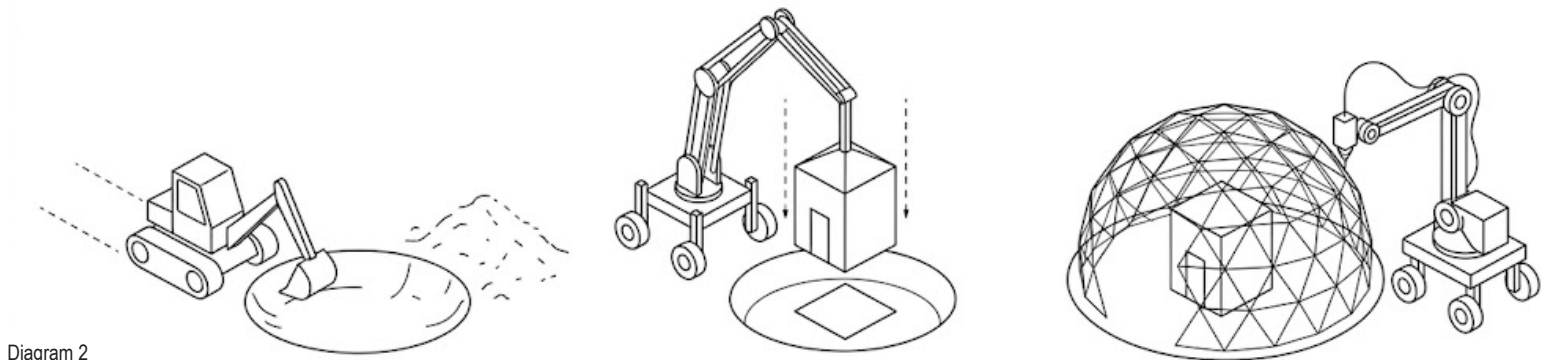
²² Fred Scharmen, *Space Settlements* (New York: Columbia Books on Architecture and the City, 2019).
²³ M. C. Roman et al., “From 3D-Printing Lunar and Mars Habitats to Affordable Sustainable Housing on Earth” (paper presented at the 50th International Conference on Environmental Systems, Lisbon, July 12–16, 2020), NASA Technical Reports Server, 3, 5, 8.
²⁴ Bennett, *Vibrant Matter*.
²⁵ Foster + Partners, “Mars Habitat.”

Every element of that interior is fabricated, and two of its materials deserve naming. The first is the ground itself: Regolith Additive Construction fuses Martian soil into the protective shell, from a feedstock roughly seventy per cent indigenous Martian material²³ The second is the vehicle: the remaining fraction is recycled from the mission that delivered it, so the craft that crossed the distance is shredded into the wall that denies the distance ever had to be crossed. Regolith, robot, and recovered polymer are not instruments serving the interior’s autonomy. They are the actors producing it.²⁴

The Palm House hid its furnace. The Mars Habitat hides nothing, and this is what makes it the harder case. Foster names the constraint openly: the distance from Earth and the communication delay it produces make real-time supervision impossible, so construction proceeds with minimal human input, the robots working to “rules and objectives rather than closely defined instructions,” which the practice presents as an advantage, a system given ends rather than steps can absorb conditions nobody anticipated.²⁵ It is tempting to read this as agency passing from the human to the nonhuman, and that reading is the project’s most useful concealment. The latitude granted to the machines is not autonomy. It is a delegation: the objectives were written in London, the algorithms trained on terrestrial data, the bodies executing them fabricated and launched from Earth. A robot improvising on Mars is not an independent agent but the Earth extended, working in a different body. Autonomy does not transfer down a chain of delegation; it only disperses the question of who decided, and the answer stays where the objectives were set. The human–nonhuman division that appears to distribute agency across the settlement in fact conceals that both sides of it are terrestrial.

The Mars Habitat does not even attempt the closure the other two claimed. It carries a year of supplies and no biosphere; its shell is radiation mass, stopping some incident energy and not the rest; the pressure vessel, the air, the water, the food, the instruments, the bodies, and the entire body of knowledge that makes the attempt thinkable all remain terrestrial. What it substitutes for closure is distance. The supply line is not severed, only stretched until it stops being visible, and a dependence too far away to be seen is still a dependence. Contained: a breathable interior. Externalized: the Earth.

The seal has never been tested. The largest piece of the Mars Habitat that exists is a 1.5-metre dome, printed for the competition’s second phase at Caterpillar’s facility near Peoria, Illinois, and then crushed to find the load at which it failed. The rest is documentation: renderings, a navigable model, a set of algorithms, and a reinforced polymer that passed directly into commercial supply on Earth, where NASA states the challenge’s second purpose plainly: habitats for Mars, and affordable, sustainable housing here.²⁶ Writing for AD in 2011, the practice’s Specialist Modelling Group had described its work as project-driven rather than academic research and named its central difficulty as closing the loop between design and performance; the Mars Habitat is that method at its limit, a project with no client, no site conditions, no users, and no possibility of contradiction, which leaves the Earth in order to return to it as technique²⁷. Fuller called the planet a spaceship in order to argue that its passengers were bound to it. Half a century later the figure is turned around and a spaceship is built in order to leave. The direction changes; the error does not. Every breath the habitat proposes is still the Earth’s, and there is no Global to escape into that is not made of the Terrestrial it claims to have left behind.²⁸ The autonomy the Mars Habitat manufactures was never real either. It has no outside it can do without: **No bubble is sealed.**



VI. CONCLUSION

Across two centuries and three scales the operation does not change. Each interior draws a line, calls what is inside conditioned and what is outside hostile, and then depends on the outside for the conditioning. The Palm House’s paradise ran on the coal of the industrial city it was posed against, and the smoke of that city settled on its roof and darkened the light its plants required. The Pod’s clean air was held in a petroleum skin and would have turned toxic on the breath of the people it admitted. The Mars Habitat’s shell is Martian soil bound with a shredded spacecraft, printed by machines carrying terrestrial objectives, sheltering bodies fed for a year from Earth. Containment is always a decision about the frame, and every frame externalizes.

What differs is the honesty. The Pod confesses: it names the oil in its own skin, hands out consent forms, and makes the fiction of clean air the content of the work. The Palm House conceals: it buries the boilers, tunnels the smoke five hundred feet, and dresses the flue as a campanile, so that the visitor sees a paradise and not a furnace. The Mars Habitat abandons: it does not hide its dependence so much as move it out of view, substituting distance for closure and offering the delegation of construction to machines as though that were the same thing as independence. The three form a sequence of increasing ambition and increasing self-deception, and only the first of them is honest about what a membrane actually does.

The significance is not antiquarian. The sealed interior has become the ordinary response to environmental failure: the filtered tower, the conditioned compound, the private supply of clean air, the off-world settlement floated as an investment thesis.²⁹ If autonomy is unavailable, if no interior can refuse both input and discharge then each of these is not a solution but a distribution. It decides who stands inside the membrane, who is handed the consent form, and who breathes what is vented back. Latour’s terrestrial politics begins from the refusal to treat the Global as a place one can actually go.³⁰ The three projects here are the architectural form of that refusal being ignored. Designing as though a seal were possible is not a technical error but a way of not counting the ground and the people on the other side of it. **No bubble is sealed.** The only question a designer actually gets to answer is what the unsealed outside is made to carry.

²⁶Roman et al., “From 3D-Printing,” 3, 5, 8..
²⁷Hugh Whitehead et al., “Driving an Ecological Agenda with Project-Led Research,” *Architectural Design* 81, no. 6 (November/December 2011): 28–35.
²⁸ Latour, *Down to Earth*.
²⁹ Scharmen, *Space Settlements*.
³⁰ Latour, *Down to Earth*.

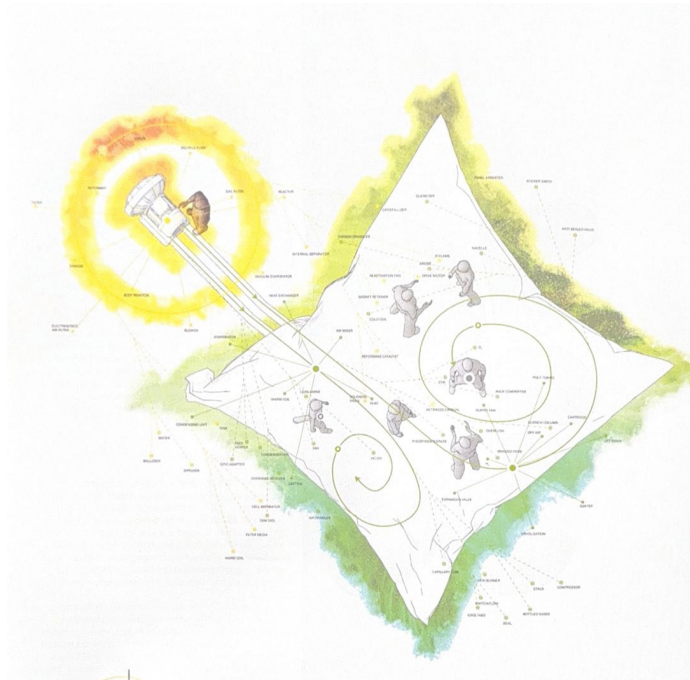


Figure 7 . Lydia Kallipoliti, “Is It Safer to Breathe Inside a Sealed Plastic Pod or Outside?” feedback/systems diagram of Ant Farm’s Clean Air Pod; ink and digital drawing, 2018. In *The Architecture of Closed Worlds* (New York: Lars Müller / Storefront, 2018), 12

V. REFERENCES

- Ant Farm.** “Breathing-That’s Their Bag.” Newspaper facsimile documenting the Clean Air Pod (“Air Emergency”), Berkeley, California, 1970. Reproduced in Felicity D. Scott, *Ant Farm: Living Archive 7*. Barcelona: Actar, 2008.
- Ant Farm.** *Inflatocookbook*. San Francisco: Ant Farm, 1973.
- Banham, Reyner.** *The Architecture of the Well-Tempered Environment*. London: Architectural Press, 1969.
- Bennett, Jane.** *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke University Press, 2010.
- Diestelkamp, Edward J.** “Richard Turner and the Palm House at Kew Gardens.” In *Structural Iron, 1750–1850*, edited by R. J. M. Sutherland, 77–102. Aldershot: Ashgate, 1997.
- Drayton, Richard.** *Nature’s Government: Science, Imperial Britain, and the “Improvement” of the World*. New Haven, CT: Yale University Press, 2000.
- Foster + Partners.** “Mars Habitat.” Project description. London: Foster + Partners, 2015. <https://www.fosterandpartners.com/projects/mars-habitat>.
- Fuller, R. Buckminster.** *Operating Manual for Spaceship Earth*. Carbondale: Southern Illinois University Press, 1969.
- Gardener’s Chronicle.** 1848. Quoted in Henrik Schoenefeldt, “The Use of Scientific Experimentation in Developing the Glazing for the Palm House at Kew,” *Construction History* 26 (2011): 34.
- Kallipoliti, Lydia.** *The Architecture of Closed Worlds, or, What Is the Power of Shit?* Zurich: Lars Müller Publishers, 2018.
- Kohlmaier, Georg, and Barna von Sartory.** *Houses of Glass: A Nineteenth-Century Building Type*. Translated by John C. Harvey. Cambridge, MA: MIT Press, 1986.
- Latour, Bruno.** *Down to Earth: Politics in the New Climatic Regime*. Translated by Catherine Porter. Cambridge: Polity Press, 2018.
- Roman, M. C., Michael R. Fiske, Shadi Nazarian, Melodie Yashar, Jason Ballard, Michael Bentley, Platt Boyd, and Amanda Moon Adams.** “From 3D-Printing Lunar and Mars Habitats to Affordable Sustainable Housing on Earth.” Paper presented at the 50th International Conference on Environmental Systems, Lisbon, Portugal, July 12–16, 2020. NASA Technical Reports Server. <https://ntrs.nasa.gov/api/citations/20200011613/downloads/20200011613.pdf>.
- Scharmen, Fred.** *Space Settlements*. New York: Columbia Books on Architecture and the City, 2019.
- Schoenefeldt, Henrik.** “The Use of Scientific Experimentation in Developing the Glazing for the Palm House at Kew.” *Construction History* 26 (2011): 19–39.
- Scott, Felicity D.** *Ant Farm: Living Archive 7*. Barcelona: Actar, 2008.
- Sloterdijk, Peter.** *Terror from the Air*. Translated by Amy Patton and Steve Corcoran. Los Angeles: Semiotext(e), 2009.
- Whitehead, Hugh, Irene Gallou, Harsh Thapar, Giovanni Betti, and Salmaan Craig.** “Driving an Ecological Agenda with Project-Led Research.” *Architectural Design* 81, no. 6 (November/December 2011): 28–35.

Notes On AI usage

I used Claude (Anthropic) as a research assistant: to help locate, verify, and cross-reference passages in those sources, to synthesize the relevant evidence from them, to test and sharpen the argument, to structure the case-study texts and the paper outline from my direction, to draft the introduction and conclusion from that outline, to assemble the three case studies into this continuous draft, and to format the citations in Chicago Manual of Style (notes–bibliography). I reviewed, revised, and edited the text throughout; the interpretation and final wording are my own.