How can biomimicry inform a sustainable,
ethical future in architecture and design?

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An undergraduate honors thesis submitted in partial fulfillment of the
requirements for the degree of
Bachelor of Science
in
University Honors
and
Architecture

Thesis Adviser
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Portland State University
2022

My work is rooted in spirit of the American technoutopian counterculture of the 1960s and 1970s, most potently exemplified by Richard Brautigan's 1967 poem, "All Watched Over by Machines of Loving Grace."[1]

I like to think (and
the sooner the better!)
of a cybernetic meadow
where mammals and computers
live together in mutually
programming harmony
like pure water
touching clear sky.

I like to think
(right now, please!)
of a cybernetic forest
filled with pines and electronics
where deer stroll peacefully
past computers
as if they were flowers
with spinning blossoms.

I like to think
(it has to be!)
of a cybernetic ecology
where we are free of our labors
and joined back to nature,
returned to our mammal
brothers and sisters,
and all watched over
by machines of loving grace.

I pull from several points of significance in my design endeavors. At first pass, perhaps the most notable theme is the convivial relationship between nature and machine. Depicted longingly in its pastoral essence, nature is unmarred by the presence of computers. Opposite sides of the same horizon, they coexist as poles attract. Posed without regard to productivity or contemporary notions of progress, computers lay among flora as harbingers of a pastoral utopia, irrevocably enmeshed.

Deeper lies the notion that that technology may liberate us from labor, such that we may return to our cohabitive roots. At the time of the poem's conception, cybernetic researchers, an emerging breed, busied themselves with the comparative study of biological and technological automated control systems.[2] Inspired by the advent of the internet, Brauntigan figured cybernetics into our future as modulator, maintainer of homeostasis, perhaps overseer of all things technological and ecological. Idealists envisioned an internet induced flow state in which systems, simplified to perfection, maintained themselves.

The poem pulls from cybernetics' humanist roots, largely established and upheld by a divergent group of MIT computer developers that worked to transform the early computer from centralized processors to tools for personal liberation in the 1970's.[3] The researchers' intent is indicative of a technological optimism and humanistic revival held by Brautigan I intend on amplifying in the fields of architecture and design. As I'll expound upon, though, I'd like to push against the notion that technology exists to systematize and serve. Rather, the restorative power in technology lies in its generative capabilities and plastic spirit, as best exemplified by biomimicry.
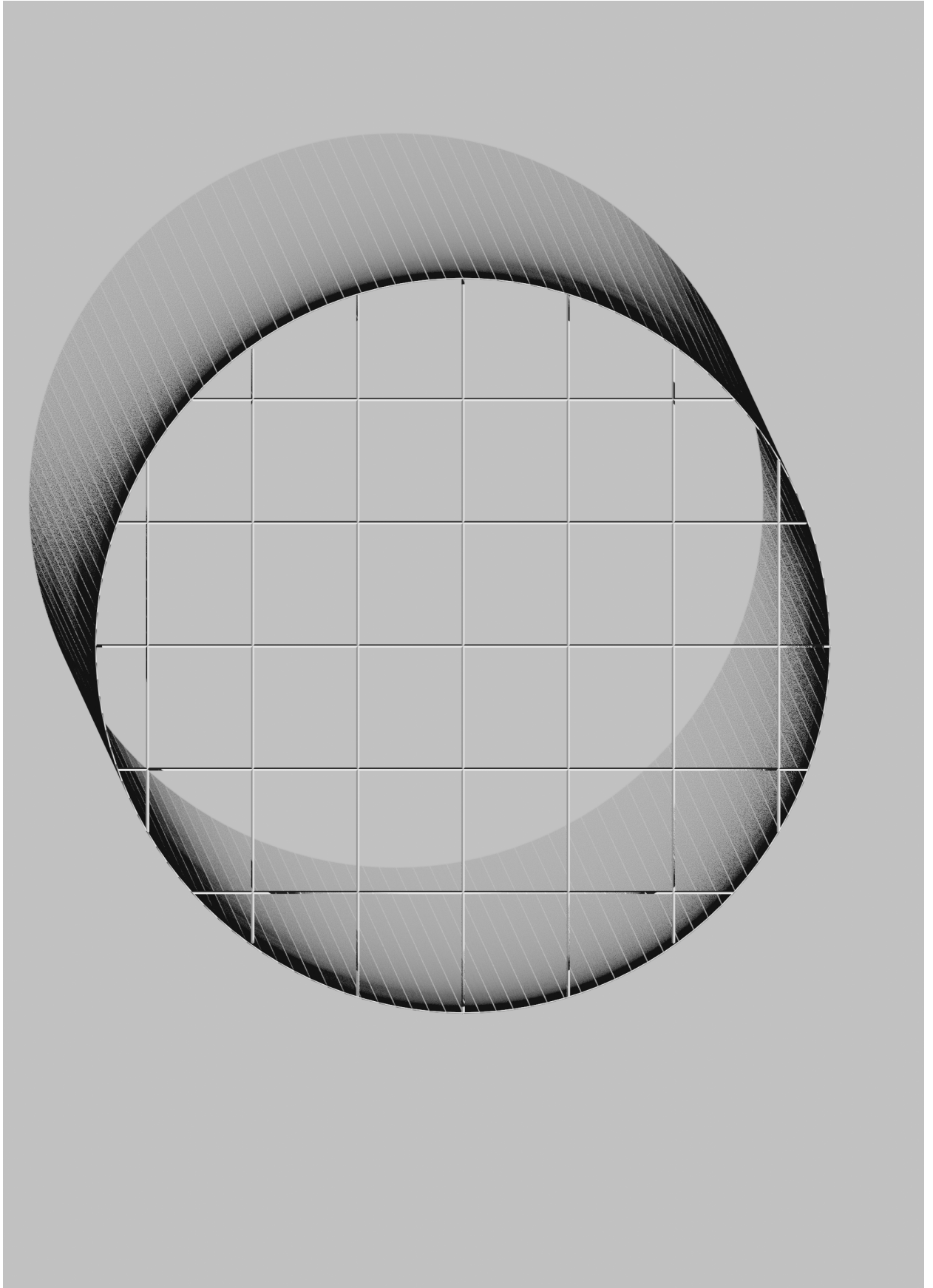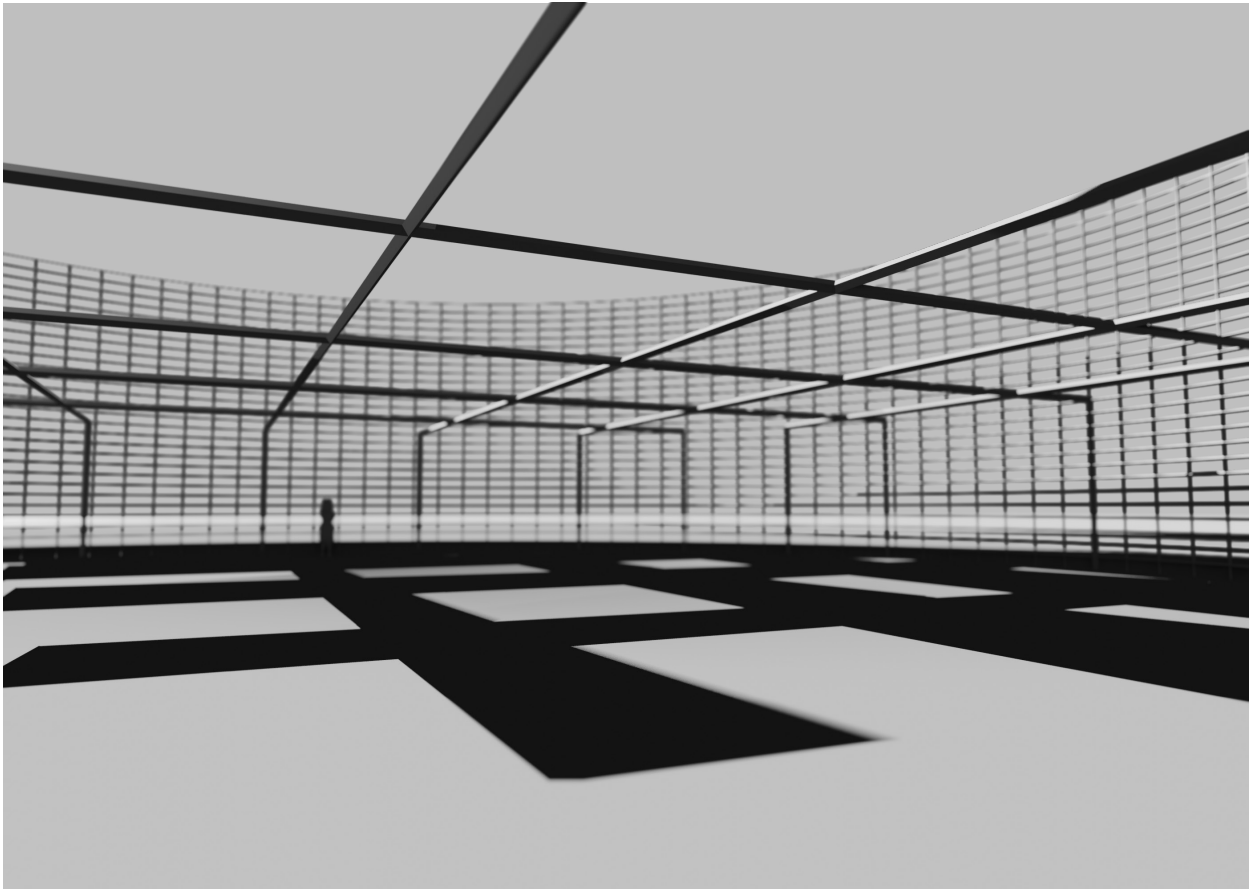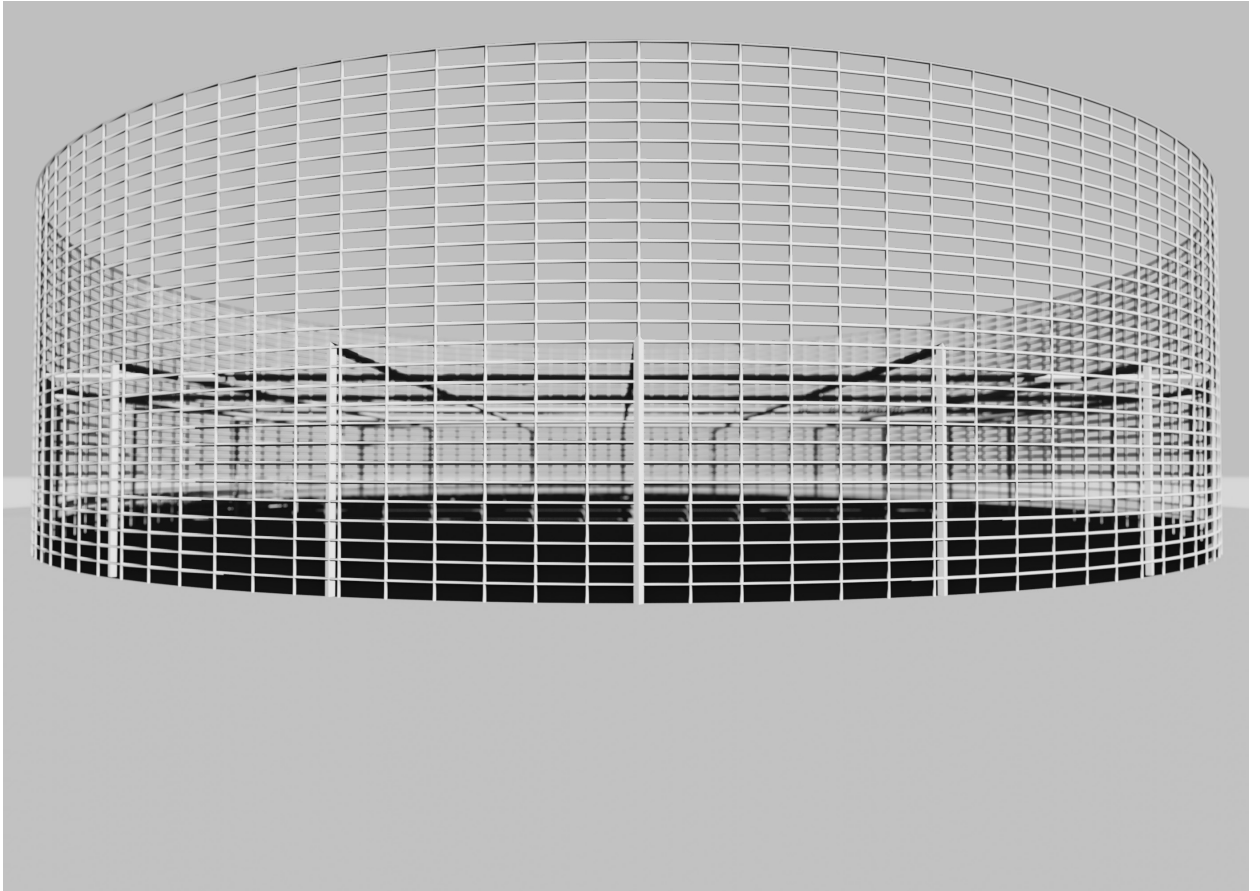
Idealized notions of Earth as a holistic entity permeated down ontological arteries into a Systems Theory of Everything in during the height of the American counterculture, as collaborative research methods blossomed.[4] Scientists and beatniks alike strove to replicate Earth in all its utopian splendor within self sustaining systems of inhabitation, seeking asylum from political instability, a deteriorating planet, and its material reality. An architecture of closed systems emerged, gaining popularity in the 1960's as "an architecture of containment and detachment…. demarcated from its surroundings by a boundary that does not allow for the transfer of matter of energy."[5] They took the form of solitary space bubbles, domestic homesteads, regenerative megastructures, and everything in between.

Though noble in theory and intention, the phenomenon was indicative of an all too elementary understanding of habitation and societal relations. These systems, conceived as one may the "circle of life," fell victim to the complexities of human character and biological obscurity. The ultimate failure of closed architectural systems such as the 37 listed in Lydia Kallipoliti's The Architecture of Closed Worlds was attributed but not limited to:

lack of clinical data, lifespan, leakage, uncontrolled descent, suffering, nitrogen buildup, fatalities, scaling problems, more scaling problems, inaccuracy, fake house, oddity, concealed appliances, plexiglass warp and yellowing, Went versus Climatron Board of Trustees, reglazing, unexpected minute contaminants, feedback visualization, closure and wishful thinking, data accuracy, seeing as believing, lost in reflection, umbilical cord, guinea pigs, depression, the architecture of composting, retaining mouldered matter, commercialization, capturing colloidal solids, homemade power, inventor's house, Disney's death, anachronism, Mickey Mouse the Dictator, exhausted master, survival fear, mediation, wishful thinking, bacterial flocking, water recovery, demoralized gerbils, malfunctioning machinery, debatable exchange, prop, toxic buildup, basement leakage, manhole leakage, effort and caring, small-scale problems, equilibrium, autonomy feeling, sick house, the architect's diploma, methane quality, mother earth news digester, design impact, financing the vicarage, travel hurdles, not a school, suntek, cloud gel and the heat mirror, profit extrapolations, envelope thickness, poor maintenance, behavioral change, aesthetic experience, trombe wall malfunction, rapid temperature fluctuations, return to nature, the myth of balance, anti-science, living enclosure, mass production, to travel or not to travel, women as seamstresses, energy bill, consumerism as public space, dizziness, capital cost, upgrading, self-sufficiency and privatization, upscaling, off-gassing, butterfly effect, atmospheric dystopia, hunger, notoriety, the dirty business of composting, camouflage, time lapse, unbuilt, language, syntax, and form, plus ultra, closure, earthbound, maintenance, water usage, middle ground, didactics, figure-ground, slowness, boredom, circadian rhythm reduction, verisimilitude, compromise, unearthing daily habits, buzzwords[6]

In short, the unintended consequences of artificially embodied systems timelessly lead to their demise. A closed system, in that it accounts for a specific set of inputs, outputs, and behaviors, proved to be incapable of handling the complexity of being both object of performance and subject of human phenomena. The items in Kallipoliti's list all wrought unintended waste in the systems they ravaged, leaving her to pose the proposition that one must "look at shit"[7] in order to effectively make use of the ecology of life.

Timothy Morton offers a different approach to ecological thinking and future imagining in his Dark Ecology, one that steps away from systems thinking and towards an ethos that entertains the inevitability of decay, disorder, and strangeness in all things systemic. His model system is at once asystemic, because after all,

"Every attempt to reduce a system to simplicity… ends up with the system reproducing itself, flowering into contradiction…. For every logical system there is a Godel sentence."[8]

The fabric of this statement folds in on itself, with simplification to blame. Morton pushes the notion that systems are defined by duality, in that as one sterilizes and simplifies one side, refuse oozes out the other. The correlating vessel may only hold so much ooze before it pushes past the barrier we've contrived, returning with a vengeance to its system of origin. Here, Morton insists that the presence of the ooze is vitally inevitable. In fact, the key to cohabitation and ecological viability may lie within the ooze.

The tendency to rationalize is only natural, and in an environment driven by data, one may be provoked by the tantalizing notion of systematic stability. However, systems models of cognition and cohabitation are deleteriously limited and ultimately self destructive. Where systems thinking sought to automatize existence, its architectural manifestations to liberate individual from interspecies agitation, a cognition informed by the limitations of systems thinking seeks to learn from moments of cohesion and furor all the same. It acknowledges spatial and temporal multiplicity, and multispecies framing. It requires the absolute awareness of our cognitive limitations here and now. Fertilized by systemic waste, it flowers into new ways of supposing.
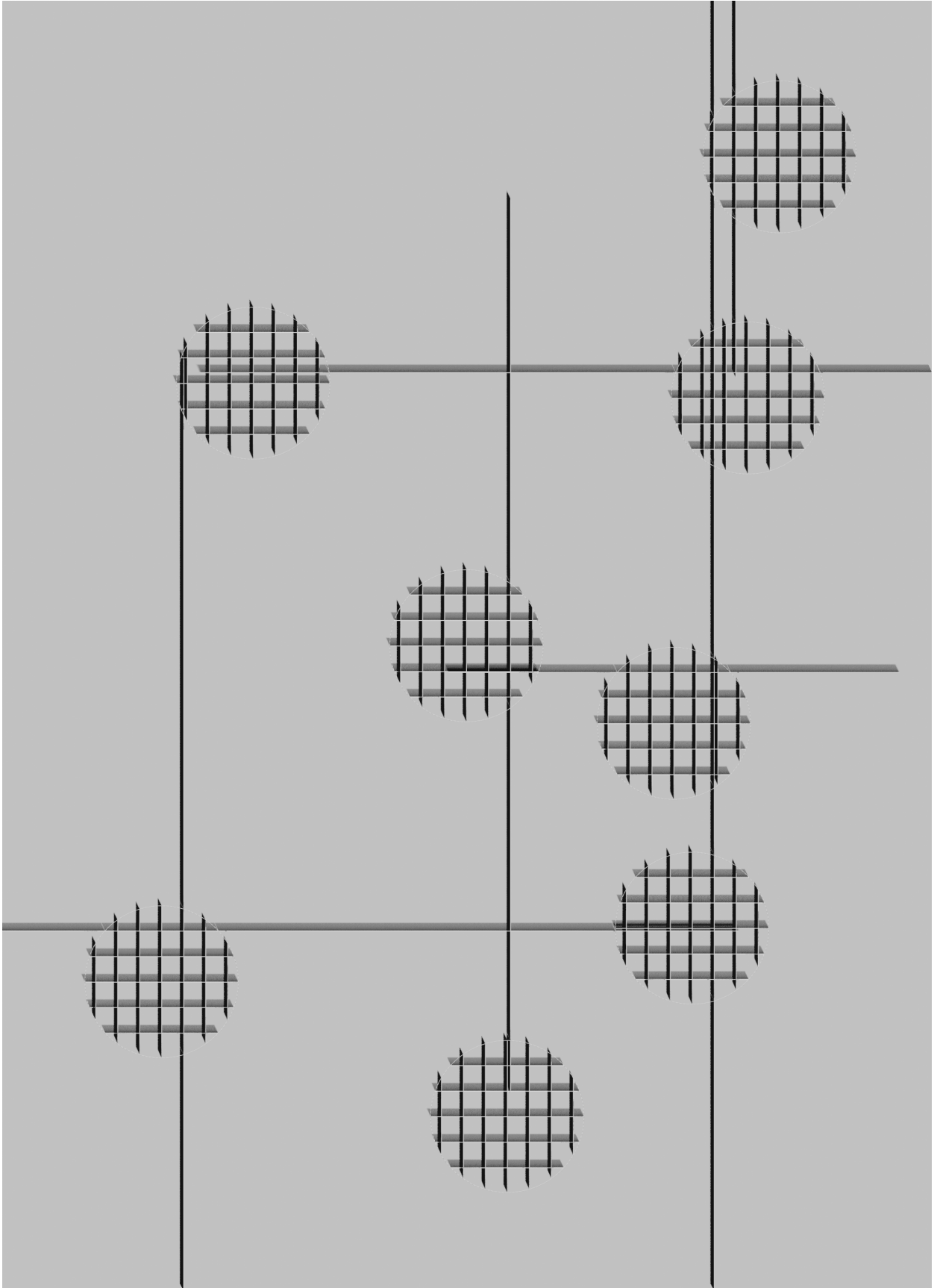
Anna Lowenhaupt Tsing's work in anthropology poses systems as mere thought experiments, subsidiary to assemblages in all their structural disparity. It addresses the anthropogenic interpretation and contextualization of the Anthropocene in which we reside, most commonly marked by the 1950 advent of hyper-industrialization. In response to modern advancements such as monoculture, factory farming, and mass manufacturing, asystemic patches thrive as harbingers of multispecies histories in Tsing's anthropology, revealing an anthropology of more-than-human social relations as nonsecular cosmologies.[9] Ghosts, the material and ethereal relics of our industrial past and present, mar our landscapes and haunt our futures.[10] Monsters, ecological disruptors that flourish in the face of modern industrial progress, portray the enmeshed nature of our multispecies engagements.[11] Together, they offer contemporary ways of knowing and imagining.

Tsing's nonsecular cosmologies imply that boundaries are illusory because systems are as interdependent as their entities. On a cellular level, our bodies are more bacteria than human. These bacterial assemblages play vital roles in digestion and immunity, and everything in between.[12] From the same endeavors that sought to eliminate impurities from environment and industry unfolds medical anomalies and immunodeficiencies. This example of interspecies relation is potent in its immediacy and making waves in medicine. Yet, the power in this phenomenon is its ability to push against our long established canon of western individualism, hierarchical relations, and purity of intellect. If the body itself is simply a vessel for bacterial symbiosis, what of multispecies assemblages and social groupings?

In the social sciences, assemblages are increasingly used as a lens through which one may conceive "indeterminacy, emergence, becoming, processuality, turbulence, and the sociomateriality of phenomena."[13] In an urban context, assemblage thinking "is interested in emergence and process, and in multiple temporalities and possibilities."[14] Cities as systems in the here and now become planes in flux, their spatial and temporal agency marred by the complexity of their positionality. Assemblage thinking questions the very nature of systems, in that systems converge and diverge, that the borders between systems are arbitrarily vague, and that feral proliferation is an essentially indeterminable yet seldom acknowledged component of any system. Bodies, economies, and technologies commingle as material characters in dialogue.

A materiality informed by assemblage thinking is at once heterogenous and structural, plastic and static. It acts as mesh, bending to contemporary conditions and filtering what it must. It defines space by the assemblages it contains, permissive of multispecies cohabitation. In its plasticity, it flows.
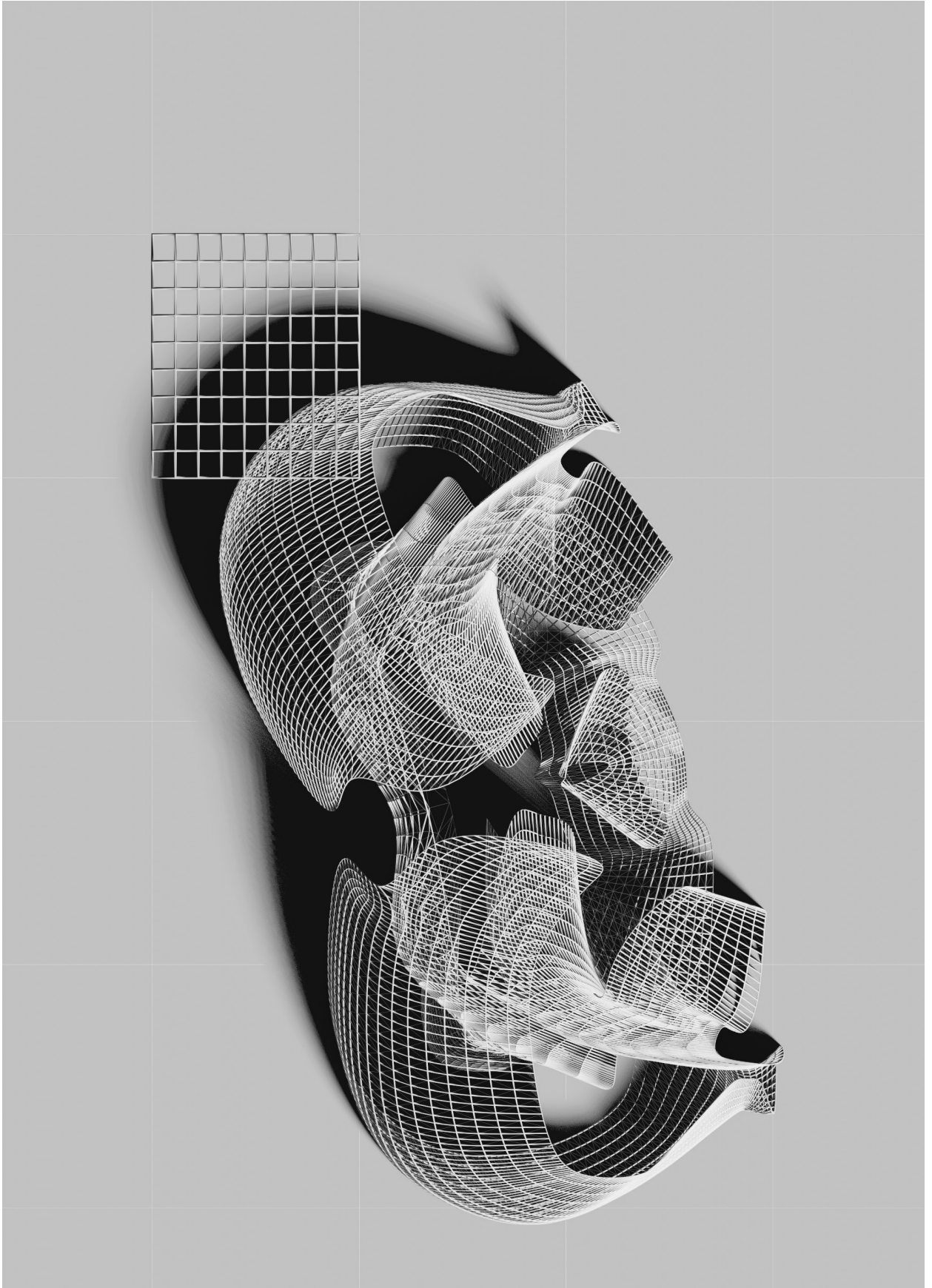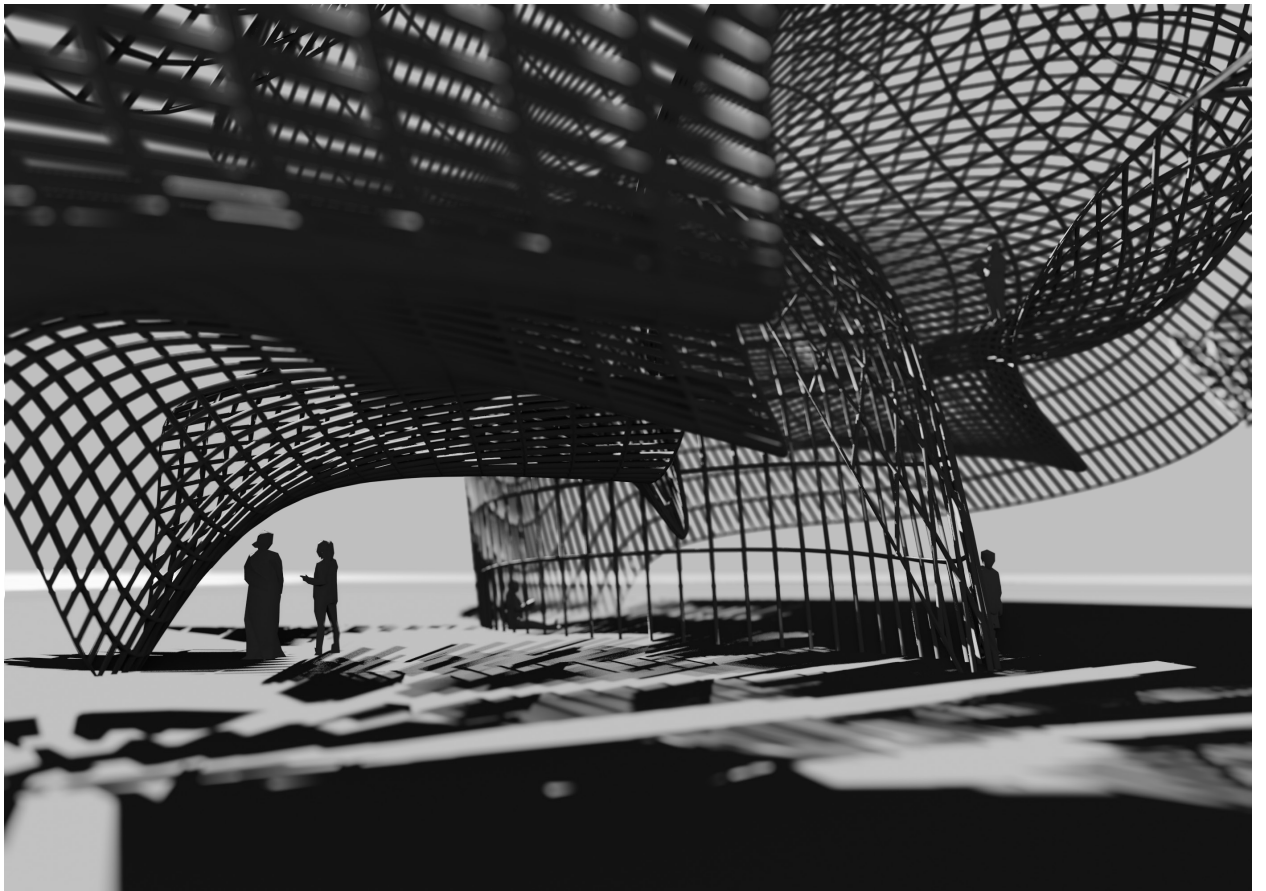
Biomimicry, defined loosely as the unification of biology and technology, has been used to accomplish compelling feats of ingenuity. Perhaps the most familiar contemporary example is the swift Japanese bullet train, its shape informed by the anatomy of a kingfisher bird.[15] At once technological and ecological, biomimicry is posed at the boundary of systems thinking and systemic abdication. It is systemic in that it draws influence from biological systems, yet endemic in the biological field is the knowledge that natural systems are conditionally interconnected, and each small scale system exhibits discontinuity and separation within a greater ecosystem.[16] The fabric of this system twists and folds in response to changing phenomena, its structural stitching submissive to the flow. This plasticity and interconnectivity is fundamental to notions of biodiversity, coexistence, and ecological resilience today.[17]

Biologists arrived here by the same means designers are driven. When confronted by systemic discontinuity (horizontal gene transfer, symbiosis, sympoesis)[18] and instability (feral proliferation),[19] they broadened their understanding of the world around them and the task at hand. Notions of coexistence and multispecies inhabitation are no longer reserved for the arts and humanities, for the romanticists, or for the cybernetic optimists. Rooted in observation and adaptation, they necessitate a multidisciplinary reframing.

In light of this disciplinary convergence, Neri Oxman's MIT based Mediated Matter Group designs and constructs biomimetic materials and wearables modeled after human biology. In the spirit of "designing in nature's way,"[20] Oxman's work encourages designers to

"... consider the ability to 3D-print synthetic, wearable skins designed to generate energy, sequester carbon or filter substances in and out of the body. Such synthetic, multi-material and bio-containing garments could operate like the human skin, as both barrier and filter. But they could also emulate, respond to, and even augment additional systems in the human corpus…"[21]

My understanding of biomimicry and its relative importance is tied to this understanding of material generation and relation. The biological fabric that exists on a molecular level is saturated by weirdness, suffused in its complexity. Structure, naturally derived and computationally resolved, manifests as a multispecies frame-

work. Posts and beams become materially varriegated mesh. Oxman's materials harbor complexity, by necessity, as a result of her team's mastery of additive manufacturing at a high spatial resolution.[22] Her scientists, designers, and computers work symbiogenically to redefine the nature of design and production.

As both buildings and wearables delineate the relationship between intra and extra, self and other, Oxman's wearables suggest a novel approach to architectural and urban formalization. Biomimicry offers heterogenous materiality as a means towards truly heterogeneous inhabitation, nurturing the complexity of diversity and dissent among structural cohesion.

Kallipoliti's call to examine waste is symptomatic of the larger phenomenon of beautiful disorder that forms the basis of Morton's weirdly, indeterminately, darkly ecological manifesto. The works thus examined rest on the notion that

"Material is the only a 'vortex,' a 'threshold,' or an 'ideogram' that accumulates meaningful associations between things, as, for instance, mud absorbs the qualities of its previous feces stage and carries within it a fecal history… dirt is information so unrefined and randomly grained that it is "interrelational loss" or incohesion between bits and particles that defines its degenerate condition."[23]

Ever boundless, biomimetic mesh may be used to peel back, to augment, to bring to the forefront the microbial and mycological happenings that undermine systemic rationale, the aphenomenal that offer their ghostly presence. Material becomes continuum, such that within it exists variegated layers and heterogeneous assemblages of matter.

The ability to emulate biological structure through additive manufacturing, then, may afford us the plasticity to reconsider what it means to contrive, produce, and inhabit. Computational software, in its ability to make just enough sense of the weirdness to bring concept into being, is a valuable tool when used in the spirit of conviviality. What follows is the language of the ooze, the plasticity of multiplicity, the candor of indeterminacy. Biomimicry may give us the license to slow down, to pick away at our fixed, no-stop temporality. When we step back, we have more space to consider what is next, and what has been.

CONCLUSION

As we tend toward urbanization,[24] it is imperative that we broaden our conception of temporality, scale, and relation. In a multispecies city, one peels systems back to reveal the ghosts of systemic disrepair. Relics of progress, capital into concrete, appear as toxicity (as synthetic contamination and viral proliferation), disrepair (as veiled decay), and displacement (human and otherwise). In our culpability, how do we flow with the furor?

In the spirit of Brauntigan and his cybernetic optimists, I offer biomimicry as a philosopher's stone. The notion that technological innovation may lead us closer to multispecies cohesion may seem counterintuitive in our current state of technological and interspecies exploitation, yet contemporary ecological cognition provides a framework by which the concepts are intrinsically entwined. Technology, as medium for plasticity, as manufacturer of mesh, lends us the ability to subtend our prohibitive structures as manifest today. Through biomimicry nature finds solace in technological advancement, such that one day we may live together in mutually programming harmony, like pure water, touching clear sky.[25]

NOTES

1. Brautigan, Richard. 1967. "All Watched Over by Machines of Loving Grace." Communication Company.
2. Turner, Fred. 2008. From Counterculture to Cyberculture: Steward Brand, the Whole Earth Network, and the Rise of Digital Utopianism. Chicago: University of Chicago Press, 2.
3. Ibid., 7.
4. Ibid., 3-4.
5. Kallipoliti, L. 2018. The architecture of closed worlds, or: What is the power of shit? Lars Müller Publishers, 3.
6. Ibid., 36-245.
7. Ibid., 3.
8. Morton, T. 2018. Dark ecology: For a logic of future coexistence. Columbia University Press, 106.
9. Tsing, A. L., Mathews, A. S., & Bubandt, N. 2019. Patchy anthropocene: Landscape structure, multispecies history, and the retooling of anthropology. Current Anthropology, 60(S20). https://doi.org/10.1086/703391, 187-188.
10. Tsing, Anna Lowenhaupt, Heather Swanson, Elaine Gan, and Nils Bubandt, eds. Arts of Living on a Damaged Planet. Minneapolis: University of Minnesota Press, 2017, G1-G11.
11. Ibid., M1-M3.
12. Ibid., M4-M5.
13. McFarlane, C. 2011. Assemblage and critical urban praxis: Part One. City, 15(2), 201–224. https://doi.org/10.1080/13604813.2011.568715, 206.
14. Ibid., 206.
15. Mazzoleni, I. 2017. Architecture follows nature-biomimetic principles for Innovative Design. CRC Pr I Llc, 6-12.
16. Ibid., 24-25.
17. Ibid., 24-25.
18. Tsing, Anna Lowenhaupt, Heather Swanson, Elaine Gan, and Nils Bubandt, eds. Arts of Living on a Damaged Planet. Minneapolis: University of Minnesota Press, 2017, M3-M6.
19. Ibid., M4-M10.
20. Oxman, N. 2017. Dermi-Domus: A grown wardrobe for bodies and buildings. Architectural Design, 87(6), 16–25. https://doi.org/10.1002/ad.2233, 25.
21. Ibid., 19.
22. Ibid., 35.
23. Kallipoliti, L. 2018. The architecture of closed worlds, or: What is the power of shit? Lars Müller Publishers, 19.

24. Mazzoleni, I. 2017. Architecture follows nature-biomimetic principles for Innovative Design. CRC Pr I Llc, 16.
25. Brautigan, Richard. 1967. "All Watched Over by Machines of Loving Grace." Communication Company.