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Notes on a Mesocosmic Architecture

Mesocosm experiments, as defined by ecosystems scientist Eugene P. Odum, are "middle-sized worlds falling between laboratory *microcosms* and the large, complex, real world *macrocosms*."[1] Architects often describe a building as a microcosm of the macroworld: a self-sufficient interior that resists relations beyond its boundaries. Such worlds within worlds imply that architecture can render in miniature the atmospheres, ecologies, and relations of larger planetary systems. Notions of architectural autonomy stand sentinel over the ideal of enclosure and independence, sealing out the messier worlds that accumulate in terrestrial life. In this epoch of climate breakdown, however, we need new ways to design *with* rather than *against* architecture's planetary embeddedness. Can the *meso* – the in-between – reframe architecture as a more tenuous medium: mixing, filtering, entangling? The meso resists the scalar simplifications of the micro-macro and tethers the built world to the materiality of *mediumness* itself. As scientist and philosopher Isabelle Stengers writes, "The meso is a site of invention where the pragmatics of the question is much more alive, more vivid, more difficult to forget than the micro or the macro, which traditionally play a game of truth. The meso must create itself. And each time, the meso affirms its co-presence with a milieu."[2] If architecture operates between the technical and the political, then the meso potentially offers a new medium for design thinking: one based on copresence, reciprocity, and interdependence.

Micro, Macro, Meso

Microcosms, or "little worlds," are sealed environments that simulate ecosystem processes of digestion, metabolization, and the exchange of energy and resources within a closed system (creating a model of the Earth). Originally developed to explore the conditions for the origins of life, microcosm experiments seek to replicate the Earth's self-sustaining biogeochemical processes with no external input except from the sun.[3] These microcosm experiments operate as planetary

1. Eugene P. Odum, "The Mesocosm," *BioScience* 34, no. 9 (October 1984): 558. Italics original.
2. Isabelle Stengers, "History Through the Middle: Between Macro and Mesopolitics," interview by Brian Massumi and Erin Manning, *INFLeXions* 3: Micropolitics: Exploring Ethico-Aesthetics (October 2009).
3. The first microcosm was developed by microbiologist Clair Edwin Folsome. See Clair Edwin Folsome, *The Origin of Life: A Warm Little Pond* (San Francisco: W. H. Freeman and Company, 1979).

proxies, creating idealized worlds in which environmental cycles could unfold in closed loops. However, the internal homeostasis of the microcosm experiment reveals a stark contrast to the planet – or macrocosm – that is becoming destabilized by human activity.[4] Developed as a response to the entangled relationships between human and natural systems, systems ecology emerged as a scientific field in the 1960s.[5] Systems ecologists developed models of complex systems in order to understand their behavior, properties, and metabolisms. By mapping a system's inputs, outputs, and energy reservoirs as a sequence of flows, scientists sought to model the interrelationships between its social, technological, and environmental conditions, studying everything from territorial patterns of development to energy consumption and resource extraction. Often criticized for relying on a "technocratic optimism" that asserted scientists' capacity to realistically represent these exchanges, such macrocosmic thinking tended to obscure the contingent and messy realities of an environment in order to create a predictive model for ecosystem behavior.[6] As philosopher and historian of science and technology Sabine Höhler writes:

In scaling smoothly between micro- and macro levels, [these scientists] operationalized a principle of totality contained in miniaturized form, and vice versa, of microcosms fully enclosed in the entirety of the planet. This seamless play of scales was both a condition and an effect of an understanding of life's structural order and functional complexity, information and energy exchange, and metabolic process and infinite reproduction.[7]

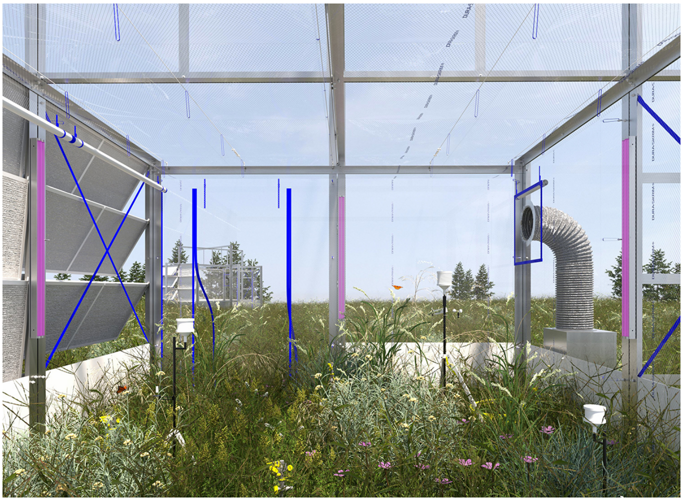
Höhler argues that the ultimate goal of these models was not only scientific observation but also "planetary environmental management," creating systems that could ameliorate, control, and optimize the impacts of human development.[8]

As these experiments and systems often demonstrate, however, ecosystem processes cannot move between scalar thresholds without changing their fundamental behaviors. No vessel or model – whatever its size – can represent the relational lifeworlds of flora, fauna, microbes, particulates, pollutants, and peoples. Between the epistemologies of the micro and the macro, the mesocosm offers an alternative transcalar model for scientists to understand these relations.

While mesocosm experiments emerged alongside systems ecology, they resist the tendency toward control that characterizes systems thinking. Neither simulated for a laboratory nor abstracted in a planetary model, mesocosms are one-to-one physical infrastructures situated directly within, and open

4. 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.
5. See Eugene P. Odum, "The New Ecology," *BioScience* 14, no. 7 (July 1964): 14–16.
6. Peter J. Taylor, "Technocratic Optimism, H.T. Odum, and the Partial Transformation of Ecological Metaphor after World War II," *Journal of the History of Biology* 21, no. 2 (Summer 1988): 213–44.
7. Höhler, "Ecospheres."
8. Ibid.

HOME-OFFICE, MESO-COSM, 2023. Digital rendering of a mesocosm interior. All images courtesy of the authors.

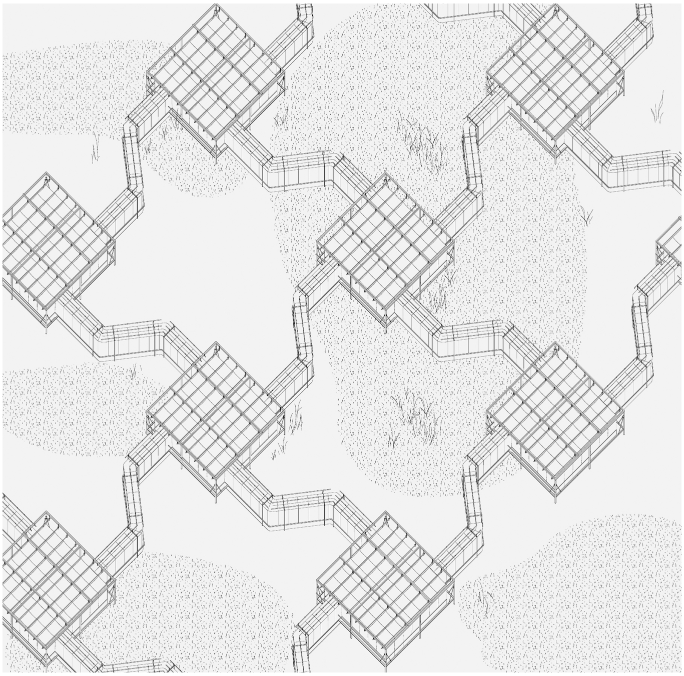


to, the landscapes they study. Because of this embeddedness, mesocosms allow scientists to reconceptualize the experiment itself as part of a heterogeneous assembly – or *medium* – of ecological processes. Mesocosms are constructed from a variety of technical and material systems including permeable multilayered envelopes to mediate the atmosphere, tubs and channels for distribution of water, structural armatures to loosely enclose fragments of the landscape, and mechanical systems for changing environmental variables. Researchers organize mesocosms into arrays of semi-enclosed landscape "patches" in which variables such as CO_2 levels, temperature, and rainfall can be changed in order to simulate future climate scenarios in an ecosystem.[9] The mesocosm is one of the few long-term, ecosystem-scaled, and field-based models of experimentation used today.[10] Mesocosm experiments offer a critical groundwork for an interdisciplinary and intergenerational project to understand anthropogenic climate change.[11]

There are hundreds of mesocosm experiments all over the world, each of which is calibrated to fit the experimental and environmental conditions of its context. While they vary from total immersion in a biome to situated but artificial simulation, they are united by the mediumness of their scale in relation to the landscape. For example, the Terrestrial Metatron in the South of France is the largest terrestrial mesocosm in the world, composed of an array of 48 environmental patches, each with an area of 100 square meters. The enclosures are composed of layered insect-proof netting and sun-shade fabric suspended from a steel frame, with a solid base that prevents soil contamination. This construction

9. See Rebecca I.A. Stewart et al., "Mesocosm Experiments as a Tool for Ecological Climate-Change Research," *Advances in Ecological Research* 48 (2013): 71–181.
10. Some critics argue that, despite their size, mesocosms are still unable to spatially and temporally encompass the full spectrum of ecosystem interdependencies and species interactions, making it difficult to extrapolate the data into broader ecological trends. However, the scale of mesocosms offers an important degree of realism in ecological experimentation. See David W. Schindler, "Whole-Ecosystem Experiments: Replication Versus Realism: The Need for Ecosystem-Scale Experiments," *Ecosystems* 1 (1998): 323–34.
11. Stewart et. al, "Mesocosm Experiments." See also Alexander Felson, "Designing Cities with Mesocosms," *New Geographies* 08: Island (November 2016): 154–64.

HOME-OFFICE, Axonometric drawing of experimental enclosure at the Metatron Terrestrial Mesocosm, in the South of France.

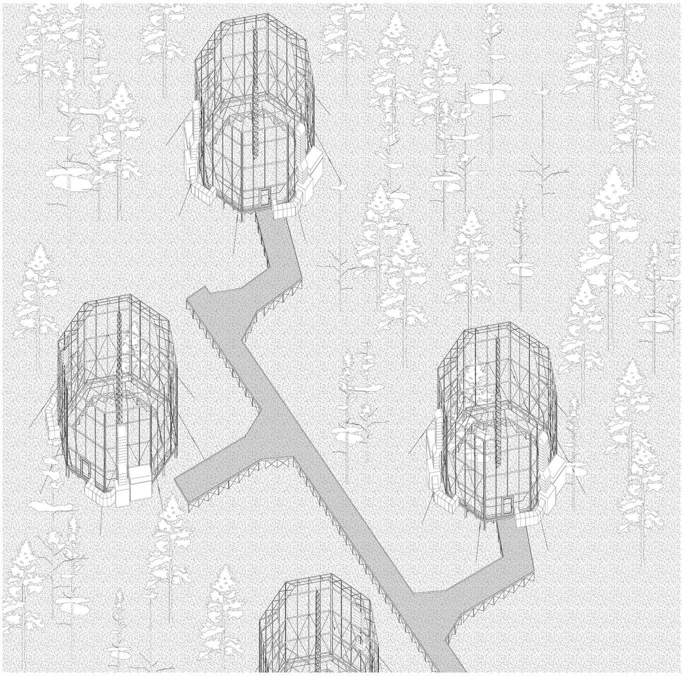


allows for light, air, and rain to interact with the grassland interior while maintaining the population equilibrium of butterflies and lizards (the subject of their study). Each patch connects to adjacent patches in the array with a kinked 10-meter tunnel designed for researchers to study the behavior and migration of species metapopulations in grasslands, observing how climate change affects dispersal patterns. Opening and closing these passages allow the experiment to expand and contract by either connecting or separating the patches.

Some mesocosm experiments explicitly test future climate scenarios. For example, the Spruce and Peatland Responses Under Changing Environments (SPRUCE) experiment at the Marcell Experimental Forest, in the Chippewa National Forest in Minnesota, studies how increased CO_2 levels and a warming climate affect mutual dynamics of spruce forest and peatland health.[12] Each of the 17 SPRUCE mesocosms is a 300-cubic-meter octagonal open-air greenhouse constructed around a patch of forest and peatland. Using external mechanical systems, researchers adjust the CO_2 levels and ambient air temperature of the enclosed volume, testing the long-term effects of increased greenhouse gasses on forest health. Sensors and LiDAR scanners observe and extract data from the enclosures throughout the 10-year initial phase of the experiment begun in 2014. Temporality becomes a crucial component of

12. US Department of Energy, “Spruce and Peatland Responses Under Changing Environments,” October 2023, https://ess.science.energy.gov/wp-content/uploads/2022/10/SPRUCE-Flyer.pdf.

HOME-OFFICE, Axonometric drawing of experimental enclosure at the Marcell Experimental Forest, in the Chippewa National Forest in Minnesota.



mesocosm experiments, demonstrating the timescales necessary for understanding the slower dynamics (and resiliencies) of ecosystems.

Mesocosm experiments are also used to test the direct impacts of urbanization on ecosystem health. The Artificial Stream and Pond System (FSA) of Germany's Federal Environment Agency is directly tied into Berlin's municipal tap water, groundwater, and wastewater.[13] Composed of a five-kilometer network of bright-green plastic channels moving from indoors to outdoors and regulated by 60 water pumps and 360 valves, the FSA can be used to re-create up to 16 interconnected streams and ponds to study the effects of pharmaceutical, agricultural, and industrial runoff. The passage of stream channels from outdoor exposure to indoor control allows for the precise calibration of light and temperature to observe how the pollutants and microbes in the city's water systems affect local aquatic ecosystems.

Ultimately, the mesocosm suggests new ways of working within the hybrid ecologies, disturbed landscapes, and more-than-human worlds of the Anthropocene. Because mesocosm experiments simulate the conditions and destructive tendencies of the technosphere, the mesocosm is a compromised simulation reflecting a compromised world. The mesocosm thus offers a useful paradox: In controlling its experimental parameters, it exposes the ecosystem within to the

13. Umweltbundesamt (Federal Environment Agency), "Artificial stream and pond system," April 12, 2015, https://www.umweltbundesamt.de/en/topics/chemicals/chemical-research-at-uba/artificial-stream-pond-system.

uncontrolled behavior of the technosphere. In this sense, the mesocosm suggests a form of environmental encounter that seeks embeddedness rather than amelioration, creative contingency rather than totalizing control. The lively encounters unfolding in the seemingly neutral scientific apparatus open up new possibilities for who/what can inhabit architecture.

Mesocosmic Architecture

As opposed to the immersive nature of the mesocosm, most typical architectural assemblies reject the surrounding environment to create hermetically sealed microcosmic worlds. Can architects challenge these established notions of human habitation and open the architectural interior to a more turbulent assembly of climates? A mesocosmic design ethos goes against many of the expectations of solidity, fixity, and permanence that characterize most architectural production, production that locks architecture into the extractive tendencies of the technosphere. Mesocosmic architecture suggests a different kind of assembly: a hybrid and contingent body that seeks to shift away from the escalating costs of our comfort – both economic and environmental – and toward a transformation of our daily habits, movements, and microclimates. While we are not suggesting the literal translation of the design of a mesocosm into a building, we believe that learning from the open-endedness, scalability, and interdependent logic of mesocosms offers a new possibility for environmental mediation through architecture. The following notes on mesocosmic architecture suggest new practices that more actively participate in the *frictions* of our changing climates.

1. Mesocosmic architecture is anti-airtight.

Mesocosm experiments use permeable, multilayered enclosures to allow the exterior world – its weathers, atmospheres, and species activity – to become part of their "enclosure." Likewise, the architectural enclosure might benefit from an ethos of permeability. Rather than an air-conditioned, electrostatically filtered, and continuously ducted box, architecture can be reconceptualized as an open-ended and open-air system with a series of thermal thresholds, shifts, and gradients.[14] Roof filters, operable windows, facade shading, and open flooring systems encourage environmental adjustments at various scales while decreasing dependence on mechanical systems. Beyond challenging our conceptions of climatic comfort, the permeability of the architectural envelope potentially simplifies construction approaches,

14. Thinking with Daniel Barber, such an open-ended architecture argues for reducing our reliance on mechanical climate systems, reducing energy expenditure, and questioning Western standards of comfort. See Daniel Barber, "After Comfort," *Log* 47: Overcoming Carbon Form (Fall 2019): 45–50.

Marcus Heine, Architektur der Simulation, Berlin, 2021. Artificial stream and pond system (FSA), Federal Environment Agency's field station, Berlin-Marienfelde.

reducing petroleum-based material components (sealants, gaskets, tapes, etc.) and standardized architectural products with embedded thermal assumptions and specifications. Such an anti-airtight architecture would create a type of environmental ambiguity that is better suited for the indeterminacy of an increasingly disrupted climate.

2. Mesocosmic architecture is interdependent.
Mesocosm experiments are designed to include the metabolic cycles and self-sustaining processes of the natural spheres. Experimental infrastructure brackets this cycle – spatially and temporally – in order to study ecological transformations. In this sense, the experiment does not *get in the way* of the continual functioning of the ecosystem, but is, in fact, open to and dependent on these processes. Architecture might likewise benefit from such an interdependence – one that does not seek operational autonomy, as in an off-grid mentality, but rather participates in the metabolic cycles of an environment. A mesocosmic architecture embeds these interdependencies in the design process, registering environmental transformations, relying on regional ecological cycles, and mutually supporting their metabolic needs. Storing energy, renewing soil, capturing water, filtering air, maintaining biodiversity and biomass, mesocosmic architecture coproduces, and is codependent on, its environment.

3. Mesocosmic architecture is nonoptimized.
Mesocosms are designed to be subject to the contingencies of the environment, operable and adjustable to allow for environmental calibration. Likewise, architectural systems might benefit from an alternative approach to climate optimization. Attitudes toward optimization affect the usability of the architecture, limiting operability and standardizing environmental systems. Optimization runs counter to a project of conviviality and requires specialized or proprietary expertise to maintain and repair systems.[15] Loose layers and thermal gradients offer *just enough* protection from inclement weather. Sometimes nonoptimized architecture is hot, sometimes it is cold, but it allows for both an attunement to and awareness of the realities of the exterior world.

15. By "conviviality," we are using Ivan Illich's definition of convivial tools as technology that is accessible, easy to operate, and maximizes a person's autonomy. See Ivan Illich, *Tools for Conviviality* (New York: Harper and Row, 1973).

4. Mesocosmic architecture is transscalar.
Mesocosm patches are precisely scaled. They are large enough to allow ecological and biogeochemical processes of a site to unfold but not so large as to hinder observation and manipulation of variables. Mesocosm experiments thus rely on the transscalar relationship between the environmental patch and the planet. As opposed to the impermeable container of the microcosm, the mesocosm acts as a scalar sieve that filters the dynamics of the spheres to observe their transformation across variable timescales. In the case of the mesocosm, the medium scale of the patch functions as a stand-in for planetary relations while also forming a constitutive part within the ecosystem. Likewise, architecture might benefit from a transscalar reconfiguration that tethers the built environment to multiple scales of time and space, from the intimate scale of a particular site to the collective conditions of the planetary.

Medium Worlds, Worlding Mediums

Architecture often employs the micro-macro analogy to animate the discipline with a scalar and cosmic vision: from Alberti's description of the city as a large house and the house as a small city, to Buckminster Fuller's *Operating Manual for Spaceship Earth*. Yet such conceptual models tend to simplify ecological relations, ignoring the complex exchanges, frictions, and reciprocities that unfold in the built environment and the natural world. Can the idea of a mesocosm replace the tropes of the micro and the macro, and reclaim architecture not as a totality but as an intermediary? Returning to Stengers, she argues that the micro-macro dialectic is a game of inflexible universals and discrete particulars, where the *meso* offers a methodology that approaches multiple scales at once, considering assemblies, procedures, and experiments that are embedded in the realities of a context.[16] Likewise, by centering "co-presence," mesocosmic architecture functions as an intermediary between multiple lifeworlds and environments. This suggests a medium scale of design thinking that ties the specificities of a site to the collective experience of planetary life.

Mesocosm experiments are embedded in the paradigmatic sites of the Anthropocene: in heterogenous assemblies of urban peripheries, ecological islands, toxic landscapes, immense infrastructures, and intensifying weather patterns. Situated in the uneasy space between technical management and environmental care, mesocosms suggest a way to reorient the politics of the scientific apparatus in the Anthropocene. As Bruno Latour argues, instead of separating technology from nature, we must leverage the "increasing degree of *intimacy* with the new natures we are constantly creating."[17] Likewise, what if we understand architecture not as the rationalization and control of the environment (for inhabitation), but rather as a practice of sensing and reframing our climatological relations? On the one hand, mesocosms exhibit many of the tendencies of the technosphere: They are technological arrays that repeat, scale, and simulate. Yet they are also living machines: sensing, dissipating, mediating, and entangling. These qualities suggest a potential for openness, friction, and entropy that enables architecture to contend with the uneven terrains of the Anthropocene. In this sense, such a mesocosmic/mesopolitical architecture suggests a potentially disruptive tool within and against the scalar logics of the technosphere.

16. Stengers, "History Through the Middle."
17. Bruno Latour, "Love Your Monsters: Why We Must Care for Our Technologies As We Do Our Children," *Breakthrough Journal* 2 (Fall 2011). Italics original.

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