2023.07.26 Lecture Notes
Lecture 5 – Neri Oxman

The End of Architecture
Amorphous, Entropic, Plasticity
OSHER at CMU
Matthew Schlueb, Instructor
Lecture 5 - Neri Oxman
Cyert Hall - 2023.07.26

PowerPoint/ScreenShare: 1pm
check box for video audio on

Neri Oxman is the most visionary architect practicing today. But, that is low hanging fruit - she may very well be most brilliant mind in all of design.

Arthur Drexler, Director of **MoMA Dept. of Architecture and Design** (replaced **Philip Johnson**), published volume of work by **Five Architects** (**1972**), the Whites **Peter Eisenman** (Venice Biennale with **Frank Gehry**, **1991**), **Michael Graves**, **Charles Gwathmey**, **John Hejduk**, and **Richard Meier**. The New York Five (**PJ**).

Ink on velum

+1

Richard Meier's Douglas House (Harbor Springs, Michigan, **1973**, 3200sq.ft.)

Made of porous wood, painted white, 4 story, forested hillside on Lake Michigan.
The problem isn't the porosity, it is the desire to keep it from degrading (naturally).

Le Corbusier's Villa Savoy: modern white, horizontal window, roof garden, free façade (pilotis/curtain wall), free plan. "copy" **Robert Stern**, the Grays (1973).

If **Gehry** didn't bring Modernism to an end, **Neri** will.
(via Disney Hall / Bilbao)

"...the problem with crisp, white, pristine houses is that their impact depends on remaining crisp, white and pristine. **Meier**'s buildings age like any other, subject to time, weather and gravity. Aging, however, doesn't suit them as it might, say, a **Richardsonian** masonry structure enhanced by the patina of time.
Meier's buildings may be born as perfect Platonic ideals, but the perfection requires regular care, even upgrades." [Architectural Record, Feb.21, 2023]

Original painted (organic) redwood exterior beams in bridge and staircase had sagged (replaced); condensation inside walls rotted wood-framing; HVAC system was inadequate for solar gain from west wall of single-glazed windows, causing it to rain inside. = 15 year renovation. **Meier** advised replacing redwood with steel, "so long as outward appearance remained as originally intended."

With little understanding of material science, assembly, durability, the average lifespan of an American house is 34 years, requiring continuous maintenance, repairs, eventual replacement. If not for physical deterioration, then psychological, by human propensity for change, fashion, competition (keeping up with the **Jones**).

AIA LEED / Passivhaus: **Carbon Neutral**

Even if we could transform all of our new buildings and the renovation of existing buildings to carbon neutral, renewable energy efficient buildings before 2030 [**Edward Mazria**'s **Architecture 2030 Challenge** (**2002**) to be carbon neutral], the increases in energy use, mining and manufacturing of materials to do so, will **accelerate us past our warming planet tipping point**, not slow or reverse pace.

AIA LEED: Adaptive Reuse

The Null Stern Hotel ("Zero Star", **Daniel Charbonnier**, **Frank & Patrik Riklin**, Artists, Teufen, Appenzellerland, Switzerland, June 5, **2009**) former nuclear bunker in the Swiss Alps converted into a hotel.

What is needed is a full stop in the building industry, as was seen during the Covid lockdown when businesses, transportation, construction nearly stopped, resulted in a drop in daily global carbon emissions of 17% (**April, 2020**).

Zero Real Estate project introduced bedrooms without roof, **walls**, or washroom. (https://nullsternhotel.ch/, **2022**).

End of Architecture

(0:29) 

(0:59) 

What if bldgs. were biologic, living?
(**@hsnrgb MidJourney** AI text > pic)

We live in radically changing times, industry accelerated by computer & internet. **Art is no longer a static** medium, **Architecture must change too**.
Refik Anadol's **Unsupervised – Machine Hallucinations** (**MoMA 2022-2023**)

Covid pandemic accelerate the trends toward remote working and less consumption, however **to reverse the momentum**, a wholly symbiotic way of life will be needed: not consuming Nature, but augmenting, to **live within the wilderness** we inhabit, **rather than extracting and domesticating** her as an expendable resource.
[Bldgs. are 40% of energy use, dominant source of greenhouse gas emissions]

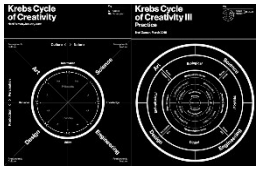
Philippe Block's (MIT PhD 2009) experiments in building material science, reducing materials, exploring bio-based. **Neri Oxman** pushes even further.

"(Back at the AA) I noticed a significant dimensional mismatch, or disconnect, between the 'what' and the 'how' of architecture. Especially during the early 90's, architects and designers were creating complex building and product forms using high-end tools and technologies for design generation and digital construction, generally without much understanding of material properties or concern for the environment. This has led to a significant rift between designers and builders. Nature, of course, doesn't have this problem; **in Nature there is an intimate link between shape, structure, material and growth**. **They are all related**."

"When I formed The **Mediated Matter Group** at **MIT**, I based it on a few core ideas borrowed from Nature: the first was that **shape is cheaper than material** in Nature, and the same should hold true for the built environment; the second was that in Nature you don't find assemblies of homogeneous materials. In nature things are **grown, not built**; making biological organisms and materials - across all kingdoms of life - highly customized, responsive, adaptive to their environment."

Associate Professor of Media Arts and Sciences at the **MIT Media Lab**
Founded **Mediated Matter Group** in **2010,** to research material science & biology
Ph.D. in Design Computation at **MIT** in **2010**.
Diploma from the **Architectural Association** in London (**Zaha Hadid**)
Completing studies at the Faculty of Architecture and Town Planning at the **Technion Israel Institute of Technology**
Training at Department of Medical Sciences at the **Hebrew University**, Jerusalem.

150+ scientific publications and inventions, in collections at **MoMA, Smithsonian, San Francisco Museum of Modern Art, Centre Pompidou, Cooper Hewitt**, ... Most significantly, has **pioneered new technology to develop each project**. Intersection of computational design, digital fabrication, materials science and synthetic biology. Interdisciplinary, interspecies collaborations.



Krebs Cycle of Creativity: Science, Engineering, Design, Art are not siloed, but output of one feeds into another. Example: **Science** converts information into knowledge, **Engineering** converts knowledge into utility, **Design** converts utility into change in behavior, and **Art** converts change in behavior into questioning ways of being through perception of information, which feeds back into science.

"If you want to be on the team, you have to produce work that will end up at the Museum of Modern Art, but that will also end up on the cover of Nature or Science magazine. And, the creation of knowledge, new insight about the physical environment is just as important as embodiment and deployment of the projects in the real world, outside of the lab, the museum, which is where we are going next."

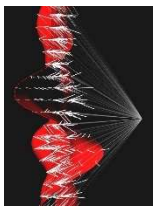
MoMA Exhibition (May13- Oct.18, **2020**: online)
[title wall: turmeric & beet root ink to change]

+2 (Covid)

Oxman coined the term, and pioneered the field of, **Material Ecology**, which considers **computation**, **fabrication**, and **material science** as inseparable dimensions of design. Products and buildings are **biologically** informed and **digitally** engineered **by, with and for, Nature,** that explores, informs, and expresses interrelationships between the **built**, the **grown**, and the **augmented**.

"Because we tend to build with bricks and mortar, and we grow with cells.
And so, we try to fuse these worlds together in all of our projects."

Created **1st Wet Lab in Architecture** (experimenting with biology & chemistry), **BioLevel 2**: permits research with tissue (including human), allows research and development of **truly organic architectural structures and envelopes**.

Raycounting (MoMA, NYC, 2007 MIT PhD):  +3 

Computational code that counts rays of light, for customized shading structures.

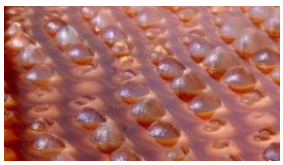
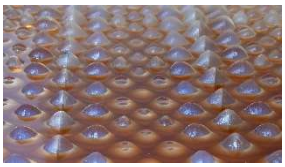
Use computer to model the process (like natural process of growth), not modeling the product. CAD is about total control, computation helps you be hands off, opposite of control.

Curvature and thickness of the form is a result of the algorithm calculating **(Block)** the intensity and directionality of light, then assigns values to each point in space relative to a reference plane, and finally 3D printed in silk-coated nylon.

Surface thickness (**density**) varied as function of structural performance.

Transparency varied as a function of light penetration.

Cartesian Wax (MoMA, NYC, 2007 MIT PhD):  

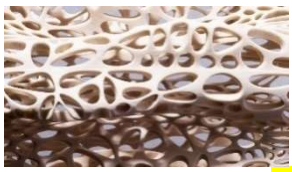
Experiment with light and heat-sensitive construction techniques, specific to a given environment. Inspired by the Cartesian Wax thesis by **Descartes** in the 1640's: the essence of wax is whatever survives various changes in the wax's physical form.

Architectural skin-like tile surface, from a single 3D–milled, semi-adjustable mold, each cast and cured at high temperatures, deforms the original mold with each cast. 

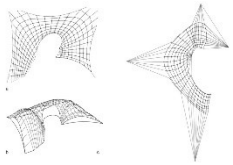
Geometrical and physical property variation in tiles by modulating temperature across entire wall, differs in stiffness and opacity. Material property variations to correct augment, structural performance. 

Gaudi's Casa Batlló chair

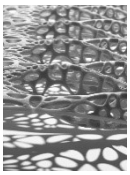
Thinner regions due to deformation, stiffer composites cast to ensure structural support under self-load. Light transmission, heat flux, stored energy modulation, and structural support. 

Monocoque (MoMA, NYC, 2007 MIT PhD): 

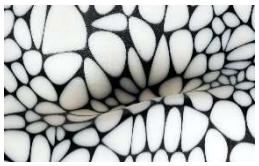
Technologies are applied to physical properties and behaviors. Texture inherits geometrical features as defined by analyzing where pressure is concentrated,



(**Block**'s **Thrust Network Analysis**, 2007) based on **Voronoi pattern** (Nature's tendency to favor efficiency: the nearest neighbor, shortest path, and tightest fit. Each cell has a seed point. Everything inside is closer to it than to any other seed. The lines between cells are always halfway between neighboring seeds.) Global and local mean curvature values inform its density, denser, smaller cells are organized in areas of steep curvature, and larger cells in areas of shallow curvature.



Hollow skeletal framework, allowing light to pass through voided low stress cells, creates shadow pattern on surface, leads to multi-material smooth surface.



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The surface patches are 3D printed in a new multi-jet matrix, simultaneously deposits materials of different properties and materials within a single build. Loads are supported by the object's external skin, similar to an egg shell.

+1

Vein-like elements that are built into the skin distribute shear stress and pressure over their surfaces, becomes softer and more flexible where tension needs to be relieved, and stiffer where more support is required. Volume of each cellular cushion is locally informed by pressure data averaged with values that represent structural support and flexibility.

November 19, 2021, **Oxman** debuted her manifesto, **NATURE X HUMANITY** at a critical juncture when the an-t(h)ro-po-mass (the mass produced by humans) has exceeded that of all living biomass on Earth. Although human beings are part of the natural world, human activity and the "goods" we design and build — from our clothes to our cities — have increasingly set us apart from nature, negatively impacting ourselves and our planet.

"Concrete, metals, bricks and glass will exceed plants, animals, bacteria, fungi. Current building technologies and material practices are main culprits, propelling us to an inevitable future, where we are called upon to build shelter against ourselves."

"What are the values, principles, knowledge, skills, that we must cultivate, as we architect a future of synergy, between the natural and the built environment?"

We call for a radical realignment between grown and built environments, with the hope and conviction that humanity has the power not only to restore, recover, and replenish the natural world but to empower it. Embracing complexity and diversity across systems and scales in design, we open ourselves to advancing beyond mere maintenance (conservation) towards the betterment (augmentation) of nature.

By the time Neri's daughter Raika is 80 years old, 6th mass extinction under way, "As master builders and authors of the an-t(h)ro-po-mass, architects, the gardeners of tomorrow, will either make or break our bond with nature."

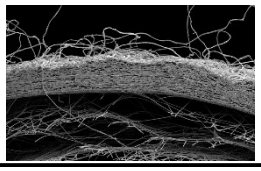
"Fuse hardware, software, wetware, to create new types of structures that can respond, adapt and evolve. ...the only way home."

"Why hurry to Mars, while we can architect a synergy between humans and nature? Rather than being forced to abandon this precious planet, let us design our way back into it? Make nature your client."

A call to architects, to architecture, to save the human species. Manifesto proposes **5 new material systems tenets**: **fibers**, **glass**, **polymers**, **pigments**, **cellular solids**.

Multi-Species over Mono-Species (Fiber)

Silk Pavilion I (Media Lab, Cambridge, 2013):

Relationships between digital and biological construction, proposing methods that unite the biologically spun and the robotically woven. Inspired by the silkworm's ability to generate a three-dimensional cocoon out of a single silk thread.


Silk Pavilion I took form as a three-meter wide dome, constructed over three weeks with a flock of 6,500 live silkworms assisted by a robotic arm. Each spun a single silk thread filament about 1km long. Combined, as long as the Silk Road. Studying how the silkworm's spinning behavior is informed by spatial and environmental conditions, able to guide the silkworm's movement to spin two-dimensional sheets rather than three-dimensional cocoons.


The base structure of the pavilion was created of 26 polygonal panels made of silk threads laid down by a Computer-Numerically Controlled (CNC) machine. Once established, a swarm of 6,500 silkworms positioned at bottom rim of the scaffold, spinning flat non-woven silk patches, locally reinforcing the gaps. An algorithm that places a single continuous thread providing various degrees of density, variations informed by the silkworm itself, deployed as a biological "printer".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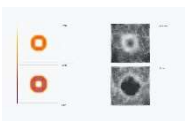


Tiny magnets to the heads of silkworms to motion-track their movements. This data to program the robotic arm to deposit silk on the metal frames. "Our aim was to translate the motion-capture data into a 3D printer connected to a robotic arm in order to study the biological structure in larger scales."

Their sensitivity to environmental conditions: found to migrate to darker and denser areas. Therefore, able to calibrate variations in the thickness of the silk sheets to desired specifications. Sun-path diagram used to modulate distribution of light and heat on the surface, influencing position of silkworms and density of silk structure.

Silk Pavilion II (MoMA, NYC, 2019): 

Can humankind and other species collaborate in the construction of buildings?

Extract silk without boiling cocoons? Average 1000 cocoons boiled = 1 silk shirt.

Pavilion II stands ten meters tall and five meters wide, tackles scale and sericulture.

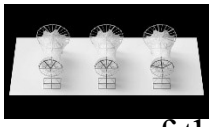
"Silk worm pavilion combines best of all worlds: organism more sophisticated than additive manufacturing, superior material (silk), computation associated with physical properties of the material, so selection of organism: 'how can we learn?' "

Discovered without vertical axis tree branch, silk worm spins flat surface, not 3D cocoon. Integrated kinetic mandrel designed to guide the natural spinning motion of the silkworms through clockwise rotation (1 rpm), facilitates the silkworms' upward spinning motion, fusing technology and nature.

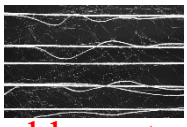
"structure made by silk worms. (my role) to guide the silk worms" – **Neri Oxman**

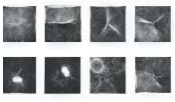
Templating: start with an underlying structure, then guide behavior of silk worm, by controlling the environment (rotation, light, heat, humidity), to affect density, orientation of silk thread.

Silk worm varies the composition of two chemical elements that make up the silk, **sericin** is the matrix/glue and **fibrin** is the fiber/structure. Varied in spinning a cocoon, it creates a stiff exterior and soft interior to metamorphosize.

Static, Stepped, Spinning:  (0:32)

Fiber density across the surface area of the structure varies as a function of local environmental factors such as the direction, duration and intensity of heat and light, affect the silkworms' movement and spinning, resulting thickness of silk layer.

Primary structure a braided steel-wire cable system (1D), the intermediate soluble knit yarn scaffold mesh (2D) as support for the silkworms biologically spun (3D), Similar **Zaha & Gehry** layered structural skin.  +3 

Silk worms urination dissolves soluble mesh scaffold, eliminating support for the silk worms, thereby creating holes in the silk fabric (silk worms become designer), release some of the tensile stress in the structure, influenced biochemically, expressing a 'metabolic footprint' of the silkworms' fluxes and flows.

Local loom   **MoMA (2020)**

17,532 silkworms sourced from Teolo, Italy. In this region of Veneto, sericulture and silk manufacturing blossomed during the 12th century Renaissance. Sericulture has been criticized by animal welfare and animal rights activists, process of harvesting silk from the cocoon kills the larva. In textile and silk industry today, silkworms are exterminated while in their cocoons, dissolving the adhesive that glues strand of silk to the layers below, allows a single silk filament to be unrolled. Silk Pavilion demonstrates can influence silkworms to spin sheets instead cocoons, thereby producing the same quantity of silk without boiling cocoons.
The silk worms can act not only as living looms but as co-designers collaborating with humans to design and construct architectural-scale structures embodying co-fabrication for cohabitation; to question 7,000 years of sericulture policy at large. And, the single-family house is not human-centric, but nature-centric.

1:45

Synthetic Apiary I (Media Lab, Cambridge, 2016):  

Bees pollenate roughly 70 per cent of our edible flowering crops; without them, we would not have the fruits and vegetables. May be key to support regenerative food systems for long-term space missions.
Synthetic Apiary for integration of biology into a new kind of architectural environment, integrated city, for the benefit of humans and non-human organisms.

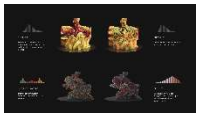
Rather than locating the apiary outside, **Synthetic Apiary** takes up an entire room and offers precise control of light, humidity and temperature to replicate the ideal environment for bees to survive and produce honey, tricks into thinking it's spring throughout the year. The colony is provided with synthetic pollen and sugar water, and its health is constantly monitored. The first demonstration of sustainable life in a completely synthetic environment. Control queen's biological clock to lay eggs.

Synthetic Apiary II (2021): 

Wax hives house tens of thousands of individuals, all working together in eusocial behavior, such as swarm intelligence, emergent behaviors and social organization. Create functional structures from comb without the use of any top-down blueprints. Learn how to incorporate them into our own construction practices – not only to cohabitate but also to co-fabricate with bees.

 +2 

Designed environments to convey information to the colony. The comb that the bees construct their response to the input information, enabling a form of communication between humans and bees. **Chemical cues** created through a novel pheromone 3D-printing process; **magnetic fields** of varying strength and direction; and **geometries of varying** complexity or designs that alter orientation (gravity).



Offered wax augmented with synthetic biomarkers, bees readily incorporate it into their construction process, likely due to high energy cost of producing fresh wax. Wax structures built by the colonies are analyzed by high-throughput X-ray computed tomography (CT) scans for a holistic digital reconstruction of structure.

Essential to our mutual survival to not protect, but moreover to empower these critical pollinators. In order to design our way out of the environmental crisis that we ourselves created, we must first learn to speak nature's language.

If **grown organics** have a lower carbon footprint than traditional **mined materials** for constructing buildings, should plants, animals, bacteria be **enslaved** to produce?

If organics can be made in a **lab**, yet still a **biological living material**, is it better?

Line **blurred between living material shelter** and **living inhabitant sheltered**...
Is a **synergetic co-habitant lifeform** that shelters **merely a wall or roof**?

1:50

[FIVE MINUTE BREAK]

1:55

Technology over Typology (Glass)

+1 1:55

Glass I (Media Lab, Cambridge, 2015):

Ancient yet modern, enclosing yet invisible, created Mesopotamia 4,500 years ago. Discovery of core-forming process for bead-making in ancient Egypt, through the invention of the metal blow pipe during Roman times, to the modern industrial Pilkington process for making large-scale flat glass.

(0:23)

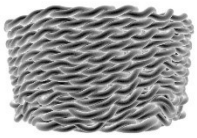
[patents 2016 and 2018]

G3DP additive manufacturing platform to print optically transparent glass.

The platform is upper chamber as a Kiln Cartridge (1900°F), lower chamber to anneal the structures, molten material through alumina-zirconia-silica nozzle.

"We had to formulate the mathematical equations to describe the fluidics of glass, at 1900°F as it jets out of the nozzle, as these equations were not available, we had to invent them, starting with the technology. Example of architects creating science, as opposed to borrowing." – **Neri Oxman**

Auto-coiling (printing error: too much distance between nozzle & bed): created outer curvature independent of interior curvature = optical lens controlling light and heat as it goes through the structure, potential for energy harvesting.



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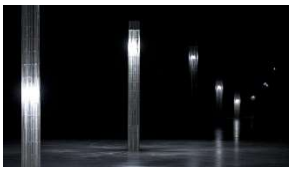
The tunability enabled by geometrical and optical variation driven by form, transparency and color variation can drive, limit or control light transmission, reflection and refraction.



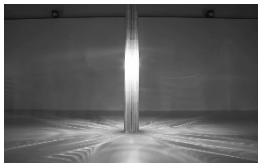
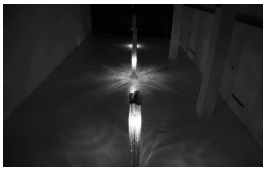
(Is glass organic? living?)

+1

Glass II (Cooper Hewitt Smithsonian Design Museum, NYC, 2016):

Glass II installation for Milan Design Week at Milan Triennale on April 4th, 2017. Series of 3m-tall glass columns manufactured with the Glass 3D Printing platform.

Demonstrating ability to 3D print range of shapes determined by desired mechanical and optical properties. Higher the physical load, the greater the surface area in plan, greater number of lobes desired, tighter turning radius for 3D printing, and contributing to geometric expression of the caustics.

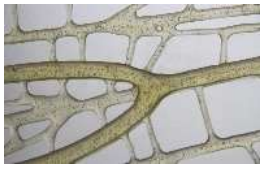



Dynamic internal lighting system (una stellina) programed to travel up and down, generating a varied caustic footprint with kaleidoscope-like patterns, resulting in changes to the surface area, sharpness, and intensity. Architecturally scaled lenses that can concentrate or disperse light from within and/or outside the glass surface.

2pm

Decay over Disposal (Polymers: chitin & cellulose)

Aguahoja I (Media Lab, Cambridge, 2018):
(AH-go-HO-kah)
United Nations Environmental Program (UNEP): over 300 million tons of plastic are produced globally each year. **Less than 10% of this material is recycled**, becomes waste, dumped into landfills and oceans; raw ingredients extracted faster than can be replenished, processed through environmentally destructive means.
Organic structures embody more efficient and adaptable material properties, outperform human engineering in diversity of functions, resilience, sustainability, and adaptability and leave no environmental marks.
Cellulose makes up more than half of **plant** matter planet-wide, along with **Pectin**. **Chitin**, thin, transparent **dragonfly wings**, soft tissue of **fungi**., and **crustaceans**.




Aguahoja (AH-go-HO-kah) a biopolymer composite material alternative to plastic, tunable properties with varied mechanical, optical, olfactory and gustatory properties, on molecular scale, using robotic arm to fabricate.

This project points towards a future where we subvert the industrial cycle of overproduction and obsolescence through the use of abundant natural materials. Ability to temporarily divert materials from healthy ecosystems, to integrate them in human designs, and to enable natural decomposition back into the environment.

By enabling digital design and fabrication with biopolymers, incentivize the protection and strengthening of ecosystems, providing new frontier of production.

React to their environment over their lifespan, adapting their geometry, mechanical behavior and color in response to fluctuations in heat, humidity, and sunlight. Time-based 'temporal' behavior as a design feature, able to sense, inform the user of, and adapt to changing environmental conditions. Over time, with the evaporation of water, the pavilion's skin-and-shell composite transitions from a **flexible** and relatively weak system to a **rigid** one that can **respond to heat and humidity**.

Upon exposure to rain water, pectin-based elements rapidly dissolve, allow cellulose- and chitosan-based elements to deform, degrade in controlled 'programmed' fashion. Through life and programmed decomposition, shelter-becomes-organism to promote the health of natural resource cycles, promoting soil microorganisms and providing nutrients for 'growing' buildings, Material Ecology.

+6

Robotic platform for 3D printing hydrogels biomaterials, additively manufactured with varied mechanical, optical, olfactory and gustatory properties. Shape and material composition informed by physical properties (stiffness and opacity), environmental conditions (load, temperature, and relative humidity), and fabrication constraints (degrees-of-freedom, arm speed, and nozzle pressure). Organic material allocation, texture, distribution computational driven, additively manufactured high resolution. This enables control over specific physical properties and environmental adaptation to changing weather conditions.

2:05

+3

Aguahoja I is a 5 meter architectural pavilion, combining shell-like and skin-like elements, derived from **shrimp shells** and **fallen leaves**, the pavilion's overall stiffness and strength are designed to withstand changing environmental conditions.

 +1  Evaporation Dissociation

Monograph show at SFMOMA (February **2022**), exposed **Aguahoja I pavilion** to the elements, **measuring the transference of calories as it decomposes** (estimated at 40,000 calories), indicating how much energy has been transferred to the direct natural environment (the garden) surrounding the built structure (the pavilion), displaying real-time weather data such as wind, humidity, temperature, and precipitation, inform structural decomposition and degradation of the pavilion over space (shape deformation) and over time (rate of decay).

An appreciation for the cycle of decay, expressing how the loss of built matter is recovered through and in the environment, a tree becomes a building, a building becomes a tree.

"Decay over disposal, world without waste. Products as replacement for plastics, entire cities that degrade in contrast to Roman notion of monumentality, buildings that survive forever." – **Neri Oxman**

"How can we start thinking about the design of buildings and products that are **alive**, are **adapting**, that are **responding** to the environment and the human body? How can we incorporate **biological materials**? How can a building survey the immune system of its inhabitants and then respond to it?" – **Neri Oxman**

Hybrid Living Materials (HLM): class of materials that combine artificial and biological matter, with a prescribed functionality.

2:10

Heterogeneity over Homogeneity (Pigment: melanin)

Totems (MoMA, NYC, 2019):

"Architectural toolbox not limited by the drafting board or computer, but as enabled by a **Wet Lab**. If an architect has access, we open the doors for not only constructing things out of already existing materials, but literally growing things. The ability to use living cells, this allows us to incorporate functionalities that were never available inside a product or a building. One example is **melanin**, the pigment in our skin, incorporating inside glass, in order to mediate between heat and light in the interior environment. So, you literally build a first of its kind, biological skin in an architectural façade." – **Neri Oxman**

Biodiversity on planet Earth is under momentous threat, **Melanin**, a naturally occurring chemical chain that gives all living things their pigmentation, can sustain and enhance biodiversity at the genetic, species and ecosystem levels.

A biomarker of evolution (160MYA), melanin is the color of life. One of the most resistant, heterogeneous, and pervasive pigments found across the kingdoms of life, substance that defines the color of skin, hair and eyes. Critical role in providing **protection from ultraviolet radiation**, variety of functions: mechanical protection, energy harvesting, cell growth, metal binding, thermal regulation, and protection from oxidative stress. Melanin is considered more valuable than gold, and its impact—in the age of climate change—is key to human survival on Earth.

 (0:06)

2:15

Melanin can be synthesized through a reaction between an enzyme from a mushroom, called tyrosinase, and the protein building block L-tyrosine. The pigment can be extracted from **bird feathers** and **cuttlefish ink** amongst other sources, then purified and filtered in a series of steps. The genes for melanin production can also be engineered into bacterial species, such as **Escherichia coli**, and thereby controlled over space and time in response to changes in the environment. For instance, its coloration could deepen as the sun reaches its peak, providing protection from solar radiation.

 +1

Totems, a series of spherical objects featuring a single connected channel filled with liquid melanin. These spheres display a wide range of colors and absorption spectra, from light yellow to dark brown. The channels within these spheres have been computationally ‘grown,’ 3D printed and biologically augmented to create pockets for the liquid melanin to reside, with channel diameters ranging from millimeters to centimeters, to control enzymatic processes inside building skin or as part of a spatial volume.

 (0:07)

Installation for exhibition, **Broken Nature: Design Takes on Human Survival** as part of the **XXII Triennale di Milano exhibition** (**2019**), features a column-based demonstration of melanin production on an architectural scale for deployment in specific environmental contexts. It is comprised of a totem—a spirit being, sacred object, or symbol that serves as an emblem of the Tree of Life, 'a biological totem' with tyrosinase, an enzyme that is light-sensitive, leading to color formation over the span of a day, deepening as the sun at zenith and lighter hues as the sun sets.


Proposal for
Nelson Mandela Centennial Memorial

Melanin-infused glass structure. It is designed to contain multiple types of melanin, naturally obtained on site and biologically synthesized at the Lab.
Provides UV protection during the day while enabling stargazing at sunset.

2:20


+2


System over Object (Cellular Structures)
Digital Construction Platform (NASA, 2021): large scale digital manufacturing. Mobile, self-driving system, 5-axis hydraulic arm (macro, gross movements) with 6-axis robotic arm (micro, fine movements) mounted on end point, for 11 degrees of freedom, 10 meter reach, similar to human shoulder and hand. Robotic arms offer greater task flexibility, excavate and build with local materials.


+5


Demonstration 50ft. diameter dome, with open top, made of expansive geothermal foam (8,000 pounds of material), fabricated in 13.5 hours over two work days. Largest continuous print, on site, by a mobile printer. Double layered form could be filled with concrete and reinforcing elements for structural strength, insulated for thermal efficiency. Completed, platform returned with push of button on iPhone.

 +1

Application for on-site data gathering for real-time design and fabrication, as autonomous system used in disaster relief, hazardous environments, and extraterrestrial terrain. Acquired by NASA's Marshall Space Flight Center for remote construction on Lunar and Martian missions.

"Not problem solvers, are **solution seekers for problems we don't know yet exist**, and that requires an innocence and wonderment that a child has." – **Neri Oxman**

2:25

March 2021, **Neri Oxman** began setting up a lab on Manhattan's West Side (787 11th Ave., 1920s Art Deco bldg., with **Rafael Vinoly** penthouse renovation) 36K sq.ft. research & implementation lab. Mount Sinai School of Medicine tenant.

"To radically change the design landscape from the ground up. To question the very nature of **how we make things**, and how we can make them in different and better ways; for us, for the planet, for other species. That is why I am forming a new company."

■ **Gehry** disrupted architecture with the computer, **from design to construction**, bringing the entire industry around to his methods.

■ **Neri** stands to do the same, disrupting the architectural practice, in **how we design** and **what we design**

Man-Nahāta (**SFMOMA**, **2022**) 

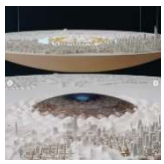
Study for **Francis Ford Coppola**'s MGLPLS (forthcoming film, **Megalopolis**)

Taking the long view of habitat loss and species extinction, Oxman revisits Manhattan's pre-1600s island, home to the **Lenape** people and known as

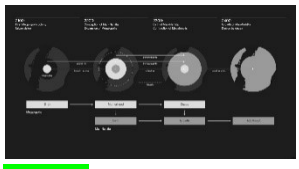
 

Mannahatta ('land of many hills'). Before the Dutch arrived, the center of Manhattan was once a diverse, natural landscape of hills, valleys, forests, fields, wetlands, salt marshes, and streams. Mannahatta had over 55 different ecological communities on a territory of 20 square miles.



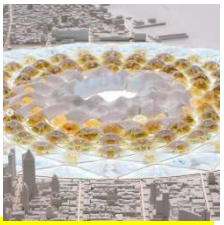
Megalopolis (film):

An architect and scientist who seeks to rebuild New York City as a **utopia** with a magical material, the **megalon**, a multi-scalar genetically modulated physical intelligence, with computational growth algorithms that can be applied across material, architectural as well as urban scales… **Material Ecology: organic, living**

   (1:05) 

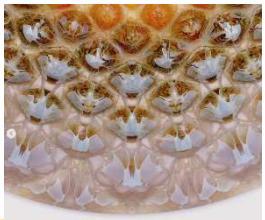
2100, climate intensifies, conditioning a re-balancing of landscape and inhabitants. **Four essential seeds**—shelter, nutrients, energy, society—self-organize into a layered circular system. Sunlight and airflow shape its morphology, the water line defines its boundaries, and the hilly landscape underlies its grid.

2300, global temperatures and sea levels rise, the city undergoes time-based decomposition, its organic substances breaking down into **megalithic architectural elements**: carbon dioxide, water, sugars, and mineral salts.



The buildings of the urban landscape are transformed through repeated morphological closing operations, simulated erosion and soil deposition are applied, from the center to the outskirts of a circular region. This results in a topography where hills are remains of skyscrapers and valleys follow the streets of the city grid.

+1



2400, the urban cityscape of Manhattan persists as a memory captured in the hills and valleys of the landscape. The wetlands, salt marshes, and biodiversity of ancient **Mannahatta** are almost completely reborn in a new form,
the old city becomes a **fossil**, on top of which a new cycle of humanity is built.

2:35

Neri Oxman:
"You don't need scientific background to protect the environment. All you need is a question. **It is not science that will save us, it is humanity**, it is kindness, it is curiosity, it is innocence, it is questioning the status quo, it is humility. And, that is why I think art and science are so intertwined.
In **1902**, you have **Einstein** and **Picasso** working on the same theme, both were interested in the space-time continuum, one creates the general theory of relativity, the other creates cubism. But, both have a sensitivity towards the questions of the time. And, just connecting with that spirit, can channel a great path."

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"I realized that architecture was more than a profession, it was a kind of destiny, a way of being in the world which was all encompassing."

"I don't know that we operate with ideas. I think we move about the world, through a kind of sensitivity or a taste in thinking (as Susan Sontag said about intelligence is a suitcase word). In context to the group, we have never been interested in short term solutions to problems we knew there are already solutions for. So, ideas that don't work or projects that don't work are often mundane, are often ones for which there exists a technology, for which there exists a process. We know we are in interesting territory and media matter relevant territory, when there is not yet a technology or process to create that thing. And then, we go in. So, we are driven by a process first approach to ideas and the Turing Test is how did they make it? I don't know how they made it. How was it produced? I don't know how it was produced. Then we go in. When we can author the process, we know we can control the narrative." – **Neri Oxman**

"Can we create practices, where nature is the only client? Can design and architectural construction challenge the industry, challenge the manufacturing processes, challenge policy? And, how do practices like this bring about change in the world, in an incredibly meaningful way? How is that new movement going to help us survive on the planet and beyond? **Because time is short and the 6th Extinction is on its way.** There is a lot of work ahead."

" I am a great believer that the things that are least important for our survival are the very things that make us human (per the wise and wonderful Savas Dimopoulos)."

"the skills I've earned in one school complimented the other: the Technion taught me how to answer, the Architectural Association taught me how to question, and at MIT I learned that achieving true novelty stems from the ability to answer a question with a question."