CULTURAL PROGRAMS OF THE NATIONAL ACADEMY OF SCIENCES

Aguahoja: Hexes
March 1 – July 31, 2018
NAS Building, West Gallery
2101 Constitution Ave., N.W.

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The Mediated Matter Group, MIT Media Lab

"For whatever we lose(like a you or a me), it's always our self we find in the sea."
—E.E. Cummings

Nature made us half water. With water, the biological world facilitates customization of an organism's physical and chemical properties—through growth and degradation—as a function of genes and environmental constraints. Designed goods, however—including garments, products, and buildings—contain little to none of the fluid that gives life. More than 300 million tons of plastic are produced globally each year, leaving harmful imprints on the environment: our seas, our trees, our bodies. Less than 10% of this material is recycled, and the rest becomes waste, dumped into landfills and oceans, where they leach out toxic chemicals and take thousands of years to degrade.

Neri Oxman and The Mediated Matter Group at MIT Media Lab aim to subvert this cycle. Their *Aguahoja* series features structures that are digitally designed and robotically fabricated out of the most abundant materials on our planet—the very materials found in trees, crustaceans, and apples. Cellulose, chitosan, and pectin are parametrically compounded, functionally graded, and digitally fabricated to create biodegradable composites with functional, mechanical, chemical, and optical gradients across length scales ranging from millimeters to meters. The structures are designed as if they were grown; no assembly is required. This exhibition features four structures from the series.

An Architect, Designer, Inventor and Associate Professor based at the MIT Media Lab, Neri Oxman pioneered the area of Material Ecology, which considers form generation, manufacturing, the environment and the material itself as inseparable dimensions of design. Oxman's team—The Mediated Matter Group—operates at the intersection of computational design, digital fabrication, materials science and synthetic biology; and applies that knowledge to design across scales and disciplines, from micro to building scale. Oxman's work is included in permanent collections at the Museum of Modern Art, San Francisco Museum of Modern Art, Centre Pompidou, Boston Museum of Fine Arts, the Smithsonian Institution, and more. Her awards include the Vilcek Prize in Design, the BSA Women in Design Award, the Silicon Valley Visionary Award and Carnegie's Pride of America.

Research and Design
The Mediated Matter Group

Contributing Team Members
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Acknowledgements
MIT Media Lab, GETTYLAB,
Robert Wood Johnson Foundation (RWJF),
Autodesk BUILD Space,
TBA-21 (Thyssen-Bornemisza Art Contemporary),
Wyss Institute at Harvard University

This exhibition was organized by **Cultural Programs of the National Academy of Sciences** in celebration of the 50th anniversary of the exhibition *Cybernetic Serendipity*.

#Aguahoja | **@CPNAS**

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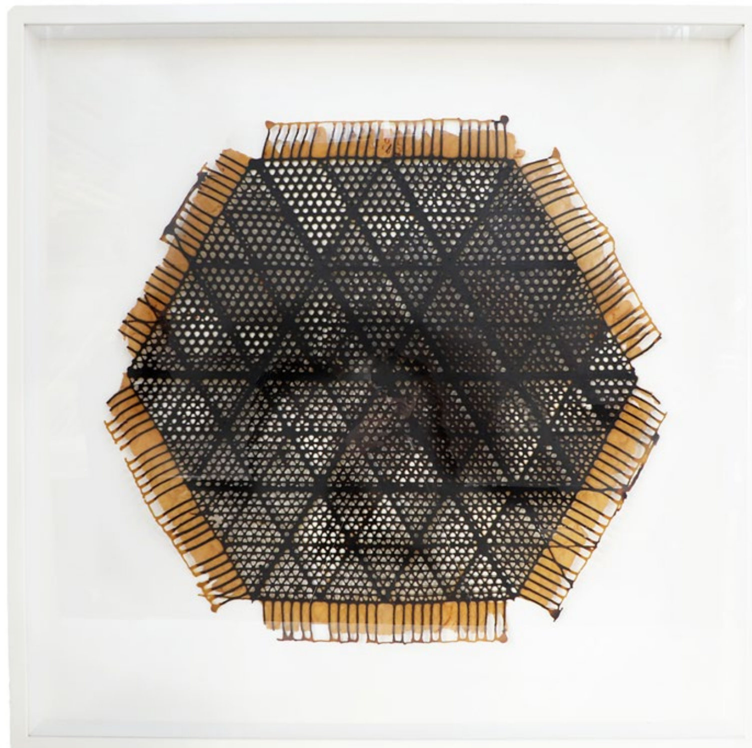
4840.9040.1200.654.532*

SKIN: 35% pectin (w/v), 5% acetic acid (v/v)
SHELL: 14% chitosan (w/v), 7% acetic acid (v/v), 60% cellulose (v/v), 1% glycerin (v/v)

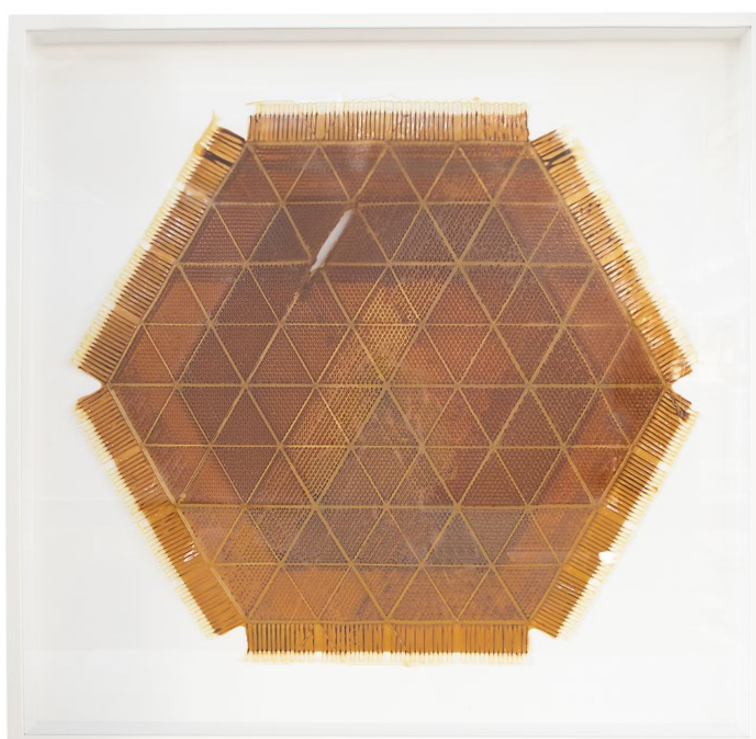
Depositing a dense, basic pectin skin in the same pattern as the chitosan-cellulose shell above takes advantage of pectin's hydrophilicity and Van der Waals forces as a stabilizing mechanism. This facilitates alignment of successive chitosan-cellulose layers and prevents warping off of the substrate as the shell dries. The geometrically sparse but thick skin enables the rigidity of the chitosan-cellulose shell to dominate the panel's mechanical and optical properties. In addition, the high viscosity of the dense chitosan-cellulose colloid required a nozzle with a greater diameter, which yielded a thicker line deposition.



5240.9040.1200.420.893*

SKIN: (Inside) 32% pectin (w/v), 8% chitosan (w/v), 5% glycerin (v/v), 2% acetic acid (v/v)
(Middle) 29% pectin (w/v), 8% chitosan (w/v), 5% glycerin (v/v), 2% acetic acid (v/v)
(Outside) 29% pectin (w/v) 8% chitosan (w/v), 5% glycerin (v/v)
SHELL: 7% chitosan (w/v), 3.5% acetic acid (v/v), 60% cellulose (v/v), 1% glycerin (v/v)

A rougher, hydrophilic surface can resist the contractile force of drying chitosan-cellulose patterning in the outer layer of this panel, enabling higher resolution printing and alignment of subsequent layers. This results in a panel with higher rigidity and tensile strength, which warps slowly over time. Conversely, a smoother, hydrophobic, and basic skin creates contrasts between the translucency and smooth texture of the pectin and the grainy, opaque chitosan-cellulose layers. Moreover, depositing the acidic chitosan-cellulose shell pattern onto a basic pectin-chitosan skin in the saturated middle and outside layers shifts the skin's chitosan out of a polyelectrolyte complex with the pectin, creating a reddish marbling effect over time. This 'marbling' is an indication of how much heat and humidity the material experiences in its environment, while increasing its dissociation rate (Kd).



Aguahoja: Hexes

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2090.9040.1200.420.0*

SHELL: 7% chitosan (w/v), 3.5% acetic acid (v/v), 60% cellulose (v/v), 1% glycerin (v/v)

This panel exemplifies the behavior of a shell without its skin. While the chitosan-cellulose shell is more flexible and less brittle without its skin, as indicated by its light golden color, the contractile forces resulting from uneven drying cause it to warp unpredictably and fracture at the points of highest tension. Moreover, the flexibility and dissociation constant of the chitosan-cellulose shell is inversely proportional to the number of layers.

2090.9040.1200.420.0*

SKIN: 35% pectin (w/v), 5% acetic acid (v/v)
SHELL: 11% chitosan (w/v), 5.5% acetic acid (v/v), 60% cellulose (v/v), 1% glycerin (v/v)

A dense, heavy, rigid, and hydrophilic pectin skin countervails a shell pattern that is light and flexible. Varying the proportions between the two determines which set of mechanical properties is dominant and how the panel may warp over time, as well as its dissociation rate (Kd). Moreover, the acidity of the pectin colloid relative to that of the chitosan-cellulose shell as it is deposited onto the dry, rigid, and brittle skin results in both faster water evaporation and absorption, thereby engendering a very dark and rigid chitosan-cellulose shell over time.

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