Imaginary Beings
2012

Imaginary Beings takes its title from Jorge Luis Borges's 1957 *Libro de los seres imaginarios* (*Book of Imaginary Beings*), a miscellany of more than a hundred fantastical beasts from folklore and literature. At the project's core is the premise that human organs—and even entire organisms—will someday be digitally designed and developed, augmenting their functionality. In Oxman's vision, technology will not only enhance humans' current abilities, but will allow us to gain new ones, including those possessed by Borges's imaginary beings, such as flight, underwater breathing, and invisibility.

The experiments displayed here propose improvements to the skeletal, pulmonary, and muscular functions of the human body. For their design and digital fabrication, Oxman drew on a library of algorithms inspired by natural forms, and developed 3D-printing technologies capable of creating prototypes with a variety of materials and textures.

Vespers
2016–18

Vespers is a collection of fifteen 3D-printed masks that explore the idea of designing with live biological materials. The collection consists of three distinct series, each reinterpreting the concept of the death mask—traditionally a wax or plaster impression of a corpse's face. Taken as a whole, the three series form a narrative arc from death to rebirth. In the first series, Oxman and The Mediated Matter Group looked at the death mask as a cultural artifact. Fabricated using an algorithm that deconstructed polyhedral meshes into subdivided surfaces, the masks were 3D printed with photopolymers, as well as with bismuth, silver, and gold, and rendered in color combinations that recur in religious practices around the world.

Vespers II represents the moment between life and death. Letting the inner structures of the masks come to the surface, the team employed a Data-driven Material Modeling (DdMM) process that used external, user-generated geometry-based data sets to produce 3D-printed objects from diverse materials.

The third series features the mask as a vessel for life—both fleeting and commencing—by incorporating living microorganisms in its design. Vespers III were printed in a colorless state and then gradually infused with pigment from E-coli bacteria that were guided by the masks' precise material distributions. The non-living materials (the photopolymers the objects were 3D printed with) provide a habitat for the living ones (the bacteria).

Totems
2019

One of Oxman and The Mediated Matter Group's research goals has been the investigation of materials and substances that can sustain and enhance the survival of all species. This quest has guided their research on melanin, a pigment that defines the color of skin, fur, hair, and eyes in millions of species; it can be found in everything from the blue of peacock feathers to the ochre of butterfly wings. A biomarker of evolution, melanin acts differently in different organisms. Defending against ultraviolet radiation in some species or harvesting energy in others, melanin is also capable of binding metals and providing thermal regulation.

In Oxman's vision, melanin might someday be used in architecture to help produce optical variations in a building's facade depending on the time of day and season, or in the construction of responsive greenhouses. The Totems columns on view here are the initial phase in this investigation. The first step in Totems' design was determining how to generate melanin on demand; the team eventually settled on a method of extracting the enzyme tyrosinase from mushrooms, which could then be used in a chemical reaction that converted the amino acid tyrosine (a protein building block) into melanin. Next, they experimented with programming melanin's interaction across scales, employing the pigments in liquid and powder form. Each of the columns seen here was 3D-printed with six distinct channels containing liquid melanin.

Glass I and II
2015–17

In 2015, Oxman and The Mediated Matter Group developed the first Glass 3D Printer (G3DP), which produces structures made of extruded layers of molten glass. Featuring a dual-heating chamber that functions in the upper part as a kiln and in the lower part as an annealer, as well as a sophisticated cooling system, the printer runs at approximately 1,900 degrees Fahrenheit (1,140 degrees Celsius).

Two years later, the team developed a second version, G3DP2, with the goal of making high-fidelity glass objects and structures at an architectural scale. With the additions of a four-axis motion-control system and a three-zone thermal-control system, G3DP2 allows for better command over the printing phase and can process a far higher quantity of molten glass—up to thirty-three pounds—in a single build. With G3DP2, the team built Glass II, a series of three ten-feet-tall columns with flowerlike cross sections. Inspired by the columns of Antoni Gaudí's Basílica de la Sagrada Família in Barcelona, the Glass II columns vary in shape, becoming narrower as they grow taller. This reduces weight at the top, allowing the base to support the structural load. The design of the columns' cross sections is similarly determined by the proposed structural load: the greater the load, the more intricate the pattern of the cross section.

Silk Pavilion II
2019

What might constitute sustainable construction methods for the future? Can humans collaborate with other species in the design and construction of objects and buildings, bringing us closer to the exquisite circularity of nature? These were some of the questions that Oxman and The Mediated Matter Group sought to answer with the development of Silk Pavilion I, a silk dome that was produced through a combination of digital (a computer-controlled robotic arm) and biological (sixty-five hundred silkworms) fabrication. By studying how silkworms respond to changes in their spatial and environmental conditions, the team was able to influence the worms' spinning patterns so that they spun in sheets, rather than cocoons. In contrast to the traditional method for harvesting silk, in which larvae are boiled alive in their cocoons to extract silk thread, this process allows the silkworms to go through their metamorphoses—and lives—in peace.

For Silk Pavilion II, which was specially designed and constructed for this exhibition, kinetic manufacturing was added to the mix. Over the course of ten days, seventeen thousand silkworms spun horizontally across a water-soluble knit draped over a stainless steel frame. As the worms progressed, a rotating mandrel helped guide their spinning motions upward. Changes in heat and light influenced the silkworms' movement, so that the resulting silk varies in density across the structure. The holes in the knit layer, which were created by silkworm excrement, release some of the structure's tensile stress.

Aguahoja
2018–19

More than 300 million tons of plastic are produced every year. Less than one tenth of this material is recycled, with vast quantities ending up in landfills or circulating indefinitely in ocean currents. Exploring biodegradable alternatives to plastic, Oxman and The Mediated Matter Group developed Aguajoha, a water-based fabrication process that uses some of the most abundant biopolymers on our planet: cellulose, which makes up more than half of plant matter; chitin, which is found in dragonfly wings and fungi tissue, among other organisms; and pectin, a fiber that occurs in various fruits. To convert these biopolymers into high-performance materials, the team developed a fabrication platform in which water is mixed with the organic matter and extruded by a robotic arm; the solution solidifies once it comes into contact with oxygen in the air. This system can print objects and structures for applications that span scales and fields of research. The structures obtained from this process were designed as if grown—their form was guided by the process of their formation, and their construction required no assembly.

The project comprises two versions, Aguahoja I and II, each consisting of a library of material experiments and a collection of hardware, software, and wetware tools and technologies. On display here are the prototypes from the first iteration.

Materialecology
2007–08

Many designers and architects have been trained to think of objects and buildings as assemblies of discrete parts with distinct functions. In the natural world, however, the structures of organisms perform different functions at different scales, simultaneously managing structural load,environmental pressures, and spatial constraints. The Materialecology project explores the potential of 3D-printing technologies to create objects that behave similarly to living things by responding and adapting to changes in their environment.

Cartesian Wax

Cartesian Wax is a prototype of a wall surface composed of several resin tiles. The tiles were individually cast and cured using a 3D-milled wax mold, in a process that increasingly deformed the mold as each tile was made. Oxman produced further geometrical and material differences by changing the temperature across the mold as each tile cured, creating variations that augment the material's overall performance. The surface of the wall is thickened in places where more structural support is needed, and its transparency can be modulated depending on light exposure.

Subterrain

Three tissues—those of a leaf, butterfly wing, and scorpion claw—were analyzed at the microscopic scale and reconstructed into three-dimensional wood prototypes using a very fine mill controlled by a computer. Oxman analyzed the behavior of these materials by applying varying loads and exposing them to different temperatures, studying how they stored energy, distributed heat flow, and deformed in response to stress and strain.

Materialecology
2007–08

Armour

This small-scale prototype is a redesign of a staple of modern construction: the I beam, a steel beam with an i-shaped cross section that provides support for structures ranging from bridges to skyscrapers. But unlike the I beam, which has relatively low resistance to torsion, Armour can carry vertical, horizontal, and rotational loads thanks to stiff structural components embedded in its soft skin. Its sectional profile and structural thickness can be varied according to the anticipated load.

Raycounting

Raycounting is a process that uses computational geometry to create full-scale objects by measuring the intensity and orientation of light rays. When applied at the architectural scale, the process could hypothetically produce facade treatments that are able to adapt to specific environmental conditions, such as sun exposure and temperature.

Monocoque and Beast

French for “single shell,” Monocoque is a construction technique that produces objects whose external skins can carry weight. The thick, load-bearing areas of these objects’ skins are embedded with veinlike elements that distribute shear stress and pressure over their surfaces. The Monocoque prototypes are part of a series titled Beasts. The series’ main project, Beast, is a model for a chaise longue whose surface has been locally modulated to fit the curvatures of a human body.