grammar study of Frank Lloyd Wright's prairie houses, the derivative system was represented as implicit in the design of the original, when instead what was produced was a synthetic system controlled by programmatic relationships. In the context of design frames, this would be akin to limiting form generation to the *digital-synthetic* frame, whereas the original system would have been strongly influenced by the contextual relationships of *natural-ecological* framing. L-system-based structures and biological form generation exhibit a similar contextual problem resulting from dramatically shifting scales and ignoring the natural and environmental forces that influence the development of plants and organisms.

Traditions of conflicting metaphors of nature vs. the mechanical metaphors in modern design were explored in order to provide context for the current influence of natural models in digital architecture and emerging trends toward synthetic models of computation. Traditional singular models for design have proven insufficient against integrative approaches to design. The capacity for parametric linking through computation in architecture was explored, suggesting methods for framing design decisions that allow for competing and interrelating criteria for design to be developed. Therefore, a system based on framing design rather than singular metaphorical models may respond to computational considerations for design. Computational design seeks innovation through synthesis of multiple streams of information from varied sources. The resulting solutions are as comprehensive as the algorithms or parametric models that calculate them. It is in this way that architecture inherently looks to external and internal sources for organizational logics and models for design. These frames for exigency in architecture provide sources for innovation and reinvention in architecture. The *natural-ecological, material-artificial, performance-energetic, cultural-anthropocentric, and digital-synthetic* design frames represent competing criteria for design that are readily integrated in comprehensive and multidisciplinary design (Figure 7). The notion of competition to promote design solution through iteration is a compelling one: it is a model of evolutionary fitness that may return the focus of architecture where it belongs, as a manifestation of energetic flows whose purpose is to give us shelter; in the modern ecological crisis that may mean shelter from our own devices, while simultaneously moving the spirit and reminding us that we, too, are nature.

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THE GREENHOUSE AND CABINET OF FUTURE FOSSILS:
INTERFACING NATURE IN THE BUILT ENVIRONMENT

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ABSTRACT

The Greenhouse and Cabinet of Future Fossils *was commissioned by the American Philosophical Society Museum, funded by Heritage Philadelphia Program, a program of The Pew Center for Arts & Heritage.*

The Greenhouse and Cabinet of Future Fossils *attempts to gather, digest, and disseminate information about nature while also incorporating cutting-edge design and fabrication techniques to ultimately produce a greenhouse of the future.*

The pavilion structure is populated with cold frame modules and futuristic ceramic and 3D printed curiosities, prefabricated and assembled in the Jefferson Garden, Philadelphia. Taking inspiration from the artifacts in the exhibition, Of Elephants and Roses: Encounters with French Natural History, 1790–1830, the greenhouse revisits 19th-century thematic issues related to nature, culture, and the city to offer new interpretations of greenhouse architecture as urban hybrid ecosystems whose nonstandard form features new material and fabrication logics that inspire a shift away from a technical approach to sustainable architecture to one rooted in design and the built environment. The pavilion mobilizes concepts of event as the public is invited to actively participate in the planting of the cold frames, thus contributing to the actual secondary structure of the greenhouse, and then disassembling the structure at the end of the installation period and disseminating the planted materials. As a conceptual and provocative backdrop to this project, references are made to important contributions recently made by a small group of accomplished scientists, architects, and researchers at a university symposium whose central theme was to discuss next steps for sustaining sustainability.

figure 1
Greenhouse and Cabinet of Future Fossils, 2011.

figure 1

1 INTRODUCTION

A greenhouse is a place for humans to interface nature in artificially produced synthetic environments. Greenhouses are, in fact, quite unnatural. Greenhouses are also active labs for learning and places to engage the culture of environment. They have been the sites of technological innovation in materials design, building construction and fabrication throughout history, particularly in developing cast iron and glass transparent construction in the 19th century in Britain and France. Material intensities in greenhouse architecture foster unique settings for relational calibrations between humans and nature. In many ways the greenhouse typology offers itself as a discursive object for the manifestations of these exchanges. This paper explores new greenhouse architectures through one specific built project titled The *Greenhouse and Cabinet of Future Fossils*, whose material and structural complexity amplify and ultimately generate interfaces between humans and nature at the scale of a pavilion extended into the city. These new greenhouse natures feature hybrid ecosystems where age-old means for controlling climate through cold frames are deployed alongside advances in material production, digital complexity, and fabrication. The result is a greenhouse that is not just a spectacle, but also fosters deep ecologies that recalibrate our relationship with nature in an urban public setting. Central to this work is an alternative strategy opening too often closely prescribed parameters of "sustainable design," remedying what professor and architect Michael Hensel recently labeled "sustainability fatigue."

2 FOREGROUND

During a recent symposium at the College of Architecture, Art and Planning at Cornell University, a small group of architects and scientists gathered to discuss next steps for *Sustaining Sustainability*. The symposium of this title was co-organized by Professor Michael Hensel, Head of the Research Center for Architecture and Tectonics at the Oslo School of Architecture and Design, and Professor Mark Cruvellier, Chair of the Department of Architecture at Cornell University. The dominant theme for this prequel event to *Alternative Approaches to Sustainability in Architecture*, due to take place next year, was affirmed in Cruvellier's opening remarks as being "alternative as primary," claiming that our built environments are in fact new ecosystems. The lectures were delivered by a diverse group of researchers and practitioners spanning multiple disciplines from biology to architecture who share a common interest for rethinking sustainability. This symposium was not centered upon exhausted issues including energy, optimization, and performance, which tend to dominate most conferences on sustainability in architecture today, but was instead focused on rethinking the entire conceptual foundation for the project, one which fundamentally examines our relationship with nature and nature's relationship with humans. Important to this shift is a move away from purely technical solutions to environmental sustainability and a move toward an understanding that our built and natural environments are equally becoming the contexts for thriving hybrid ecosystems. A central question throughout the symposium concerned anthropocentric versus nonanthropocentric modalities in negotiating architecture and sustainability (Sabin 2012).

2.1 Niche Ecologies

Hensel launched the symposium with a provocative keynote lecture calling for a nonanthropocentric architectural agenda for sustaining sustainability, an agenda defining humans as equal to and not separate from nature. He challenged the audience to consider new architectural projects featuring

figure 2

figure 2
Greenhouse and Cabinet of Future Fossils, 2011. Taking inspiration from the artifacts in the exhibition Of Elephants and Roses: Encounters with French Natural History, 1790–1830, the pavilion structure is populated with cold frame modules and futuristic ceramic and 3D printed curiosities, prefabricated and assembled in the Jefferson Garden, Philadelphia. Photo: Brent Wahl.

niche environments with several material skins that in their compilation generate built ecosystems. This agenda was outlined with eight major themes spanning multiple scales, from material performance to settlement patterns and process. Hensel challenged projects that are only engaged in complex shape making: biomorphic expressions that fall flat as discrete objects disengaged from their natural environments. In particular, Hensel criticized architectural projects with thin exteriors where the "table cloth is laid across the entire site."

Hensel championed common architectural concepts employing degrees of interiority and exteriority where multiple envelopes unfold, one interior into the next. Less common perhaps, at least in the context of the topic of sustainability, were the sited projects. The work of Frei Otto and the Blur Building by Diller Scofidio+Renfro were mentioned as exemplary projects where the building envelope is considered to foster its own climate unfolding outward. Spidernethewood by R&Sie(n), 2007, Nimes, France, was featured for its inventiveness in employing vegetation that extends and connects the built threshold with the local climate. This sits in contrast to what Hensel calls "eco wallpaper," architectural elements that do not offer long-term sustainable solutions due to their lack of linkages to existing climates and ecosystems. In both projects, the nature of each ecosystem is intertwined within a cultural spectrum, respectively located at extremes—of the spectacular and an intensely private domain.

3 19TH-CENTURY GREENHOUSE NATURES

In the case of *The Greenhouse and Cabinet of Future Fossils*, contemporary niche ecologies are explored through advanced digital technologies and fabrication in the context of shared technological and cultural relationships present between Philadelphia and Paris during the 19th century. During this time we see the birth of the lab scientist and the amplification of an anthropocentric relationship with the natural environment in the western world. The greenhouse itself became the epicenter for the control and display of nature as a new environmental spectacle for the masses. *The Greenhouse and Cabinet of Future Fossils* attempts to revisit some of these themes to opportunistically recalibrate our relationship with nature in an urban setting through advanced digital processes in architectural design. Central to this is an interest in rethinking sustainable architecture, where technical issues of optimization and energy manipulation are not primary and are instead centered upon facilitating built interfaces between humans and nature in public urban settings. Technological advances in digital tooling and material production are mined for alternative geometries and formal expressions that inspire the general public about new greenhouse natures in the city (Figure 2).

figure 3

Greenhouse and Cabinet of Future Fossils, 2011. Line drawing showing placement of cold frame modules within the cross-rib system. Each cold frame is removable and portable, giving it dual purpose as part of a collection in the greenhouse and also personalized as a small container garden for urban dwellers.

figure 4

Greenhouse and Cabinet of Future Fossils, planted cold frames, 2011. Photo: Kathryn Rufe.

3.1 Between the Field and the Cabinet

Taking inspiration from the artifacts and themes present in the exhibition, *Of Elephants and Roses: Encounters with French Natural History, 1790–1830, The Greenhouse and Cabinet of Future Fossils* attempts to gather, digest, and disseminate information about nature while also incorporating cutting-edge design and fabrication techniques to ultimately produce a greenhouse of the future (Sabin 2012).

Central to these interests is the topic of transformation operating at three distinct time scales and at three stages within the design process. The first involves research into the emergent spatial concepts of the field and the cabinet as present in the means and methods undertaken to collect and study scientific data during the 19th century. As Dorinda Outram points out in her essay *"New Spaces in Natural History,"* the shaping of natural history at the beginning of the 19th century had as much to do with the spaces allocated for the study of nature as it did with how the body perceived and digested information about nature. According to Georges Cuvier, a French naturalist and zoologist in the early 19th century, true knowledge did not come from the whole-body experience of the field, but of the introspective and slow gaze of the scientist within his study, the cabinet: the precursor to the *lab*. This statement is in line with his seminal work in comparative anatomy, where he compared internal structures and relationships of organisms as opposed to outwardly formal characteristics (Outram 1996). This sits in contrast to more traditional knowledge-gathering mechanisms of the time, which entailed traversing unbounded nature, collecting and assembling data from a vast, expansive geographical terrain. Common to both data-collecting scenarios is the association of movement with curiosity.

The cabinet or lab may be described as a bounded condition that affords an introspective and synthetic relationship with the field, but at an objective distance. The unbounded—the scientist out in the natural terrain—offers a sensorial and full-body immersion within the field. For curiosity to take place, a transformation ensues in both situations. This transformation is encapsulated by the open and dramatic spatial attributes of the outer-body in the field while simultaneously expressing the closed and steady gaze of the inner-body confined within the boundaries of the cabinet (Outram 1996). In the case of *The Greenhouse and Cabinet of Future Fossils*, the concepts of the field and the cabinet are synthesized and brought together through formal, geometrical, and spatial configurations. This is defined as a three-dimensional tapestry of organic and synthetic material layers formally arranged as arrays of short and long ribs translated and abstracted from a generative design strategy based upon unraveling mathematical knots. In addition to finalizing the lateral structural stability of the primary ribbed frame, the interior cabinet is geometrically materialized as a wall grid of cold frames and display vitrines (Figures 3 and 4). Each individual cold frame is integral to the overall structural concept of the greenhouse. The cabinet is materialized and parametrically controlled through the modularity of digitally fabricated cold frame boxes that populate an unraveling structural tapestry. Overall, *The Greenhouse and Cabinet of Future Fossils* attempts to display, gather, and experience nature between two perceptual terrains occupied by the field and the cabinet.

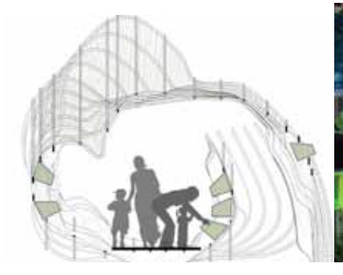

figure 3

figure 4

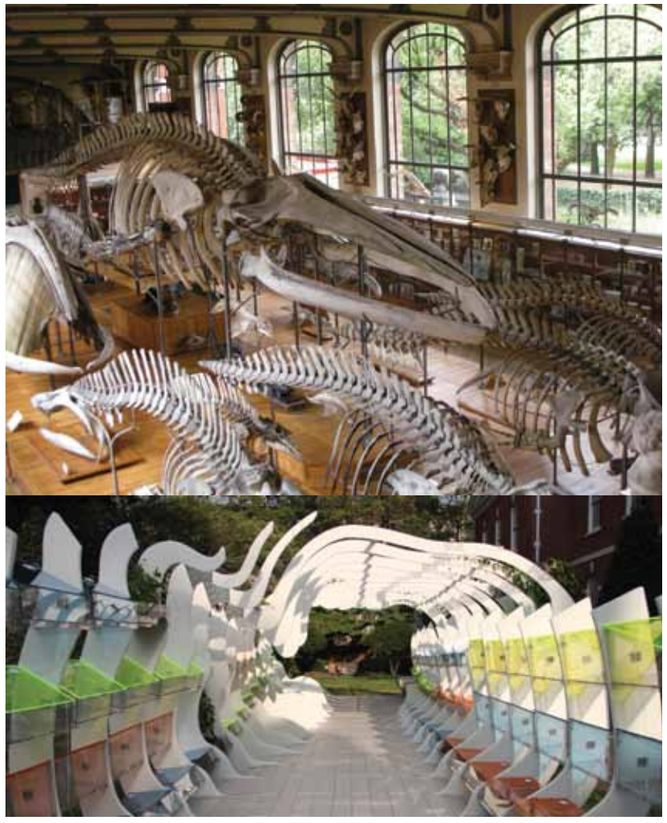

figure 5

figure 5

Left: Georges Cuvier's incredible organisms housed in the Gallery of Paleontology and Comparative Anatomy at the Jardin des Plantes in Paris. Right: View from the Jefferson Garden gate through the greenhouse structure prior to planting the cold frames. Photo: Jenny E. Sabin and Meagan Whetstone.

3.2 Fostering New Natures

Rather than a space built for scientists, the greenhouse is a structure with 125 1' × 2' lidded cold frame boxes to passively control climate locally and for use by ordinary city dwellers. Each box is assembled by hand from snap-fit CNC-cut polycarbonate sheets. The transparent boxes recall the display vitrines of 19th-century museums and are intended to display common gardening as equal to scientific curiosities. Each box is planted by a participant drawn from the public at large. The result is a thriving hybrid ecosystem that engages urban dwellers—a new greenhouse in the city, for the city. Each cold frame box was designed to be portable and removable from the greenhouse structure, with the intent that city dwellers could take the individual cold frames after the installation period and use them as small gardens in window boxes, etc. Thus, the greenhouse not only serves as spectacle for the larger urban public, but also has the capacity to become personalized as smaller architectural elements or personal gardens. This level of personalization with nature is not only fruitful conceptual ground for new models of greenhouse architectures, but it is also a necessary first act in recalibrating human-nature relationships in urban environments. This is a

figure 6

Left: Greenhouse and Cabinet of Future Fossils, laser-cut schematic model, 2011. Photo: Jenny E. Sabin. Right: The primary geometrical system of the greenhouse structure is generated by a select group of profile curves from the unraveling mathematical knots. The material palette consists of four integrated systems: snap-fit CNC-cut cold frame boxes, CNC-cut primary HDPE ribs, 100 percent recycled extruded plastic lumber layered to form long bracing ribs, vine canopy composed of woven cable, and stainless steel X-bracing located in two bays for added reinforcement.

figures 7 and 8

The structure is composed of a primary rib and cross-bracing system of CNC-cut recyclable high-density polyethylene sheets prefabricated locally in Philadelphia. Photo (top): Brent Wahl.

figure 6

figure 7

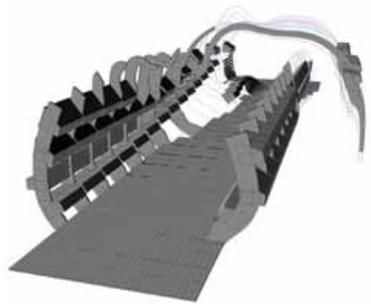

figure 8

notion also upheld within current research on wildlife habitats in our urban built environments. While the greenhouse does not foster new ecosystems for wildlife, it does provide alternative venues for urban gardening in both assembled and dispersed arrangements.

3.3 Urban Ecosystems

John Marzluff is a professor of wildlife science at the University of Washington whose research focuses on pressing conservation issues concerning the social behavior and ecology of bird species, specifically jays and ravens. Marzluff's talk, "Sustaining the Connections Between Humans and Nature in Urban Ecosystems: A Bird's Eye View," unfolded a call for contextual consideration: "To conserve diversity, we cannot do the same thing everywhere." Marzluff's research revealed that urban areas are capable of extraordinary diversity. More specifically, he described "where colonization of specific bird species outpaces extirpation, urban areas hold diverse avifaunas." An avifauna refers to all of the birds within a given geographic region. Importantly, management and planning must be equally diverse to administer these new urban ecosystems. While human engagement is typically low in urban centers, Marzluff's message calls for more human engagement with nature in our cities as a method for fostering new and hybrid urban ecosystems. City dwellers, for example, must be actively involved in managing nest boxes and bird feeders. As Marzluff described, human engagement in the context of urban ecosystems puts a face on biodiversity and thus recalibrates our relationship with nature by making it personal. Perhaps architecture may facilitate this recalibration?

figure 9

4 GEOMETRIC TRANSFORMATIONS

The geometric expression of the greenhouse is based upon several interacting parameters. Key to this is exciting the general public about new formal expressions for greenhouse architecture facilitated by advancements in digital fabrication and material logics. The first is an unraveling of a 3–8 torus knot through time. These knot morphologies were chosen for two reasons. The first relates the geometric behavior of an unraveling knot to the desired spatial and formal shift in the greenhouse from *field* to *cabinet* or from open to closed. The siting of the greenhouse abuts the only entrance to the Jefferson Garden, which faces Independence Hall in the heart of historic Philadelphia. Visitors are forced to walk through the greenhouse to enter the garden, thus filtering their experience from street to greenhouse to garden and back again. The primary geometrical system of the greenhouse structure is generated by a select group of profile curves from the unraveling mathematical knots that in turn convey a spatial and formal transformation as visitors move from the exterior to the interior.

The second highlights an abstract and synthetic formal relationship between the configuration of the unraveling knot and the internal structures and relationships revealed in Cuvier's incredible organisms housed in the Gallery of Paleontology and Comparative Anatomy at the Jardin des Plantes in Paris.

4.1 Mathematics and Nature

Mathematical scripts are used as a sketch tool to explore experimental geometries that share synthetic relationships with models found in nature. In addition to employing generative design strategies, the overall form is thickened and thinned parametrically to optimize the placement of at least 125 cold frame modules. Lateral stability of the structure is increased by the placement of each cold frame and further checked through finite element analysis. Through iteration and scripting, it is possible to simulate and inhabit geometry as nature does, absent of representation and translation, in a constant formation, where geometry and matter are one. In this sense, software is a new material ground to explore formal relationships in the context of contextual constraints, be they mathematical, environmental, or programmatic. The greenhouse configuration as a set of 20 vertical cross-ribs also recalls the bones of giant vertebrates put on display as a public spectacle in the 19th century (Figure 5).

The greenhouse takes up similar themes related to movement through the formal and mathematical transformations described previously and as an interface with nature at multiple scales and synthetic terrains. From the interior "cabinet," the structure opens up to the world around it through an arched expanse that curves up and over the inner area, creating a space that is simultaneously inside and outside—enclosed but not confined.

4.2 Cabinet of Future Fossils

The irregular organic forms of the arches and walls are strewn with creeping vines, and the walls incorporate the translucent, removable cold frames (mini-greenhouses). These natural interfaces

figure 9

Cabinet of Future Fossils, 3D-printed seed pods and mathematical flowers generated by mathematical scripts, detail, 2011. Photo: Jenny E. Sabin.

figure 10

The architect is now in full control of the design-to-manufacture process through the use of digital tools and mathematically sophisticated models and scripts. In the case of the greenhouse, a generative study of knots becomes the geometric and material ground that is refined and later developed into 20 cross-rib cut files for a CNC machine. CNC-cut cross-ribs and laser-cut splice plates are prefabricated and brought to site for rapid assembly. Photo: Jenny E. Sabin.

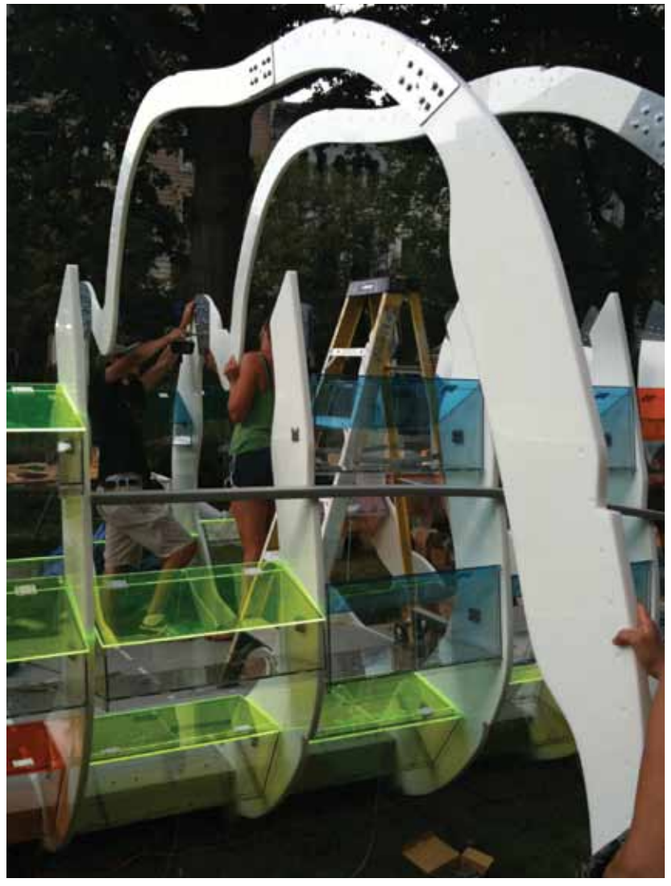

figure 10

operate at the scale of the city as viewed from the street, at the scale of Jefferson Garden itself, and at the scales of the greenhouse structure and cold frame modules. Each cold frame slides and locks into the greenhouse structure and contains both planted matter and 3D-printed forms. The greenhouse canopy is populated with a second organic skin composed of small black-eyed susan blossoms, white and lavender clematis, and scarlet runner beans. Movement also played a role in the objectification of nature during the early part of the 19th century. Artifacts within the APS Museum exhibition such as the Sevres ceramics and popular accessories such as handbags, irons, and fans imprinted with various mammalian motifs worked to disseminate information about nature to the general public across all socioeconomic brackets. As objects of desire, these artifacts also generated a new nature outside of the bounds of the scientist, the field, and the cabinet. *The Cabinet of Future Fossils* plays with and reinterprets these same thematic issues.

The interior gallery under the vine canopy houses *The Cabinet of Future Fossils*, a modular system holding digitally generated and newly fabricated ceramic and 3D-printed artifacts inspired by nature, complexity, and generative design processes (Figure 9).

Like the fossils used by French scientists in post-revolutionary France to classify extinct mammoths and mastodons, these three-dimensional "future fossils" imply an era of the future, a new nature that will, in turn, look back on these synthetically created "natural" objects of the age of computation and digital fabrication. These forms are also a play on 19th-century "cabinets" that were filled with a vast variety of specimens and fossils, which were at once scientifically relevant and a spectacle for the general public to view.

5 CONCLUSION

The widespread use of digital tools in architectural practice enables the designer to opportunistically extract processes and forms found in nature for architectural investigation. Looking to nature for design models certainly is not new, but our relationship with making and digital fabrication is.

The architect is now in full control of the design-to-manufacture process through the use of digital tools and mathematically sophisticated models and scripts. In the case of the greenhouse, a generative study of knots becomes the geometric and material ground that is refined and later developed into 20 cross-rib cut files for a computer numerically controlled (CNC) machine (Figure 10). While these technological breakthroughs are certainly interesting and now commonplace, we must elevate digital crafting beyond mere formal production and toward more meaningful pursuits that engage the culture of environment. This affords not only new formal expressions, but also the opportunity to design, fabricate, and build new architectural solutions that excite and engage the general public in the context of pressing problems that need attention in light of "sustainability fatigue."

figure 11

The overall form is parametrically adjusted and governed by the cold frame module, also integral for lateral stability. Its configuration as a set of 20 vertical cross-ribs also recalls the bones of giant vertebrates put on display as a public spectacle in the 19th century. The greenhouse itself becomes a fossil of the future that bridges science, technology, and design. Photo: Meagan Whetstone.

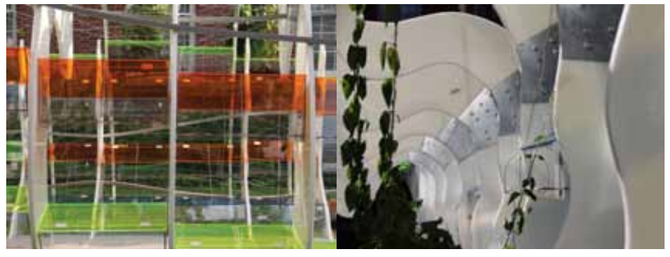

figure 11

figure 12

The secondary structure is composed of 125 cold frame boxes—fabricated from CNC-cut polycarbonate and acrylic—that are both planted and removed as keepsakes, objects for dispersal within the urban and domesticated confines of Philadelphia and beyond. The greenhouse structure features a variegated surface typology containing both earth, grown matter, and colorful acrylic lids for each cold frame module. Photo: Brent Wahl (left) and Merrill Mason (right).

figure 12

The symposium described previously provoked a new set of questions concerning design research models, transdisciplinary collaboration, next steps, and most importantly, the cultural realm within Hensel's call for a nonanthropocentric architectural agenda for *sustaining sustainability.* Similar to these primary mandates, the greenhouse attempts to interface and foster the *culture* of environment.

John Marzluff's message is simple: "in order to sustain connections between humans and nature, we need to put a face on biodiversity by making it personal." For Marzluff, deep ecology is also cultural. We need to place importance upon recalibrating our relationship with nature in order to address next steps in sustainable design. Sustainable architecture should therefore be less concerned with issues of optimization and energy manipulation and more emphatic about facilitating built interfaces between humans and nature. The greenhouse and lab spectacles of 19th-century France were sites of technological innovation in materials design, building construction, and fabrication. Importantly, these structures also celebrated the *culture* of environment. Material intensities in greenhouse architecture foster unique settings for relational calibrations between humans and nature. *The Greenhouse and Cabinet of Future Fossils* is a contemporary twist on such an interface, a new nature in the built environment.

CREDITS

The Greenhouse and Cabinet of Future Fossils was commissioned by the American Philosophical Society Museum, funded by Heritage Philadelphia Program, a program of The Pew Center for Arts & Heritage.

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ARCHITECTURE OF AN ACTIVE CONTEXT

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ABSTRACT

As we stand with our feet on earth's outermost surface we build an architecture today that is much like it was several thousand years earlier, in an attempt to extend that outer shell with one of our own making. Artificial masses are built from a refinement of this existing geologic layer into materials of stone, steel, concrete, and glass that assemble to produce new pockets of space through the buildings they create. However, the sixth century BC writer Thales of Miletus put a different perspective on this: he insisted that we live, in reality, not on the summit of a solid earth but at the bottom of an ocean of air (Holmyard 1931). And so, as architecture continues to build up the outermost layer of earth's surface through a mimicking, embellishing, and enhancing of the materials which it comes from, it raises the question of why we have not brought a similar relationship to the materialities at the bottom of this "ocean" of air to create the spaces we call architecture.

If you were looking to level a complaint with the architectural profession, stating that it has not been ambitious enough in scope would not be one. Architects have never shied away from the opportunity to design everything from the building's shell to the teaspoon used to stir your sugar in its matching cup. But it would seem that the profession has developed a rather large blind spot in terms of what it sees as a malleable material with which to engage. Architects have made assumptions as to what is beyond our scope of action, refraining from engaging a range of material variables due to a belief that the task would be too great or simply beyond our physical control. So even though we are enveloped by them continuously, both on the exterior as well as the interior of our buildings, it must be assumed that the particles, waves, and frequencies of energy that move around us are thought by architects to be too faint and shaky to unload upon them any heavy obligations, that they are too unwieldy for us to control to create the physical boundaries of separation, security, and movement required of architecture. This has resulted in a cultivated set of blinders that essentially defines architecture as a set of mediation devices (surfaces, walls, and inert masses) for tempering the environmental context it is situated in from the individuals and activities within. The spaces we inhabit are defined by their ability to decide what gets in and what stays out (sunlight, precipitation, winds). We place our organizational demands and aesthetic opinions on the surfaces that mediate these variables rather than seeing them as available for manipulation as a building material on their own. The intention here is to recalibrate the materialities that make up that environmental context to build architecture.

The starting point is a rather naive question: can we design the energy systems that course in and around us daily as an architectural material so as to take on the needs of activities, securities, and lifestyles associated with architecture? Can the variables that we would normally mediate against instead be heightened and amplified so as to become the architecture itself? That which many would incorrectly dismiss as simply "air" today—thought to be homogeneous, scale-less, and vacant due in part to the limits of our human sensory system to perceive more fully otherwise—might tomorrow be further articulated, populated, and layered so as to become a materiality that will build spatial boundaries, define activities of individuals and movement, and act as architectural space. Our environmental context consists of a diverse range of materials (particles and waves of energy, spectrum of light, sound waves, and chemical particles) that can be manipulated and formed to meet our needs. The opportunity before us today is to embrace the needs of organizational structures and aesthetics by designing the active context that surrounds us through the material energies that define it.