

BEESLEY
SIBYL – PROJECTS 2010-2012

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This book is published to accompany the Hylozoic Series: Sibyl installation at the 18th Biennale of Sydney, Cockatoo Island, Sydney, Australia, 2012.

The series of projects shown within this book explore a new generation of responsive spaces. The immersive environments of the Hylozoic Series invite viewers to raise fundamental questions about how architecture might behave in the future. Might future buildings begin to know and care about us? Might they start, in primitive ways, to become alive?

Responding to the movement of visitors, ripples of vibration, glowing light, and whispering sound move throughout the immersive layers of these spaces. Floating overhead, many hundreds of thousands of custom-made components spread out into diffuse, translucent clouds. The Hylozoic environments can sense and interact with viewers, and they contain chemical systems that act like a primitive metabolism, processing and exchanging material with the environment.

Projects illustrated within this book have developed by Canadian artist and architect Philip Beesley and collaborators between 2010 and 2012, following the Hylozoic Ground installation at the 2010 Venice Biennale for Architecture. These installations are located in Enghien-les-Bains, Madrid, Salt Lake City, Toronto, Rotterdam, Sydney, and Wellington.

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PHILIP BEESLEY

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1 Neil Spiller, 'Liberating the Infinite Architectural Substance', in Philip Beesley (ed.), *Hylozoic Ground: Liminal Responsive Architecture*, Riverside Architectural Press, Toronto, 2010, p. 51

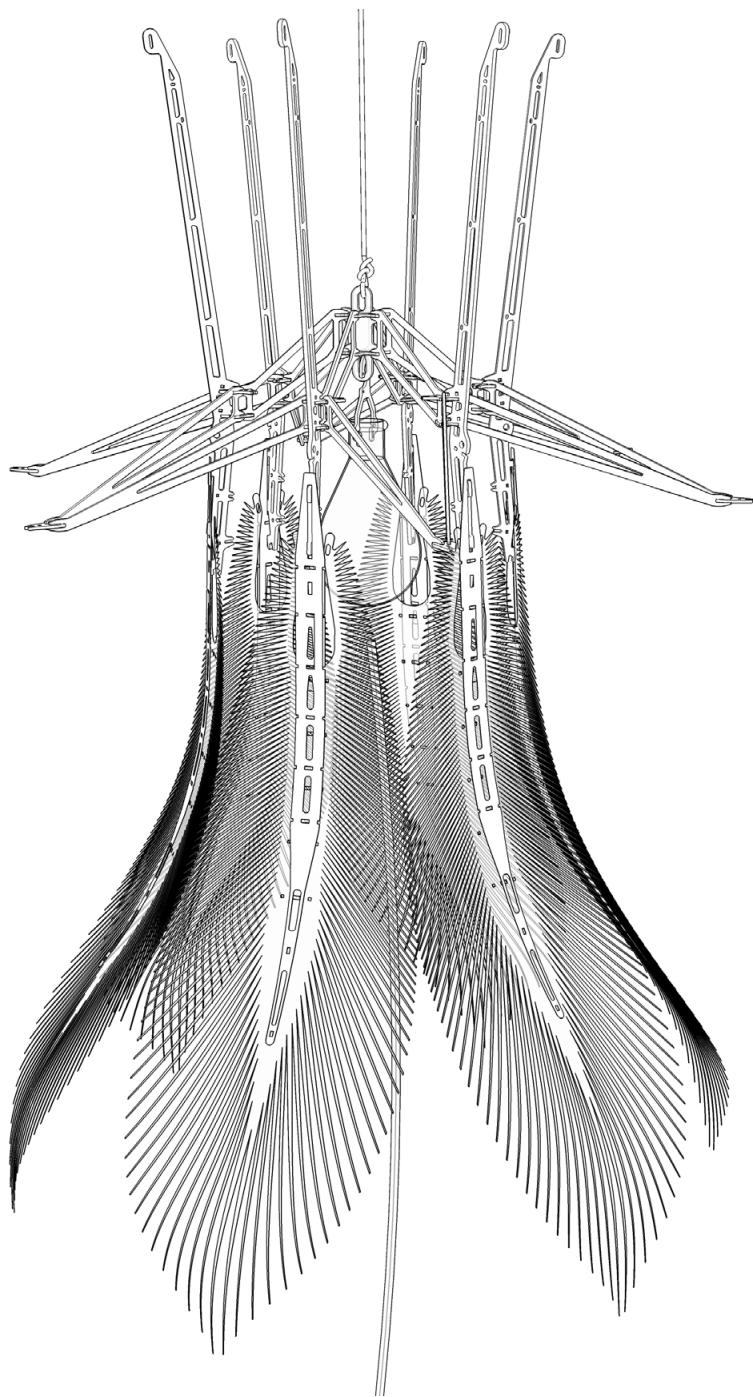
2 Geoff Manaugh, 'Synthetic Geology: Landscape Remediation in an Age of Benign Geotextiles', in Philip Beesley (ed.), *Hylozoic Ground: Liminal Responsive Architecture*, Riverside Architectural Press, Toronto, 2010, p. 44

3 Charles Stankieveh, 'Sewing/ Sowing: Cultivating Responsive Geotextiles', in Philip Beesley (ed.), *Kinetic Architectures & Geotextile Installations*, Riverside Architectural Press, Toronto, 2007, p. 43

At Toronto's 2010 Nuit Blanche, I watched as tens of thousands of visitors came in contact with Philip Beesley's *Aurora*. Approaching the piece with a mixture of awe and tentativeness, visitors could not contain themselves. The lines were long, the night was chilly, and the slow movement of an anxious crowd was like a steady pulse of the heart – bringing people in and pushing them towards the egress. Visitors responded to Beesley's built environment as if it was alive, but was the work responding to human presence? Perhaps there was also a certain fear factor: how would something so transparent react if one ventured too near? Once visitors understood that *Aurora* could no more harm them than it could amuse them, they moved on – yet it left a lasting impression.

The 18th Biennale of Sydney's title, *all our relations*, corresponds to Beesley's concept of the 'hylozoic': that all matter, both animate and inanimate, has life.¹ To this idea, we can now add artificial or technology-based worlds. Beesley's built environments begin to address the subject/object relationship in such a confounding way because the so-called objects are now responding to human presence, thus giving the work almost subject status. When we come into contact with his work – with all its highly integrated systems of interactive fronds, filters and whiskers, built around an intricate lattice of transparent acrylic links – it appears to come to life. The visible membrane is so highly interconnected, with an infrastructure almost too complex to imagine, that it's beautiful to see. He calls this 'benign geotextile', an idea he's worked on since the mid-1990s, in which organic installations are eventually absorbed by the surrounding natural forces.² This relationship between a visual signifier as geo-textile and the environment is one that closely considers the importance of integration and composition – ideas that stand in stark contrast to earlier modernist paradigms – and that *all our relations* attempts to articulate. The new dimensions that shape our current reality do not constitute 'a spectrum – along which binaries compete – but multiple, mutually inclusive dimensions'.³

Gerald McMaster
Co-Artistic Director, Biennale of Sydney



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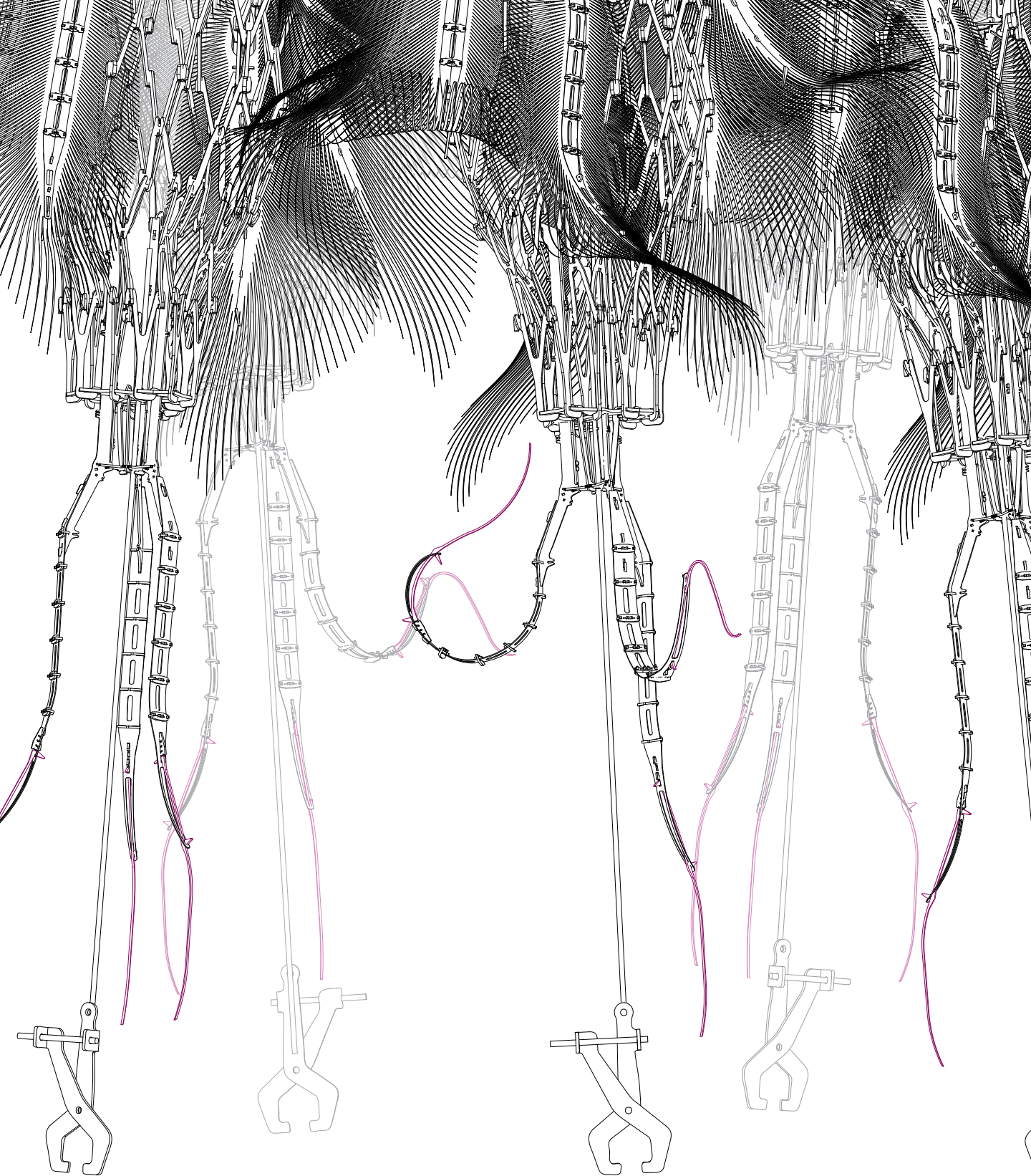












facing page

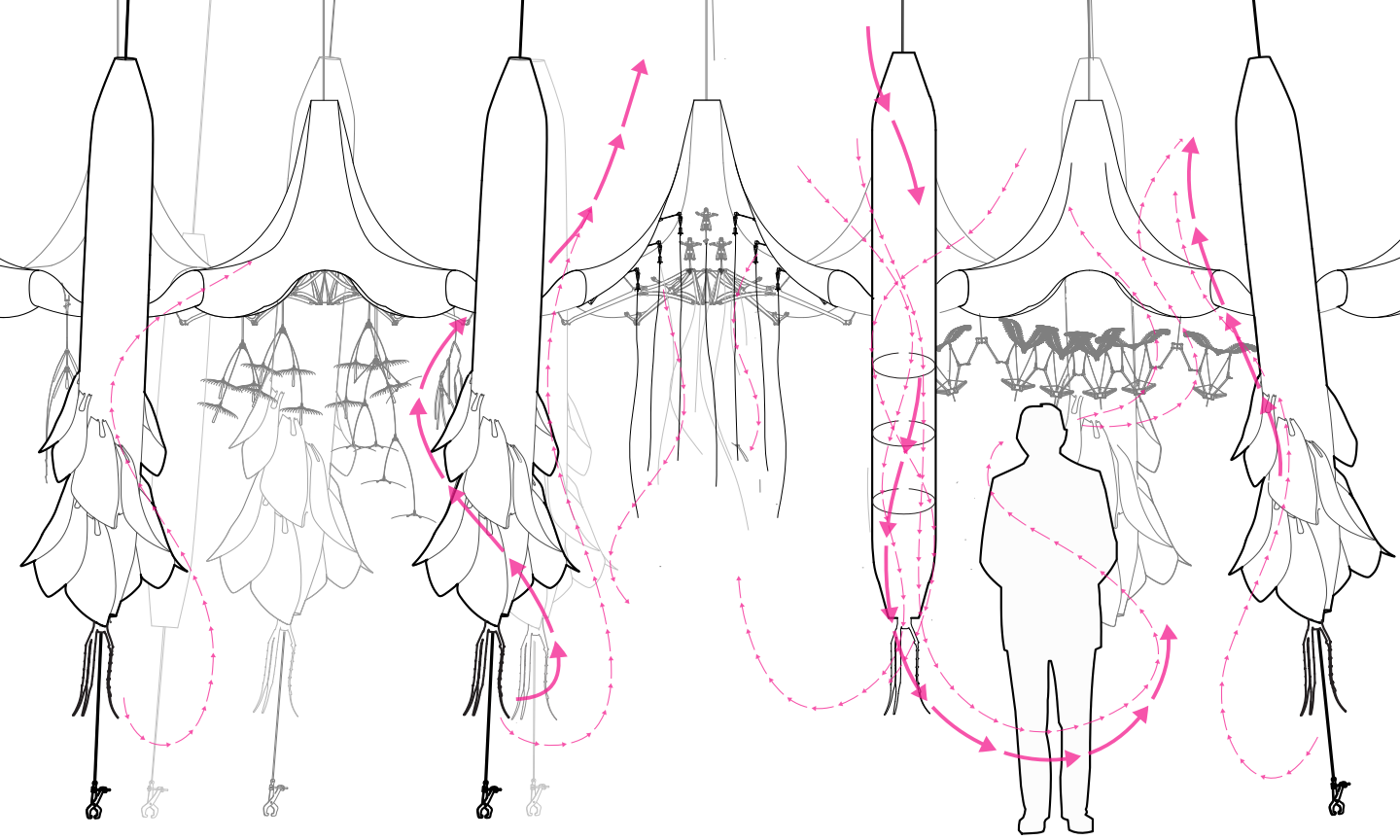
- 1 Sensor lashes produce direct reflex motion in response to viewers.

The *Hylozoic* Series

The series of projects shown within this book explore a new generation of responsive spaces. The immersive environments of the *Hylozoic Series* invite viewers to raise fundamental questions about how architecture might behave in the future. Might future buildings begin to 'know' and 'care' about us? Might they start, in very primitive ways, to become alive?

Responding to the movement of visitors, ripples of vibration, glowing light, and whispering sound move throughout the immersive layers of these spaces. Floating overhead, hundreds of thousands of custom-made components spread out into diffuse, translucent clouds. *Hylozoic* environments can sense and interact with viewers and contain chemical systems that act like a primitive metabolism, processing and exchanging material with the environment. Floating overhead, many hundreds of thousands of custom-made components spread out into diffuse, translucent clouds. The structural cores are delicate transparent meshworks of acrylic and silicone, that form vaulted canopies and groves of basket-like columns. These are clothed with dense clusters of feathered filter clusters and interconnected chains of glass vesicles. A primitive chemical metabolism is housed within the massed vessels. 'Protocells' within this system show the early stages of self-generating growth, exchanging chemicals that can help to renew surrounding spaces.

These environments use a steadily evolving family of custom-made lightweight components made by digital fabrication. Custom-made interlinking components make up the mechanisms and structural layers. Fine-grained interactive control systems use nested arrays of microprocessors that are integrated within the meshwork.



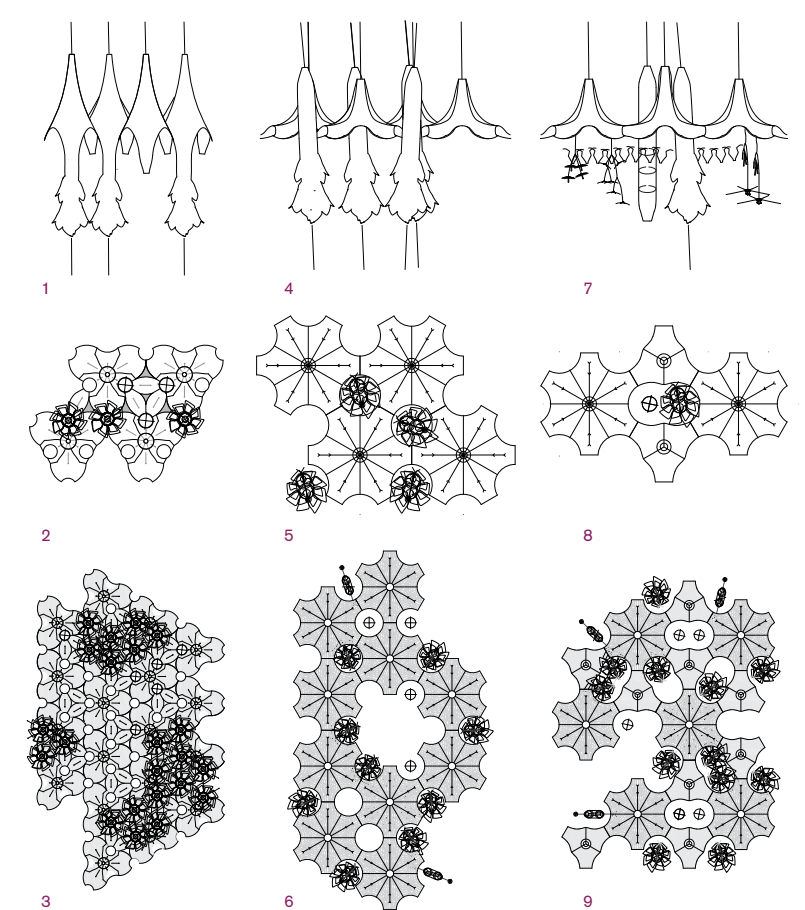
These projects are guided by the work's ancient Greek namesake 'hylozoism', or the belief that all matter has life. The work builds upon preceding installations including the *Hylozoic Ground* installation, mounted within the Canadian Pavilion at the 2010 Venice Biennale for Architecture. Textile-like structural cores, distributed interactive control systems and chemical metabolisms have each moved through multiple stages of development during the two years since that event. New functions are progressively integrated within each location, sharing and revising families of custom component designs. The physical component systems have evolved into robust, highly resilient structures capable of use within permanent installations. Much like the layered organization of human neural systems, microprocessor control systems are now using nested 'subsumption' organization that allows tribe-like groups of mechanisms to communicate and gather into larger patterns of massed behaviour. Active carbon-capture systems are now appearing within delicate glasswork circulation systems. Softly glowing patterns of light stimulate growth and provide signaling that encourages viewers to interact with the environment.

This work is developed through collaborations in art, architecture, engineering, and synthetic biology. A main studio of sculptors, industrial designers and engineers is located in Toronto and Cambridge, Ontario, working closely

2 Visualization of programmed series of motions initiated by occupants within the Hylozoic environment

3 Evolution of Hylozoic Series forms and configurations

- 1-3 First generation. Hylozoic Soil, Montreal Museum of Fine Arts, Montreal, 2007
- 4-6 Second generation. Hylozoic Grove, Museum of the Future, Ars Electronica, Linz, 2008
- 7-9 Fourth generation. Hylozoic Soil, Biologic Art, SIGGRAPH, New Orleans, Louisiana, 2009



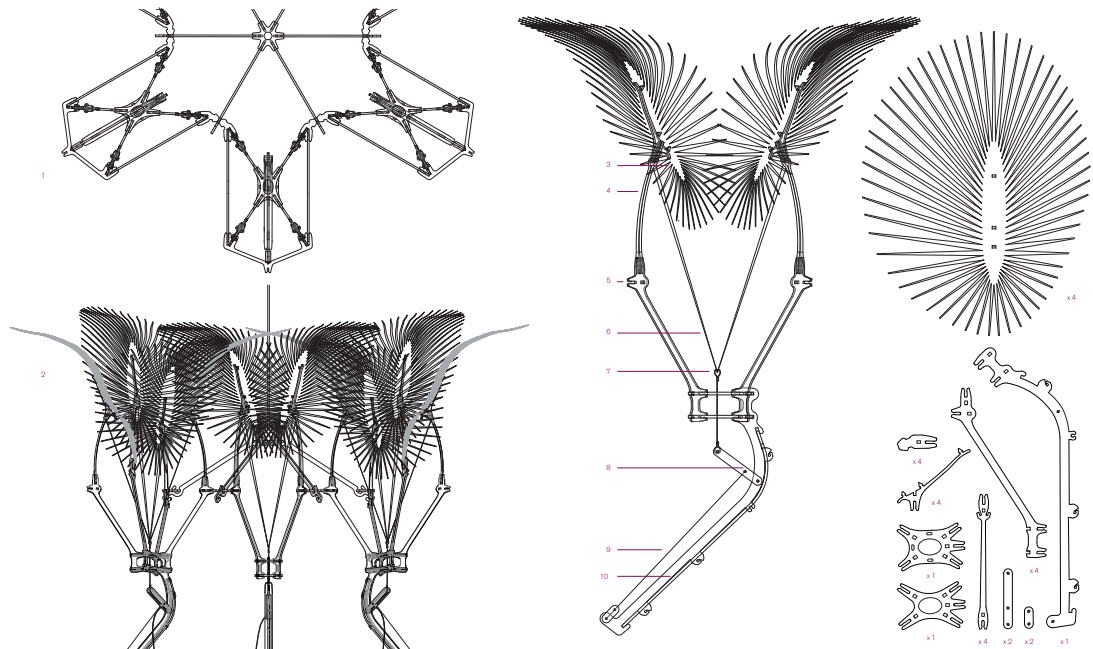
with computational engineering in Waterloo and chemical research in London and Odense. While technical research underlies this work, the work is rooted within imaginary projections that lie beyond the literal functions that have been achieved in the work. The hybrid spaces of the *Hylozoic Series* offer collective negotiation about what life is, how we relate to the environments around us, and how these new relationships might carry us into the future.

Curious emotional experiences can result from interacting with these environments, often intermixing intimacy and alienation. Perhaps these mixed emotions are inevitable when work moves from purely artificial design towards the realm of living systems. Rather unapologetically, the collaborative voices from this studio speak with optimism about forming relationships with the world. Speaking of this work, the critic Detlef Mertins said "[these] interactive installations—part creatures, part environments; part mechanical, part biological—remind us that the cosmological point of reference for architecture has shifted from the human to the non-human: from the Vitruvian man inscribed in a circle and a square as the guarantor of universal validity, to the tangled web of creatures and environments within which humanity lives a promiscuous life."⁴

4 Detlef Mertins in Philip Beesley, *Hylozoic Ground: Liminal responsive architecture*, Riverside Architectural Press, 2010, p. 7.

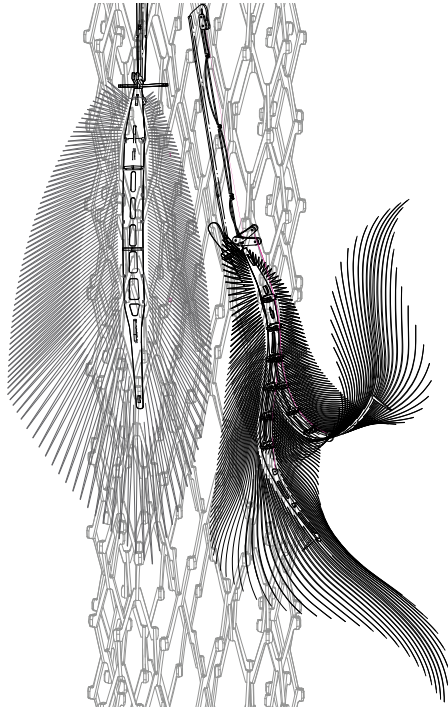
following pages

- 5 diagrams of Filter and Breathing Pores as installed at the Venice Biennale
- 6 Panoramic view of Hylozoic Ground as installed at the Venice Biennale



filter layer assembly diagram

1 Filter cluster plan 2 Filter cluster elevation 3 Filter feather 4 Leaf spring 5 Connection to adjacent filters
6 Tension cable 7 Tension hook 8 Lever arm 9 Shape memory alloy (SMA) actuator 10 Sled assembly



breathing pore assembly diagram

1 Breathing pore assembly actuated position 2 Breathing pore assembly rest position 3 Adjustable SMA clip 4 SMA
5 Lever 6 Tensioned tendon 7 Strengthening gusset for main spine 8 Gland clip 9 Copolyester tongue 10 Tongue clip 11 Arm units for attachment to mesh 12 Tongue struts 13 Feather





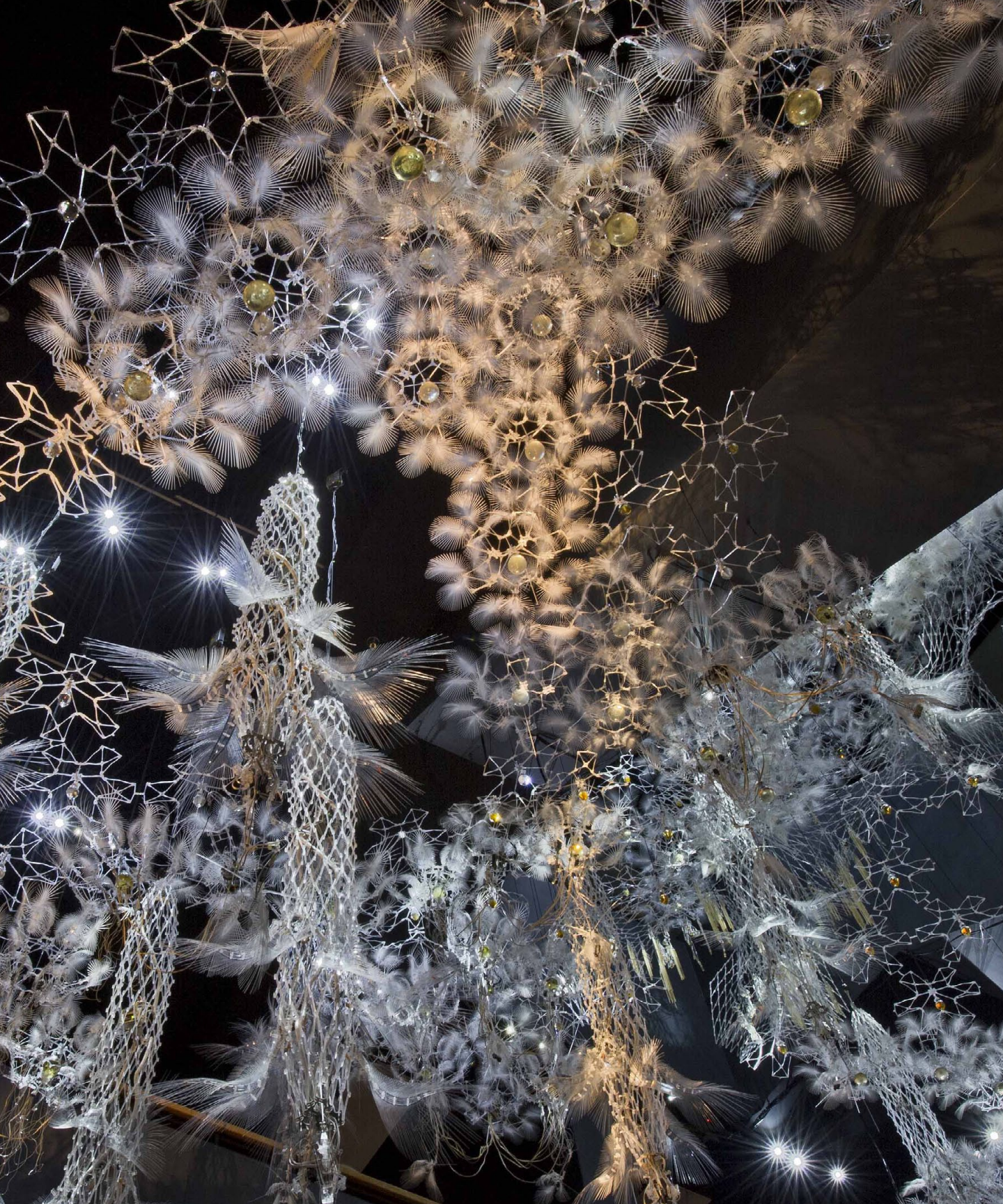
Evolution and Innovation

facing page

1 Hylozoic Series: Espacio detail,
Madrid, 2012

The design of components and systems for the *Hylozoic Series* is a collaborative process. New works are developed through a continual cycle of research and development, prototyping and refinement. Since the first installation of the *Hylozoic Series* at the Musée des beaux-arts de Montréal in 2007, a series of innovations in distributed computation and mechatronics, lightweight meshwork fabrications, and integrated fluid chemical systems have contributed to the immersive qualities of the environments. Each iteration of the *Hylozoic Series* acts as an architectural sculpture in parallel as a testing ground for new engineering research. Development streams focusing on chemistry, computation and interactivity, sound and lighting run in parallel to industrial design of components. Widely varying scales are constantly considered, moving from highly enlarged details such as tooling paths and custom fastening, to large-scale accumulations of floating clouds of material. Physical prototypes and digital simulations are produced in many cycles for each component. By moving in cycles, studio designers gain the ability to work with precision, considering how a component will function at multiple scales and how the broader context of the environment might be affected. Simplicity and economy are prevailing qualities that guide a process that incrementally refines and improves each part in specific ways—strengthening a local weakness, preventing a joint from cracking, or increasing range of motion.

Recent projects undertaken by Beesley's Toronto studio illustrate how specialized ideas are guiding the immersive qualities of the Hylozoic environment. Initial phases of the *Hylozoic Series* concentrated on the textile-



facing page

2 *Hylozoic Veil* view from below,
Salt Lake City, 2011

like qualities of a specialized diagonally-oriented corrugated meshwork that could span and curve, making highly flexible architectural canopies and column structures. Digital fabrication within the studio has supported many generations of refinement of these textile structures. By fitting mechanisms within the flexible surfaces, early generations of the environments gained kinetic functions, flexing and shifting in response to the presence of visitors. Distributed computation systems for controlling these responsive functions were originally based on open-source 'Arduino' microprocessors. Custom-built processors are now being integrated, using shift registers that allow very simple components to handle large volumes of varying signals. Arrays of specialized glassware are now being developed to provide labyrinthine fluid circulation and filtering functions. These circulation systems have been recently developed by combining the expertise of specialized craftspeople with three-dimensional printed prototypes from the studio. Filtering systems employ this glasswork to support the artificial-life chemical interactions integrated within the most recent generations of the *Hylozoic* environments.

HYLOZOIC VEIL

The Leonardo, Salt Lake City, Utah, 2011

Hylozoic Veil opened alongside the official opening of The Leonardo, a museum dedicated to exploring the intersections between technology, science, art, and the humanities. The sculpture integrates large portions of the *Hylozoic Ground* installation developed for the 2010 Venice Biennale for Architecture. It occupies the three-storey space of the Tanner Atrium, which provides central orientation for the varying levels of the building.

Visitors enter the museum and encounter a soaring volume with multiple cloud-like sculpture layers suspended within the lower levels. Banks of escalators invite visitors to move upward through these floating layers, reaching intricately detailed upper sections that contain horizontal expanses of kinetic filters and densely massed glass vessels containing protocells. Hyperbolic vaulted canopies composed of corrugated diagrid acrylic meshwork stretch horizontally to enclose the second level of the sculpture. These structures are densely encrusted with glasswork chains and hovering fronds of acrylic and mylar. Viewers can continue upward through this level to the upper floor of the atrium, reaching an auditorium and a lounge with soaring views of the desert and mountains that surround the city. Gossamer meshworks with feathered fronds and miniature glass vessels cover the uppermost levels. Delicate networks of miniature lights move in slowly rolling patterns that respond to the movements of viewers at this upper level.

A special feature of *Hylozoic Veil* is its stream of data that provides continuous information, tracking the shifting patterns of individual sensors and mechanisms as they operate in response to crowd movements.

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facing page

3 *Hylozoic Veil* view from below,
Salt Lake City, 2011



SARGASSO

Luminato Festival, Toronto, Ontario, 2011

Commissoned by the Luminato Festival, *Sargasso* was designed for the sweeping atrium of Santiago Calatrava’s Allen Lambert Galleria. The work was conceived as a canopy that would slowly shift and float above the city, a forest-like hovering field, kin to primitive life-forms within dense jungles and ocean reefs.

The outer canopy layer of *Sargasso* stretched east and west into the heights of the public hall and met the ground at the centre of the installation. The sloping and curving membrane framed a pool of space that functioned as an open space for public gathering. An inner canopy layer was suspended over this central area, containing an aerial grotto of kinetic bladders and glasswork.

Sargasso refers to the vast, tangled floating masses of living matter and cast-off material that drifts at the centre of the Atlantic.

facing page
4 *Sargasso*, Toronto, 2011



CLOUD BROCADE

WORKShop Gallery, Toronto, Ontario, 2011-12

Le Festival Bains Numériques, Enghien-les-Bains, France, 2012

Cloud Brocade is a vertically oriented suspended geotextile equipped with a network of delicate glass vessels, capable of acting as a space-dividing screen and alternately as a wall-oriented relief panel. The system is organized in three vertical layers that work in concert, performing functions of filtering, accumulation and chemical digestion. Tetrahedral pyramid skeletons made from custom laser-cut acrylic components form a delicate space-truss, studded with an array of small glass vessels that slowly gather atmospheric deposits. The textile-like structure is organized as a Penrose tessellation, a non-repeating geometry that employs ten constant angles within a family of rhombic skeletons. A network of tubes affixed to the truss creates a basic circulatory system, connecting the glass vessels and enabling passive chemical exchanges. A felted layer of mylar fronds lines the opposing side of the truss. This component acts as a one-way filtering membrane that pulls valuable matter into the inner layers.

facing page

- 5 *Cloud Brocade* detail, Toronto, 2012. Photo credit - Millie Samanski.



HYLOZOIC SOIL: ESPACIO

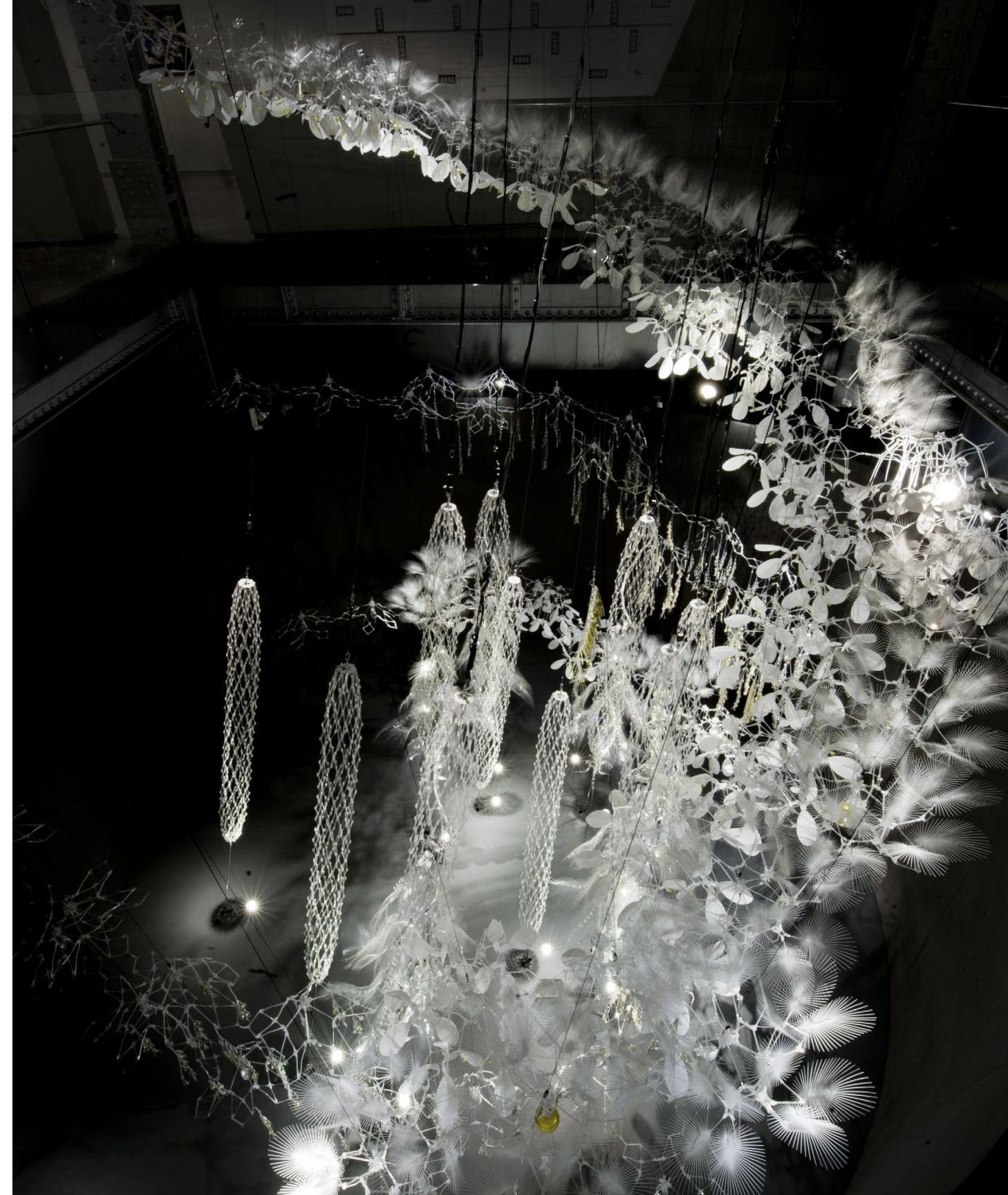
Fundación Telefónica, Madrid, Spain, 2012

The *Espacio* sculpture was installed within the new Espacio space of Fundación Telefónica in Madrid. The three-storey museum is housed within an historic skyscraper located along the Gran Vía, within the heart of the city. *Hylozoic Soil: Espacio* integrates component systems that were originally presented at Madrid's Matadero complex for the VIDA 11.0 Arts and Artificial Life Awards in 2009.

New groves of protocell-filled glass vessels and horizontal filtering layers are arranged as a spiraling river of hovering forms, running around a grove of suspended meshwork 'breathing' columns. The installation was experienced by viewers from several vantage points – from within the sculpture, as they stood on the main floor of the gallery space, and also from above, as the work spiraled and ascended into the second level of the space where it could be viewed alongside an accompanying exhibit that included a major collection of historic Cubist paintings by Juan Gris.

facing page

6 Hylozoic Soil: Espacio, Madrid, 2012.



PROTOCELL FIELD

Dutch Electronic Art Festival,
Rotterdam, Netherlands, 2012

ProtoCell Field was installed for the Dutch Electronic Art Festival in Rotterdam in April of 2012. The sculpture was arranged to form a chapel-like canopy within the vaulted main space of the 1915 ‘Hoofdpostkantoor’ (Head Post Office) on the Coolensingel, designed by architect G.C. Bremer.

New systems of responsive meshwork columns were introduced for this experimental installation. Vibrating clouds of fronds and lengths of pulsing LED lights were arranged in helical chains that spiraled up around each column. Thought-controlled electro-encephalograph headsets were employed as controllers for these column systems. A performance event at the festival employed these new interfaces and explored gently shifting pulsing patterns of light and sound.

facing page

7 ProtoCell Field, Rotterdam, 2012.



HYLOZOIC SERIES: VESICA

The City Gallery, Wellington, New Zealand, 2012

The *Vesica* sculpture introduces a new series of details that include clustered horizontal filtering systems, massed glasswork vessel chains, and increasingly delicate outer meshwork filters. An immersive space within Wellington's City Gallery was constructed that included spreads of cushions laid along the floor surfaces, inviting viewers to sit and rest underneath the immersive canopy of the sculpture.

Vesica refers to a medieval art tradition in which holy figures are housed within a luminous aura or halo. The maternal 'vesica' halo also refers to the intersecting zone within two overlapping circles; a transitional space symbolically located between Heaven and Earth. Within this liminal state, individual bodies may become entwined.

facing page

8 Hylozoic Series: Vesica,
Wellington, 2012.



HYLOZOIC SERIES: SIBYL

18th Biennale of Sydney, Cockatoo Island, Sydney, Australia, 2012

Sibyl is installed within a massive basilica-like hall of stone and metal truss-work lying within a historic shipbuilding complex on Cockatoo Island within the harbour of Sydney. The space of the sculpture intersects a high, central passage and reaches back into a recess that provides a shelter of darkness and quiet. Rivers of delicate hexagonal skeleton filters reach high overhead and spiral down to surround an intimate room that lies within the centre.

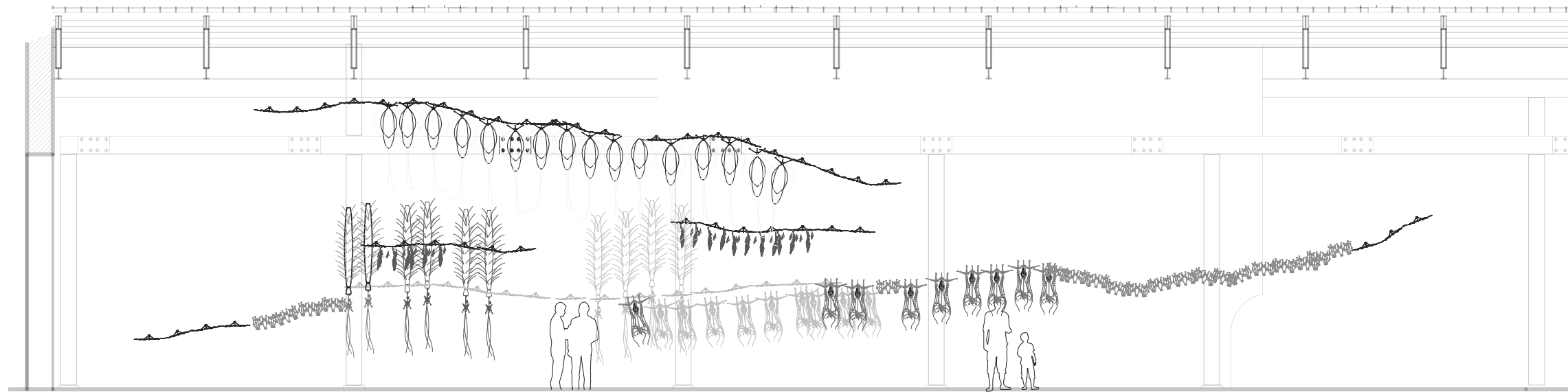
Groves of meshwork columns frame the darkened inner end of this space. Scented wicks and glands attract visitors close to the lower details of these columns, detailed with delicate glass spines that glow in response to approaching visitors. Shivering patterns of vibration and rustling sound move upward when individual clusters are stimulated by viewers. Reaching outward toward a public entry oriented to the central hall are layers of undulating seaweed-like filter clusters, housing protocell flasks. Touch-sensitive whiskers are fitted to each filter cluster, inviting viewers to gently stimulate the growth within the flasks. At the uppermost levels, lying just below the roof trusses that enclose the space, clusters of gauze bladders open and close in rolling, tide-like motions, responding to the larger movements of viewers below.

The space was used as a prison and reformatory prior to its industrial use. The fragile detailing contrasts the primal qualities of the surroundings.

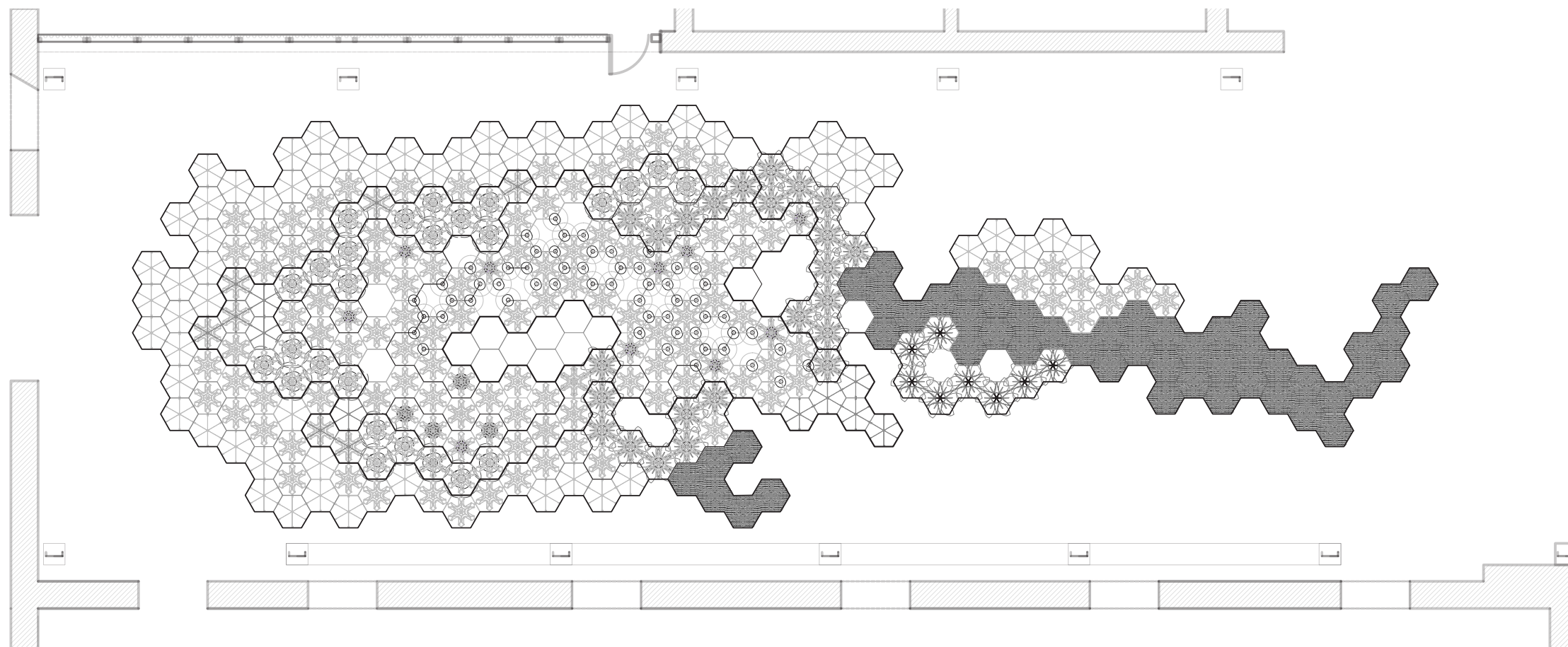
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facing page
9 Protocell Field, Rotterdam, 2012.





10 Hylozoic Series: Sibyl Section
Drawing, 2012.



11 Hylozoic Series: Sibyl Plan
Drawing, 2012.



facing page

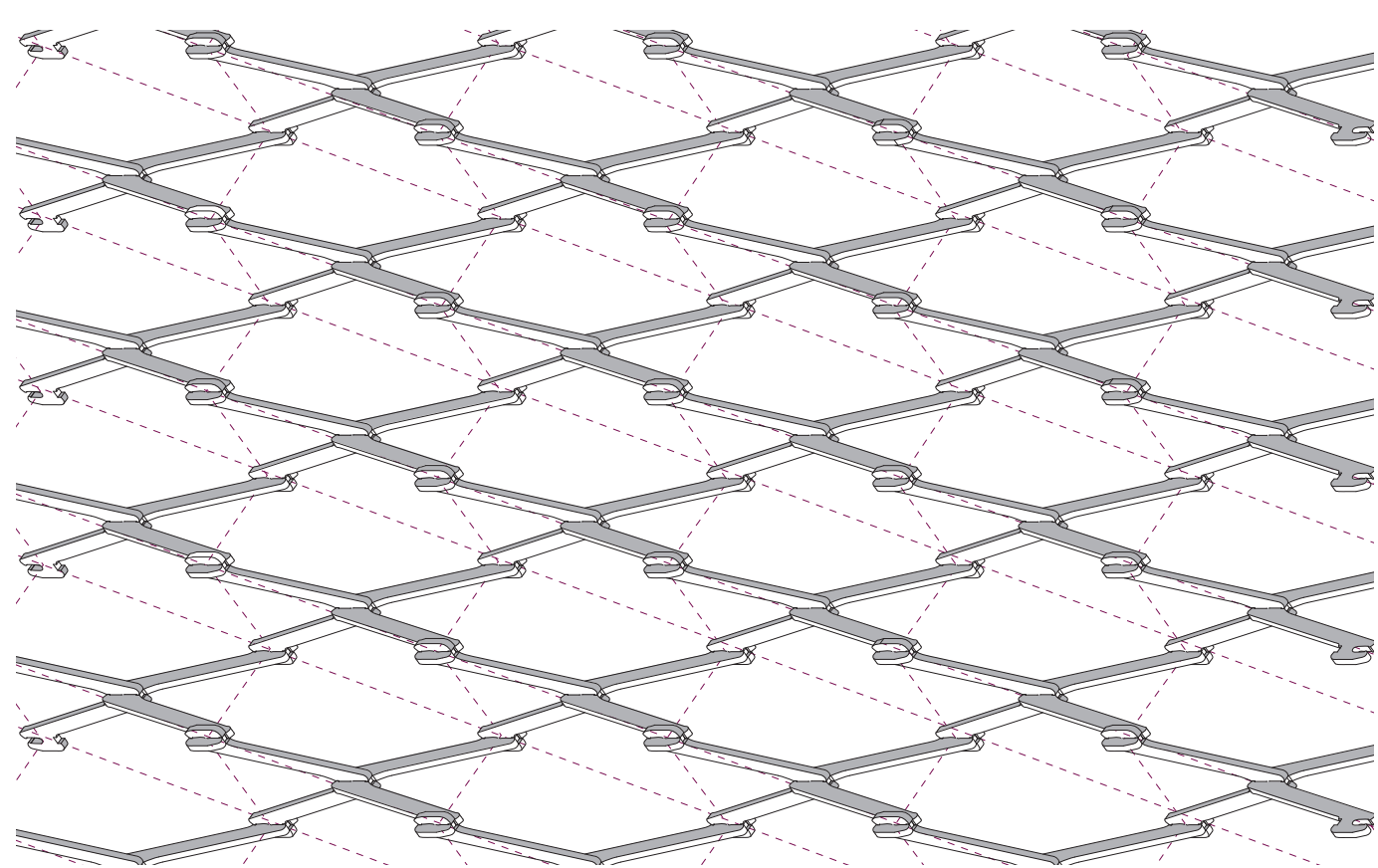
1 Cloud Brocade, Toronto, 2012.

Textile Systems

The organizing systems of the *Hylozoic* topology are guided by variation, flexibility, and order. In contrast to design principles of the past century that favoured optimal equations where maximum volume might be enclosed by the minimum possible surface, the structures seen in the *Hylozoic* environment prefer diffuse, deeply reticulated skins. These forms turn away from the minimum surface exposures of pure spheres and cubes as they seek to increase their exposure and interchange with the atmosphere.

Special tessellations, space-filling arrangements of individual structural tile units, are used to organize the textile-like layers of the *Hylozoic Series*. Hexagonal meshworks are organized by a three-dimensional triangular array that guides fields of attachment points. Junction details within many varying kinds of components are organized to fit within these general systems. Because these organizing systems use suspended, flexible fields of attachment points, warping and buckling can readily occur. This permits multiple orienting systems to be used in parallel within the same environment. Non-repeating 'quasiperiodic' systems tend to appear in parallel with repeating periodic grids of rhombic and hexagonal forms. Penrose tessellations, invented by British physicist Roger Penrose, are generated from sets of 'prototiles' that make up tessellation patterns. While local symmetries and repeating clusters of units appear throughout a Penrose tessellation, the fabric as a whole does not repeat its patterns. Preceding projects that employ Penrose organization includes *Orgone Reef*, *Orpheus Filter*, and *Implant Matrix*, and more recently in the filter layers within the *Hylozoic Series*.

Variations within rigid geometric patterns also occur when bifurcations and hybrid elements are inserted within ordered arrays. In recent projects, intersections between overlaid tileworks provide special qualities that include large-scale foam-like patterns. By combining hexagonal and Penrose arrays, and allowing for some twisting and warping to reconcile in three dimensions, warped foam-like fabrics appear. The resulting geometry suggests an ability to handle structural forces and invites circulation and component organization, indicating a potential for multiple-function systems.

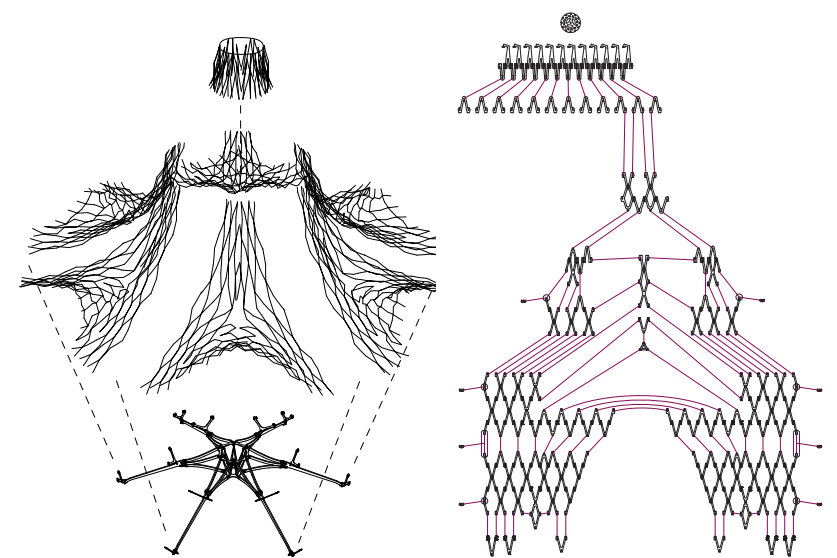


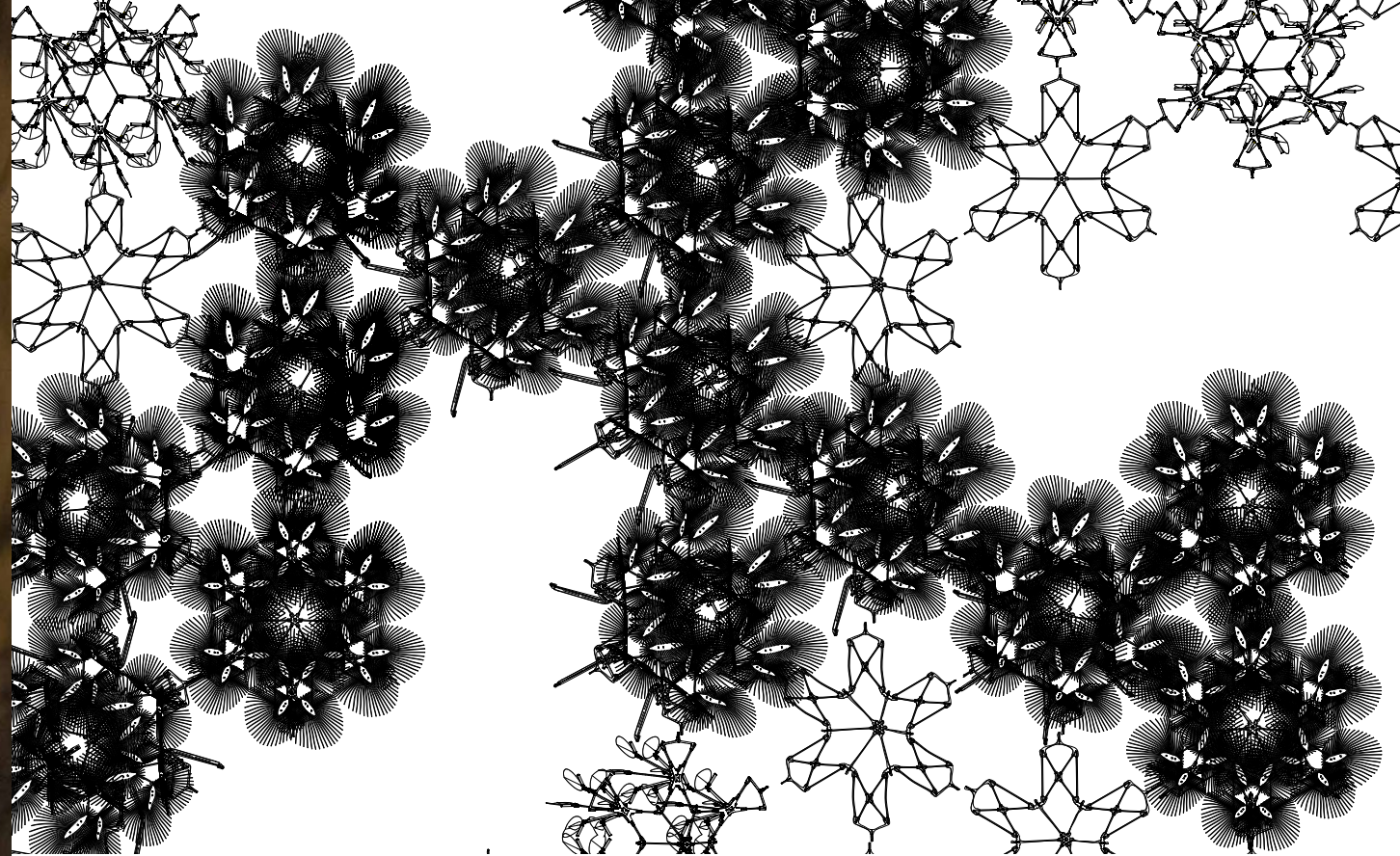
above
2 Hylozoic chevron diagrid system

right
3 Lily canopy assembly diagram.

far right
4 Petal assembly diagram.

facing page
5 Meshwork detail, Hylozoic Veil,
Salt Lake City, 2012

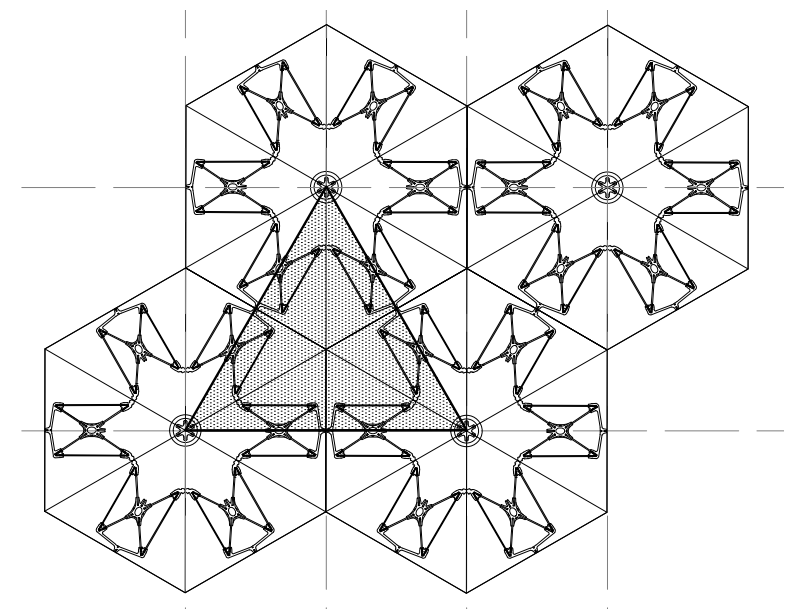


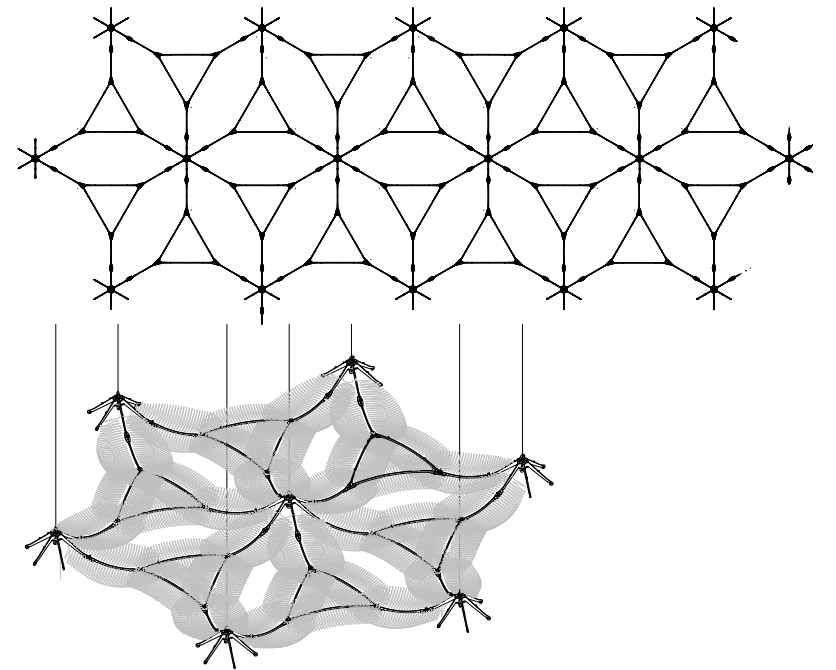
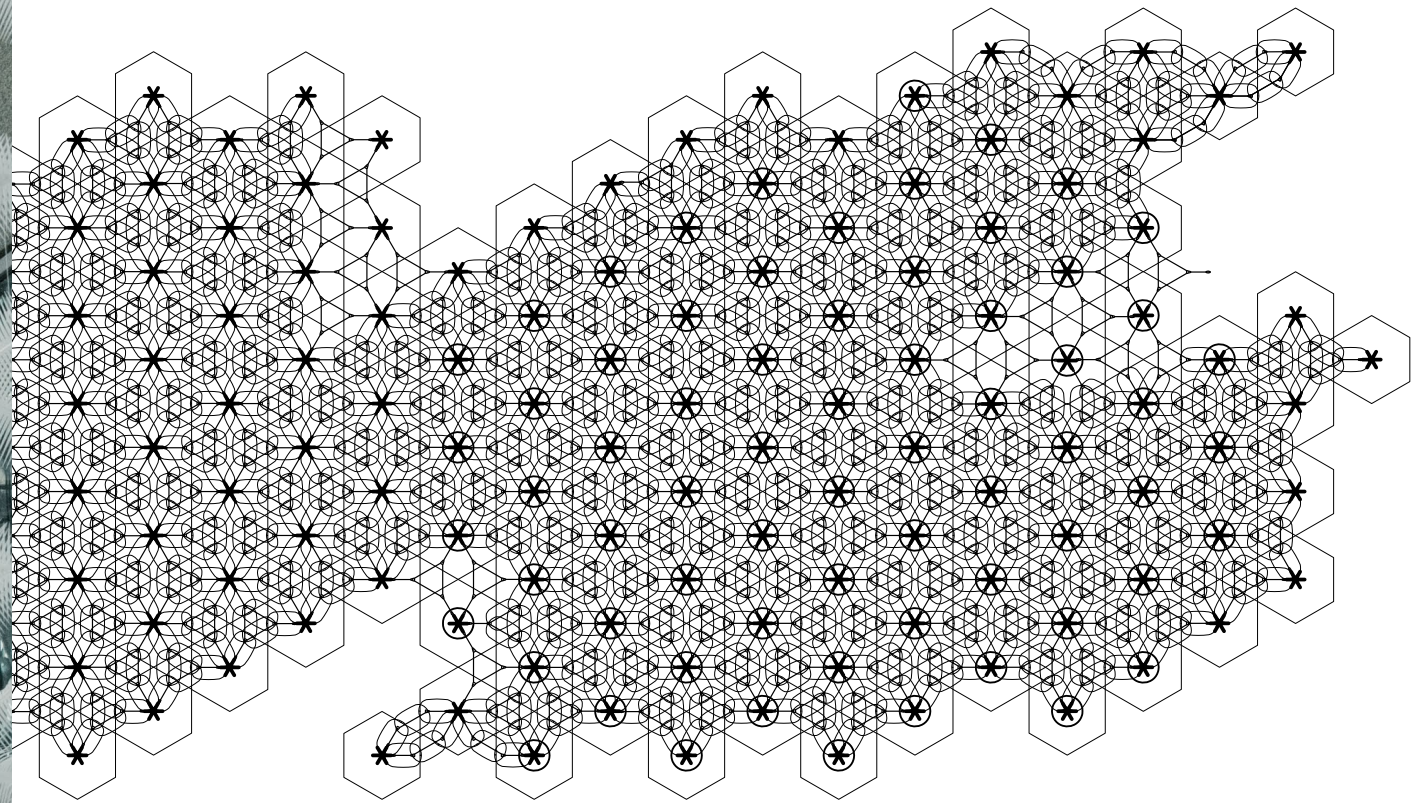


6 Rhombic grid plan and detail, *Hylozoic Series*.

facing page

7 *Hylozoic Veil* detail, Salt Lake City, 2012.

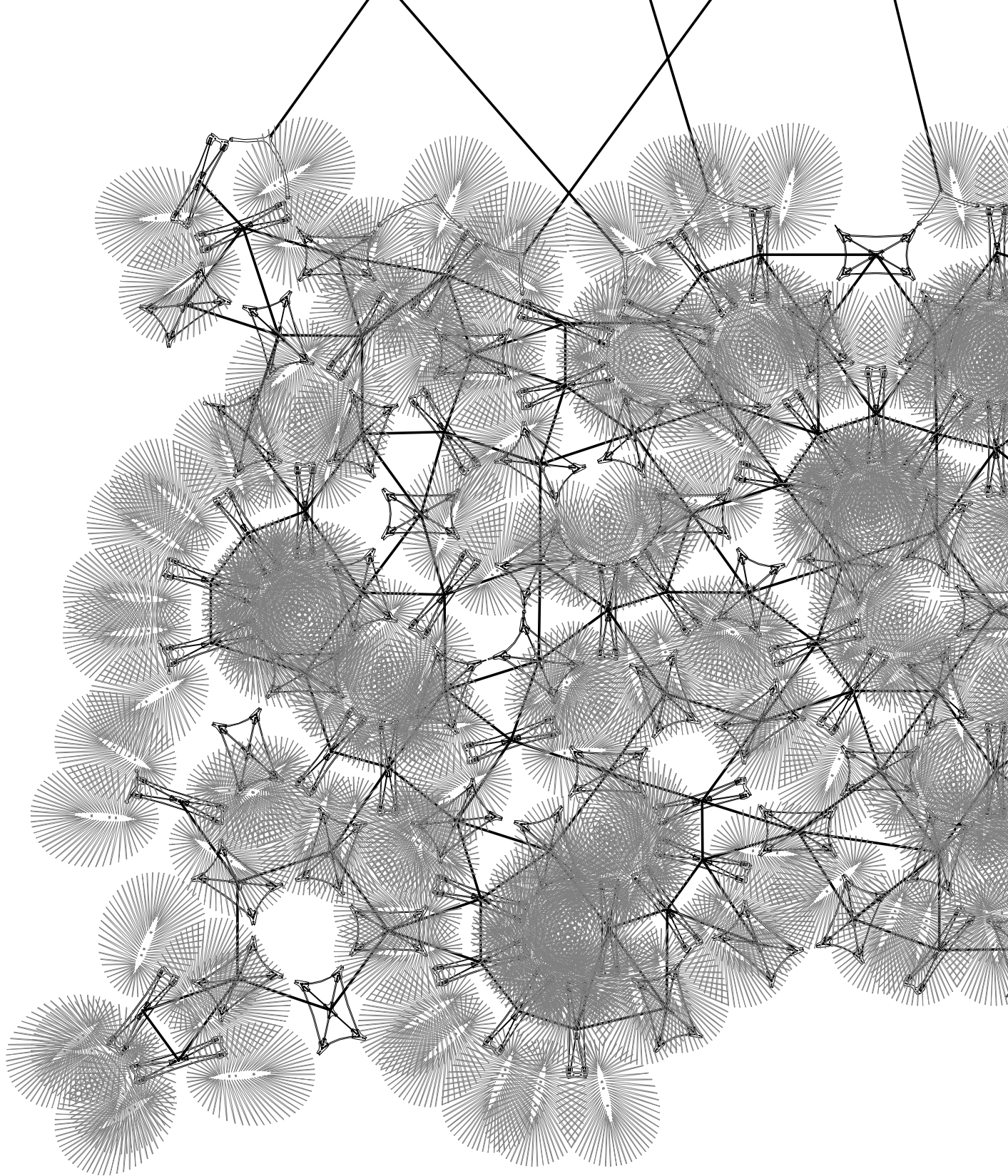




8 Outer veil grid plan,
Sargasso, Toronto, 2012.

facing page

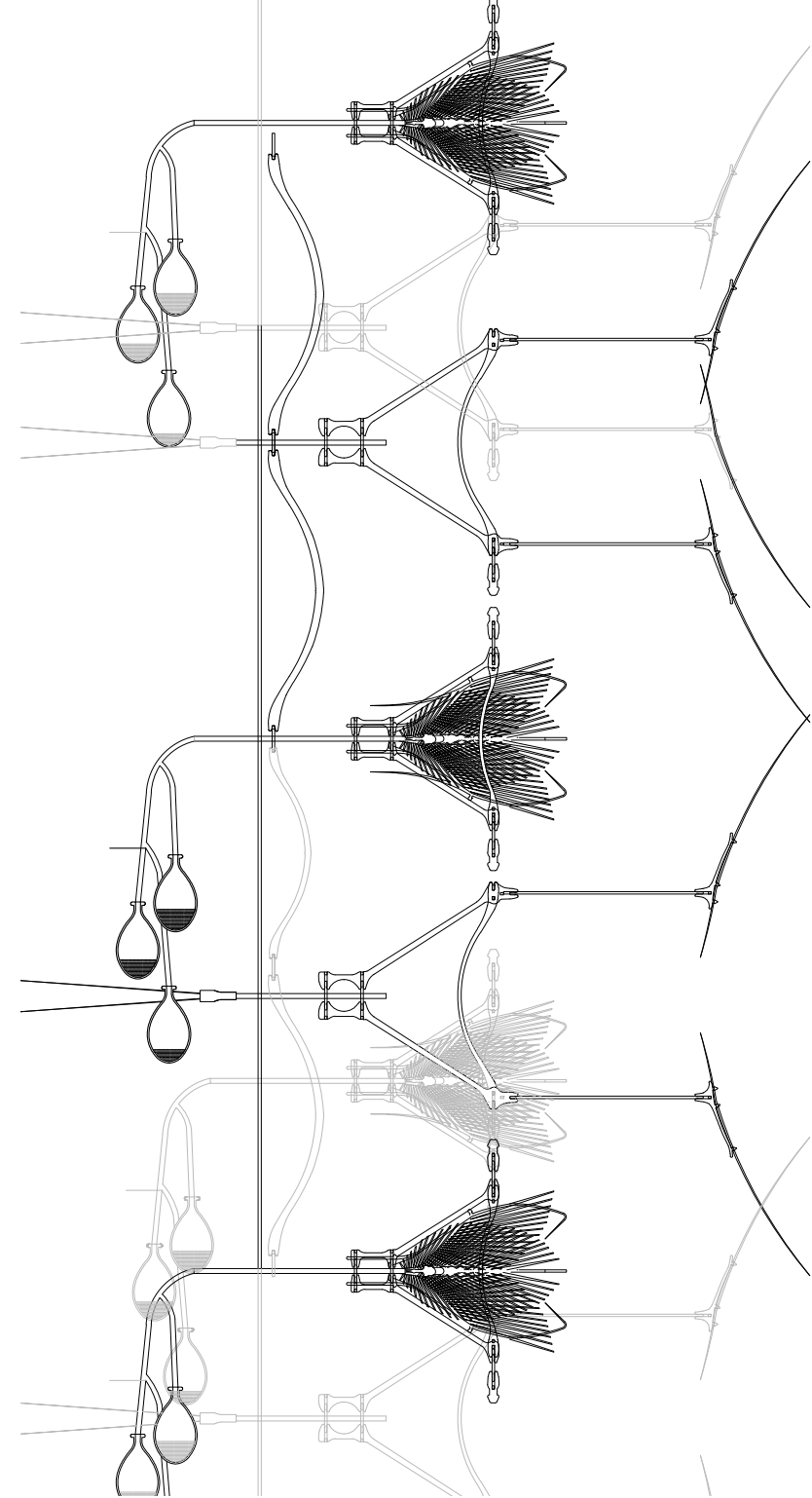
9 Sargasso detail, Toronto, 2012.



10 Cloud Brocade detail side view,
Toronto, 2012.

facing page

11 Cloud Brocade front view,
Toronto, 2012.





facing page

1 Performers wearing wireless neuroheadsets take part in an act of 'collective consciousness' at the Dutch Electronic Art Festival, 2012.

Embedded Intelligence

The organization of the microprocessor-based interactive system embedded within the *Hylozoic* environment represents two main levels within a hierarchy: a communication level, and a control level. The higher, or top, level of intelligence is composed of a communication system that enables neighbourhood behaviours and global behaviours - reactions in composite. This is achieved through a 'one-to-many' communication system where all nodes within the sculpture listen to one channel, and all nodes send messages out on a different channel.

This relationship is reversed for the master node which listens on the slave channel, and sends on the master channel. The master node is able to talk to all elements at once. All other slaves or nodes are only able to send when the master allows it, and only when the master is listening.

The systems currently being developed at Beesley's studio will move toward a limited 'embedded intelligence' within the environment. This will allow for a more distributed organization where individual nodes are connected to multiple sub-nodes, each directly wired to transducers. The sub-node takes a control signal from the root node and translates it into sets of individual transducer control operations.

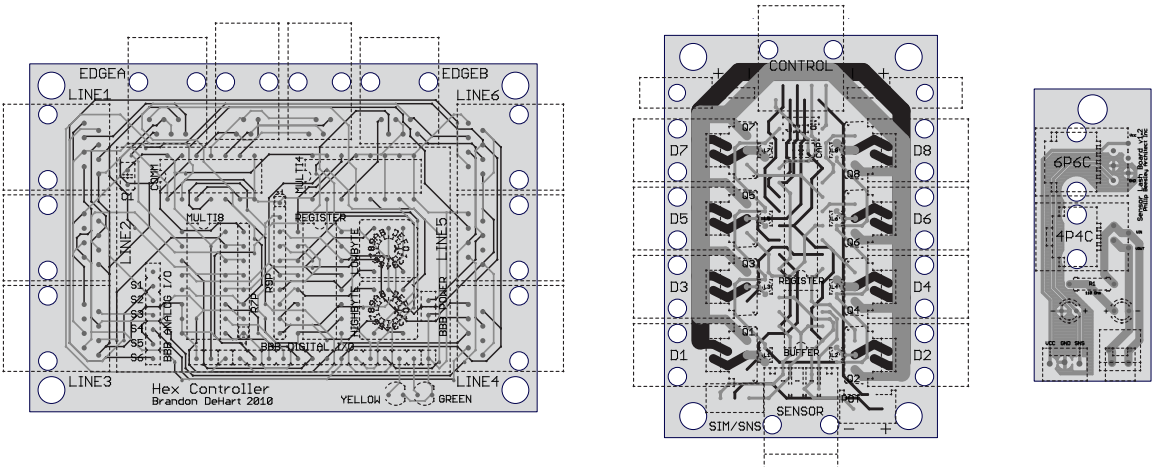
Next generation developments planned for this communication system include incorporation of both wireless and integrated power supply wiring. These measures will allow freedom in node placement within the lightweight meshwork structures. Also envisioned is a move away from the relatively rigid pyramidal organization of a 'master-slave' network, to a new intermeshed communication system which will allow for peer-to-peer

communications and ‘group decisions’ of sculptural components, free from communication with the master controls.

These developments will involve the introduction of ‘subsumption’ architecture, a control strategy used to enable automated reflex-like links between sensing and actuation, without the involvement of higher-level processors. An analogy of subsumption may be observed within human physiology, where bundled ganglia such as the sensitive clusters within elbows, knees, sternum and pineal are configured to cause muscular reflexes automatically, before the brain is notified of sensory events.

This organization would allow layers of increasingly complex local behaviour to be orchestrated. Currently, when viewers encounter the sensor lashes at the tips of breathing columns, the resulting signal travels up to a central column microprocessor for interpretation and signals are in turn sent back to the local sensor lash, causing twitching reflexes at the site of the original signal. With subsumption features, embedded reflexes directly at the original site could occur, free from the need to involve a central processor. Sensor activity, however, could still be reported and the output control overridden by central controls. This feature offers the potential for a greatly increased flexibility and complexity in the level of sculptural behaviour experienced by viewers.

Finally, sensor functions are also being developed to enable thermal, optical and acoustic inputs. Body heat, and related intimate human physiological responses may be tracked by these functions. A future intention is to enable pheromone sensing, employing engineered protocell functions that can function as specialized ‘chemical noses’.

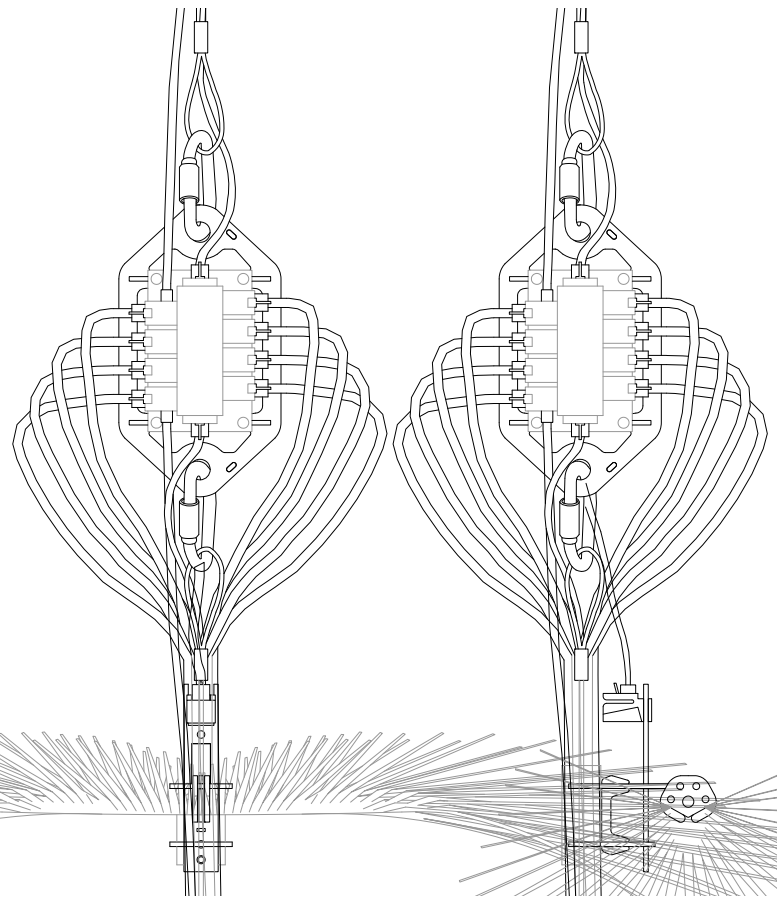


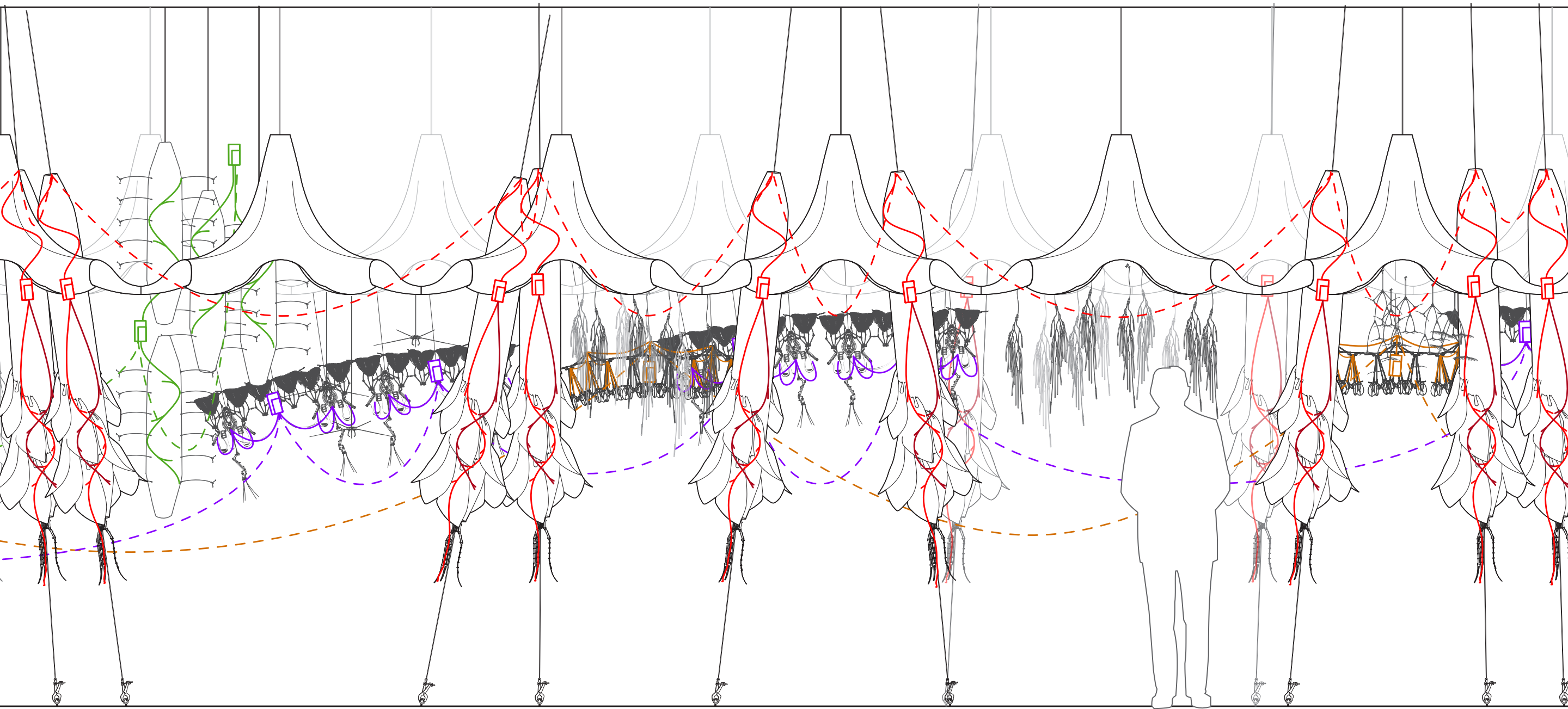
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2 Examples of custom printed circuit boards designed for the Hylozoic Series and other projects

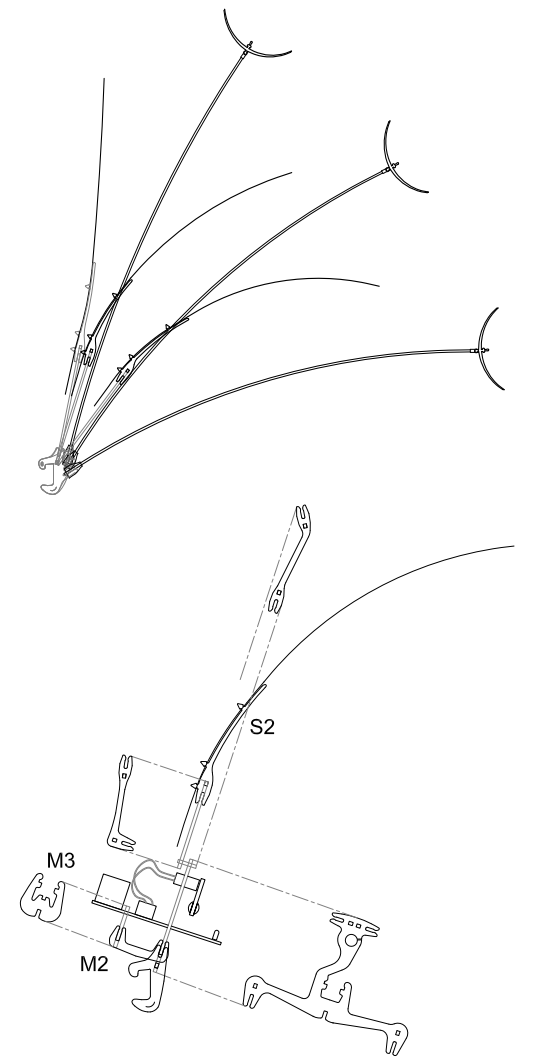
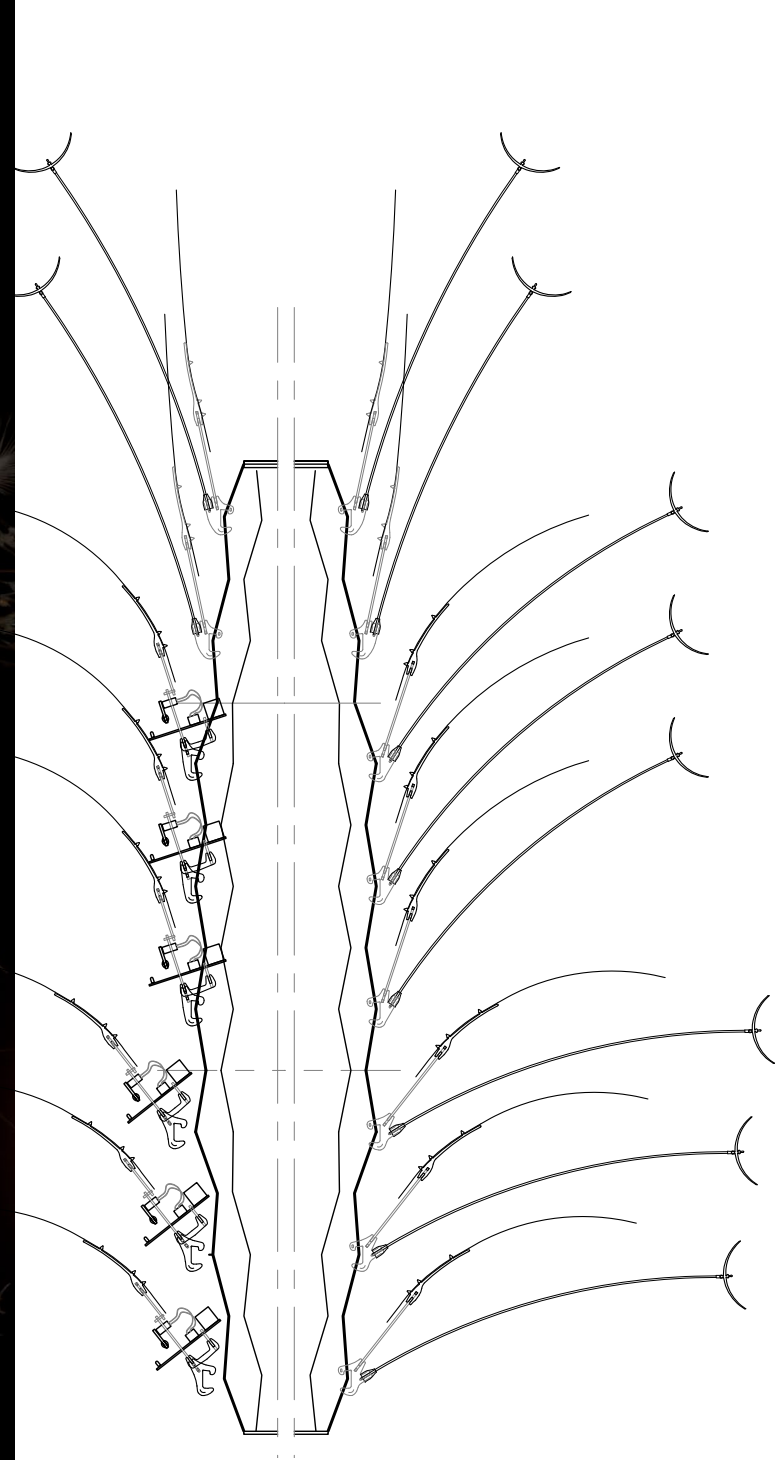
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3 Diagram showing the integration of sculptural elements and custom electronics for Aurora, Toronto, 2010.





4 Schematic diagram of the Hylozoic Series interactive network, Venice, 2010.



5 Sound column assembly.

facing page

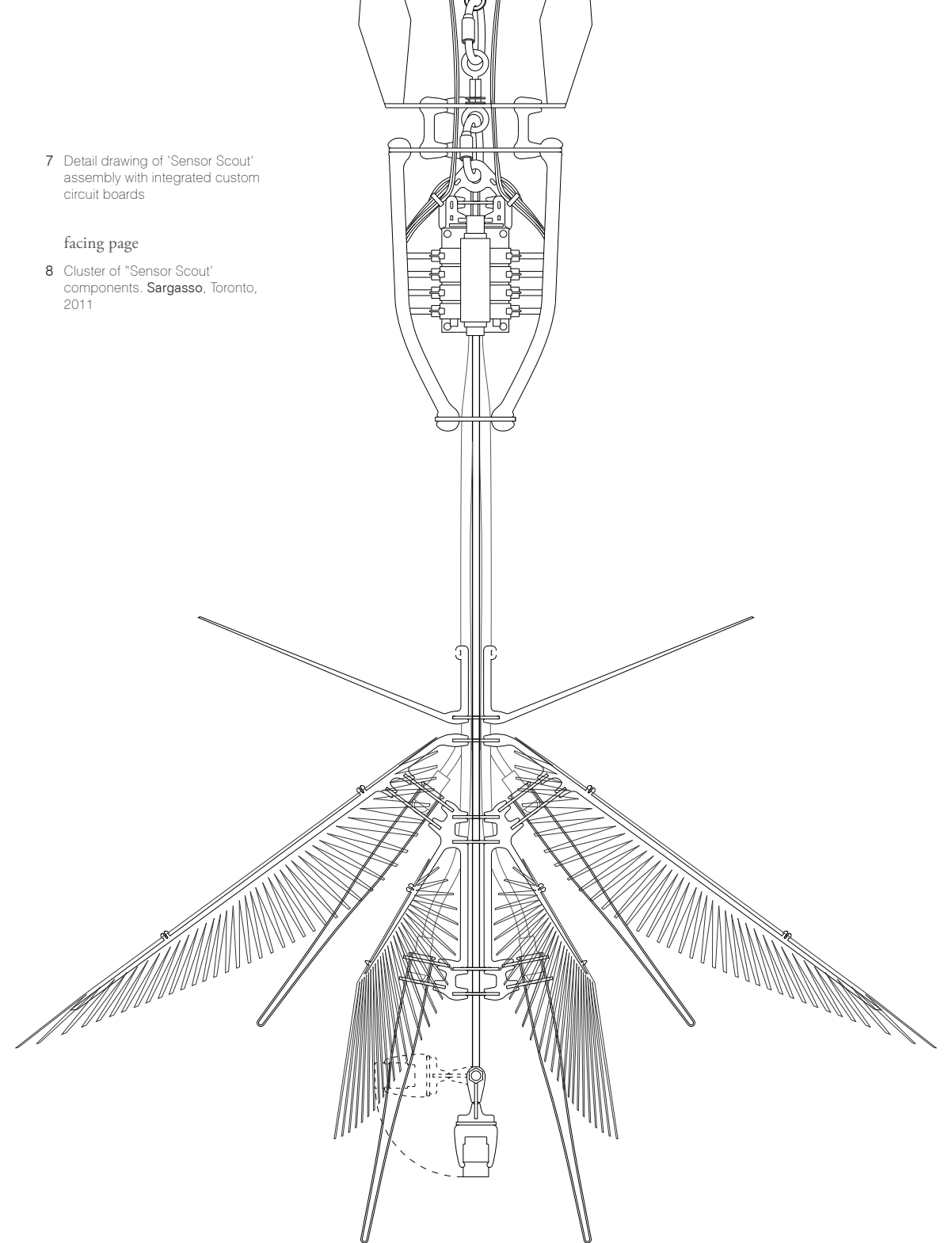
6 Hylozoic Series: Vesica, Wellington, 2012.

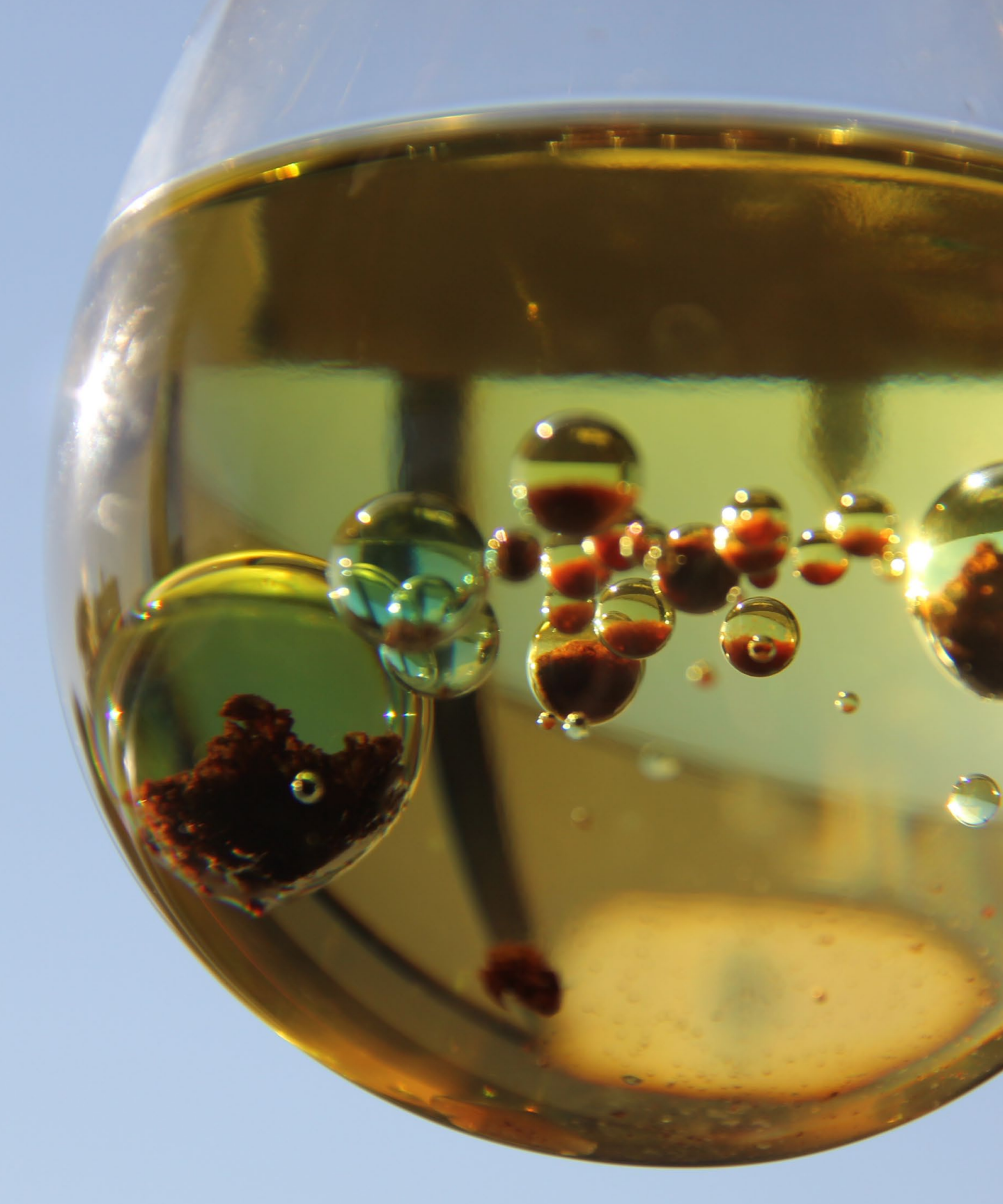


7 Detail drawing of 'Sensor Scout' assembly with integrated custom circuit boards

facing page

8 Cluster of "Sensor Scout" components. Sargasso, Toronto, 2011





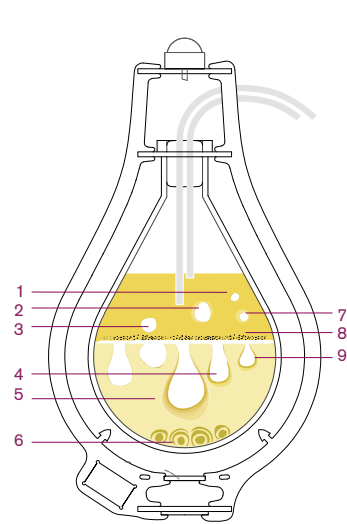
facing page
1 Protocell detail.

Living Systems

The presence of protocells within the *Hylozoic* environment allow for a metabolic system to emerge within the sculpture. Protocells are simple models of living cells made from inorganic ingredients that exhibit some of the same properties as living cells and perform similar functions such as metabolism, movement, replication, information, evolution and self-assembly. Embedded within flasks, protocells produce a buffered environment where liquids heavier and lighter than water are set up as scaffolds. A state akin to weightlessness is achieved in the space where the two states meet, a balanced environment in which chemicals can precipitate, vesicles can form, and viscous systems can emerge. For the viewer, protocells are experienced as a display of an architectural lymphatic network.

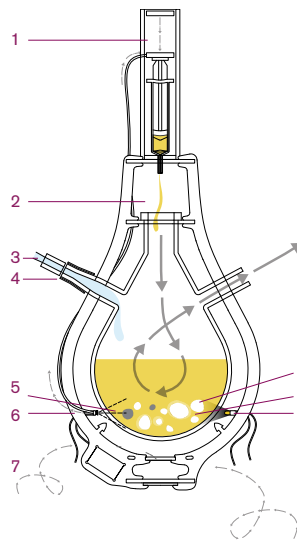
The adaptive chemistries within the wet system capture traces of carbon from the vaporous surroundings and build delicate structural scaffolds. Engineered protocells and chells (liquid-supported artificial cells that share some of the characteristics of natural living cells) are arranged in a series of embedded incubator flasks. Bursts of light and vibration, triggered by the responses of occupants moving within the work, influence the growth of the protocells, catalyzing the formation of vesicles and inducing secondary deposits of benign materials. Sensors monitor the health of the growing flasks and provide feedback that influences the behaviour of the interactive system surrounding the viewer.

Protocell presence within *Hylozoic* environments illustrates new design research now focusing on the speculative implementation of protocell chemistries into architectural systems. This research has implications



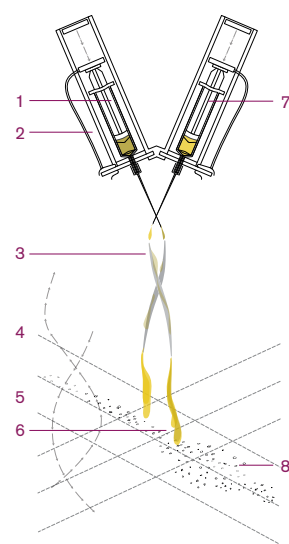
2 Liesegang ring-like reactions.

- 1 Copper sulphate
- 2 Ferrofluid solution
- 3 Attenuated sodium hydroxide solution
- 4 Magnetite crystal 'seeds'
- 5 Diethyl pheryl phthalate (DEPP)
- 6 Complex of various precipitate forming metal ions
- 7 Calcium chloride
- 8 Olive oil
- 9 Protozell



3 Protopearl flask.

- 1 Syringe driver with protopearl formulation
- 2 Air: nitrogen, oxygen, carbon dioxide
- 3 Venice canal water
- 4 Filtration unit
- 5 Copper ions, metal ions in solution from Venice canal water
- 6 Sensor
- 7 Agitation
- 8 The airflow outlet will act as overflow
- 9 From Venice water: magnesium, barium and calcium ions
- 10 Protopearls
- 11 Emitter



4 Extended Traube membranes.

- 1 Copper sulphate + gelatine
- 2 Timed release syringe drivers
- 3 Metal scaffolding to collect and direct traube cell reagents
- 4 Absorbent matrix to support Traube cell grow
- 5 Agitation from hylozoic matrix, vibrational forces further extend membranes
- 6 Traube cell extension (Copper hexacyanoferrate with complex polymer scaffolding alginate/gelatine)
- 7 Copper hexacyanoferrate + alginate + gelatin
- 8 Hygroscopic attractant permeates absorbent matrix

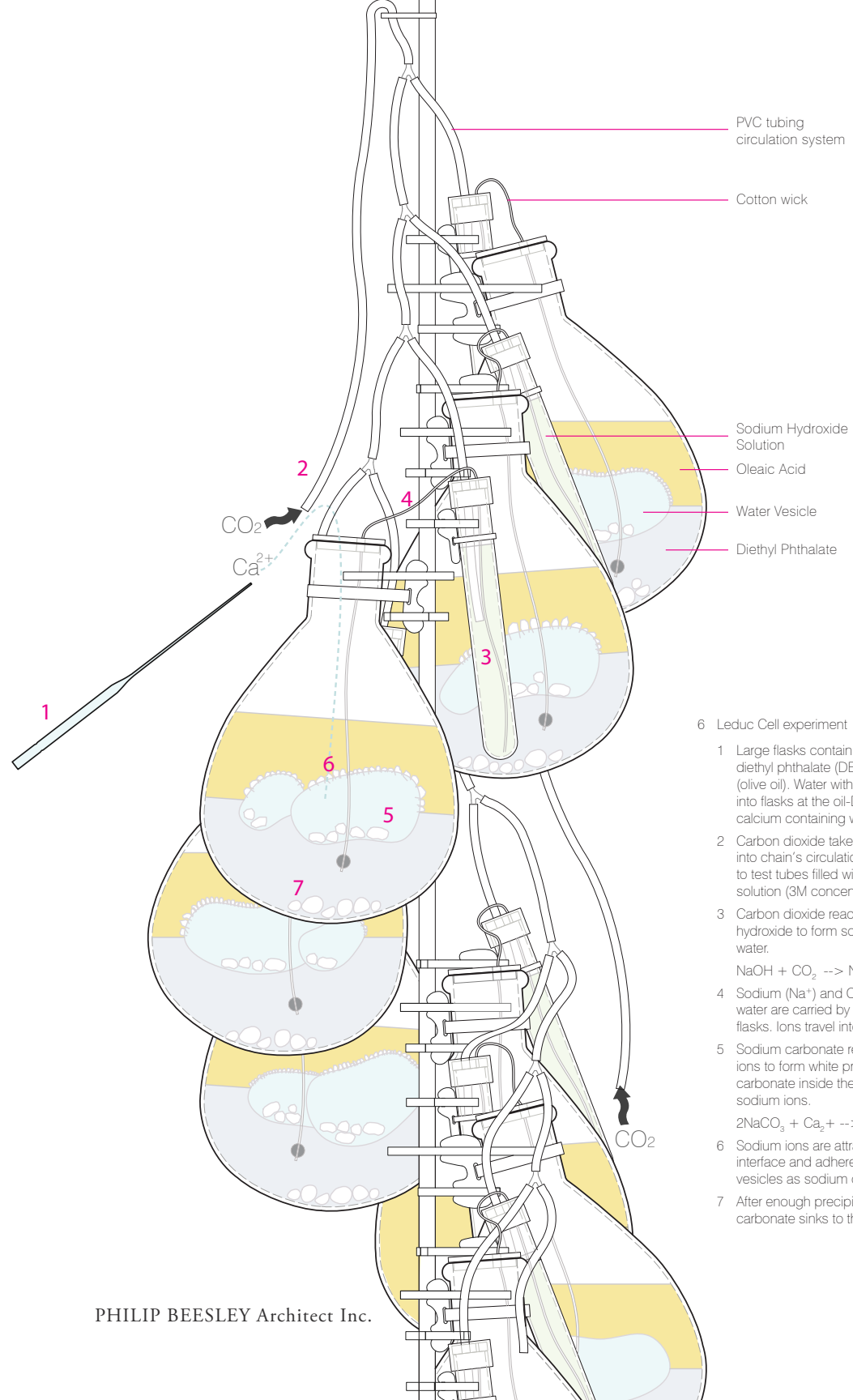
for architecture and the built environment as a whole, suggesting that the development of near-living smart materials is achievable. These materials could quite literally 'grow' themselves, sense and respond to environmental stimuli, share resources, filter pollutants, and self-repair.

Future *Hylozoic* systems will allow for the synthetic biology that currently occurs in vitro (in glass vessels) to move outwards, ex vitro, and into a primitive artificial circulatory system. Part of this would include incorporating a new sensor network, which could read the density of chemical flasks and adjust surrounding environmental conditions to support protocell growth in other areas of the system. Pheromone sensing capabilities are also being developed, so that octaves of expanded physiology around a viewer could become an architectural space. The cloud of chemistry emitted from a viewer would itself become a tangible medium.



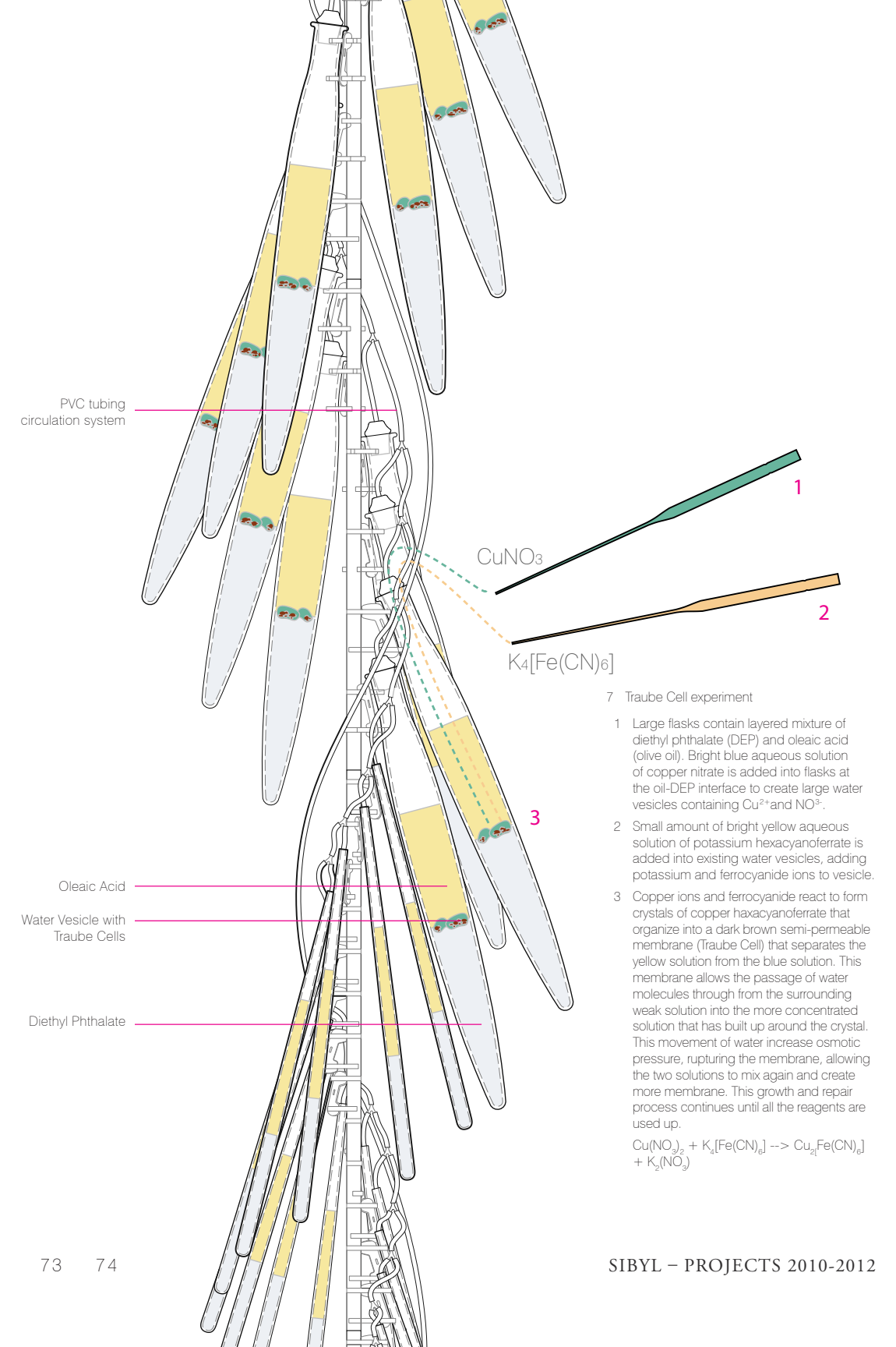
facing page

5 *Hylozoic Series: Vesica*,
Wellington, 2012.



6 Leduc Cell experiment

- 1 Large flasks contain layered mixture of diethyl phthalate (DEP) and oleic acid (olive oil). Water with calcium ions is added into flasks at the oil-DEP interface to create calcium containing water vesicles.
- 2 Carbon dioxide taken in through diffusion into chain's circulation system and travels to test tubes filled with sodium hydroxide solution (3M concentration).
- 3 Carbon dioxide reacts with sodium hydroxide to form sodium carbonate and water.
 $\text{NaOH} + \text{CO}_2 \rightarrow \text{NaCO}_3 + \text{H}_2\text{O}$
- 4 Sodium (Na⁺) and Carbonate ions (CO₃²⁻) in water are carried by cotton wick into large flasks. Ions travel into water vesicles.
- 5 Sodium carbonate reacts with calcium ions to form white precipitate of calcium carbonate inside the water vesicles and sodium ions.
 $2\text{NaCO}_3 + \text{Ca}_2^{2+} \rightarrow \text{CaCO}_3 + 2\text{Na}^+$
- 6 Sodium ions are attracted to the water-oil interface and adhere to the edges of the vesicles as sodium oleate.
- 7 After enough precipitate forms, the calcium carbonate sinks to the bottom of the flask.



7 Traube Cell experiment

- 1 Large flasks contain layered mixture of diethyl phthalate (DEP) and oleic acid (olive oil). Bright blue aqueous solution of copper nitrate is added into flasks at the oil-DEP interface to create large water vesicles containing Cu²⁺ and NO₃⁻.
- 2 Small amount of bright yellow aqueous solution of potassium hexacyanoferrate is added into existing water vesicles, adding potassium and ferrocyanide ions to vesicle.
- 3 Copper ions and ferrocyanide react to form crystals of copper hexacyanoferrate that organize into a dark brown semi-permeable membrane (Traube Cell) that separates the yellow solution from the blue solution. This membrane allows the passage of water molecules through from the surrounding weak solution into the more concentrated solution that has built up around the crystal. This movement of water increases osmotic pressure, rupturing the membrane, allowing the two solutions to mix again and create more membrane. This growth and repair process continues until all the reagents are used up.

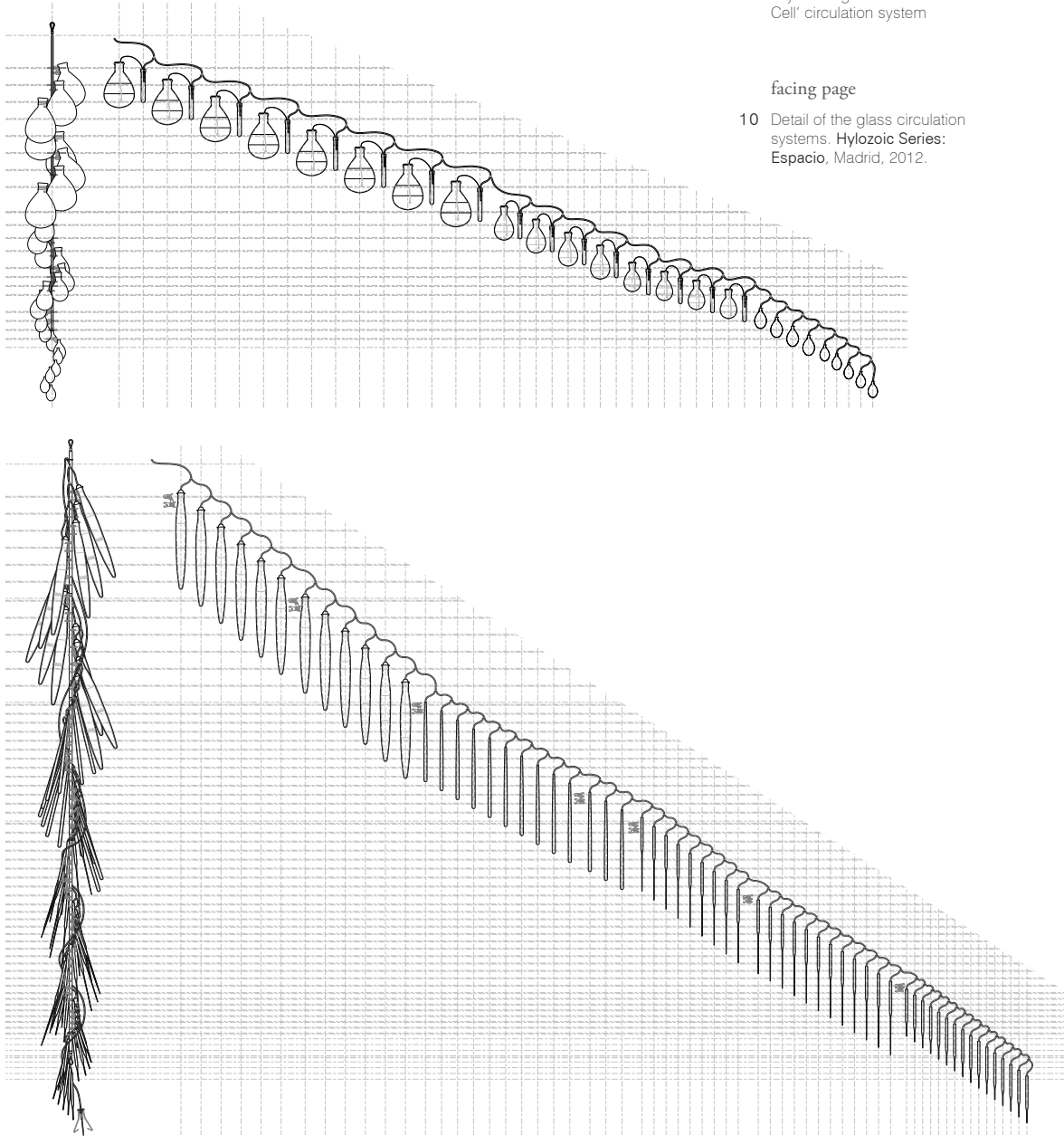


8 Layout diagram of the 'Leduc
Cell' circulation system

9 Layout diagram of the 'Traube
Cell' circulation system

facing page

10 Detail of the glass circulation
systems. *Hylozoic Series*:
Espacio, Madrid, 2012.



Philip Beesley ARCHITECT INC

Toronto-based practice Philip Beesley Architect Inc (PBAI) is an interdisciplinary design firm that integrates art, stage and lighting projects. The studio’s design methods incorporate advanced digital visualization, industrial design, digital prototyping, and mechatronics engineering. Interdisciplinary art projects, graphic design, exhibit design, stage and lighting projects are also frequently undertaken. Sculptural work in the past decade has focused on lightweight textile environments, and landscape installations. Experimental projects have increasingly focused on immersive digitally fabricated lightweight textile structures and interactive kinetic systems that use dense arrays of microprocessors, sensors and actuator systems. These environments combine synthetic and near-living systems in pursuit of a distributed emotional consciousness.

Core team members of PBAI include Rob Gorbet (mechatronics engineer and visual artist), Rachel Armstrong (artificial life researcher), Eric Bury (graphic designer and visual artist) and Jonathan Tyrrell (interactive system coordinator and sound artist). Currently there are 15 artists, designers, architects, and engineers within the collective.

Philip Beesley

Philip Beesley is a professor in the School of Architecture at the University of Waterloo. A practitioner of architecture and digital media art, he was educated in visual art at Queen’s University, in technology at Humber College, and in architecture at the University of Toronto. At Waterloo he serves as Director for the Integrated Group for Visualization, Design and Manufacturing, and as Director for Riverside Architectural Press. He also holds the position of Examiner at University College London.

Dedicated to expanding the role for the arts integrated within architecture, Beesley has worked in sculpture, next-generation digital media and cross-disciplinary experimental visual art for the past three decades. He has focused on public buildings accompanied by field-oriented sculpture and landscape installations, exhibition and stage design. His experimental projects in the past several years have increasingly worked with immersive digitally fabricated lightweight “textile” structures, while the most recent generations of his work feature interactive kinetic systems that use dense arrays of microprocessors, sensors and actuator systems. These environments pursue distributed emotional consciousness and combine synthetic and near-living systems.

Beesley’s work was selected to represent Canada at the 2010 Venice Biennale for Architecture, and he has been recognized by the Prix de Rome in Architecture, VIDA 11.0, FEIDAD, two Governor General’s Awards, and as a Katerva finalist.



HYLOZOIC SERIES: SIBYL
18th Biennale of Sydney, Cockatoo Island, 2012

Project Lead	Production (Toronto)	Production (Australia)	
Jonathan Tyrrell	Fysal Amirzada	<i>At time of printing</i>	Holly Julian
	Andrea Lau	Callum Andrews	Megan Julian
Collaborators	Ryan Ferko	Nicola Balch	Jo Kinniburgh
Rachel Armstrong	Miho Inaba	Alain Baril	Francesca McInnes
Rob Gorbet	Anjali Jaywar	Philippe Baylaucq	Eleanor Peres
Mark-David Hosale	Ian Lie	Tom Bingham	Wajdy Qattan
	Tosin Sanni	Annabel Blackman	Frances Robinson
PBAI Core Team	Taiana Selbach	Marston Bowen	Lena Thomassen
Sue Balint	Tomasz Smereka	Anthony Burke	Dean Wall
Eric Bury	Patrick Svilans	Dean Calabrese	Chen Zhuang
Martin Correa	Siubhan Taylor	Lorraine Chan	
Brandon DeHart	Chris Tron	Kathryn Chang	
Susanne Eeg		Natali Dundovic	
Pedro Garcia		Jay Griffin	
Andrea Ling		James Guerrisi	
Elena Moliotsias		Joshua Harrex	
Leonor Munoz		Sophie Harris	
Anne Paxton		Adam Hoh	
Adam Schwartzentruber		Patrick Issa	
Mingyi Zhou			

PROTOCELL FIELD
Dutch Electronic Art Festival, Rotterdam, 2012

Project Lead	Adam Schwartzentruber	Production (Netherlands)
Andrea Ling	Jonathan Tyrrell	Philippe Baylaucq
	Mingyi Zhou	Zuzanna Biloveska
Collaborator		Susanne Eeg
Mark-David Hosale	Production (Toronto)	Beatriz Gonzalez
	Fysal Amirzada	Almud Krejza
Consultants	Andrea Lau	Veronica Lombardi
Dr. Luis Garcia Dominguez	Candice Chung	Ieke Trinks
Alan Macy	Ryan Ferko	Patricia Rijgersberg
Alexander Moakler	Miho Inaba	
	Anjali Jaywar	Performers ('Evening of...' Netherlands)
PBAI Core Team	Ian Lie	Alice Bodanzky
Sue Balint	Tosin Sanni	Sang Lee
Eric Bury	Taiana Selbach	Robert Sternau
Martin Correa	Tomasz Smereka	Marion Traenkle
Brandon DeHart	Patrick Svilans	Ieke Trinks
Susanne Eeg	Siubhan Taylor	
Pedro Garcia	Jenelle Thacker	
Elena Moliotsias	Chris Tron	
Anne Paxton	Ying Yu	



HYLOZOIC SERIES: VESICA
The City Gallery, Wellington, New Zealand, 2012

Project Team	Production (Toronto)	Production (Wellington)
Jonathan Tyrrell Martin Correa	Andrea Lau Chris Tron Fabian Mosquera	Alex Buckman Meredith Cnowe Luke De Villiers
Collaborators	Jihee Choi Jordan Livings Kendra Sintim-Aboagye Nadine Taha Patrick Svilans Rayana Hossain Robin Munro Ryan Ferko Taiana Selbach Tomasz Smereka Ying Yu	Sarah Kong Sarah Mokhtar Daniel Van Polanen
PBAI Core Team		
Sue Balint Eric Bury Brandon DeHart Pedro Garcia Andrea Ling Elena Moliotsias Anne Paxton Adam Schwartzentruber Anne Sewell Mingyi Zhou		

CLOUD BROCADE
Le Festival Bains Numériques, 2012

Design Team	Production
Eric Bury Martin Correa Susanne Eeg Jonathan Tyrrell	Ramona Adlakha Mehreen Ali Allison Cheng Ji Hee Choi Ishan Patel Patrick Svilans
PBAI Core Team	
Sue Balint Brandon DeHart Hayley Isaacs Andrea Ling Elena Moliotsias Anne Paxton Anne Sewell Kristie Taylor Mingyi Zhou	

HYLOZOIC SOIL: ESPACIO
Fundación Telefónica, Madrid, Spain, 2012

Project Lead	Fabrication
Eric Bury	Ryan Ferko Rayana Hossain Andrea Lau Jordan Livings Fabian Mosquera Robin Munro Taiana Selbach Kendra Sintim-Aboagye Tomasz Smereka Patrick Svilans Nadine Taha Chris Tron
Collaborator	
Rob Gorbet	
PBAI Core Team	
Anne Sewell Sue Balint David Blackmore Brandon DeHart Hayley Isaacs Manuel Kretzer Andrea Ling Elena Moliotsias Anne Paxton Yoshikatsu Wachi Jane Wong Mingyi Zhou	