Soil and Protoplasm: The Hylozoic Ground Project

By Rachel Armstrong and Philip Beesley

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Housed in the Canadian Pavilion in the Giardini in Venice during the 2010 Architecture Biennale, the Hylozoic Ground project provided visitors with the unique experience of interacting with a responsive and 'live' textile matrix. **Philip Beesley** and **Rachel Armstrong** describe the extraordinary 'soil-less' environment that they collaborated on and how it provides a new model for a synthetic but evolutionary ecology.

Philip Beesley, Hylozoic Ground installation, Canadian Pavilion, Venice Biennale, 2010. Detail of protocell incubator. Pulsing light responds to visitors touching whisker sensors suspended below the glass flasks. Protocell formation is influenced by small increments of energy transmitted by the pulses.

Philip Beesley, Hylozoic Ground installation, Canadian Pavilion, Venice Biennale, 2010
Detail of glass flask containing the protocell incubator, including oil stratum above and diethyl phenyl phthalate below.

Hylozoic Ground is an environment organised as a textile matrix supporting responsive actions and 'living' technologies, conceived as the first stages of self-renewing functions that might take root within a future architecture.

Can soil be constructed? The architecture of the Hylozoic Ground project pursues qualities of new soil. Hylozoic Ground is an environment organised as a textile matrix supporting responsive actions and 'living' technologies, conceived as the first stages of self-renewing functions that might take root within a future architecture. This environment, Canada's entry to the 2010 Venice Architecture Biennale, is part of a series of collaborative installations that have been developed over the past four years with a collective associated with the University of Waterloo, Canada, including designers led by Hayley Isaacs at PBAI (Philip Beesley Architect Inc) in Toronto, engineers directed by Rob Gorbet in Waterloo, and the AVATAR and FLinT research centres in London and Odense.[1] The first of the series was commissioned for the Montreal Museum of Fine Arts in 2007–8 and interim stages have appeared in Linz, Madrid, New Orleans, Enschede, Quebec City and Mexico City. Like the current environment in Venice, each of these stages of development has been framed as an open system that combines details from preceding environments with contributions from numerous designers and assistants in each city. The work has been developed and components manufactured by digital fabrication within the PBAI studio.

The work is conceived as a new primitive hut that speaks of cultural origins within wilderness. The Hylozoic building system forms embroidered surfaces of a hybrid public architecture, a sprawling, tangled series of small public spaces. If attention turns from social gathering within these spaces towards the enclosing 'soil matrix' fabric, close inspection will reveal physical and chemical elements in various stages of transformation. The Hylozoic environment is a model system of a synthetic ecology undergoing an evolutionary process. Visitors can observe the initial state of the environment's ingredients, influence dynamic processes that respond to external presence, and review these ongoing modifications over time.

The geotextile forms and protocell circulation systems that prevail in recent generations of the ongoing Hylozoic Ground project pursue practical methods for building synthetic earth. The oscillation of this new soil's alternating collapse and expansion offers an emphatically ambivalent, fertile building material for a renewed architecture. The Hylozoic Ground environment can be described as a suspended geotextile,[2]

Philip Beesley, Hydrozoic Soil: Méduse Field, Recto-Verso Collaborative, Méduse Centre, Quebec City, 2010
Filter layers are organised like atmospheric weather systems within the Hylozoic Soil environment.

Artificial chemical cell species form habitats within the Hylozoic soil matrix that are capable of thriving under the initial conditions. Given enough time to evolve, new species take hold, as spontaneous physical and chemical changes take place within the living technology.

gradually accumulating hybrid soil from ingredients drawn from its surroundings. Akin to the functions of a living system, embedded machine intelligence allows human interaction to trigger breathing, caressing and swallowing motions and hybrid metabolic exchanges. These empathic motions ripple out from hives of kinetic valves and pores in peristaltic waves, creating a diffuse pumping that pulls air, moisture and stray organic matter through the filtering Hylozoic membranes. A distributed array of proximity sensors activates these primitive responsive devices, stirring the air in thickened areas of the matrix. Dense groves of frond-like 'breathing' pores, tongues and thickets of twitching whiskers are organised in spiralling rows that curl in and around its mesh surfaces. A trickling water source connects the matrix to the Venice lagoon.

Alongside mechanised component systems, a wet system of flasks, bladders and interconnected channels has been introduced into the environment, supporting simple chemical exchanges that share some of the renewing functions of a human lymphatic system. Thousands of primitive glands containing synthetic digestive liquids and salts are clustered throughout the system, located at the base of each breathing pore and within suspended colonies of whiskers and trapping burrs. The salt derivatives serve a hygroscopic function, pulling fluids out of the surrounding environment. Thickened vapours surround these bladder clusters.

Adaptive chemistries within this system capture traces of carbon from the vaporous surroundings and build delicate structural scaffolds. Engineered protocells and 'iChells' – 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, created by the responses of visitors standing within the work, influence the growth of the protocells, catalysing the formation of vesicles and inducing secondary deposits of benign materials. Sensors monitor the health of the growing flasks and give feedback that governs the behaviour of the interactive system surrounding the viewer. The flux of viscous, humid atmospheres creates a hybrid expanded protoplasm with changing boundaries. These design systems provide an expanded physiology akin to the layered envelopes created by nightdresses and bedclothes surrounding a sleeping body.

Organic soil is made of structurally repetitive organic and inorganic materials that possess heterogeneous properties. Similar to the complex assemblies of tissues and organs in living systems, soil contains functions that are supported by an orchestrated variety of cells. The various elements of a soil matrix are spatially arranged in a way that provides suitable surfaces for self-organising and evolving biochemical exchanges. The chemistries self-regulate and interact and they confer the various molecular species with behaviours of living systems such as growth and sensitivity to their surroundings.

Similar to these properties of organic soil, the soil matrix of the Hylozoic environment is composed of a responsive framework made of inert materials and a 'living' technology layer made of the various species of adaptive chemistries that include organic 'protocell' technology and inorganic iChell (chemical cell) membranes. Protocells and iChells are chemical models of primitive artificial cells working together to form the tissues and organs of the soil matrix. The self-assembling chemistries of the protocells and iChells offer 'minimal cell' criteria – container, metabolism, information.[3] These cells therefore exhibit some of the properties of living systems, even if not considered by researchers to be truly alive.

Artificial chemical cell species form habitats within the Hylozoic soil matrix that are capable of thriving under the initial conditions. Given enough time to evolve, new species take hold, as spontaneous physical and chemical changes take place within the living technology. The new species further modify the habitat by altering physical variables such as the amount of carbon dioxide in the atmosphere or the mineral composition of the synthetic tissues and organs of the Hylozoic soil. The exchanges between adaptive chemistries, responsive materials and environmental fluxes within the Hylozoic soil matrix oscillate and respond to each other and also, crucially, to people passing through the environment. Together these processes result in a series of transformations within the soil matrix that manifest over time as a 'synthetic succession'. This living succession of protocell and iChell technology forms the tissues and organs of the Hylozoic soil matrix. Key ingredients include incubators (protocells), carbon-capture protopearls (protocells) and traube membranes (iChells).

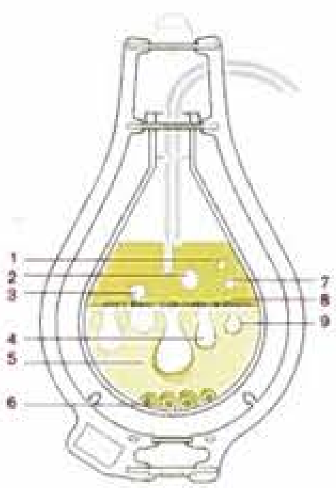
below: Entry view. Flexing, breathing meshworks populated by humidity-filled fields of bladders and kinetic pores frame a tangled series of small public gathering spaces.

bottom left: Protocell incubator system. Ferrofluid vesicles are suspended between oil and diethyl phenyl phthalate liquid layers.

bottom right: Protopearl flask system. Harmless, pearl-like carbonate deposits result from the processing of Venice canal water by protocells housed within the flask system.

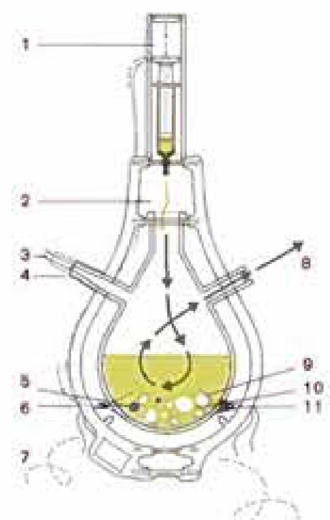
bottom left: Extended traube cell system. Extended traube cells would spread over geotextile scaffolds in the next generation of Hylozoic series.

bottom right: Filter layer, hygroscopic islands and meshwork canopy system. The general systems diagram shows the protocell 'lymph' system at a lower level embedded with layered filters driven by shape-memory alloy mechanisms. Fields of humidity-bearing bladders are suspended above, and corrugated diagrid meshwork canopies support the assembly.



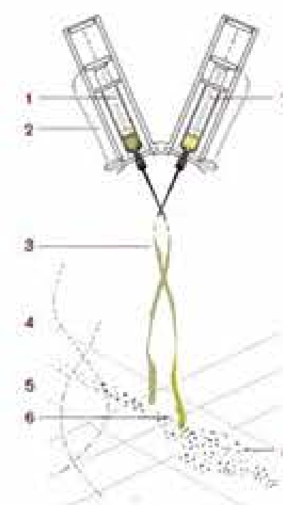
Liesegang ring-like reactions.

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



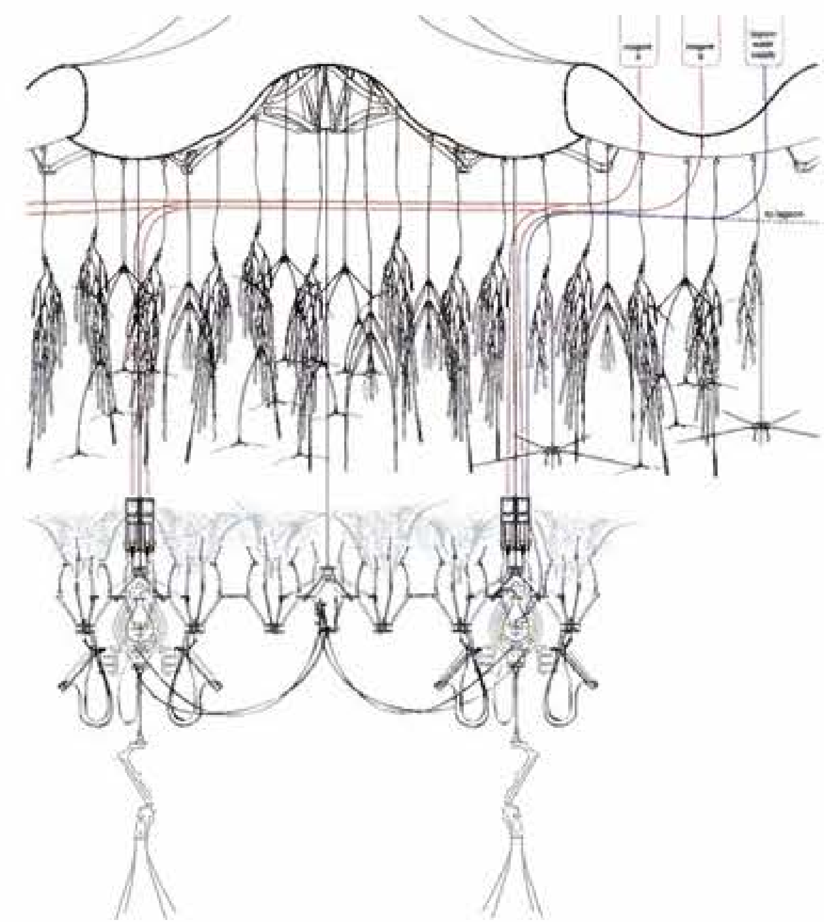
Protopearl flask.

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 air flow outlet will act as overflow
9 From Venice water: magnesium, barium and calcium ions
10 Protopearls
11 Emitter



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



below left: Slow ripples of movement cascade out from filters and columns, responding to electronic signals from proximity and touch sensors embedded within the system.

below right: Detail of filters, columns and canopy system. Meshed networks of filters suspended below hyperbolic skeletal canopies are embedded with protocell incubator flasks. Trickling lagoon water irrigates the system.

opposite: Light pulses pass through neighbouring flasks in waves. The flasks are surrounded by sieve-like fronds that slowly draw air through the layer.

space boils out of local circumstance. As with the fabric that emerges from the steady cadence of knitting or crocheting, the chevron links are combined in repeating rows, and their numbers tend to drift and bifurcate. Adding links within linked rows crowds the surface, producing warped and reticulated surfaces that expand outwards in three dimensions.

In the next phase of development, following the Venice installation, traube membrane iChell systems will be included within the Hylozoic filter layers. A traube cell is an artificial, inorganic model of a cell that consists of a semipermeable membrane surrounding a vesicle that allows water to pass inside, but not back out again. The growing, seaweed-like membranes of traube cells are driven by hydraulic forces that create expanding and diffusing forms. A continuous supply of raw materials provided through a syringe driver will ensure continuous mingling of the traube salts. The membrane produced by the copper hexacyanoferrate is initially soft and hardens on drying. A continual feed of traube salts, supported on an organic polymer matrix such as alginate, creates a sequentially layered structure that adds thickness to the membrane. The combination of older dried layers and younger moisture-laden deposits creates a many-layered matrix that traps water for growth and adds structural integrity to the developing chemistry.

In these next stages, traube cell functions might move out of the secure containment of current systems of glass flasks and flexible tubing, flowing over the supports of porous meshwork scaffolding systems. The generation of viscous, mucus-like membranes in open air involves a host of practical design challenges, while offering increasingly direct fulfilment of active 'geotextile' soil-building functions. Installations containing these evolving details are slated for Salt Lake City, Reims and Beijing during 2011.

What ground, what soil, might be adequate for viable and involved dwelling? Soil has always been the *prima materia* of architecture. But this contemporary soil does not quietly offer itself to the enlightened framing of space. Natural soil might seem to stand silently, apparently offering secure mass and compression as plastic, friable resources for framing human territory. But soil's lumpen, sodden masses counter any enlightened world of social construction. Soil desires collapse. Soil's inexorable infolding of matter within matter maximises surface area and eliminates space, compacting interminably into dark. Soil eliminates and eviscerates space. The soil crust of the earth covers and disguises myriad layers formed from condensation and deposition. Soil consumes and erases daily circumstance within its unspeakably silent, primal fertility. And, soil also desires springing growth. The soil crust of the earth seethes with myriad seeded viscera, minuscule fragments gathering and efflorescing, redolent with chorusing oceans of growth to come. Soil's inexorable flowering genesis of matter building upon matter overwhelms and saturates space, riddling voids and boiling and flaming outwards. The ambivalence latent within soil makes it a monstrous doppelgänger for architecture.

The Hylozoic series offers a diffuse matrix, a site for assimilation and transformation. This matrix offers a map of a dissociated body moving to and fro across junctures of conception, charged with territory whose gendered roots speak of birth. If, quickened by a humid microclimate and organic atmospheres blooming around human occupation, the vesicles and primitive glands crowding the Hylozoic Ground surface spoke, they might call and lure, voicing abject hunger. This soil is pulling. Its environment seeks and depends on human presence as elemental food. ⊿

Notes

1. The ongoing series is directed by Philip Beesley with principal collaborators Rob Gorbet and Rachel Armstrong. Key individuals include design associates Hayley Isaacs, Eric Bury and Jonathan Tyrrell. The Hylozoic Ground Venice team includes production director Pernilla Ohrstedt, funding and promotion by Poet Farrell and Sascha Hastings, designers Carlos Carillo Duran, Federica Pianta, Carlo-Luigi Pasini and Adam Schwartzentruber, engineers Brandon Dehart and Andre Hladio, protocell research associates Martin Hanczyc and Davide De Lucrezia, and photographer Pierre Charron.
2. Geotextiles are civil engineering structural layers that provide support for landscapes. Many geotextiles are biodegradable, and are eventually taken over by organic growth.
3. Steen Rasmussen et al, 'Bridging Nonliving and Living Matter', *Artificial Life* 9, 2003, pp 267–316.
4. Terence W Deacon, 'Emergence—The Hole at the Wheel's Hub', in Philip Clayton and Paul Davies (eds), *The Re-Emergence of Emergence: The Emergentist Hypothesis from Science to Religion*, Oxford University Press (Oxford), 2006, pp 111–51.
5. The geometries of this system are 'quasiperiodic', combining rigid repetition with corrupted inclusions and drift. Penrose tilings following the 10-way division of a circle alternate with close-packed regular hexagonal geometry.

Some passages from this essay are adapted from Philip Beesley, Pernilla Ohrstedt and Hayley Isaacs (eds), *Hylozoic Ground: Liminal Responsive Architecture*, Riverside Architectural Press (Cambridge, ON), 2010.

References

Citation for the above:

Armstrong, Rachel, and Philip Beesley. “Soil and Protoplasm: The Hylozoic Ground Project.” *Architectural Design* 81.2 (2011): 78-89.

For further reading:

Armstrong, Rachel, and Neil Spiller. "Synthetic biology: Living quarters." *Nature* 467.7318 (2010): 916-918.

Beesley, Philip, Matthew Chan, Rob Gorbet, Dana Kulić, and Mo Memarian. “Evolving Systems within Immersive Architectural Environments: New Research by the Living Architecture Systems Group” *Next Generation Building* 2.1 (2015): 31-56. Print.

Beesley, Philip. “Dissipative Architectures: Workshop with CITA Studio, Royal Danish Academy of Fine Arts, School of Architecture.” *Royal Danish Academy of Fine Arts School of Architecture* Nov (2015): 5-28. Print.

Beesley, Philip, Matthew T.K. Chan, Rob Gorbet, and Dana Kulić. “Curiosity-Based Learning Algorithm for Distributed Interactive Sculptural Systems.” *2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* 28 Sept – 02 Oct (2015): 3435-3441. Print.

Beesley, Philip, ed. *Near-Living Architecture: Work in Progress from the Hylozoic Ground Collaboration 2011-2014*. Toronto: Riverside Architectural Press, 2014. Print.

Beesley, Philip. “Diffusive Thermal Architecture: New Work from the Hylozoic Series.” *Architectural Design* 84 (2014): 90-99.

Beesley, Philip. “Dissipative Prototyping Methods: A Manifesto.” Guest Ed. Rachel Armstrong. *Journal of the British Interplanetary Society* 67.7/8/9 (2014): 338-345.

Beesley, Philip. *Sibyl: Projects 2010-2012*. Toronto: Riverside Architectural Press, 2012. Print.

Beesley, Philip. “Feeling Matter: Empathy & Affinity in the Hylozoic Series.” *Meta.Morf A Matter of Feeling*. Ed. Espen Gangvik. Trondheim: TEKS Publishing, 2012. Print.

Beesley, Philip. “Soil and Protoplasm.” *Manufacturing the Bespoke.* Ed. Bob Sheil. London: Wiley, 2010. 102-119.

Beesley, Philip. “Case Study: Meshes as interactive surfaces.” *Digital Fabrication in Architecture*. By Nick Dunn. London: Laurence King, 2010. 46-48.

Beesley, Philip. *Hylozoic Ground: Liminal Responsive Architectures.* Toronto: Riverside Architectural Press, 2010. Print.

Beesley, Philip. “Hylozoic soil.” *Leonardo* 42.4 (2009): 360–361.

Beesley, Philip, ed. *Kinetic Architectures and Geotextiles Installations.* Toronto: Riverside Architectural Press, 2007 & 2010. Print.