Arch 393 Option Studio **THRESHOLDS: Entropic Growth and Form**

Philip Beesley/Living Architecture Systems Group

Mondays and Thursdays, 9:30-12:30 a.m. and 1:30.-6 p.m.

September 6, 2018

This studio will explore responsive architectural thresholds. The studio will be organized in a series of design explorations and prototypes accompanied by visualizations. In the studio you will design resilient structural scaffolds populated by active kinetic, light and sound components. Physical prototyping and technical drawing will be practiced as core crafts. This studio will build upon the orthography, digital and physical modeling and fabrication methods that you have already learned in previous studios, but no highly specialized additional skills are required before entering the studio. You will be asked to learn new techniques and will be supported by workshops and hands-on demonstrations. The studio will especially suit students who are interested in working in multiple cycles of design, prototyping, testing and experimental building.

Light, sound and motion will be considered. Advanced material manipulations including thermal forming and sheet material manipulation will be demonstrated. Electronically active control systems in kit form will be provided with technical support for integration. Design with electronic controls is beyond the scope of this course, but further involvement in scripting and electronics can be supported if individuals are interested in pursuing these approaches.

The option of overlap between individual designs and a collective physical installation as a final production will be decided by discussion with the class. You will be asked to provide materials for your prototyping supported by a substantial materials subsidy provided by the Living Architecture Systems Group (LASG). An engineering research LASG associate will be present guiding methods for manipulating electronic systems.

A small publication documenting the work of this studio with contributions by participating students would be produced as part of LASG research.

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Unstable, wandering boundaries without certain territory might speak of risk. However, could those qualities possibly contribute to substantial architecture? This studio explores precarious natural forces that create flux and instability–*entropic* systems--within new interactive architecture.

A fundamental law of physics states that as time passes entropy always increases. If we used conventional definitions that equate entropy with disorder, we might see our lives as fleeting. The exquisitely ordered states of living organisms, repairing and renewing themselves until they die, might seem the opposite of entropy. However does entropy inevitably mean 'disorder', and does that term inevitably lead to death and decay? New voices are applying the earlier 20th century insights of physicist Ilya Prigogine and the biomathematician D'Arcy Wentworth Thompson to open, living systems. New physics research suggests that entropy can be a profoundly positive quality. Recent voices even assert that entropy is a fundamental quality that helps to create and renew life. How could unstable, apparently disorderly forces be compatible with life? If renewed definitions reveal the refreshing and renewing qualities of entropy, embedding those directly within the intermeshed forces and dynamic topologies that make up the forms of our natural world, might this contribute to new kinds of architectural design?

A striking conception that seems to counter the assumption that life depends on resisting entropy was offered by Ilya Prigogine in his 1978 Nobel address. [i] In his research, he asserted that the closed

systems of classical science and historical mechanical engineering are fundamentally different than the conditions of the natural world. Upending conceptions of inevitable decay within the natural world, he described wholes realms of *dissipative* forms- the barred, clumping textures of cumulus clouds and rolling standing waves in the ocean and in constantly shifting dunes, formed by constant energy shedding, dissipation- holding their forms steady amidst constantly fluxing exchanges of force. Dissipative forms lie around us. They can be seen in veils of smoke billowing at the outer reaches of a fire, torrents of spiraling liquids, and mineral felts efflorescing within an osmotic cell reaction. [ii] Prigogine asserted that these kinds of forms appeared consistently, directly following natural law. He demonstrated that they could be consistently found within constantly cycling systems, the natural result of the far-from-equilibrium forces that constantly move through the world. Dissipative forms might seem ephemeral and fragile, but they are in fact tenacious and durable, holding their organizations in dynamic balance while at the same time materials and energy constantly cycle through them.

This renewed interpretation is accompanied by a shift from analyzing the world as a closed system. Classical physics and machinic control have tended to focus on closed, bounded worlds in which action is always met by an equal and opposite reaction. In contrast, Prigogine's work is founded upon open systems-- on the far-from-equilibrium state of the earth immersed in the sun and the constant flux of air and ocean.

With this the word entropy needs redefinition. Instead of 'disorder', entropy can be redefined as a fundamental force that seeks a maximum of diverse freedom and a maximum of potential. With such a fundamental shift in conception of energy and material exchange within passing time, the walls and envelopes of physical architecture have substantial reasons to shift in turn. Might a renewed architecture construct dynamic, constantly shifting open thresholds, seeking constantly renewed thresholds of exchange? Might architecture foster productive kinds of instability, helping to create a maximum of entropy within its internal systems and their larger environments while at the same time maintaining homeostasis for its inhabitants?

Design principles can be found by drawing on physical examples of coupled interactions and interconnections. *Form*, as the biomathematician D'Arcy Wentworth Thompson wrote in his famous 1917 treatise On Growth and Form, is a *diagram of forces*.[iii] Seen through the lens of recent physics, the profound interconnectedness of Thompson's maxim can be renewed: dissipative architectural forms can be a diagram of entropic forces.The densely layered forms of a jungle are made of diffusive, deeply interwoven materials that expand and interact with their surroundings. A new city designed to easily handle unstable conditions of cooling and heating in rapid cycles of shedding heat and warming and collecting heat might well look like a hybrid forest where each building is made from dense layers of ivy-like filters and multiple overlapping layers of porous openings. Similarly, the kind of diffusive forms seen in reticulated snowflakes and the microscopic manifolds of mitochondria have a common form-language of intense reticulation. Their increased surface areas make their reaction-surfaces potent.

Instead of valuing resistance and closure, new form-languages for architecture could foster mutual relationships and maximum interaction. A renewed kind of unapologetically fragile, open architecture can be found.

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[i] Ilya Prigogine, '**The 1977 Nobel Prize in Chemistry**,' Nobelprize.org. Nobel Media AB 2014, http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1977/press.html

[ii] Adapted from Philip Beesley, **'Precarious Living Reactions: New Paradigms for Robotic Architecture',** in **Towards a Robotic Architecture: Framework and Processes**, edited by Mahesh Daas and Andrew Wit, ORO Editions, 2018, ISBN 978-1-939621-63-4

[iii] Thompson, D. W., **On Growth and Form**, Cambridge University Press, 1917

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SCHEDULE

preliminary, to be updated

If you wish, you may integrate work submitted in preceding assignments into next stages. Collaborative work may be included. Credit and identfy this work where applicable.

Assignment One: LIMEN
Assigned: Thursday, Sept. 6
Electronic Controls Workshop: Monday Sept. 10
Review: Monday, Sept. 17
Production: Create a threshold that explores prototype scaffold systems with integrated kit components
Evaluation: 10% of final grade

Assignment Two: REACTORS
Assigned: Monday, Sept. 17
Review: Monday, Oct. 15
Production: Building from standard details, explore prototype mechanisms and components for light, sound and motion
Evaluation: 20% of final grade

Assignment Three: LITTORAL SPACES
Assigned: Monday, Oct. 15
Workshop: Thursday, Oct. 18
Review: Monday, Nov. 5
Production: Using analogies from wetlands and liquid immersion, develop individual drawings and visualizations that imagine qualities of passage within urban realms. Accompany the visualizations with systems diagrams.
20% of final grade

Assignment Four: THRESHOLDS
Assigned: Monday, Nov. 5
Workshop: Thursday, Nov. 15
Interim coordination review: Monday, Nov. 19
Review: Thursday, Dec. 7
Production: develop individual explorations and potential collective installation, supported by technical drawing. Document your work for publication.
Evaluation: 50% of final grade

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Assignment One
LIMEN

Assigned: Thursday, Sept. 6
Electronic Controls Workshop: Monday Sept. 10, with Parichit Kumar
Review: Monday, Sept. 17
Production: Prototype scaffold with integrated kit components, accompanied by diagram
Evaluation: 10% of final grade, based on conceptual quality, scope and ambition, and craft quality.
Present: Erect your prototype within the studio space. Hanging frames will be arranged. Pin up diagram adjacent to the protype. Be prepared for review beginning at 9:30 a.m.

Produce a first prototype of an architectural threshold that includes a scaffold system and that includes an active responsive function. Accompany your study with a diagram that records the essential arrangements of your prototype and that projects the dynamic relationships that could result. Share your sketch explorations.

Work in cycles of sketching, fabrication, testing and observation.

A first workshop will introduce a kit of electronics controls.

Pattern languages will be shared supporting fabrication of component systems and structural scaffolds.

'Tinkering' that freely adapts existing components using relatively raw, open relationships can be encouraged, alternating with precise refinement of harmonized and unified systems.

The final work you produce for this assignment may be a fragment.