Permanence and Permeability
Intervention Architecture and Cellular Botany

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Abstract
This paper encourages rethinking assumptions about enclosure and the assignment of materials in creative reuse projects by analogy with plant cellular structure, borrowing from 19th-century architectural theorist John Ruskin, who was fiercely opposed to architectural restoration.

Ruskin used extensive analogies between plants and buildings throughout his life and particularly admired plants which he perceived to be simultaneously decaying and undecaying. Contemporary with Ruskin's largely philosophical botanical musings and other early theories about the enclosure of life at the cellular scale, German architect Gottfried Semper's "Caribbean hut" explicitly decoupled the structure of a wall, which he associated with its roof, and the wall's primary function as social and physical enclosure, which he associated with a membrane-like textile hanging from the roof.

Semper's hut functions similarly to a basic plant cell, in which the cell wall and the cell membrane perform separate functions—an apt analogy for 21st-century renovation projects. Whereas new-build projects tend to privilege the wall that "does it all," existing building stock, often inadequate by the latest standards of efficiency, could be coupled with newer experimental materials which have desirable ecological properties but which on their own do not substitute for load-bearing walls.

> All things, if they are to have a vital effect, must be enveloped. Thus all things that are turned towards the outside yield prematurely to gradual decay—it is below the surface of these unliving husks, or at a deeper level, that the originating fabric of life is brought forth.
>
> — Johann Wolfgang von Goethe, *On Morphology*, 1807[1]

Introduction
Countless arguments can be made in favor of working with old material creatively as an alternative to demolition, restoration, or one-to-one preservation, which itself can have high energy costs. As worries mount about humans' impact on the climate and environment, material retention is certainly a priority.

Another powerful argument in favor of creative intervention comes from theorist Svetlana Boym, whose book *The Future of Nostalgia* (2001) addressed the stigma associated with nostalgia, which made it a taboo subject for many 20th-century architects. While Boym criticized what she called "restorative nostalgia," the desire to recapture the past as it was, she also defined "reflective nostalgia" (or "creative nostalgia") as a universal human emotion of longing for the past while grappling with its unknowability.[2] Whereas restorative nostalgia is associated with toxic nationalism and architectural restoration, creative nostalgia is a potential antidote to the restorative kind, inviting imagination of the multiple alternate realities which the past might represent today.

Histories of Enclosure in Architecture and Cellular Biology

John Ruskin on (Anti-) Restoration and Cellular Botany

A famous opponent of restoration, John Ruskin, offered up in his *Seven Lamps of Architecture* (1849) a rubric for what he called "vital" imitation of past architectures, which required, according to him, "frankness" and "audacity."[3] Ruskin's prescription could equally be applied to evaluate the "vitality" of new design interventions into older buildings—that is, their ability, in Boym's terms, to suggest what could have been in the past while also remaining committed to their own contemporary context.[4] Frankness about the extent of intervention and audacity in adding the mark of the modern-day are critical to progress.

Ruskin made comparisons between plants and buildings throughout his life, and by the time he wrote his own botany textbook *Proserpina* (1875), he wrote that true life, as embedded in a building by a talented craftsman, never dies but always contributes to future cycles of life.[5] *Proserpina*'s first chapter is about moss, whose every fiber, according to Ruskin, always has a part that is decaying and a part that is undecaying—an apt analogy for vital contemporary interventions into historic buildings.[6] Throughout *Proserpina*, Ruskin, like many botanists before and after him, used architectural analogies to explain plant structure at both the macro and microscopic scales. These analogies included three parts of the root which he named store-houses, refuges, and ruins. He claimed that the structure remaining within the ruin provided "a basis for the growth of the future plant."[7]

Early Cellular Biologists' Theories of Enclosure

The association of the microscopic spatial organization of plants with that of human habitation dates back to the discovery of the plant cell by Robert Hooke in the mid-seventeenth century. The first drawing of cells was published in Hooke's *Micrographia* (1665), in which he coined the term cell, because of a perceived similarity to monastic cells (Figure 1). The illustrated specimen is a piece of dead cork, in which the only remnants of the once-living cells are the dried-out cell walls, composed of hardy cellulose. Hooke's cork "cells" may have turned out to be dead, but how dead? Certainly dead cork can still be used, and the material is more malleable than many materials that were never alive.

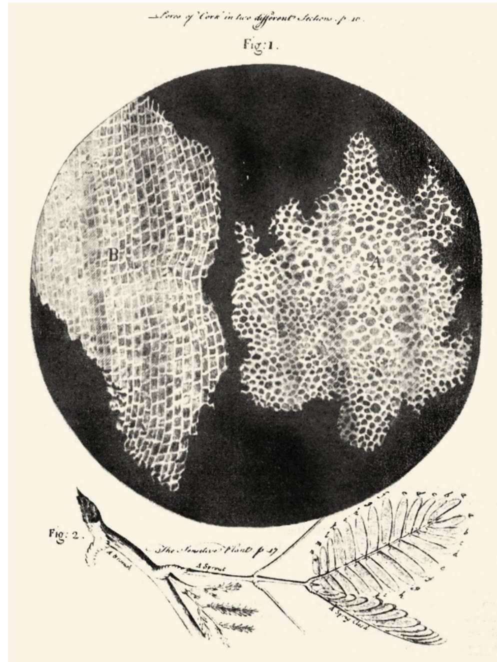

Figure 1. The first drawing of cells, from dried cork, in Robert Hooke's *Micrographia* (1665).

Just as the idea that a building might have a singular identity and origin is uniquely modern, so is the idea that one can draw a stark line between life and death—although this dichotomy is now a fundamental organizing principle in much of the Western world. The dead were first physically segregated from the living by removal to cemeteries outside the city around the turn of the 19th century—a circumstance considered by many historians to be a precondition for modernity. It is no accident that this trend coincided with the first major advances in cell theory since Hooke's discovery of the cell in the 1660s.

At the turn of the 19th century, no one had seen cell membranes yet—or any specific structure enclosing an animal cell—because their microscopes weren't good enough, but many felt confident that they existed and some even reported having seen them, simply because they expected them to be there when they looked.[8] Across disciplines, there was a deep-seated expectation that life required tight enclosure.

Before the mid-20th century—that is, before electron microscopy—most biology textbooks used similar philosophical assumptions and

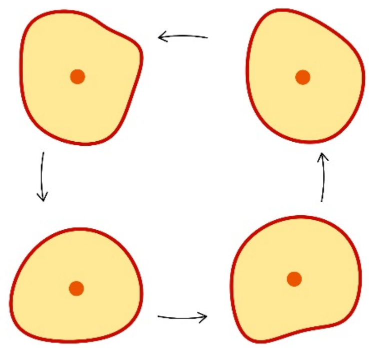

Figure 2. Basic cell model. A flexible membrane (red) with low permeability, enclosing cytoplasm surrounding a nucleus. Architectural "membrane models" do not always include the temporal changes as shown here. Organelles are omitted as they rarely come up in such analogies.

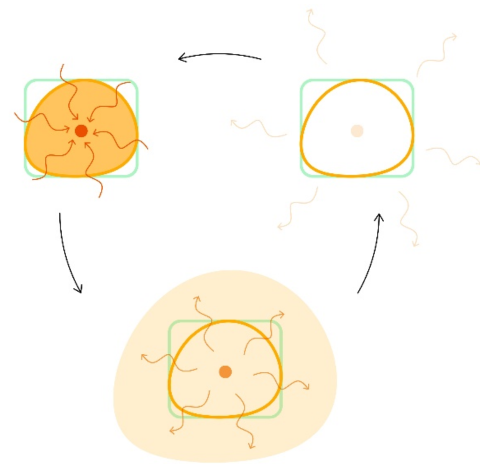

Figure 3. The pseudo-cellular Semper hut model. A freely permeable membrane (yellow) is suspended from a structure (blue) surrounding a hearth which burns cyclically. While the fire burns (top left), energy and people congregate around the hearth, within the enclosing membrane. The fire dies as people venture out during the day (bottom), leaving the hut sometimes uninhabited (top right), to begin the cycle again.

logic (where evidence was lacking or incomplete) to explain biology. Here is a representative quote, by zoologist E. Newton Harvey, in the foreword to a textbook on permeability in 1943:

> Organisms could not have evolved without relatively impermeable membranes to surround the cell constituents. This barrier between the inside and the outside, the inner and external world of each living unit, has been and always must be considered one of the fundamental structures of a cell…. [D]ead [cells] are completely permeable to diffusible substances, while the living retain one material and pass another. This difference, selective permeability, is so marked that it becomes the surest test to distinguish the living from the dead, holding where all other methods fail.[9]

Also up until the mid-20th century, while most biologists believed in the ubiquity of cell membranes, there was a small but devoted contingent of scientists who believed in the existence of membraneless cells.[10] Although their theories have since been disproven, some of their intuitions about the ways cellular components might cohere without a boundary are surprisingly close to the modern-day understanding of membraneless organelles, a class of intracellular compartments which has been almost impossible to study until very recent advancements in live-cell imaging.[11] Descriptions of these membraneless entities (both postulated and scientifically verified) call into question the stipulation that life requires a definite boundary or container. Instead, they suggest that various combinations of intrinsic and extrinsic forces may be sufficient to organize life at the cellular level.

Enclosure in Gottfried Semper's Pseudo-Cellular Primitive Hut

In his *Four Elements of Architecture* (1851), Gottfried Semper describes what he imagines as the first building, his version of the primitive hut, in terms reminiscent of cellular biology.[12] Semper's titular four elements are the hearth, the roof (structure), the enclosure (textile), and the mound. His primitive hut has no load-bearing walls; the "true walls" are the "boundaries of space"—by textiles hung from the roof which define inhabitation around the hearth.[13] The true walls' function is neither structure nor security, but inclusion, more so than exclusion, implying that external forces are irrelevant. This image evokes the most basic cell membrane model, which was in development at the time of

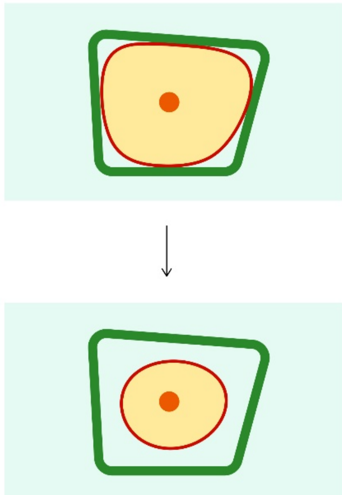

Figure 4. The plant cell wall and cell membrane. When a plant cell is placed in a hypotonic solution, one that exerts less water pressure than the cell, the cell will shrink as water leaves the cell. The cell wall stays intact, while the membrane-enclosed cell shrinks away from it.

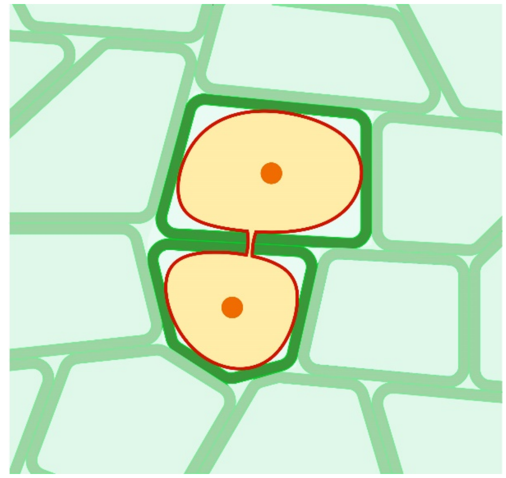

Figure 5. Adjacent plant cells often adhere to each other at points of connection along their cell walls. Openings called plasmodesmata may connect the cytoplasm of one cell directly to that of the adjacent cell, traversing both the cell walls and cell membranes.

Semper's writing and which included the nucleus (analogous to the hearth), the membrane (enclosure), the cytoplasm (vital contents such as people and energy), and various organelles (Figure 2).

Perhaps the most conspicuous omission from the basic membrane model is that of structure—an omission which Semper himself did not make. In Semper's model, the textile enclosure is suspended from the structural roof. In this respect Semper's hut intuits later advancements in cell biology, when it was discovered that most cells require extracellular structural components to support the membrane, including the complex extracellular matrix in animal cells and the cell wall in plant cells. Any architectural model including a membrane and respecting the laws of gravity must provide a separate structural framework (or enough energy continually to inflate the membrane), leaving the membrane to perform some combination of spatial delineation, energy containment, and/or social or environmental filtering.

Cellular and social organization are often compared in terms of a drive towards equilibrium or homeostasis, but homeostasis should not be confused with inertia. In fact, homeostasis—or life—requires constant movement, permeability, and energy expenditure. Semper's hypothetical inhabitants would be out hunting and gathering throughout the day, returning home and experiencing relative calm at night. Thus, Semper's hut is less a traditional cell and more a gathering center point about which bodies contract and expand well past the boundaries of the enclosure (Figure 3). The vital energy of the hearth is likely calibrated accordingly throughout the day. This model of the primitive hut is a reminder that architecture is not only a spatial organizing mechanism, but also a temporal organizing mechanism.

For comparison with Semper's hut, Figure 4 illustrates what happens to a plant cell when it shrinks due to water loss when placed in a salty solution (one with relatively low water pressure): the cell, bounded by the membrane, changes size and shape dramatically, but it does not lose any of its potential territory thanks to the sturdy cell wall, which maintains its shape and is considered "freely permeable" by biologists. In addition to the separation of structure and enclosure embodied by the permeable cell wall, an architecturally provocative feature of the plant cell is the frequent adhesion between cell walls of adjacent plant cells (Figure 5). At these points of contact, channels can form that traverse not only both cell walls, but also both membranes, allowing freer exchange between the two cells, which retain their structure even as their more "vital" enclosure shifts with use and circulation.

Conclusion

Implications for 21st-Century Architecture

The analogy of the plant cell suggests new ways of thinking about enclosure in terms of material, temporality, and function. Do we really need all walls to do everything—insulation, acoustics, light filtering, structure, privacy, and so on—all the time equally? In ground-up construction, we often think of the wall this way: in the interest of cost and energy efficiency, it makes sense for every component to serve as many functions as possible. However, the idea of delaminating wall functions in the style of Semper or of the plant cell has the potential change the way we think about material assignments and levels of enclosure within intervention architecture. When we already have so much existing building stock to work with—even if a lot of it does not perform all possible functions of a wall to modern standards—the plant cell structure suggests that an existing masonry building, for example, might provide a structural framework within which to selectively condition and treat interior spaces using newer materials and tectonic systems.

One intervention project which can be considered analogous to cellular botanical structures is Witherford Watson Mann's renovation of Astley Castle (2013), whose newest walls and previously existing walls have significantly different physical footprints. Witherford Watson Mann's addition treats the older building, ruined by fire in the 1970s, as a partial structural layer and foundation, analogous to Ruskin's plant "ruins" upon which new plants grow. Some of the new walls literally use older walls as foundations—but significant portions of the building as defined by the older walls, including the dining room, are left open-air and essentially unconditioned by modern standards. The newer walls provide conditioned enclosure only where it was deemed essential. Because Astley Castle is a short-term holiday rental, the architects were able to use the project to question assumptions about necessary levels of comfort and insulation, as well as the potential benefits of a more open system.[14]

Another recent example is Architecten de Vylder Vinck Taillieu's PC Caritas (2016), a progressive mental healthcare facility built within the walls of a partially ruined masonry villa. Rather than demolish the building or restore it to something like its original complete form, the architects selectively created insulated interior spaces within the shell, leaving a lot of open-air, largely unconditioned interstitial space. Because the clinic itself wanted to question traditional understanding and treatment of mental illness, they were also willing to question traditional enclosure and comfort, with a result formally analogous to the plant cell whose membrane shrinks away from its wall.[15]

Not only might the delamination of different types of enclosure lead architects to reuse more existing building stock and to question the amount of conditioned space and degree of energy expended in those spaces, but it might also raise new possibilities for new materials, many biologically based, which have drawn attention in the last decade—for instance, mushroom mycelium or bricks manufactured from loofahs or sea sponges. Perhaps because of the tendency towards efficiency and the desire for a singular wall that does everything, these investigations often seem to begin and end with single-material pavilions which test the limits of the material in each of the capacities by which we evaluate walls, and at least one of which the material may fail. For example, mushroom mycelium has a compressive strength about 100 times lower than concrete, significantly limiting its viability to provide the basis for exterior structural walls with any longevity.[16] Instead of asking if this material can substitute for concrete, brick, or steel, such experimental materials might go much further if we asked what they can do in conjunction with the concrete, brick, and steel we already have in abundance assembled in our cities.

Ultimately, when we begin to decouple different levels of walls' performance, function, and structure, the interplay between our existing building stock and new material treatments might begin to challenge deeply held assumptions about what levels of enclosure, conditioning, and permeability are desirable for spaces with different functions, both new and old.

Endnotes

1. Johann Wolfgang von Goethe, trans. Pamela Johnson, from Sigfried Ebeling, *Space as Membrane* [1926], ed.

Spyros Papapetros (London: Architectural Association, 2010): 18

2. Svetlana Boym, *The Future of Nostalgia* (Basic Books: New York, 2001): xviii.

3. John Ruskin, *The Seven Lamps of Architecture* [1849], Sixth edition (Sunnyside, Kent: George Allen, 1889): 152.

4. I describe this rubric for creative intervention at length in a forthcoming book chapter: "The Afterlife of Dying Buildings: Ruskin and Preservation in the Twenty-First Century" in *Ruskin's Ecologies* (Courtauld Books Online, expected 2020).

5. John Ruskin, *Proserpina: Studies of Wayside Flowers, While the Air Was Yet Pure Among the Alps, and in the Scotland and England Which My Father Knew* [1875], Vol. 1, Third edition (London: George Allen, 1897): 70-71.

6. Ruskin, *Proserpina*, 23.

7. Ruskin, *Proserpina*, 267.

8. Henry Harris, The Birth of the Cell (New Haven: Yale University Press, 1999): 149. See also, Laura Otis, Membranes: Metaphors of Invasion in Nineteenth-Century Literature, Science, and Politics (Baltimore: Johns Hopkins University Press, 1999): 4.

9. E. Newton Harvey, Foreword in *The Permeability of Natural Membranes*, ed. Hugh Davson and J. F. Danielli, (Cambridge: The University Press, 1943).

10. As late as 1939, Ernest Everett Just noted that "[o]pponents of the membrane's existence declare that since the cell-substance is in the colloid state, it is unnecessary to postulate the presence of a membrane: the mere boundary of the colloidal system is sufficient to preserve the cell's integrity." *The Biology of the Cell Surface* (Philadelphia: P. Blakiston's Son & Co., 1939): 70.

11. James Shorter, "Membraneless Organelles: Phasing in and out," *Nature Chemistry* 8 (June 2016): 528-530.

12. The discussion of Semper's pseudo-cellular organization is adapted from my article "Below the Surface of These Unliving Husks" in *Pidgin* 25 (2019).

13. Gottfried Semper, originally from The Four Elements of Architecture [1851], republished in *Architectural Theory Volume I: An Anthology from Vitruvius to 1850*, ed. Harry Francis Mallgrave (Malden, MA: Blackwell Publishing, 2006): 537.

14. William Mann, 'Inhabiting the Ruin: Work at Astley Castle'. Originally published in *Association for Studies in the Conservation of Historic Buildings Transactions* 35 (2013).

15. "PC Caritas," EU Mies Award [2019], accessed June 30, 2020, https://www.miesarch.com/work/4113.

16. M.Z. Karimjee, "Biodegradable Architecture, Finite Construction for Endless Futures," Azrieli School of Architecture and Urbanism, Ottawa, Ontario, 2014.