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Extraordinary Performances at the Salk Institute for Biological Studies

While the design tactics and systems of the Salk Institute for Biological Studies are well documented, its performance remains less explored. Based upon extended in situ observation, I present an account of the building in terms of its day-to-day performances as well as cumulative evidence of its performance over its forty-year history. Contrary to accounts that focus on the building's extraordinary qualities, this article argues that in the end, it is ordinary details and systems that engender its most consequential performances. Central to this account is an approach that integrates organizational, technical, and aesthetic performance parameters for a polyvalent understanding of performance in architecture.

Many accounts of Louis Kahn's Salk Institute for Biological Studies (1959–1965) inevitably converge on the extraordinary qualities of its courtyard.[1] These accounts often lead to a visual and phenomenological tourism of the building, isolating its performance to the ocular play of water, sun, surface, and setting. Consider, however, that in 1965, the laboratory buildings were complete yet the court and forecourt remained mud pits and Kahn did not know what to do with them.[2] This is indicative of the intense design investment made elsewhere at the institute. As Jonas Salk himself noted, ''The building can't be read from the court.''[3] Its salient performances occur elsewhere (Figure 1). Toward this end, other accounts of the building avoid the temptation to describe it only in visual terms and instead present an objective narrative of the design and development of its spaces and systems.[4] These accounts productively focus on the building as a built object rather than its performative capacities. A third approach to the Salk Institute more directly documents aspects of its performance. A notable example of this is French historian of science Bruno Latour's anthropological research at the institute in the mid-seventies as documented in his subsequent book, *Laboratory Life: The Construction of Scientific Facts*.[5] Latour immersed himself in a Salk laboratory and observed the habits of scientists working in the building. As Salk noted in the introduction to *Laboratory Life*, ''Bruno Latour, a philosopher-sociologist, began a sociological study of biology and along the way came to see sociology biologically.''[6] Although Latour was preoccupied with the social construction of scientific production, his observations revealed that the building's spaces and systems were also active agents in the construction of scientific facts.[7] For Latour, ''the laboratory began to take on the appearance of a system of literary inscription.''[8] In short, his extended field observations sponsored a new reading of the building's performance.

Just as Latour's observations about the building resulted from extended in situ field research, the research for this article likewise emerged from in situ work in the Facility Services Department at the Salk Institute. I was hired to update their as-built set of drawings.[9] I shared an office with the head janitor in the building's interstitial pipe space, made rounds with various janitors and trades people, had access to the entire building and its archive, and spent each day measuring and drawing its every surface. The impetus behind this in situ custodial work was the idea that there are two types of people who know a building well: its architects and its custodians.[10] The former tend to emphasize its spatial and aesthetic qualities, while the latter inevitably understand its temporal and operational parameters. My intent was to focus less on the building as a composed visual object and more on the composition's behaviors and effects. After weeks of observations as well as conversations with the facility manager, janitors, tourists, Nobel Laureates, plumbers, and long-time secretaries, I began to understand significant systems and details indicative of its complex performance that were not articulated in extant literature.

Performance

In *The Mangle of Practice: Time, Agency, and Science*, Andrew Pickering describes an epistemological shift in the sciences from a representational to a performative idiom.[11] A similar shift is occurring in architecture today: architecture is increasingly legitimated by its performative capacities.[12] Jean-Francois Lyotard describes the advantages of this epistemological shift:

> The performativity criterion has its 'advantages.' It excludes in principle adherence to metaphysical discourse; it requires the renunciation of fables; it demands clear minds

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1. "The building can't be read from the court." (Photo by author.)

and cold wills; it replaces the definition of essences with the calculation of interactions; it makes 'players' assume responsibility not only for the statements they propose, but also for the rules to which they submit those statements in order to render them acceptable. It brings the pragmatic functions of knowledge clearly to light, to the extent that they seem to relate to the criterion of efficiency: the pragmatics of argumentation, of the production of proof, of the transmission of learning, and of the apprenticeship of the imagination.[13]

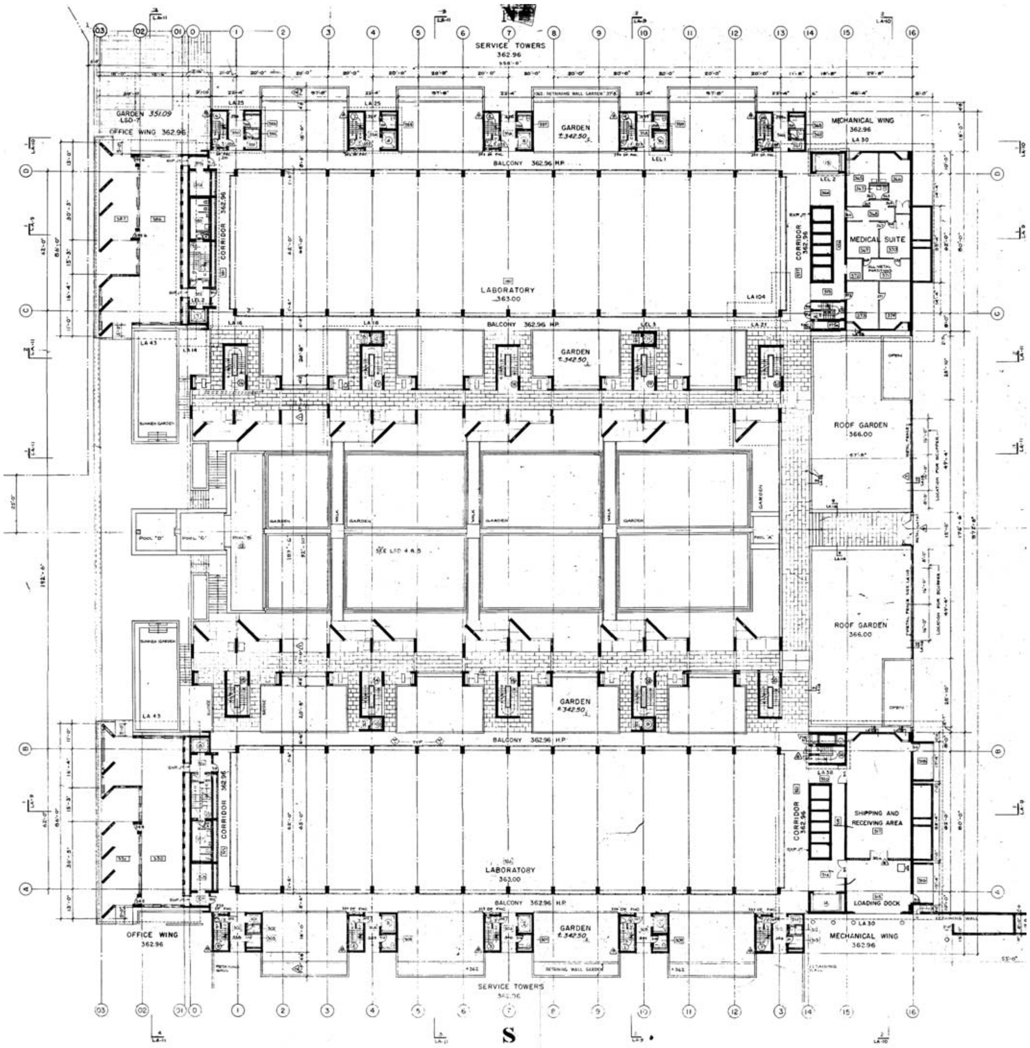
Within this shift, however, architecture's understanding of performance is often isolated to visual effects, energy efficiency, or a developer's financial return but less commonly integrates a comprehensive view of building performances. In some cases, visual and scenographic effects dominate an understanding of performance, perhaps owing to inherited representational legacies that privilege visual effects.[14] In building science, performance is often reduced to overly specific and intricately quantified representations of a building assembly's behavior that does not include, and may diminish, other technical parameters such as constructability or serviceability that nonetheless affect the ultimate performance of a building.[15] With each of these reductive and deterministic understandings of performance, the integrating practices of the architect are diminished. A more polyvalent understanding of performance in architecture is necessary to capture the advantages of this shift to performative idioms.

In *Perform or Else: From Discipline to Performance*, Jon McKenzie articulates three paradigms of performance: aesthetic efficacy, organizational efficiency, and technological effectiveness that characterize a general theory of performance today across multiple areas of knowledge.[16] These paradigms of performance converge in the design, construction, and use of a building. Building on Pickering's and McKenzie's perspectives, performance in architecture integrates, with equal rigor, several practices and performances in the evaluation of a building. This avoids the tendency to confine performance to the visual field or to reductive quantitative information. Such a polyvalent understanding of performance amplifies the integrating practices of the architect and sponsors higher level effects for buildings.

To grasp an integrated understanding of the Salk Institute's performance, it is essential to observe the building in action over time. As Ezra Stoller stated about the building, "The agency that drives the complex is time."[17] Yet, the complex is also driven by human and material agencies. Through the process of in situ empirical observation, these agencies merged and yielded an understanding of the building's performance that could not be discerned from the typical archive of drawings, photographs, texts, tours, and literature. Extended observation of the building revealed aesthetic, organizational, and technical performances and capacities not evident in received accounts. Often, extraordinary details, specifications, systems, and maintenance regimes rather than extraordinary spaces and surfaces engendered the consequential aspects of the building's performance. In what follows, I will describe how these extraordinary systems of the building enable key aspects of its performance.

The Performance Principle of Salk

During this period of in situ observation and conversations with facility management, one principle that drives the performance of the twenty-nine buildings that compose the original laboratories became apparent: to support and maximize uninterrupted research time at the laboratory benches (Figure 2).[18] The material, spatial, and energy systems of the building are guided by this principle. As Kahn stated, "The service of the building had to be designed for the success of the experiment."[19] However, Dr. Salk further stipulated that the laboratories must be able to continuously change and adapt to future research activity: "It was to be built with an evolutionary plan in mind; the capacity to adapt and to change is an integral part of the structure itself . . . it has developed new capacities, new functions, and new purposes."[20] This adaptability is central to the building's real program and is at the core of its performance. The implications of this imperative far exceed mere spatial and physical accommodation of such change. For this independent research institution, there is a direct correlation between bench research time and the grant funding that constitutes the Institute's operational budget. In such an economic model, required maintenance, research support, and renovations can cause disturbances in the flow of work and lost revenue. Eddies of lost bench research time could accumulate into institutionally dire financial consequences since such bench work occurs continuously. According to the facility manager, the vitality of an autonomous research institute is unusually sensitive to this principle of uninterrupted laboratory work.[21] Yet, the Salk Institute has physically grown during its forty-two-year existence. During



2. 1963 construction document with complete buildings and speculative courtyard gardens. (Printed with permission of the Architectural Archives of the University of Pennsylvania.)

this time, its diurnal efficiencies have systemically cycled up to support institutional growth. As Salk requested, the performance of the architecture has successfully engendered the institute's expansions in research agendas, capacities, capital development, and physical construction: the inverse of net dissipation. Whence this growth? How does the institute evolve as required despite ongoing research and ongoing building modifications by at least fifty institute plumbers, electricians, carpenters, and an equal regime of custodial staff servicing the building each day? All this is in addition to various independent contractor crews completely renovating the laboratories and elaborate HVAC systems on (at least) a seven-year cycle to accommodate the changing purposes and functions of the laboratories as scientists and research projects fluctuate. It is a remarkable characteristic of the architecture that it not only dampens such perturbation but also eventuates in an institution that exhibits life-like behavior: it grows on account of its design. Kahn, Salk, and their team rigorously sought physical, spatial, and temporal systems that would support research over time. An understanding of the performance of these systems begins in its rarely visited interstitial pipe space.

The Pipe Laboratory's Organizational Performance

While the rhetorical logic of the interstitial pipe space of the laboratory buildings has been widely documented as a seminal example of a ''servant/served'' space, the importance of this zone in terms of its performance is underestimated and the implications of its spatial and construction details are not well documented (Figure 3).[22] As Kahn stated, ''The space above each laboratory is, in reality, a pipe laboratory.''[23] In his view, the experimental action of the custodian or plumber in the interstitial space was equally important to the experimental action of the scientific space below. In fact, more than half of the square footage of the original building complex is the interstitial space and the mechanical infrastructure that services the laboratories.[24] Yet, the significance of this particular floor area ratio for the vitality of the institute is not fully discernible as a spatial logic but rather in its use over time. A key to understanding the Salk Institute's organizational performance is not merely its principle of uninterrupted bench research work but equally its correlate: uninterrupted maintenance work. The interstitial space not only enables uninterrupted maintenance but also organizes and coordinates this work. The pipe laboratory at Salk is a fully rationalized, self-repeating organization that allows all services and research to occur simultaneously.[25] The logic of the pipe space organizes all one thousand employees, from Nobel Laureates to janitors, into adjacent planes of action: pipe space/laboratory space. In the ''Nature of Organizing Action,'' Ralph Lillie describes the activity of developing living organisms in a way that captures the role of the pipe laboratory in the life of the institute:

> [It is] primarily and fundamentally an integrating center. Materials and energies which previously were isolated and independent come into closer association, under some kind of directive influence or compulsion, to form a characteristically organized unity.[26]

The pipe laboratory is best understood as an integrating center. Its logic exerts directive influence that guides its materials, energies, and work over time. Dr. Salk, though, did not view the pipe laboratory merely as a space for the movement of air, water, and work. He described it as a mesenchyme space.[27] Mesenchyme is the portion of an embryo containing nonspecific cells that develop into other tissue and organ systems. In other words, mesenchyme tissue is specifically generic; its precisely open-ended qualities engender multiple organic possibilities. Dr. Salk's term captures the critical capacity of this zone in the building. In contrast to the metaphorical term ''circulation'' in architecture, mesenchyme aptly describes the temporal adaptability and capacity for engenderment inherent in the spatial logic and construction of the pipe laboratory.[28] The pipe laboratory's specifically generic character is central to the organizational performance and growth of the institute. Certain construction details and material affinities, often extraordinary, actuate the performative logic of this mesenchyme space.

3. Pipe laboratory. (Photo by Ezra Stoller, Esto.)

The Pipe Laboratory's Technical Performance

The pipe laboratory contains extraordinary, yet critical details that contribute to the building's technical performance. Take, for example, the somewhat anomalous lead scuppers at the base of the slots that punctuate the otherwise solid mass of the pipe laboratory (Figure 4). Why does an interior space have a scupper?[29] The solid lead scupper is the tail end of a deeply integrated system: a seemingly disparate affiliation of caulk, extruded aluminum, in situ concrete, posttensioning, and lead scuppers. As has been documented, aluminum extrusions cast serviceable striations into the depth of the in situ concrete slab that separates the research laboratories from the pipe laboratories (Figures 5 and 6). The services required for the uninterrupted research at the bench tops arrive through these ceiling striations above each laboratory. The sides of the pan are Uni-strut dimensioned extrusions that provide slots for flexible attachment of the dropped utilities. The convoluted profile of the extrusion casts the aluminum into the in situ concrete slabs spanning between Vierendeel trusses. A replaceable sheet metal cap covers these slots. Significantly, every penetration of these caps has been routinely caulked since the institute's inception.

One intent of this practice is to create two distinct air zones, keeping the dust in the pipe laboratory out of the science laboratory.[30] An equally important intent of this routine is to not interrupt research, especially in the case of a water event in the pipe space such as a pipe break. While this is rather straightforward, the relationship between the caulk and the posttensioning of the Vierendeel trusses exhibits a very fine scale of thinking in respect to performance. The posttensioned Vierendeel truss slightly cambers the floor of the pipe space upwards (Figure 7). While overtly structural, its subtle arc also creates a positive slope and functions, as one janitor noted, to help shed water to the slightly sloped pipe laboratory corridors where it can finally evacuate through the vertical slots and lead scuppers that modulate the otherwise solid mesenchyme mass (Figure 8).[31] This is but one example of an extraordinary—but highly integrated and nuanced—system that is guided by the principle of uninterrupted laboratory work that permeates the logic of the building. The details of these assemblies might seem initially rather mundane but over time contribute directly to the performance of the building. Other design decisions, such as the building's specifications, exhibit similarly subtle yet ultimately consequential performances.

4. Lead scuppers and slots. (Photo by author.)

5. Served Space. (Printed with permission of the Architectural Archives of the University of Pennsylvania.)

Other Technical Performances: Material and Systems Specification

Kahn and his team selected a spectrum of materials ranging from warm travertine, pozzolana concrete, silvered gray weathered teak, and A242 stainless steel. As an aesthetic performance, the aim was a grayscale material continuum with subtle effects in varying light. Other accounts have, in detail, documented these material specifications and their construction.[32] Yet, each of these material specifications also contributes to the building's larger performance principle. P.W. Roberts, the facility's first chief engineer, noted this aspect of the material selection: ''The materials require no surface treatment after installation. This means lower operating costs and more money for research.''[33] While the material specifications clearly were intended to yield a consistency in the visual field, they were also driven by an economic and temporal logic that redirects facility maintenance and its associated capital toward supporting research.

This principle is also evident in the specification of the building's service systems through serviceability and redundancy. An example of its serviceability occurred during my work there. The South Laboratory Building was in the midst of an intensive HVAC infrastructure upgrade that involved exchanging its original constant air volume reheat system with a variable air volume system with mixing box diffusers. This involved replacing all the original supply and return ducts, including the primary fifty-four inch ducts. The replacement work was completed while research continued in the laboratories below.

Redundancy is another specification and operational strategy that reinforces the performance principle. Each type of service (hot water, chilled water, distilled water, wastewater, air, steam, liquefied carbon dioxide, compressed air, conditioned air, exhaust air, carbon monoxide, and other specialty gases) has two or more source redundancies that serve to provide for uninterrupted supply. Likewise, the building's cogeneration plant generates enough electricity for uninterrupted supply, but it is also connected to the utility grid for redundancy to purchase or sell back power. Backup fuel systems and emergency generators also provide extended operation during disruption. The extent of these redundant systems underscores the priority of uninterrupted research.

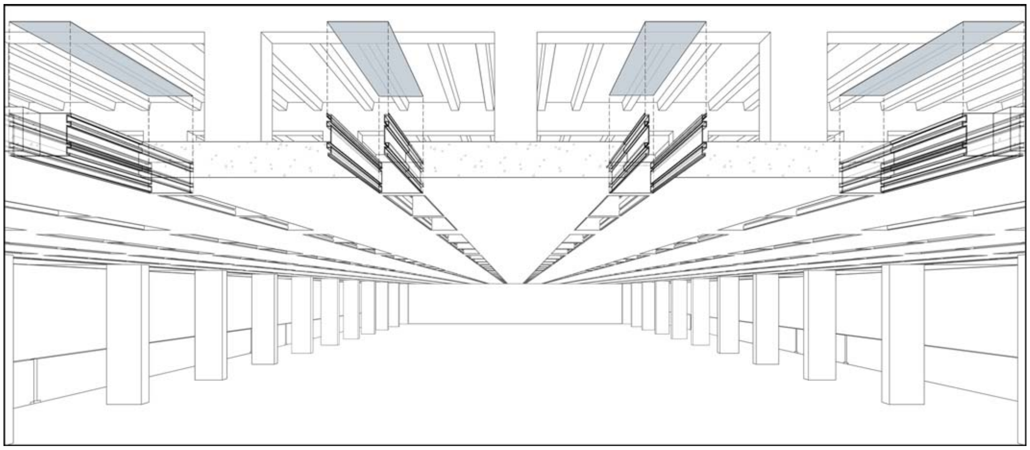
Aspects of these consequential technical and organizational performances of the Salk Institute's interstitial space have often been emulated, but its performance has never been fully repeated. An underperforming example can be found in the interstitial space of the mid-nineties' East Laboratory Building at the Salk Institute. Due to value engineering, the interstitial space in this building is not a full separate storey and does not contain a full structural floor. This has diminished the role of the interstitial space in this building and significantly compromised its technical and organizational performances. The result is that the spaces below have been used as office and storage space rather than laboratories.[34] An example of a higher performing interstitial space is the Fred Hutchinson Cancer Research Center in Seattle. Based on his observations of the technical, organizational, and economic performance of the original Salk interstitial space, Facility Services Vice President Guy Ott insisted on a true interstitial floor rather than an accessible ceiling.[35] These examples underscore the performative logic of the original building.

Aesthetic Performances

While I was in the field, I explicitly avoided reading about the building. Instead, I focused on the accounts of the individuals who have used the building on a daily basis for the past forty-two years. But after these field observations were complete, certain primary sources suggested new interpretations. As Latour noted during his field research, ''No one has ever observed a fact, a theory, or a machine that could survive outside of the networks that gave birth to them.''[36] This was also the case with three Kahn texts that uniquely prepared his work on the Salk Institute.

While his buildings are often highly legible, Kahn's writings often obfuscate the work especially for the uninitiated or those less inclined to his purposefully poetic rhetorical devices. However, after the extended empirical observation of the institute, the following passage from his 1955 essay, ''Order Is,'' appears far more instrumental than abstract:

> ***Design*** is not making beauty
> Beauty emerges from selection
> affinities
> integration
> love
> . . . Beauty will evolve[37]



6. Striated ceiling slots. (Drawing by author.)

Auspiciously, the only instance I found Kahn referencing beauty in regard to the Salk Institute is in his description of the organizational performance of the pipe laboratory:

> The separation of served and servant spaces is beautifully expressed at Salk, in that you have a laboratory for experiments and a laboratory of pipes which you can see downwards or upwards. This space is just as tall as the space where experiments are made. These rooms have large pipes that feed upwards or downwards. You walk into service these areas. They are just as important as the biological laboratories . . ..[38]

These two passages suggest that, for Kahn, the building's mundane technical and organizational orders can also sponsor a type of emergent beauty. This could expand our understanding of aesthetic performances in architecture.[39] Although architects focus on what an order is, here Kahn is equally interested in what the order becomes. In this case, emergent aesthetic performances are inextricably connected to technical and organizational aspects of the work. This sense of beauty that is a systemic product of organizational and technical parameters is difficult to discern if the building is perceived only as an object; it exceeds a building's objecthood. For Kahn, this beauty is apprehended in the variables of time, not space. It emerges from the ''Order Is'' variables of ''selection, affinities, integration, and love.'' In the Salk Institute, this emergent performance evolves from design decisions directed by the extraordinary specifications of material and methods for construction (''selection''), the technical development of extraordinary material systems among varied, and even disparate, technical requirements (''affinities''), and the ordinary yet elaborate organizational and temporal coordination of those material systems in the construction and operation of a building over time (''integration''). His fourth term, ''love,'' relates to the persistence of the designer in the evolution of these design decisions and aesthetic performances. The impetus of this last term is evident in an earlier, more pragmatic text:

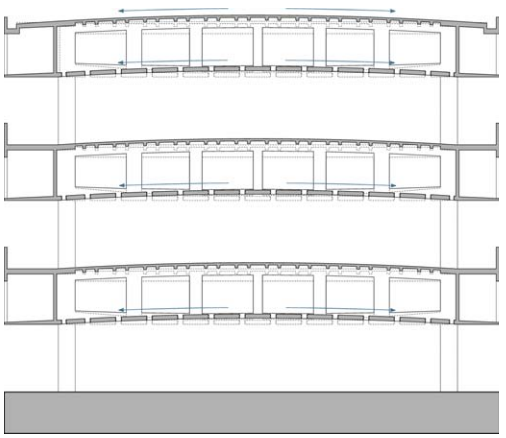
> We should try more to devise structures which can harbor the mechanical needs of rooms and spaces and require no covering. Ceilings with the structure furred intend to erase the scale. The feeling that our present-day architecture needs embellishment stems in part from our tendency to fair joints out of existence—in other words, to conceal how parts are put together. If we were to train ourselves to draw as we build, from the bottom up, stopping our pencils at the joints of pouring or erecting, ornament would evolve out of our love for the perfection of construction and we would develop new methods of construction. It would follow that the pasting on of lighting and acoustical material, the burying of tortured unwanted ducts, conduits, and pipelines would become intolerable. How it was done, how it works, should filter through the entire process of building, to architect, engineer, builder, and craftsman in the trades.[40]

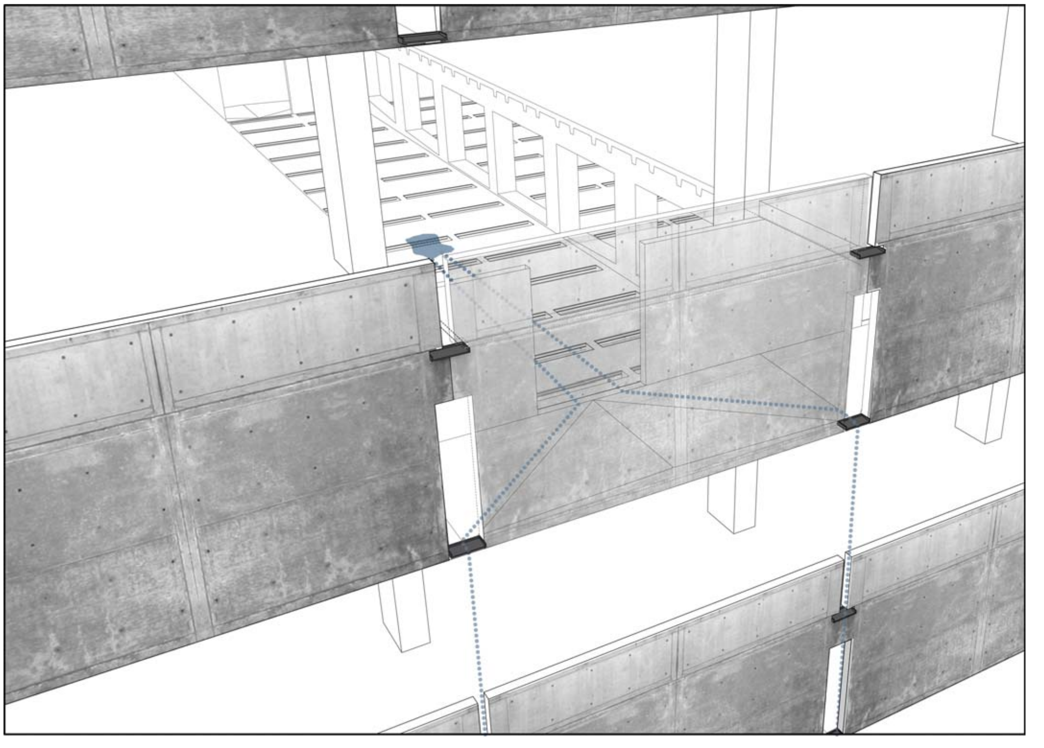
Kahn suggests that the aesthetic performances of novelty and ornament evolve from the persistent evolution of the pragmatic and technical requirements of construction. As such, design-induced ornament is inherently practical for Kahn, and it is practically everywhere at the Salk Institute. In his view, architectural drawing should rehearse construction, testing not for conformance to predetermined agendas but rather the performance of responsive assemblies. Rather than merely representational, drawing should be at once projective and experimental action where cumulative knowledge supplants previous assumptions. These texts suggest that the design of the institute evolved through this process of selection, affinities, and integration of architectural systems (a performative project) rather than just the affirmation of mystical or metaphysical assumptions (a representational project). As Thomas Leslie has noted, ''The profundity of these buildings lies instead within the realm of the everyday, that far from being transcendental, the design and construction of Kahn's best work are entirely rooted in the prosaic realities of practice and technique.''[41] Yet, it is important to note that the Salk Institute does indeed transcend as required—in physical rather than metaphysical ways—in its capacity for growth and adaptability that exceeds its initial constructed conditions. This is at the core of its performance and is not mere deterministic functionalism but rather a focus on the emergent capacity of the building that Dr. Salk sought.

Architecture's Integrated Performance

Viewed in this way, aspects of Kahn's aesthetic, organizational, and technical practices at this point have more affinities with the trajectory of the sciences than with the direction of his own discipline in the following decades. As architecture swerved toward various language games, representational and stylistic agendas, and the pursuit of autonomy in the late 1960s and after, the sciences headed toward the study of complexity, emergence, and self-organization.[42] The complexity sciences focus on the interacting components and transformations of a particular system over time.[43] These systems yield nonlinear effects and higher level behaviors not evident in the initial state of the system. As such, they pose unique questions for design and the performance of buildings.[44] Kahn's work on the Salk Institute, paralleled in his writings, anticipates aspects of the emergent behavior of material and immaterial organizations that are central to this complexity discourse and the discourse on performance in architecture today. The building's composition, systems, and details are most vitally understood as enablers of complex performances such as its capacity for mesenchyme-like adaptability, change, and growth rather than the stasis of its tectonic and visual appearances alone. As Salk requested, the specifically generic confluence of performance parameters in the mesenchyme adaptation enables a form of self-organization that engenders the institute's consequential performance and expansion. The building demonstrates that these often ordinary parameters, if developed with equal rigor, yield emergent behaviors and characteristics not otherwise possible in isolated architectural systems. When observed as an integrated system in operation over time, the building is a poignant demonstration that complex architectural performance can—and perhaps can only—emerge from a seemingly simple compositional logic. The composition's actual complexity is only evident through the evolutionary use and adaptive capacity of its apparent simplicity. Perhaps the most vital relationship between design and performance evident at the Salk Institute for architects is that the simple, hard logics of a building are the seat of its soft, complex modalities.

7. Exaggerated camber of the Vierendeel trusses. (Drawing by author.)





8. Water event evacuation path. (Drawing by author.)

Notes

1. Two examples would include: Steven Holl, *Anchoring* (New York: Princeton Architectural Press, 1991), pp. 9–10 and John Lobell, *Between Silence and Light: Spirit in the Architecture of Louis I. Kahn* (Boulder, CO: Shambhala, 1979), pp. 76–83.
2. Luis Barragan's laconic consultation on the problem of the unresolved Salk Institute courtyard is documented in Daniel S. Friedman, ''Salk Institute for Biological Studies, La Jolla, California, 1959-65,'' in David B. Brownlee and David G. Long, eds., *Louis I. Kahn: In the Realm of Architecture* (New York: Rizzoli, 1991), pp. 330–39.
3. Jonas Salk quoted in Esther McCoy, ''Dr. Salk Talks about His Institute,'' *The Architectural Forum* 127, no. 5 (December 1967): 32.
4. A few examples would include: D.S. Friedman, ''Salk Institute for Biological Studies, La Jolla, California, 1959-65,'' in David B. Brownlee and David G. Long, eds., *Louis I. Kahn: In the Realm of Architecture* (New York: Rizzoli, 1991), pp. 330–39; Thomas Leslie, *Louis I Kahn: Building Art, Building Science* (New York: George Braziller, 2005); Kenneth Frampton, *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture* (Cambridge, MA: MIT Press, 1995); and Edward R. Ford, *The Details of Modern Architecture: Volume 2, 1928-1988* (Cambridge, MA: MIT Press, 2003). T. Leslie's *Louis I. Kahn: Building Art, Building Science* describes the building's systems in terms of Kahn's proclivity for performance and points toward a performative description of Kahn.
5. Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton, NJ: Princeton University Press, 1986), pp. 43–103.
6. Ibid., pp. 12–13.
7. Ibid., pp. 43–53.
8. Ibid., p. 52.
9. I worked at the Institute for three months.
10. I owe this observation to Daniel S. Friedman.
11. The ''Mangle'' that Pickering describes is the assemblage of human and material agency that drives any practice over time. Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science* (Chicago, IL: University of Chicago Press, 1995), pp. 1–34.
12. See Branko Klarevic and Ali M. Malikawi, eds., *Performative Architecture: Beyond Instrumentality* (New York: Spon Press, 2005), pp. 21–224.

This book captures a range of current perspectives on the topic of performance within architecture. Other aspects of architecture are legitimated through performance-based rating programs such as the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program and its equivalents in Europe.

13. Jean-Francois Lyotard, *The Postmodern Condition: A Report on Knowledge*, Geoff Bennington and Brain Massumi, trans. (Minneapolis: University of Minnesota Press, 1979), p. 62.

14. The historical construction of these visual preoccupations in our culture is well documented: Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, MA: MIT Press, 1990), pp. 1–24. One recent, productive example of such preoccupations in architecture is Farshid Moussavi and Michael Kubo, eds., *The Function of Ornament* (Barcelona, Spain: Actar, 2006), pp. 5–11. Current production techniques in architecture can be divided into two categories: representational techniques appropriated from filmmakers designed to produce images and more instrumental techniques that are developed to test or fabricate architectural systems.

15. Quantitative building performance analysis will play a role in performance, but our understanding of performance must not end there. As Pickering notes, performance idioms make use of representational modes but are not determined by them. Pickering, *The Mangle of Practice*, p. 7.

16. Jon McKenzie, *Perform or Else: From Discipline to Performance* (New York: Routledge, 2001), pp. 5–12. This introduction to these performance paradigms is expanded in subsequent chapters.

17. Ezra Stoller, *''Preface'' The Salk Institute* (New York: Princeton Architectural Press, 1999), p. VII.

18. This observation emerged from observation and conversation with facility managers, custodians, and scientists.

19. Richard Saul Wurman, ed., *What Will Be Has Always Been: The Words of Louis I Kahn* (New York: Access Press and Rizzoli International, 1986), p. 23.

20. Jonas Salk, ''Architecture of Reality,'' *Rassegna* 28 (March 1985): 21.

21. Gary Van Gerpen (Salk Institute facility manager) in discussion with author, January 2003.

22. D.S. Friedman, p. 332; Leonard R. Bachman, '''Served and Servant Spaces': Richards Medical Building and the Salk Institute of Biological Studies,'' in *Integrated Buildings: The Systems Basis of Architecture* (New York: John Wiley & Sons, 2003), p. 83.

23. Alessandra Latour, ed., *Louis I. Kahn: Writings, Lectures, and Interviews* (New York: Rizzoli International, 1991), p. 207.

24. The original buildings contained 411,580 gross square feet. The six laboratories accounted for 95,400 square feet. The Western offices and courtyard studies accounted for just under another thirty-five thousand square feet. Thus, together the programmed, occupied spaces account for only 130,400 square feet.

25. The services that arrive in each bay of the pipe laboratory are laid out in an identical manner. This organizes the ongoing maintenance work that occurs in the pipe laboratories.

26. Ralph S. Lillie, ''The Nature of Organizing Action,'' *American Naturalist*, 72, no. 742 (September to October, 1938), pp. 389–415.

27. R.S. Wurman, *What Will Be Has Always Been*, p. 130.

28. Adrian Forty provides an etymological account of the circulation metaphor and its limitations in architecture. Adrian Forty, '''Spatial Mechanics': Scientific Metaphors in Architecture,'' in Peter Galison and Emily Thompson, eds., *The Architecture of Science* (Cambridge, MA: MIT Press, 1999), pp. 213–31.

29. R.S. Wurman, *What Will Be Has Always Been*, p. 242.

30. Kahn, p. 207.

31. The construction drawings call for a half-inch camber for the Vierendeel trusses. The truss and the striated slabs of the pipe space floor were cast flat, and the posttensioning drew the truss and slabs up to the specified camber. The floors of the pipe space corridors slope from the middle of each bay (high) to the centerline of each truss (low) at the location of the lead scupper.

32. The teak exterior cladding was specified without any finishing. The intention was to let the teak weather to its silvery gray. Thomas Leslie provides a thorough account of the material specifications of the building. T. Leslie, *Louis I. Kahn: Building Art, Building Science* (New York: Braziller, 2005), pp. 160–61. Also see E.R. Ford, *The Details of Modern Architecture* (Cambridge, MA: MIT Press, 2003), pp. 317–21.

33. ''Salk Institute: Provocative Setting for an Endless Search.'' *Engineering News-Record* (McGraw-Hill, January 27, 1966). Subsequent facility managers alternately finished the teak and either stripped or blasted the teak. The result is that the cladding is now substantially thinner than when installed.

34. This point was frequently mentioned during tours with various managers and custodians. From their point of view, the logic of the pipe space must have a separate structural floor, as in the original buildings, to justify its expense.

35. See ''Laboratories for the 21st Century: Case Studies,'' http://www.labs21century.gov/pdf/cs_fhcrc_508.pdf (accessed December 20, 2007).

36. Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, MA: Harvard University Press, 1987), p. 248.

37. Louis I. Kahn, ''Order Is.'' In *Louis I. Kahn: Writings, Lectures and Interviews*, Alessandra Latour, ed. (New York: Rizzoli International, 1991), pp. 58–59.

38. R.S. Wurman, *What Will Be Has Always Been*, p. 130.

39. While the aesthetic performances discussed here certainly participate in the canon of aesthetics in the Western world, Kahn's conception of beauty in these texts points toward an emergent form of beauty based upon organizational and technical performances.

40. Louis I. Kahn, ''How to Develop New Methods of Construction.'' In *Louis I. Kahn: Writings, Lectures, and Interviews*, Alessandra Latour, ed. (New York: Rizzoli International, 1991), p. 157.

41. T. Leslie, *Louis I. Kahn: Building Art, Building Science*, p. 4.

42. As emblematic cases, contrast the trajectory of architecture in K. Michael Hays, *Architecture Theory since 1968* (Cambridge, MA: MIT Press, 2000) with Illyia Prigione and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantam Books, 1984), pp. 27–129. These books provide cases of the sustained representational focus of architectural theory and practice in contrast to the performative materialism of the new sciences.

43. A range of texts are useful introductions to the study of complexity in the sciences: I. Prigione and I. Stengers, *Order Out of Chaos*; M. Mitchell Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York: Simon & Schuster, 1992); Roger Lewin, *Complexity: Life at the Edge of Chaos* (Chicago, IL: University of Chicago Press, 1999); Stuart Kaufman, *At Home in The Universe: The Search for the Laws of Self-Organization and Complexity* (Oxford: Oxford University Press, 1995); and Steven Johnson, *Emergence: The Connected Lives of Ants, Brains, Cities and Software* (New York: Scribner, 2001).

44. In the shift from representational to performance idioms, the intelligence of the new sciences for architects lies in a fundamental redefinition of the object in architecture rather than the intricate, isomorphic representational possibilities that some designers appropriate from work in the new sciences. For a summation of this redefinition of the object, see Sanford Kwinter, ''The Complex and the Singular,'' in *Architectures of Time* (Cambridge, MA: MIT Press, 2001).