THE DESIGN PROCESS FOR THE HUMAN WORKPLACE
THE ARCHITECTURE OF SCIENCE

by James H. Collins, Jr., AIA, LEED

– From Peter Galison and Emily Thompson. *The Architecture of Science*. Cambridge: The MIT Press, 1999.

Early in 1983, Princeton University deliberated its declining position as a forerunner in the field of the biochemical sciences. Its President, William Bowen, recognized that recent advances in the field of molecular biology were mobilizing modern science. Monumental advances like DNA mapping and genetic engineering would have implications not only for science and medicine, but also for the associated areas of healthcare and healthcare legislation. Clearly, if Princeton intended to enhance its reputation in the discipline of molecular biology, the university would require a new facility that seamlessly integrated design and technology. To this end, the university committed to the construction of a $29 million, 114,000 square foot facility intended to house a new department that would compete directly with those of the other educational institutions that had anticipated this “intellectual revolution” in science.

After a nationwide search, Dr. Arnold Levine and Dr. Thomas Shenk were recruited from the State University of New York at Stonybrook to head up the new Department of Molecular Biology. In keeping with Levine’s goal to create a “community of scientists” at Princeton, a site for the new facility was chosen for its proximity to the other scientific disciplines – biology, geology, physics, and mathematics – in a conspicuous and distinguished locus on the Princeton campus.

One of the primary objectives of Princeton University in constructing the Lewis Thomas Laboratory was to lure a team of the field’s most prominent research scientists to the school. Ideally, the university hoped to achieve its goal by offering the potential faculty a state-of-the-art research and teaching laboratory. The new laboratory would challenge Princeton University’s conservative construction policy by promising to be one of the largest buildings on campus, and undoubtedly one of the most expensive.

Because of the urgency of the project, the traditional method for hiring architects was abandoned, and the schedule was accelerated. The responsibility for hiring architectural and design firms at Princeton fell to the Office of Physical Facilities. Typically, the office would compose a short list of appropriate design firms and then manage a selection process in which representatives form the particular department to be housed in the new building would evaluate these firms and forward a recommendation through the President’s Advisory Committee on Architecture to the University’s Board of Trustees, which would ultimately confirm the hiring of the proposed architectural firm. In an effort to accelerate this selection process, President Bowen proposed the marriage of two architectural firms that were already actively working on the campus, Payette Associates Inc. and Venturi, Rauch and Scott Brown (or VRSB, as the firm was known until it became Venturi, Scott Brown and Associates in 1989).

We at Payette were the architects of more than 100,000 square feet of renovation and new construction in the Frick Chemistry Complex. We understood the requirements of designing laboratories at the university. We were also recognized as one of the nation’s experts in the design of molecular biology laboratories. We had recently designed a new molecular biology research facility for Harvard University, the Sherman Fairchild Biochemistry Building, as well as a similar building for the Massachusetts General Hospital in Boston.

Princeton University alumnus Robert Venturi and his firm had successfully completed a critically acclaimed building on campus, Gordon Wu Hall, and had recently developed the campus design guidelines for the area of campus in which the proposed building was to be located. They were therefore an obvious choice to develop the new building’s exterior.

At President Bowen's urging, Payette and VRSB were invited to submit a proposal and were chosen to lead the project. Payette, because of its expertise in technical buildings, would develop the program and design the interior spaces. VRSB, with a budget of $2.5 million, would work with the facade and site plan, integrating the new building with its traditional, neo-Gothic surroundings. Each organization had a clearly bounded sphere of influence. As Thomas Payette put it, any design on the outside was VRSB's ultimate decision, and the design on the inside was Payette's ultimate decision. Payette would be the architects of record and would have overall responsibility for the project management and documentation. By the very nature of this collaborative endeavor, teamwork was stressed over individual inspiration.

It was determined that the building would be developed around the "generic" laboratory vision of the new chairman of the Department, Arnold Levine. To establish a baseline from which to develop a common vision of the building, Payette invited Levine and Robert Venturi to tour the Sherman Fairchild Laboratory at Harvard.

The Sherman Fairchild Building was a good place to start because it physically embodied many of the fundamental planning and design concepts that Payette promoted. All the laboratories were located along the exterior of the building, maximizing natural views and natural light. The building was organized around a simple rhythm of generic lab modules, expanses of glass within the building brought exterior light into the interior spaces and visually connected spaces and people, and a large amount of natural wood humanized the scientific environment.

Levine summed up his overall acceptance of this design approach when he told Tom Payette, "Why don't you just give me a building just like this!" The visit was also useful in addressing some of Bob Venturi's preliminary concerns. In his early study of the College Walk site, Venturi had recommended that the building's shorter end be located along the walk, on the assumption that windows would exist in the few office spaces and the lab itself would be a big windowless box. A study of many of the research laboratories in existence at that time might lead anyone to that assumption. With the realization that the preferred planning approach, which the department chair supported, allowed for extensive exterior windows, Venturi realized that a whole world of proportion and rhythm could be explored. The site visit was a success, as everyone now appeared to have a strong basis of common values from which to develop the design.

As the majority of the buildings' occupants were yet to be recruited, the program and the concept of the building organization had to be developed on a generic basis by a small team. Arnold Levine, his associate Tom Shenk, and I, as Payette project architect, formed the core of the programming effort. On a weekly basis I would fly to Arnie's laboratory at Stony Brook to discuss the project. Arnie had truly enjoyed the Fairchild visit and wanted to take many of its planning approaches one step further. Arnie, Tom, and I agreed that the Sherman Fairchild lab module was a good model with which to start, but that two major adjustments would be introduced to the module at Princeton. Since the completion of the Sherman Fairchild Building, Payette had recently completed the construction of the Wellman Research Building at the Massachusetts General Hospital. Although it embraced many of the same planning concepts as the Harvard building, it introduced others into the model. It did not employ a race track corridor system; rather, it made use of an implied corridor system, and the labs employed a large "open lab" concept.

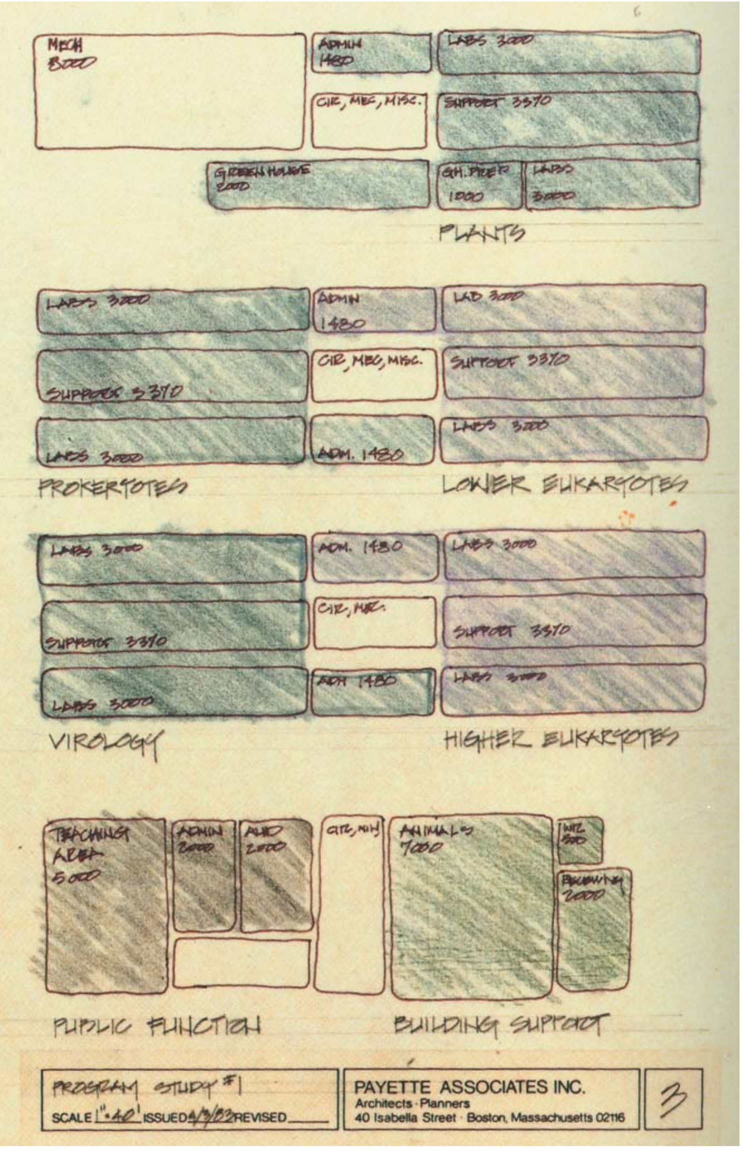
This open lab concept was not new. The large open lab had been successfully used as early as 1965 in Louis Kahn's design of the Salk Laboratories in La Jolla, California, but Salk and a few other notable laboratories were the exception. At the time the Lewis Thomas Lab was being planned, the dominant approach was to design discrete, small laboratories reflecting the hierarchical nature of "senior scientists" and "junior assistants." Most scientific laboratories did little to encourage interaction among scientists, either through their organization or through their architecture: Offices were tucked away in labs, making them inaccessible and inconvenient, and inflexible laboratory modules reflected the philosophy of "server" and "served."

During the 1980s, Payette and other laboratory design firms challenged this archaic model. As corporate and private funding for basic research in the life sciences dissipated, governmental sources of funding became increasingly common. Pressure to reexamine the marketability of scientific research increased, and governmental organizations like the National Science Foundation liked to see their dollars funneled into potentially lucrative research projects, often carried out at new, multidisciplinary science and technology centers. As a result, scientists were interacting more than ever with their peers, with scientists from other disciplines, and with the business community, in an effort to "cross-pollinate." Impeding this interaction, however, was the architecture of the standard laboratory design: Protected areas and containment facilities kept researchers physically isolated; hard, sterile work surfaces discouraged sociability; and a highly controlled mechanical environment similarly set up barriers.

Arnold Levine emphasized the importance of discussion and interaction to the successful realization of molecular biology. In the formulation of new strategies, molecular research scientists tend to rely on the input and free exchange of ideas from their colleagues and students. Essentially, they act and react as an interdisciplinary and interdependent organism. Given the framework of this communal relationship, a design approach was established that demanded wide open expanses, or the semblance of such to facilitate interactive behavior. We believed that, through our manipulation and demarcation of space in the laboratories, an environment that encouraged growth and scientific activity could be created.

We have maintained that the success of the Lewis Thomas Laboratory is largely grounded in the free communication that evolved among the university, Arnold Levine, Payette and VRSB – a veritable symbiotic relationship that prevailed throughout the length of the project. The team functioned in a manner strikingly similar to the behavior we hoped the design would support. We acted and reacted as an interdisciplinary and interdependent organism. Discussion and interaction became essential for the successful realization of our concepts. In formulating new strategies, we relied on the input and free exchange of ideas from our colleagues.

The project, proposed in March 1983, was slated for completion and occupancy by October 1985. Because of the abbreviated schedule, project meetings with the owner, scheduled every two weeks, helped to refine the building's functions and goals. Although there were technical constraints, we continued to pursue the goal of a structure that provided ample light, windows, open spaces, and spaces for reflective study. By May 1983, the building had developed a very straightforward and unassumingly rectangular shape.



Color-coded early program study for the organization of space in the Lewis Thomas Laboratory for Molecular Biology at Princeton University. Five research divisions were defined, distinguished by the biological material with which they worked.

The rationale was simple: The laboratory had evolved as a type of building whose exterior appearance is derived from the nature of its interior functions. In essence, specific requirements of program and interior layout delineated its facades in terms of scale, rhythm, and proportion. Arnold Levine had suggested that, in his experience, a three-story building seemed to allow for the most interaction among groups. Although two or four floors were also deemed acceptable, three floors also seemed ideal for the number of required shared facilities. Levine envisioned five research divisions, distinguished by the biological material with which they worked: higher eukaryotes, prokaryotes, viruses, lower eukaryotes, and plants. Lower eukaryotes and prokaryotes were not closely related to any specific support facility and thus could be on their own. The smallest of the groups, plants, could also be located in a more remote location, since it had no requirement for being in close proximity to either the animal facility or to the animal research groups. In spite of this segregation, we wanted to create an environment in which no one would feel isolated, even though his or her biological concentration dictated a separately controlled environment. This goal was accomplished through the use of glass instead of solid walls, creating a visual connection that promotes awareness of fellow researchers. In addition to the sense of connected space produced by moveable fixtures and glass windows between labs and internal support areas, this technique also provided maximal diffusion of natural light throughout the structure. To enhance further the human element in a highly technical laboratory, natural materials such as oak were chosen for all wainscoting, doors, furniture, and casework.

By July 1983, we had a firm breakdown of space, furniture, and equipment needs. Clarifying these internal relationships finally freed VRSB to plan the exterior and approach the siting constraints for a rectangular building. In short, the character of the exterior was approached as a response to the simple rhythms and proportions of the floor plans. The highly ornamental patterned surfaces of the long facades evoke a sense of history. Robert Venturi is notably influenced by Elizabethan manor houses and New England mills, and both served as prototypes for the overall appearance of the building. As Venturi has remarked, "Architects have traditionally used symbolism in architecture to enrich its content and to include other dimensions, some almost literary, which make architecture a not purely spatial medium."[1] The distinctive patterning, this time in brick and stone to reflect Princeton's traditions building materials, would come later.

The building was planned to have three stories in the front and four stories in the back, reflecting the slope of the site down to the south. The two long elevations would indicate a consistent arrangement of identical bays, both inside and out, via repetitive window openings. These openings had a deep reveal, or wall thickness, to accommodate a mechanical zone on the exterior wall as well as to provide natural sun shading, and to underscore the overall aesthetic tone, which complemented that of the surrounding buildings. These facades were determined to utilize varying orders of scale; large to reflect the building's institutional quality, resulting from the height needed to accommodate the mechanical systems, and small to relate to the user's perception of the building. In its overall design, the building was highly repetitive and orderly. However, inconsistencies were intentionally introduced into the design to add visual contrast and a sense of character.

Following some deliberation, it was decided that the entrance and lobby would be asymmetrically placed in the front facade in reaction to the placement of shared core support facilities and to relate do the landscape design of the neighboring Guyot Hall. VRSB chose to manipulate the building's rectangular shape and reduce its blockiness by softening the edges of the end elevations. VRSB's desire for an exception in each of the end elevations provided the perfect opportunity to develop small informal lounge spaces that would foster and support a variety of activities. In turn, the positioning of the lounge areas at these localities would have further implications for VRSB's ornamental masonry and was ultimately to assume a far greater sense of importance when it was realized that the building is typically approached obliquely.

The building was to be situated parallel to College Walk, the university's main pedestrian path, to reinforce the walk's spatial identity. This created an entrance from the facility to the main campus on Washington Road from the south and visual identification with the Guyot Hall complex to the north. VRSB's intent was physically and symbolically to connect the Guyot complex and the molecular biology building through both the new building's siting and its landscape design. Here, we attempted to create a sense of amenity in the space between the two buildings through landscaping, which involved terracing, paving, planting, and modifying the configuration of College Walk at this end. Although a low retaining wall was created, the resulting formalization was tempered through a design that utilized a maximum of lawn and a minimum of paving in the tradition of the Gothic residential courts at Princeton University. In effect, the resulting eastern end of College Walk would contrast with the nearly fully paved Butler plaza at the western end.

By February 1984, it was understood that each level of the new building would measure approximately 278 X 85 feet. A 1,000 square foot central meeting room, numerous lounge areas, and an outdoor patio, as well as laboratories, classrooms, and offices would house the 220 occupants of the building. The ground floor would possess a large and a small seminar room, teaching laboratories, and mechanical and electrical equipment areas. Additionally, a gallery would occupy the western section, and animal cage rooms, workrooms, offices, and general storage rooms would be located in the eastern section. The penthouse area, encompassing nearly one half the width of the roof and running its full length, would consist of five greenhouses, mechanical equipment rooms, and small laboratory rooms. A loading dock that offered storage rooms for gas cylinders, chemical waste, and solvents would be located outside along the building's east wall, adjoining the ground-floor level.

Because this building would involve research in a rapidly progressing field, the goal of planning for unpredictable change continually challenged our design approach. Indeed, in any laboratory design, planning for the future is nearly as important as is planning for the present. Since molecular biology is evolving almost daily, there is constant pressure to adjust to ever changing standards and trends. Understandably, because a great deal of flexibility was expected in order to meet these unforeseen future challenges, these attributes were fundamental to the project's viability. For example, Princeton expected at some point to convert some perimeter laboratories into high-containment, high-equipment-density laboratories. To accommodate this need in the particular laboratories identified for conversion, dual supply and exhaust boxes were specified to handle increased cooling load requirements, even though the possibility remained that the university might decide against this conversion, if the space became earmarked for another future use.

The laboratory module was also designed to accommodate additional piped and electrical services, enabling easy conversion of an instrument space, for example, to a biochemistry laboratory, or a seminar room to a physics laboratory. Planning with such a strong degree of forethought usually proves invaluable, both to the client and the designer. Typically, during the programming phase, however, certain palpable factors become apparent that do restrict a design's flexibility.

There were initial problems associated with the placement of certain specialized mechanical rooms, such as the biological containment facility, where infectious agents would be isolated. We placed it as the core of the facility, with all user spaces on the periphery; thus, its placement delineated the layout of the lobby and ground floor. Our reasoning for this position was initially derived from the simple premise that humans react favorably to their connection with the outdoors through window exposure and associated views. Hoods would be on the corridor side of the laboratory to allow for desk and work space placement at the perimeter. Ceilings were conspicuously absent from these laboratories and main corridors. By this time, our goal – an overwhelming sense of light and space, enveloped by technical precision – was nearly achieved.

The facility with which the mechanical systems would be maintained also became a priority. Because many mechanical systems in laboratories precisely control often hazardous environments, these systems are quite complex, and they require expert maintenance. The people who customarily service these systems face subsequent difficulties when attempting to approach these systems as they would any other. To avoid dangerous situations involving either themselves or the laboratories' inhabitants, either these technicians need to be highly specialized, or the systems' maintenance needs to be simplified.

As David Rowan, the principal in charge of the project, related, “I think that maintenance is a big problem. Very few institutions have knowledgeable maintenance departments that really know how to adequately maintain the equipment. You try to keep things as simple as possible.”[2] One of many ways we attempted to adhere to this strategy was by designing the hot lab without a hung ceiling to facilitate access to the charcoal filters that purify the air. The requirement to make filters easily accessible was not based solely on the frequency with which they would be changed. In fact, charcoal filters can be quite heavy, and attempting to manipulate them while one is perched on top of a ladder can be difficult and dangerous.

Typical open lab space in the Lewis Thomas Laboratory for Molecular Biology at Princeton University. The ceiling equipment was left exposed to expedite access to and maintenance of pipes, ducts, and cables.

As a result, longer intervals may elapse than are appropriate between changes. For low maintenance and ease of reconfiguration, an open ceiling with exposed pipes, ductwork, and a data network cabling tray was chosen.

Because a full 25 percent of the Lewis Thomas Laboratory was dedicated to the associated mechanical systems, the placement of these systems in numerous instances had to be scrupulously negotiated. Educated guesses informed these negotiations as much as did factual realities. There were unforeseeable equipment requirements: Were lasers to be used? If so, could our proposed cooling system handle this future load? Other mechanical issues, such as this building’s high ventilation rate requirements, also presented challenges. In the animal area, ventilation systems were designed to operate at full capacity twenty-four hours per day. When the space requirements for this facility were in the planning stages, the animal care committee members believed that the present animal population would be exceeded in the future. If the population were to be expanded by, say, 50 percent, we needed to insure that the proposed cooling system could handle this additional strain. In another of many examples, the degree of acidity in proposed calculations of chemical waste was unknown. R.G. Vanderweil Inc., the mechanical engineering contractor, understood that there would be some acid waste that would require treatment, but the quantity remained uncertain. We ceaselessly searched for the answers that eluded us. What type of allowances needed to be made? Would an increase in the acidity create additional problems in the storage of this hazardous waste? Had these storage facilities in the loading dock area been designed to handle an increase in materials? At the same time, we needed to conform to the requirements of regulatory agencies such as the Environmental Protection Agency and the National Fire Protection Agency in planning for the disposal and storage of these hazardous and potentially flammable materials.

As I earlier stated, we perpetually planned for the unknown future and direction of molecular biology. Judgments were usually made by tailoring our previous design philosophies to our current client's needs and special situations. Exhaust stacks were designed to accommodate a ten-foot increase in height, to provide an effective means for correcting unanticipated problems once the building was completed. Also, laboratories were exhausted individually through separate ducts to the penthouse before connecting to the central exhaust system. These ducts would provide for flexibility in accommodating future hoods.

Throughout the entire design process, allowances needed to be made, predictions ventured, and safety issues assiduously addressed. Whereas some elements of the program appeared to have been fixed through program space requirements, in actuality, the planning was structurally tight, while allowing for a great deal of flexibility. Space above each lab was planned to allow the mechanical and electrical systems to be moved easily and installed elsewhere without disrupting the lab below. Large, open lab spaces could be reconfigured and subdivided in the event that existing laboratory needs changed. Because much of the electrical and utility space was run up through shafts at either end of the loftlike laboratories, rather than up through each individual laboratory station, a great deal of flexibility was incorporated.

The central staircase, connecting the ground and first floors of the Lewis Thomas Laboratory for Molecular Biology at Princeton University. Students, faculty, and staff all come together and mix within this space throughout the day.

Admittedly, although the creation of a viable and effective laboratory involves numerous technological constraints, at Payette, we know that research is ultimately about people. People like choice, thus we sought to provide a variety of different kinds of spaces within the building: closed, quiet spaces for contemplation and individual work; open public spaces for spontaneous activity and discussion outside the laboratories; and research space that also encourages the continuous exchange of information between investigators. A generous staircase, for instance, generally invites exchanges between and among floors, as people constantly pass each other and relate their laboratory experiences.

Central foyer and stairwell on the first floor of the Lewis Thomas Laboratory for Molecular Biology at Princeton University. The extensive use of glass brings “borrowed light” well into the building’s interior. Here, light from the foyer and the distant conference room is brought into the enclosed stairwell, encouraging passers-by to stop and converse on the lower landing.

Traffic patterns can be tightly controlled when a single corridor functions as a main thoroughfare. At the Lewis Thomas Laboratory, offices were grouped in clusters rather than in separate laboratories to reinforce the strong sense of community felt among the members of this interdisciplinary group. Blackboards were strategically placed to invite spontaneous interactions and impromptu gatherings. In essence, by manipulating the frequency with which researchers exchange information, architects can effectively promote the sharing of knowledge through the sharing of space, resources, and facilities.

Researchers and students at the Lewis Thomas Laboratory appreciate the building for simple reasons: its flexible laboratory spaces and its sense of openness, with ample natural light and generous spatial opportunities that encourage commingling and casual conversation. They like the lab because it feels like an academic building, not a spaceship. They like the oak trim. They like it because they have to spend most of their lives there and it is a nice place in which to live. On this level we architects and these scientists are very much the same. We are interested in discovering, understanding, and influencing life.

In recent years, architectural theorists have disagreed over whether or not the social behavior of a building’s users is influenced, even determined, by the physical environment in which that behavior occurs. Proponents of this influence – architectural determinists – believe that designers can direct social behavior through their work. Using the Lewis Thomas Laboratory at Princeton University as a case study, we can positively attest that there is a direct correlation between the work environment and the workers’ intellectual and physical activity. Furthermore, a sense of order, continuity, and cohesive structure are all expected to have a positive impact on the way scientists relate to their surroundings.

We can, as architects, through our definition and manipulation of space, create a positive and nurturing environment for research scientists. Spatial planning can foster the paradoxical factors inherent to the research laboratory: innovation and replication, discussion and reflection, teamwork and competition. Through our design of the Lewis Thomas Laboratory, we at Payette have demonstrated the significant influence that human behavior must have on the environmental planning and design professions. Many in the field continue to view research labs as highly controlled environments supported by intense, space-consuming mechanical systems. They cite examples where major science has been accomplished in the most inhospitable of places. Given our own experience in building for the scientific community, we are inclined to believe that the very opposite is true. Perhaps Dr. Jonas Salk, who discovered the polio vaccine and founded the research institute that bears his name, summed up our theory most accurately when he discussed Louis Kahn's design of his institute:

> My ambition was to optimize the functioning of the human mind, to deal with the issues and questions with which the human mind is concerned. I wanted to creates something that would influence the realm of the mind – the minds of those who would gather here to carry on this kind of work. I was seeking a retreat atmosphere for reflection and work, away from the business and noise of the world... Architecture is used here. Some people pursue science for human use, in contrast to science for the sake of science. This architecture is for human use, to serve a purpose.[3]

Endnotes

[1] Robert Venturi, "Diversity, relevance and representation in historicism, or plus ça change..." *Architectural Record* 170 (June 1982): 114-119, quote on p. 115.

[2] Conversation with the author.

[3] Salk is quoted in Michael J. Crosbie, "The Salk Institute," *Progressive Architecture* (October 1993): 47.