LABORLANDSCHAFT
Redesigning The Industrial Laboratory Module

by Alexander H. Farley

Bachelor of Arts in Biology
Bachelor of Arts in Fine Arts
University of Pennsylvania, 2001

Submitted to the Department of Architecture
in partial fulfillment of the requirements for the degree of
Master of Architecture at the Massachusetts Institute of Technology

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This thesis proposes to redesign the industrial pharmaceutical laboratory typology by rethinking the composition of the laboratory module; the smallest functional sub-unit of the laboratory type. The design for this thesis applies contemporary corporate counter-culture spatial organizational ideas onto the laboratory module. Central to these concepts is an architecture that is user-oriented and environmentally sensitive rather than managerially-oriented. The spatial organization seeks to flatten the managerial hierarchy by eliminating explicit office spaces. The laboratory is instead spatially divided according to affinity for behaviors and activities rather than strict programmatic designations.

The laboratory module was initially conceived during World War II as a spatial system to accommodate inter-disciplinary research and development teams in an industrial laboratory setting. However, the spatial design of the module has become deterministically dictated by managerial control systems and calibrated by infrastructural service, rather than serving the environmental and social needs of the researchers. Contemporary laboratory architecture requires the same shift away from spaces organized for clerical work to fluid and open fields that have occurred in corporate architecture.

However, architectural design cannot control occupant’s behaviors, but it can endorse a specific networked culture through the configuration of spaces. The use of common flexible spaces endorses and encourages social interaction. Likewise the form and figure of the laboratory establishes an environmental tone by allowing the research spaces to sit within an open field. This open field aspect allows for maximum daylighting and greater levels of visual and social interaction. Through a “plug and play” service infrastructure, the lab benches and fume hoods can behave more as setting and furniture rather than rigid spatial datums. Additionally, this spaces also provides for reconfigurability and easy upgradability. By seeking to move away from standard laboratory spatial solutions and conventions the design takes the position that a laboratory field condition encourages new modes of scientific interaction and production. This laboratory functions as much as an intellectual playground as it does a functional research laboratory.

Thesis Supervisor: Andrew M. Scott
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As I write these last words I find it poetic that this project started out with me typing away at my laptop at home as a snowstorm swirled and now in the early morning hours another snowstorm moves over Boston. It is also interesting that the times at studio at MIT that are easiest for me to remember are all weather related: six snow storms, one snowpocalypse, one hurricane (and three Thanksgivings and one New Years).

My presence here at the end of my decade plus in academia owes a debt to several teachers who have all taken a chance on me: Steven Seeholzer, Ph.D. who got me my first job at the Fox Chase Cancer Institute, Nina Luning Prak, M.D. Ph.D. and Haig Kazazian, M.D. who got me into every Ph.D. program that I applied to, and Nina, Susanna Jacobson, and Doug Martenson who unquestioningly wrote me recommendations for architecture when I unexpectedly quit graduate school.

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The nature of space reflects what it wants to be.

Louis I. Kahn
This thesis proposes to redesign the industrial wet laboratory typology through a rethinking of the design and configuration of the laboratory module; the smallest functional sub-unit of the laboratory. The laboratory module was initially conceived during World War II as a spatial system to accommodate inter-disciplinary research and development teams in an industrial laboratory setting. However, the spatial design of the module has become deterministically dictated by managerial control and calibrated by infrastructural service systems. The architect James Collins defines the laboratory typology as: "(a) highly controlled environment supported by intense, space-consuming mechanical systems."(1) This definition describes a building typology in which the occupant is subservient to technology rather than the technologies being subservient to the users' needs or enhancing the user experience. In an age in which high technology and bio-pharmaceutical company's desire methods for increased innovation, it is clear that users and social interactions need to be privileged in the design of laboratories. The old modular laboratory design clearly cannot support this design goal and needs to be rethought. The new module will be calibrated by social spaces and researcher comfort rather than managerial, infrastructural or technical requirements.

The central question that this project needs to address is: What are the developing issues in bio-pharma that will potentially affect the architectural design of laboratory spaces? What are the developing issues in architectural design that will potentially affect the practice of bio-pharma?
Figure 1 - Research Space Innovations + United States R&D Spending
In the post-war years the advent of governmental funding agencies (especially in the U.S.) witnessed a substantial investment in the research and development first related to military technologies and then an explosion in investment as systems to leverage these technologies for non-defense uses fully matured. (Fig. 1) Out of this growth in research and development the research laboratory building type emerged in the response to the specific technical and social needs of modern scientific and engineering research. As discussed later in this thesis Bell Labs pioneered the design first of the laboratory module (the central sub-unit of the laboratory type) and then with the architect Eero Saarinen the research laboratory as a component of the public image of the modern American corporation. However, as corporations have transitioned from national concerns to global concerns, the Saarinen model of an isolated suburban campus is no longer valid. The mirror-glass modernist ‘black boxes’ of the IBM and Bell Labs speaks more to Cold War social and behavioral paranoias than the highly
network and connected society that we live in. This shift social interactions and the pervasion of this shift in to research and development settings needs to be reflected in the architecture of the laboratory. The problems in American research and development that emerge from the architectural and social legacy of the post-war years can be seen in the efficiency of the United States to generate patents per dollar invested (one measure of innovation) compared to other modernized economies and especially economies that have similar r+d funding to GDP ratios.(Fig. 2) A growing concern in many scientific endeavors is the need for inter-disciplinary teams. The standard laboratory typology is designed for single researchers or very small groups of scientists with similar backgrounds. Clearly research into the design of laboratory spaces that can support the social interactions inherent in inter-disciplinary research and the shifting technical and servicing requirements could prove fruitful in spurring innovation as well as catalyze the idea of humanized corporate spaces as the architectural norm for the laboratory type.
Bell Telephone's laboratory in Murray Hill, NJ was designed by Voorhees, Walker, Foley and Smith in 1939. The laboratory is significant in its invention of the laboratory module, the smallest autonomous unit of the lab. The pressures of WWII required Bell Labs to assemble inter-disciplinary groups. (Rankin, p. 782) Previous lab spaces were designed for specific scientific disciplines. VWFS implemented a modular structural and infrastructural system in which many types of research could be carried out in the same space and light-weight walls could be reconfigured with changes to the research program. Much of the design can still be seen in the layout of both industrial and academic labs.

Figure 3 - Bell Labs, Murray Hill, NJ - 1941

Bell Labs, Murray Hill, NJ - 1941

The Corporate Scientist
Bell Laboratory designed by Eero Saarinen in 1955 established a model for post-war corporate and industrial research campuses that is still emulated. The design reflects the techno-sublime through the introduction of a mirrored glass curtain wall facade and sited in a secluded suburban New Jersey site. The rigidity and opacity of the design and materials situates the design in a more paranoid and defensive era that is no longer relevant. The design was conceived to establish and maintain a status quo.
Current laboratory spaces find their origin first in the cloistered monastery and the studies of wealthy landed nobles. Both spaces designed for the solitary production of knowledge. The first and often copied examples of modular and corporate laboratories built by Bell Laboratory set forth a model for how the scientist engages both the laboratory typology and corporate organization. In the Organizational Complex, the architect Reinhold Martin sees the scientist situated within the larger military-industrial complex: “The scientist (since the scientist was assumed to be male, despite significant numbers of women working in these fields) was an organization man whose individuality nevertheless needed to be protected from the onslaught of group life in the corporation, and who played a role in the corporate organicism comparable to the cybernetic brains being grown by IBM.”(2) Despite the modernization of the workplace, the scientist is still very much treated as the isolated monk. The scientists’ research and acquisition of knowledge, while benefitting a larger corporate organization, is still a solitary pursuit. This is evident in the introverted spatial configuration of the lab benches and cell-like offices. (Fig. 3)

Concurrent with the development of the laboratory typology and corporate architecture, Martin describes General Motors as approaching the individual relationship with the corporation differently: “... Hawthorne provided firm evidence that productivity depended less of the relative monotony of the work or the environmental conditions under which it was performed than on the worker’s satisfaction at feeling a part of a greater whole, achieved through recognition of the worker’s contribution to the overall production process.”(3) Clearly, a disjunction has emerged between contemporary notions of the individual and the organization and the reliance of this standard laboratory configuration.

The paradigmatic model created by Bell Laboratory, instantiated the idea of the laboratory module. These designs seek to dictate the overall form of the laboratory through the design of the least reducible research unit: the module. The thinking and design of the laboratory module is derived from Vorhees, Walker, Foley and Smith’s (VWFS) design for Bell Telephone’s laboratory in Murray Hill, New Jersey. The pressures of the war
demanded industrial research groups to move as fast and efficiently as possible. The “flexibility” of the module was articulated in the organicists terms through a logic of cellular aggregation. The laboratory’s functional organs were miniaturized as 6’ square planning modules or cells.(4) This initial innovation morphed into the post-war modernist suburban corporate research campus exemplified by Eero Saarinen’s design for the new Bell Laboratory. The design expresses the cold-war paranoia through through introduction of a black mirrored-glass façade and monumental monolithic design. (Fig. 4a+b)

Out of this in 1975 Bell Telephone calculated that the spaces were reconfigured every 7 years.(5) One impediment to a shift away from this model is the treatment of service systems as the guiding design and construction datum. There is clearly potential in the exploration of flexible infrastructural systems. The post-war military-industrial complex gave rise to the introduction of infrastructural systems that locked the boundaries of the lab within inflexible service datums.
When many elements are made to act as one, this is what I will now call a black box.

Bruno Latour
The Black Box is used in this thesis is an analytical construct to understand the incumbent and integrated technological agents and systems that are now only considered in terms of the input and output of data and information. This thesis first identifies the elements of the laboratory and laboratory design that are taken as standard practice that impact the sustainability and the social atmosphere.

Figure 5 - Money enters the systems but what actually determines the proportion of the resultant output?
Figure 6 - The Construction of Pharmaceutical Treatments
Drug Delivery
Development of a methodology to deliver a treatment to the patient subject.

Clinical - Phase I
FDA supervised administration of double-blind test to a restricted group of subjects.

Clinical - Phase II
FDA supervised administration of double-blind test to an expanded group of subjects.

Clinical - Phase III
FDA supervised administration of double-blind test to a large group of subjects.

Market
FDA approval for the drug to be prescribed or sold over-the-counter.
An impediment to advancing a user-oriented laboratory typology can be understood using Bruno Latour’s concept of the black box. Blackboxing is “the way scientific and technical work is made invisible by its own success. When a machine runs efficiently, when a matter of fact is settled, one need focus only on its inputs and outputs and not on its internal complexity. Thus, paradoxically, the more science and technology succeed, the more opaque and obscure they become.” (6) (Fig. 5) Latour borrows his black box metaphor from cybernetic denoting a piece of machinery that “runs by itself”. That is, when a series of instructions are too complicated to be repeated without interruption, a black box is drawn around it, allowing it to function only by giving it “input” and “output” data. For example a CPU inside a computer is a black box. Its inner complexity doesn’t have to be known; one only needs to use it in his/her daily activities. The concept of the black box is useful here as the initial modular laboratory design worked well enough that architects and lab planners began to treat the typology and laboratory culture as a black box. The architect designs the laboratory using a checklist comprised of service, programmatic elements, and spatial configurations. If the checklist is completed, then the laboratory will work. There are of course notable exceptions such as Louis Kahn’s Richard’s Medical Research building and to some extent Frank Gehry’s Stata Center, which will be discussed later.

The black boxing of the laboratory now stands at cross-purposes with the desires of contemporary bio-pharmaceutical companies such as Novartis. As discussed later, despite high-minded goals and an innovative campus masterplan, Novartis’ corporate headquarters in Basel Switzerland is still comprised of typical laboratory buildings.

However, one issue inherent to the unchanging nature of the black boxed laboratory typology is what Reyner Banham term’s the “Wampanoag Effect”. “Briefly the USS Wampanoag (a technologically innovative Naval architecture) was withdrawn from service in 1868, after a year of exemplary performance, simply because senior US naval officers were so culture-bound to more primitive navigational and propulsive techniques that they could not admit the virtues of the Wampanoag’s more advanced tech-
ology."(8) In essence the admiralty decommissioned the ship because it “would not produce the type of sailor that the American navy had hitherto reared.” It is not so much that the management was rejecting and blocking advance technology, but that there was a concern that the technological advances threatened the identity and meaning of the sailors. The control systems embedded in the standard laboratory typology and module have not changed in 80 years, not because there aren't better ways of configuring the laboratory, but because of a desire to maintain classical managerial hierarchies rather than adapt to modern social network typologies adopted by contemporary corporate entities such as Google and Facebook and expressed in the spaces of said entities headquarters.

Outside of science, especially in the technology and software industry, recent years have seen corporations express an overwhelming desire to catalyze innovation through spatial experience. There is a definite lack of consensus among architectural designers and sociologists on the role that architecture and spatial experience can influence an occupants' behavior and mood. As the architect James Collins discusses:

“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 behavior occurs. Proponents of this influence — architectural determinists — believe that designers can direct social behavior through their work.”(9)

Contemporary architecture has largely considered the laboratory as a purely industrial typology, rarely pushing the architectural design to reflect the shifting nature and needs of research programs. Normative laboratory designs more often become lost in mirrored facades and infrastructural poche than trying to catalyze creativity or systemically adapting to the shifting experimental environments of scientific disciplines. Architecture cannot dictate human behavior through spatial organization, but it can endorse or discourage behaviors and social interactions.

However, it is rare for these concepts and systems to be leveraged
to the benefit of the biomedical laboratory researcher. The legacy of the military-industrial-academic complex is still inscribed upon the design and control of the production spaces that privilege managerial desires and control methods rather than optimizing the space for the needs of researchers. The spatial configurations of the laboratory speak very much to Michel Foucault's sense of governmentality and to some extent biopolitics. In which in the space the living functions and behaviors are tied to managerial oversight and control systems. Additionally, it is relatively rare for corporate laboratories to be sited within an urban context that engages both the urban fabric and social needs of the researchers. Within the larger context of exurban and urban migration from suburbia, the new industrial laboratory must be able to engage an urban context.

As the innovation of ground-breaking medical treatments has slowed. Science as a whole and industrial biomedical research in particular has demonstrated an increasing dependence on inter-disciplinary teams in the development process. In the face of greater technical and knowledge specialization, there is no one single discipline that can bring a treatment to market. Pharmaceutical companies require teams with a broad range of knowledge and technical expertise. In contemporary drug development settings, no one person can intellectually manage every step of the drug pipeline. The multi-disciplinary team requires collective inspiration.

These inter-disciplinary teams require spaces that foster the creation and dissemination of collective knowledge. The thing that makes the laboratory typology unique is the mode of production. Physical labor produces knowledge, which is purely ephemeral, rather than a physical product. The final drug or treatment is substantially dissociated intellectually and temporally from the labor of development. The sociologist Thomas Gieryn observes that it is the space of the laboratory typology that provides an identity for both the science being performed and the research performing the experiments:

"Built places materialize identities for the people, organizations, and practice they house. Through their very existence, outward appearances, and internal arrangements of
space, research buildings give meaning to science, scientists, disciplines, and universities for those who work inside and for those who just pass by.”(10)

In their pioneering science studies work Bruno Latour and Steve Woolgar (while at the Salk Institute) observed that a typical experiment produces only inconclusive fragments that may or may not support the hypothesis and can be attributed to the failure of the apparatus or experimental method. Essentially the majority of the research process involves making subjective decisions of what data to keep and what data to throw out.(11) In the context of contemporary industrial research (which also extends into drug trials), it is necessary for the researchers to interact and collaborate as much as possible in order to maintain a consensus for what data is necessary and sufficient to move forward. Latour and Woolgar put forth the concept that the objects of scientific study are socially constructed within the laboratory—that they cannot be attributed with an existence outside of the instruments that measure them and the minds that interpret them. They view scientific activity as a system of beliefs, oral traditions and culturally specific practices— in short, science is reconstructed not as a procedure or as a set of principles but as a culture. The architectural and spatial implications of this idea on the design of the thesis are clear: the designed space needs to engender and enhance this culture rather than inhibit it. This will be expressed in the design by rejecting the standard isolated research space and embracing the laboratory space as a field condition.

The post-war years provided innovation in the modes of production and systems of social organization. Precedents that inform how an industrial biomedical laboratory can engender innovation through placing social experience as the primary design issue can be found outside of the traditional wet laboratory.

World War II precipitated the adoption of industrial modes of production, modes that in turn engendered conflicts in the construction of a centered human subject.(12) The research space of Post-war industrial laboratories have been designed to engender an efficient and productive cor-
porate scientist. To a certain extent, a laboratory space that is designed around social interactions of a group of scientists rather than the requirements of a single researcher is a departure from the classic spatial organization of the laboratory. A discipline derived from monastic orders and the leisurely pursuits of landed nobles, science has traditionally been an insular and introverted enterprise. This is reflected in the introverted character of many laboratory buildings and university campuses. The lack of research space that encourages social interaction inhibits problem-solving. “What is this environment? It is the realization that everything starts with the individual.” For IBM President Thomas J. Watson, the corporation should be thought of as family. At IBM’s Research Center, Eero Saarinen translated this in his own way of putting it was that the plan made “no special distinction between white-collar or overall-clad employees.” In other words, the architecture of modular blue patterns – nonhierarchical and flexible in order to accommodate an “individual” constituency ready to follow IBM into an unpredictable future – was mobilized in Minnesota to displace (or dissimulate) the social hierarchies written into white collars and gray flannel, in the name of “human relations” among mass-produced IBMers. As Saarinen had done in his unpublished description of the building, the article announced that the IBM plant had been designed for two objectives: “one, to provide an orderly scheme for maximum flexibility and growth, and two, to create harmonious and efficient working conditions.”
The RAND Corporation headquarters in Santa Monica, California designed by H. Roy Kelly in 1953 is one of the first architectural spaces to use architectural space to promote an inter-disciplinary community. The building arranges the office spaces around a series of courtyards and uses cleverly designed and varied circulation routes through the courtyards to allow for unexpected and chance social interactions.
Today our main problem is that of organized complexity. Concepts like those of organization, wholeness, directiveness, teleology, control, self-regulation, differentiation and the like are alien to conventional physics. However, they pop up everywhere in the biological, behavioural and social sciences, and are, in fact, indispensable for dealing with living organisms or social groups. Thus, a basic problem posed to modern science is a general theory of organization.
The process of deconstructing a black box creates a glass box. The glass box elucidates the systems that translate an input into an output. The laboratory design proposed in this thesis uses this methodology in the literal and metaphorical exposure of the elements that define that laboratory typology.
Architecturalization of the social network
It is also out of the architecture and ideas of the military-industrial complex that this project finds direction for rethinking the laboratory module. The layout of the RAND corporation headquarters in Santa Monica, California is an example of the ways in which spatial organization can be utilized to encourage the interaction of researchers from disparate backgrounds within a space that promotes a flattened power hierarchy. Precedents that inform how a industrial biomedical laboratory can engender innovation through placing social experience as the primary design issue can be found outside of the traditional wet laboratory. It is thus necessary to look at architectural precedents outside of laboratory architecture to rethink the laboratory module.

A strong example of this design intent can be seen in Herman Hertzberger’s 1973 Centraal Beheer design. The design fosters community and openness through aggregation of open and autonomous units. The opened floor plan creates a flattened social and managerial hierarchy. Spatial involutions allow for customized and individualized personal spaces within the context of an open floor plan. This thesis seeks to have design express the laboratory typology as a glass box, the opposite of the black box. The glass boxing exposes the systems: infrastructural, control, and social to the users of the laboratory.

A partial example of a glass-boxed design can be seen in MIT’s Media Lab expansion. The idea of a spatial experience that provides spatial continuity between highly social and highly private spaces is seen in Fumihiko Maki’s 2007 MIT Media Lab design. The nested laboratory spaces and transparent partitions organized around communal spaces fosters an intensely collaborative environment.
The Centraal Beheer insurance company's headquarters designed by Herman Hertzberger in 1972 implements the idea of "spatial possibility" through the aggregation of autonomous units. The use of aggregated units is coupled with ideas about creating community and communal space through urban design moves in which the building very much operates like a miniature city. A great success of the project is the potential for the units to simultaneously accommodate an open floor plan and individualizable personal space. Personal spaces are carved out of the unit and aggregate through recursive quadrant subdivisions.
Spatial Organization Strategy

Aggregation

Conference Room

Circulation Strategy

Module

Communal Arcade

Atrium Nodes

Massing

Servicing Strategy

Service + Space
// The MIT Media Lab

The MIT Media Lab, designed by Fumihiko Maki in 2009, provides a spatial system of interlocking laboratory spaces to physically promote the cross-disciplinary nature of the Media Lab’s research groups. Social interactions in these spaces are not isolated to the purely physical, but include the visual through the use of glazed interior walls and lab spaces organized around an open communal space.

Massing + Organizational Strategies
Many of these ideas for the rethinking of the lab find their genesis in Louis Kahn’s design for the Salk Institute. Designed in close collaboration with Jonas Salk, the intent of the design reflected Jonas Salk’s personal life philosophy:

“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 create something that would influence the realm of the mind – the minds of those who would gather here to carry on this 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 contract to science for the sake of science. This architecture is for human use, to serve a purpose.” (16)

Inherent in the glass-boxed researcher-oriented space are two main components: a social continuity provided by a spatial and programmatic continuity. That is, the researcher is able to occupy a contiguous space that provides sub-spaces for both social interactions and personal reflection. An environment that does not allow the infrastructural service to calibrate the spatial experience. The isolation of infrastructure from the laboratory space allows the laboratory space to become open. As in the Media Lab, the highly social nature of the open space is tempered by smaller private spaces arrayed between the lab and the open courtyard. As the architect James Collins observes, a major design shift in the Salk Institute laboratories is the use of an implied corridor. The open laboratory space uses the casework and storage equipment to visually imply circulation routes rather than the standard corridor racetrack setup of previous labs. (17) The Salk Institute’s laboratory space displays a kind of proto field condition. A consequence of this designed flexibility in both buildings is the need for greater structural support and deeper floor plates. (18) The Salk Institute introduces occupiable beams within the concrete Vierendeel truss to allow for the open lab floor plan and the Media lab thickens the floor plates to 2m to accommodate the arbitrary placement of heavy research equipment. (Fig. 7)
The Salk Institute designed in 1963 by Louis I. Kahn for Jonas Salk, the creator of the Polio vaccine, seeks to build upon the servant and served concept in the laboratory started in the Richards Laboratory. This is accomplished by partitioning all of the service elements into discrete floors. The result of this configuration is that the laboratory spaces are completely open and unimpeded by the infrastructural service systems.
One of the clearest elements separating industrial and academic labs has been the attitude to the outside. Academia organizes around courtyards and greens while industrial labs look outward.(19) Novartis campus – adopting academic planning scheme. Traditionally, the industrial laboratory is differentiated from the academic laboratory by having the building look outwards rather than organizing program around open courtyards and greens. The use of open courtyards as explicit social spaces is one reason why the RAND headquarters transcended the typical industrial work atmosphere. The master planning of the Novartis corporate headquarters in Basel Switzerland reimagines the industrial lab as a community that promotes and stimulating environments. (Fig. 8)

The larger goal of the Salk Institute was to create an environment that engaged dialogues between the sciences and the arts. This goal is promoted through the planimetric configuration of the spaces. The twin laboratory blocks border an open courtyard thoroughfare. This spatial arrangement promotes chance social interactions between members of different research groups. Smaller spaces are arrayed against the courtyard to provide a space for the contemplation of research problems.

Figure 7 - Media Lab Section
// Novartis campus

The Novartis campus in Basel, Switzerland was masterplanned by Studio di Architettura in 2003. The masterplan pushes the notion that research spaces can promote a humane lifestyle for its researchers at the urban scale. Each space and mass within the masterplan has been calibrated to maximize day-lighting and the environmental and experiential comfort of the researchers. The design of the masterplan treats the arts as an integral component of the overall design.

The design is unique in that it is bringing notions of the outdoor community experience from academia to the internalized typologies and layout of a typical industrial campus.
As a building that is occupied nearly twenty four hours a day, the researcher’s comfort should be privileged over technical needs. The scientist here is not the prosthetic of the building, but rather the laboratory space is a natural extension of the researcher’s body. Advances in the understanding of how building systems use energy allows the architect to reduce inefficiencies introduced through design. Advances in active systems for buildings allows the architecture to dynamically adjust and optimize themselves when environmental conditions. Intelligently opening envelopes to release waste heat or closing when the climate cools. An active and reactive façade allows both for the optimization of researcher comfort and provides a channel through which the internal environment of the research space can be directly communicated with the general public. That is the greater levels of production and physical exertion the more apparent the production will be to the general public. Concomitant with ideas of innovation stemming from socialized spaces is the extent that environment plays in spatial experience. In this thesis design this can be furthered by creating a more responsive environment. An active façade can also be used to express the level of production of the research collective.
The reward for work well done is the opportunity to do more.

Jonas Salk
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This project is industrial and corporate in design, however integral to the thesis of the design the site needs to be part of a larger ecosystem of academia, government, and commerce. This constraint isolates the number of sites to only a select number of cities. Boston, specifically the Fort Point / Seaport District, makes an ideal site due to the high degree of bio-pharma and university clustering as well as the availability of undeveloped properties. However, due to Boston’s substantial landmaking history, the site and a substantial portion of the Seaport waterfront is vulnerable to flooding and sea level rise. The logic for the choice of site and resulting design is described across three scales.

**City Scale**

The clustering of biotech companies, universities, and research hospitals is considered for the placement of the site.

**Neighborhood Scale**

The neighborhood of Fort Point / Seaport district is used for spaces that do not require the design to acquiesce to the standard urban grid, access to multiple forms of public transportation, proximity to like bio-pharma and technology companies, and the potential to create a dialogue with the public through the extension and integration of the Harbor walk.

**Local Scale**

The specific building design and figure responds to and forms symbiotic relationships with the neighborhood’s edge conditions and landscapes as well as instantiating a design strategy for expansion and continued development of the site.
The choice of site at both the city and neighborhood scales is influenced by the work of Thomas Allen and colleagues published in an MIT Engineering Systems Division white paper. In the paper Allen et al. make the argument that communication increases at all scales as an inverse function of the distance between agents. That is scientists and engineers in a building have a higher level of communication with each other the closer they are and the fewer physical obstructions. In an earlier work Allen demonstrated the probability of regular technical communication among engineers to decline as the inverse square of the distance between their work stations. Allen et al. extend this finding to the city scale: “It is widely believed that propinquity will stimulate communication and scientific exchange among firms, especially among small firms formed on the basis of a common technology. This is one of the basic premises supporting the argument for the geographic clustering of newly-formed high technology firms.” The central argument for clustering independent of communication is the necessity for companies’ access to talent and mind-share. Allen concludes: “It will be easier to attract specialized staff, because the qualified pool of applicants is much larger. It is also easier to find venture capital, suppliers, and support services within a cluster. The reason that Boston shows substantial clustering emerges out of claims for the synergistic benefits of firms sharing scientific knowledge, especially if there are university laboratories near the cluster. Based on this data the likely choice for the project’s site would be in Cambridge. However, the grid is deeply embedded in the urban fabric of Cambridge as well as necessitating a rather tall design. Neither of these elements speak to the thesis’ need for an environmentally sensitive user-oriented laboratory design. The Fort Point / Seaport district does not have the same level of clustering, but is an area of active development and is the home to several established biotechnology companies.
Figure 9 - Biotech + Academia Clustering
Biotechnology Companies
Universities + Institutes (Major)
Universities (Minor)
Hospitals
Site

Biotech + Academia Clustering
Fort Point serves as an inscription of the commercial and industrial development and repurposing of spaces in Boston in the second halves of the 19th and 20th centuries. The existing urban fabric, save for the buildings built in the last 20 years, are the unique result of a highly consistent, architecture, planning, and urban fabric that physically captures a period in Boston’s history in which manufacturing and industry held primacy as economic drivers. Since its inception Fort Point has been a locus of commerce and industry for Boston. Sitting completely on reclaimed land developed solely by the Boston Wharf Company, the architecture of the area, as a product of a single development corporation, is unusually coherent and well-preserved. The majority of the buildings are masonry with simple volumes and flat roofs. The buildings serve as a reflection of a critical period of social, economic, and physical development of both Boston and New England. It is perhaps the collapse of the wool industry in Fort Point and the abandonment of the buildings that ultimately allowed the buildings to be preserved.

The channel is named after the colonial fort located on Fort Hill in an elevated area immediately south of downtown Boston. In the early 19th century, Fort Point hill was leveled and the resulting earth reused to extend land off of the northern edge of South Boston. Fort Point Channel separates South Boston and the current Fort Point ladmass from downtown Boston and the Financial District, and the Boston Harbor. Originally much larger the southern portion of the channel has been gradually filled in, primarily to expand the South Bay rail yard and several highways (the Central artery and the Southeast expressway). Driven initially by efforts of the Boston Wharf Company (BWCo) in 1836 to expand wharf space, Fort Point has until recently been a location for industry. The BWCo leveraged the adjacency of the wharf space and port to rent warehouse and loft space to Boston manufacturing companies. It is perhaps because of the sharp decline in manufacturing between 1920-1940 in Boston and the physical separation of Fort Point from downtown Boston’s circulation systems that Summer Street urban fabric has remained more or less intact and unchanged. It was not until artists moved into the vacated lofts that the site regained relevance and vitality. Fort Point’s development is inexorably embedded within the con-
History

text of Boston’s and Eastern Massachusetts’s industrial, commercial, and transportational development in the 19th and early 20th centuries.8

The Fort Point portion of South Boston was developed by the Boston Wharf Company (BWCo) from 1836 to 1882, primarily as properties for warehouses, lofts and factories for companies that could benefit from an adjacency to the BWCo’s wharves. Incorporated in 1836 for the purpose of building and operating wharves, BWCo evolved into an industrial real estate company at the end of the nineteenth century, as business conditions and opportunities changed. Between 1837 and 1882, BWCo filled in the marshes to which it had rights in phases, advancing from south to north.(9) The creation of the land finds its genesis in the Commonwealth of Massachusetts’s colonial laws enabling shoreline property owners’ rights to tidal flats extending 1650’ from the shoreline. Enacted to encourage the construction

South Boston Sea Port
of wharves, the law was leveraged for the creation of land off of the shore and the extension of wharves.10 The Boston Wharf Company constructed most of the buildings from the 1880’s to the 1920’s for the manufacture and storage of a various goods. Approximately 70% of the urban fabric in Fort Point was constructed prior to 1930.11 Initially the industry centered on sugar, molasses, and shifted to wool during the late 19th and early 20th centuries.(12)

For the first two decades of developed, the property was inaccessible. It was not until 1855 and the construction of the Mount Washington bridge across the Fort Point channel was the BWCo land attached to downtown Boston. Immediately after the completion of the Mt. Washington bridge, the Midland Railroad constructed a bridge at approximately the same location as the current Summer St. bridge. Both bridges had drawbridge components, which allowed for boats and barges to travel to the southern portions of the channel, but often impeded traffic across the channel. Later these roles were reversed with trains receiving right-of-way and forcing the bridges to remain lowered starting at the time the train was supposed to cross until the train actually crossed the channel. It was not until the construction of the Congress Street bridge in 1875 and reconstruction of the Mt. Washington bridge in 1870, that BWCo had adequate commercial access from downtown Boston to its properties.(13) This increased commercial access led to a shift in the BWCo focus towards the construction of warehouse and industrial properties. Leasing and renting land to the New England Confectionery Company and wool vendors and textile manufacturers.

The decrease in use of woolen garments and the introduction of synthetic fibers led to a decline in the wool trade and subsequent abandonment of the buildings. By the 1920’s use of the properties had sharply declined with the closing and southern migration of the wool industry. It was not until the late 1970’s that the Summer Street properties were productively re-inhabited. Artists and design firms slowly moved into the large loft spaces. This region is now the Fort Points Arts Community.
Historical Photos

Summer St. and Fort Point - 1925

Construction of S. Station - 1898

Northern Ave. Bridge - 1930

Northern Ave. Bridge - 1937

Williams wool - 300 Summer St. - 1907

Wormwood factory - 1898
The main driver for Fort Point's industrial growth was the connection of Summer Street to downtown Boston. Until the mid-19th century Summer St., also called Seven Star Lane, served as the main circulation artery into Fort Point.(14) The construction of the Summer Street Bridge in 1900 was initiated by the merger of railroad companies consolidating shipping lines and the agreement to build a new, union station. The merger necessitated a realignment of the tracks over to the Boston side of the channel. This allowed the railroad bridge adjacent to Summer Street and the tracks crossing the BWCo property to be removed. The result was that the properties on Summer St. were free for development. The union station project, ultimately named South Station, was a substantial capital project that necessitated filling old docks and wharves and constructing new bridges, tracks, and a large terminal building and 90 years later a
// Shaping Forces

tunnel. South Station opened in 1898 at the terminus of the old railroad bridge. In place of the bridge, the railroad built a highway bridge off of Summer St. and into Fort Point. (15) The bridge immediately shaped the Fort Point physical streetscape. (16) A necessity of continuing access to the rail yard was to raise Summer St. over the tracks.

It is partially due to the lack of public transportation that the buildings had become abandoned and why the FPAC was able to use and later rent the spaces at such rates. The completion of first the Big Dig and then the establishment of the MBTA Silver Line has led to a transition of Summer Street from an artist community into office spaces. The Silver Line while directly avoiding the eastern portion of Summer Street has opened up access to Fort Point to greater Boston. The MBTA run the Silver Line first through a tunneled portion extending off of South station. This tunneled portion, known as Silver Line Phase II, was constructed in conjunction with the Big Dig. Phase II opened for service on Friday, Dec. 17, 2004. Service was extended to Logan Airport starting on January 2, 2005. This tunneled portion is also an important component the greater Boston highway system. Opened first in 1995 to commercial traffic and then in 2003 to general traffic. The tunneled portion connects to the Ted Williams’ tunnel and completes the I-90 turnpike.
The leveling of Fort Point Hill

1878 1887 1892
1900 1908 1921
2000 2013

Figure 10 - Growth of Seaport Land Mass
// Geography

Almost the entirety of the Fort Point land was created by the BWCo, in a process that filled the site from 1837-1882, with minor expansion occurring into the twentieth century; including filling in southern portions of the Fort Point channel. The BWCo built the streets, laid out lots, and also erected most of the buildings, which were designed by the company's two staff architects.(17) The BWCo extended the land starting at First St. moving north using the unorthodox method of first installing a sea wall and the filling in behind the wall. The first panel of Figure 10 shows the area in the period prior to BWCo first efforts to extend the land. The first expansion of Fort Point occurred in 1878 with the land extending to the Congress St. bridge.
In 1887, The BWCo substantially expanded the land with the Western edge approximating the current channel bank and the creation of land for the rail yards adjacent to the wharf. The land was further expanded in 1888, the period between 1878 and 1888 represents the largest single expansion of the property with a substantial expansion to the wharf edge moving eastward. The final expansions occurred in 1900, 1908, and 1921 as the BWCo completed the creation of the Fort Point property. Summer St. extends from Downtown Crossing in the Financial District over the Fort Point Channel and into South Boston until it intersects with East First Street and becomes L Street. South Station at the other end. The final expansion is the result of earth from the Big Dig.
The Fort Point Arts Community (FPAC) is the result of artists taking initiative in preserving affordable housing. A fire in 1976 at Plante Shoe Factory in Jamaica Plain caused the destruction of a large collection of artist spaces. The artists migrated to the at-the-time forgotten Fort Point area adjacent to Summer Street. The old BWCo properties, with high ceilings, freight elevators, large windows, and strong floors, provided ideal studio spaces. In 1980, the Fort Point Artists Community form as a tax-exempt 501(c)3 corporation with the mission to: “enrich the Fort Point area with an artist live/work population that contributes to the district’s and the City of Boston’s cultural life.” (FPAC website) The FPAC was founded out of the frustration experienced by Fort Point artists frustrated with illegal live/work spaces that violated city zoning regulations. In 1982 the FPAC reorganized as 249 A Street Cooperative using funding from the National Endowment for the Arts.(18) The reorganization was a consequence of the FPAC members being low-income wage earners it was easier to get financed collectively. Named after the address in Fort Point, the 249 A Street site was chosen on the basis of the site’s 72,000 gross square feet. In 1992 the FPAC developed further artist spaces on the eastern edge of Summer St. site.
// The Public + The Neighborhood

As a method to have the laboratory interface with the surrounding neighborhood and Boston the site endeavours to bring the Boston Harbor Walk back to the shoreline. The Big Dig infill that created the site did not provide for public waterfront access. By introducing waterfront access for the public at the site the design can make steps to initiate a dialogue with the public. In continuing to reject the Cold War isolationist campus the design can push ideas of transparency and openness.
Real Estate

The real estate market in Fort Point has paralleled the same swings experienced by the greater Boston real estate market. It is clear though that certain properties have increased at rates higher than others. Spurred on by the housing bubble, several properties were redeveloped and new properties developed on empty lots. However, with the collapse of the housing bubble, many of the new properties have almost all depreciated in value. In contrast, the older properties have appreciated greatly from the earliest public assessor records in 1985.(21) Most striking is the average percentage appreciation on the north side of Summer St. and the site currently being used by the Boston Children's Museum. The value of the museum's property is a direct result of the site becoming exempt from property taxes. The north-side Summer St. properties are presumably a result of continued maintenance and renovation as well as easier access to public parking on Congress St.
Property values 1985 - height in millions of dollars

Property values 2013 - height in millions of dollars

Change in Fort Point property values over last 25 yrs
Residents

The neighborhood is comprised almost solely of commercial and industrial buildings. However, there is no real sense of community due to a lack of civic amenities.

Developers

The neighborhood has multiple active mid-rise commercial and residential developments. However, the architecture does not activate the area.

BRA

The Boston Redevelopment Authority, led by Kairos Shen, coordinates development and redevelopment projects. They also have final say over whether or not projects go forward.
The site sits in an area of substantial development with substantial mid-rise commercial and residential developments on Fish and Fan piers. Adjacent to the site is Innovation Square, Vertex Pharmaceuticals, and the Bronstein Center (which houses Ginko Biotech and Immunex Pharmaceuticals). Half-way through this thesis, active development commenced on the project’s site. This is significant in that the proposed design deactivates the waterfront and weakens the existing community by installing a sprawl of single story warehouses.
Panorama - Looking North - Fall

West Entrance

Proposed Development

South Approach - Fall
The urban fabric of Fort Point is characterized by a high level of uniformity. Despite the redevelopment and gentrification of the area in the last 20 years, most of the buildings standing on this site today represent the latter stage of the company's history, when it became a real estate company. The great majority of the buildings are lofts constructed between the 1880s and 1920s, and most are 5-6 stories. (19) The vast majority of the BWCo developed properties were designed by two architects: Morton D. Safford (1893 - 1917) and Howard B. Prescott (1917 - 1939). As a result of the limited number of designers and steady commercial forces, Fort Point is a paradigmatic collection of the early loft and warehouse buildings typology. The buildings in the Fort Point Channel district are, with only a few exceptions, loft structures – multi-story buildings used for warehousing and light manufacturing – built between the 1880s and 1920s. (20) Unsurprisingly, BWCo as the sole owner and developer of the land allowed for unique private planning and zoning. Unlike the buildings of downtown Boston, the buildings of Fort Point are built to the extents of the lots strategically interspersed with alleyways and loading zones. As a whole the buildings remain unornamented save for the lower portions of the facades. This relative homogeneity of the building types is remarkable in a city with a high level of building typology. One feature that has substantially changed the Summer Street area is the removal of the rail lines. In place are mid-rise and high-rise developments, a seaport, and the Institute for Contemporary Art. Despite this redevelopment, the area is very much marked by a persistent void space where the rail lines used to sit. As a result traffic moves more fluidly a quickly over Summer Street presumably quickening the pace of life along the western portion of the street.
Site + Precedent Comparisons

Novartis Corporate Campus  MIT - Media Lab  Salk Institute
Site Analysis

In moving into the design phase of the thesis it is important to get a handle on the physical and environmental qualities of the site. The figure ground images below show the relationship between the massing of several of the precedent analyses with the site. The scope of the project and the figure ground images demonstrate that this is a site that can support a multitude of designs of rather large scale while still allowing the design to remain free of any geometric influence from the urban grid inherent in other sites in Boston.

The massing strategies of the project will attempt to remedy this through strategic punctures and orienting the building mass to have the majority of the glazing on the south-eastern facing facades.

Following this conclusion several environmental analyses indicate that it is difficult for many design to be sufficiently daylit and have full views of the harbor. The climate of the site is slightly different than the rest of the city by have the majority of the building mass exposed to prevailing winds. However, this can be used to an advantage by pulling in cold air off of the sea surface to passively cool the servicing infrastructure.

Lastly, through computational analysis it appears that the adjacent buildings and site context have little to no impact on heat build-up or daylighting.
Climate Consultant Site Analysis - Logan Airport

ENVIRONMENTAL ANALYSIS SIMULATIONS

Wind-Rose
Boston Logan IntL Arpt, MA, USA
1 JAN 1:00 - 31 DEC 24:00
Calm for 0.40% of the time = 35 hours.
Each closed polyline shows frequency of 1.2%. = 102 hours.

Hourly Data: Wind Speed (m/s)

Hourly Data: Relative Humidity (%)

Hourly Data: Dry Bulb Temperature (°C)
Climate Consultant Site Analysis - Logan Airport

Illumination Range

Radiation Range

Radiation

Temperature Range

www.energy-design-tools.aud.ucla.edu
Sun path over site over single calendar year
Site continuous daylight autonomy

Site continuous building radiation

Site environmental analysis shows that adjacent buildings are set back far enough from the site to have no environmental impact on the design.
As one of the first things that visitors to Boston will see, the site is engaged as a mode of discourse. The siting creates a discourse between for the economic and development goals of the city geared towards technology and service. Built on the waterfront on reclaimed land, the design simultaneously engages the history of land development in Boston and looks to the future of Boston's economy. By extending the Harbor walk the design also seeks to create a discourse between the public's perception of science and the actual practice.
Introduction

Site

Design

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Appendices

Works Cited
"...a building is not a static object but a moving project, and that even once it has been built, it ages, it is transformed by its users, modified by all of what happens inside and outside, and that it will pass or be renovated, adulterated and transformed beyond recognition." – Bruno Latour (1)

This project envisions a corporate headquarter for a large bio-pharmaceutical company. The design is a mid-rise structure sited in an urban context. The laboratory provides space for 600 scientists and support staff. The form and parti of the design find their origin in the words of sociologist Thomas Gieryn: “The function of corporate headquarters has always been as much about the identity of the corporation as it has been about supporting the workers in that building.” (2) This stands in contrast with many of the precedents. Brought on by the increasing need to access and encourage the highest levels of scientific and technological research, the postwar proliferation of research laboratories effectively re-territorialized the corporation, disengaging the centers of industrial research from the manufacturing plants out of which they had sprung during the 1920’s and 1930’s and granting them a separate identity within the corporate hierarchy. (3) This design begins to both redefine what industry is in Boston, by occupying an historically industrial area and by pushing corporate science out of the post-war suburban context.

There is a reciprocal relationship between people and places. As the naturalist D'Arcy Thompson posits: "Forms which are so concomitant with life that they are seemingly controlled by life." (4) Beauty is derived from fitness to the purpose for which something has been constructed. James Collins: “Spatial planning can foster the paradoxical factors inherent to the
research laboratory: innovations and replication, discussion and reflection, teamwork and competition.” (REF) A central design goal of this thesis is to engineer an infrastructure that allows for a spatial flexibility that both enhances the social culture and allows the space to continue to best serve the culture as it changes. The architect Moshe Safdie observes: “The seasonal transformation of plants for example suggests that architecture should be able to transform from season to season, that it should be convertible or changeable as it responds to different climatic conditions. The spiral patterns of leaves maximizing exposure to sunlight and the continuous movement of cactus leaves avoiding over-exposure both offer beautiful metaphors for architecture that could respond to specific climates and topography.(5)

The title of this thesis, laborlandschaft (German for the laboratory landscape), borrows from the German Schnelle brothers’ concept of laborlandschaft or the office landscape. The architect Frank Duffy uses this concept in describing his vision for a rethought workplace. Duffy contends that the average office building has been designed from structural, technical and economic considerations that have little to do with what the man at his desk really needs: or, for that matter, what the company needs.6 The landscaped office is a large service space that allows for the disposition of groups and equipment to not be governed by building shape, or by preconceived ideas such as straight lines of desks – only by working relationships and working needs.(7) Issues such as privacy, loss of status and individuality and the physical problems of noise and distraction inherent in the open plan are solved in this design by careful planning of the furniture set, suspended enclosed offices, and moveable screens. The basic strategy of the landscaped design is the design is based on a full understanding of what ‘actually’ happens in the space not on what people ‘think’ happens in the space.
Research Module 1 - 4,100 m²:
- 4°C Cold Room
- -20°C Cold Room
- Bench Space - Individual
- Bench Space - Team
- Bonded Storage
- Microscopy Room
- Equipment Space (3-phase)
- Offices
- Reagent Storage
- Tissue Culture

Vivarium Module 1 - 800 m²:
- Cage Rooms
- Clean Corridors
- Dirty Corridors
- Micromanipulator + Transgenics
- Surgical Suites
- Quarantine

Scale-Up + Module 1 - 2,000 m²:
- 4°C Cold Room
- -20°C Cold Room
- Equipment Space (3-phase)
- Gowning + Lockers
- Microscopy Room
- Media Preparation
- Purification + HPLC
- Reagent Storage
- DNA + Protein Sequencing
- Tissue Culture

Research Module 2 - 3,000 m²:
- 4°C Cold Room
- -20°C Cold Room
- Bench Space - Individual
- Bench Space - Team
- Bonded Storage
- Microscopy Room
- Equipment Space (3-phase)
- Offices
- Reagent Storage
- Tissue Culture

Administration Module 1 - 1,000 m²:
- Conference Suits
- Library
- Offices - Individual
- Offices - Team
- Shipping + Receiving
- Data Center
- IMT

Amenities Module 1 - 800 m²:
- Auditorium
- Gymnasium
- Lockers
- Swimming Pool

Program - 6,900 m²:
Service + Served Barscape

Bars Slip For Views + Daylight

Bars Split By Amenities Bar

Central Circulation + Social Concentrator
"[e]very feature of the man created environment has [an] inher- 
ent physiognomy [and] thus is an object of communication." –
Gyorgy Kepes The New Landscape in Art and Science⁹

An inherent element of the design’s flexibility is the tempo- 
rality of the building after it is built. The design allows for change for both 
programmatic reasons and also to initiate a discourse about architectural 
design and the actual occupant use of built designs. Bruno Latour describes 
these two elements as a central split in the practice of architecture and the 
way humans inhabit space. In Latour’s words architectural design is purely 
about representation; representations executed solely in Euclidean space. 
As Latour contends: “You need only to think for one minute, before con-
fessing that Euclidean space is the space in which buildings are drawn on 
paper but not the environment in which buildings are built – and even less 
the world in which they are lived.”(9) Whereas little in the universe is spa-
tially or temporally acquiesces to the litteral and figurative straight lines of 
Euclidean space. Latour adds: “No one, of course, lives in Euclidean space; 
it would be impossible, and adding the “fourth dimension,” as people say 
– that is, time – does not make this system of coordinates a better cradle 
for “housing,” so to speak, our own complex movements.”(10) This design 
strives for a built space that has the potential to transcend the designer’s 
representation of the spatial configuration by providing a space and infra-
structure that allows the users to organize, customize, optimize and per-
sonalize the research spaces.

One design method this thesis employs (and is facilitated 
by the plug and play infrastructure) is to allow the lab spaces, benches, and 
furniture to exist as a field condition. The architect Stan Allen defines the 
field condition as: “...a design strategy based on the aggregation of small, 
self-similar parts to create local differences while maintaining overall co-
herence; field condition implies the design of systems and assemblages, 
paying close attention to intervals and the spaces between things.”(11) 
There is essentially a blurred relationship between the figure and the
Plug + Play Lab Bench Servicing System

Lab bench plugs into sub-floor service manifold

Lab bench can rotate about the service port
ground. The implications of a field condition for the spatial organization of the laboratory and laboratory set is... The field condition is employed as a tool to empower the occupants to move beyond the authoritarian subjectivity of the designer and search for spatial configurations that maximize comfort and productivity.

As Duffy points out, until recently: “The dominant organizational mode of the conventional office was ‘the office as factory’ – a place where individuals processed work, under supervision, at their own workstations. Such work is low in interaction – apart from social chatter – as well as low in the autonomy given to individual office workers.”(12) Recent years have witnessed the birth of a corporate counter-culture, led by Google, Facebook, and many technology incubator spaces, that rejects the notion of ‘office as factory’ and instead orient the space to the users rather than managers. Central to this corporate counter-culture is a shift away from strict programmatic assignments for spaces and instead conceptualizing the spaces as having affinity for certain types of human behavior. Duffy identifies four major spatial organizational types: hive (individual processes), cell (concentrated study), den (group processes), and club (transactional knowledge).(13) (Fig. 11) The parti of the thesis utilizes these organization types in order to establish a logic and hierarchy that reflects the central goal of user comfort and maximized innovation. (Fig. 12) Hives are characterized by individual, routine-process work with low levels of interaction and low autonomy. Hive workers sit continuously at simple workstations for long periods of time.(14) This type best characterizes the standard spatial organization of the laboratory typology and the type that this design most explicitly tries to avoid. Cell offices accommodate individual, concentrated work with little interaction. Highly autonomous people occupy them in an intermittent, irregular pattern.(15) The design also seeks to minimize cell spaces as they inhibit social interaction. A minimal amount of cell space is provided as a means to allow for temporary privacy and small meetings. Den offices are associate with group work, typically highly interactive but not necessarily highly autonomous. Den spaces are designed for group working and often provide a range of several simple settings, usually arranged in an open-plan.(16) The den type best reflects the design intent for the
research spaces. Club organization are for knowledge work, i.e. for office work that transcends data-handling because it can only be done through exercising considerable judgment and intelligence. Typically, work in such organizations is both highly autonomous and highly interactive. The pattern of occupancy tends to be intermittent over an extended work day.\(^{17}\) The design uses this organization type to mediate the connections between the research spaces in plan by incorporating a central club-type bar (Fig. 13)

Figure 11 - Spatial behavioral affinities after F. Duffy
Moveable Offices

Figure 12 - Social Parti
Figure 13 - Starting Formal Parti
and sectionally through mezzanines designed for work desks that allow researchers from different floors to interact. (Fig 14)

In describing the spatial context of the environment that humans inhabit Latour posits: “…phenomenologists (and psychologists of the Gibsonian school) have never tired of showing that there is an immense distance in the way an embodied mind experiences its surroundings from the “objective” shape that “material” objects are said to possess.”(18) “…we have to add human subjective intentional dimensions to a “material: world that is well described by geometric shapes and mathematical calculations.”(19) That is, in the school of phenomenology, there are certain physical and material elements that have specific types of embodied meaning to humans. The architectural theorist Sarah Goldhagen uses the example of the large oak tree. The oak tree is subconsciously understood to provide shelter and protection because of its strong materials and wide canopy. “…instead of referring to the symbolism implicit in the architecture of the Richards Medical Research Laboratories in Pennsylvania as a scientific building, we should follow the painstaking ways its users reacted to and misused the building after the fact of its construction, and thus engaged in thorny negotiations with its architect Louis Kahn, with glass and daylight;”(20) This ties back into Latour’s argument: “Matter is not “in” Euclidean space for the excellent reason that Euclidean space is our own way of accessing objects (of knowing and manipulating them) and making them move without transformation (that is, maintaining a certain number of characteristics); it is definitely not the way material entities (wood, steel, space, time, paint, marble, etc.) have to transform themselves to remain extant.”(21)
Distance-dependence of Communication
Barriers to Socialization in the Laboratory

Physical obstructions isolate scientists.

Open spaces encourage fluid communication between scientists.
Duffy's flattening managerial hierarchy through adjusting circulation paths.

Duffy's example of burolandschaft: the office landscape

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Key

1. A casio punching matrix. Machines are accessible for maintenance; overlapping of access area alone space.
2. Jobs arranged to avoid eye-to-eye confrontation. Notice also that desks are arranged so that chairs do not obscure the gap.
3. Desks placed closer to referring window surfaces.
4. A "subjective" space (empty). Directed visibility is about 30%; everything beyond is background. Together with screens and plants, this arrangement prevents the individual from being lost in the group space.
5. A plant protection of desks forming a primary route.
6. A primary route, designed to be "shared" in a direct route.

---

Original design concept for the layout: note the screened workplaces for managers and the relatively clear circulation in use. The same part of the layout has become more dense. The routes are less clear, the arrangement of the workplaces is more complex and the relationship of managers' workplaces to the rest is less predictable.

---

Fig 1.1

Duffy's example of burolandschaft: the office landscape

---

1. A grouping of desks, designed to emphasize entry;
2. Desks arranged to avoid overcrowding.
3. Areas marked occasionally for fitting a shared by persons.
4. Using near windows, desks have been made for local living instead.
5. Concrete visual protection for the head of a unit arrangement, of views, filing cabinets, plants etc.
6. Spaces expressed by artificial space, which constitutes being overlooked.
7. A source of space.
8. A rear view near a window.
Lab Module Space with view East over Boston Harbor
Section A
The vulnerability of the site to flooding and sea-level rise is mitigated through the addition of an additional 5m of earth. The earth is surcharged to improve foundational stability and a sea wall is used to retain the added earth and prevent erosion of the foundation. The design embraces these factors as an opportunity to extend the Harbour walk and have the research spaces cantilevered over the water. This relationship in turn strengthens the public-private relationship of the design.
Section B

Landings are registered - No visual connections

Landings are separated - visual connections

Figure 14 - Sectional Parti after H. Hertzberger
The architect Frank Duffy and writer Stuart Brand one way to negotiate this split in architectural design is to conceptualize buildings as being composed as several layers of change. Duffy calls this concept shearing layers, wherein the components of a building evolve in different timescales. (22) Duffy summarizes the concept thusly: “Our basic argument is that there isn’t any such thing as a building. A building properly conceived is several layers of longevity of built components.” (23) The layers are classified as: site, structure, skin, services, space plan, stuff. Site is the geographical location, it is eternal. Structure is the foundation and load-bearing elements that are difficult and expensive to change, it exists on a timescale of 30 to 300 years depending on material and construction method. Skin is the exterior surface, it exists on a timescale of 20 years and is changed to reflect performance needs and fashion. Services are the working components of the building: communications, electrical, plumbing, HVAC and mechanical. Services exist on a timescale of 7 to 15 years. Deeply embedded and complicated servicing systems can often lead to the premature demolition of a building. Space plan is the interior layout of walls, ceilings, floors, and circulation. Commercial buildings change space plans every 3 to 7 years. Stuff is the furniture and interior finishes, they are constantly change. The concept is based and adapted from the work of ecologist Robert O’Neill and colleagues and systems theorist Stanley Salthe, in which there are processes in nature that operate at different timescales and as a result there is little or no exchange of energy or information between them. (24) Brand proposes that successful architectural design often supports a slippage of layers, in which faster evolving layers such as service are not obstructed by slower evolving layers such as structure. This design seeks to allow these layers to interact and influence each other functionally as much as possible in order to allow the design to adapt and respond to occupant needs as efficiently as possible over its life-span.
Concrete Shear Walls, Vertical Service Chases + Lab Support Spaces

3rd Floor - Concrete Chilled Beam Floor Plates

2nd Floor - Concrete Chilled Beam Floor Plates

Reconfigurable Offices + Lab Benches

1st Floor + Mezzanine Collaboration spaces
The physic garden to the west of the laboratory serves two functions in the overall design: as space for the mixing of the public with the laboratory workers and to ground the site in the horticultural roots of pharmaceutical remedies and treatments.

The garden sits adjacent to the Harbor Walk extension creating a space that can mediate the public pedestrian traffic along the walk as well as create a western-most civic destination for the walk to encourage full use of the waterfront.

The use of the physic garden serves as a bridge between the historical use of the garden as a place to grow medicinal herbaceous plants. The display of the variety of plants that have over time been used as the source for many modern pharmaceuticals can instruct the scientists about their historical roots. In turn this bridge can also be used to create a dialogue with the public on the nature of ‘synthetic’ pharmaceuticals and their ‘natural’ origins. Thus designed space can be used to inform the public.

The garden continues the grain of the served and service parti of the lab with the garden beds arrayed along the grain with oblique cuts that follow the hallways that connect the laboratory modules.
// Site + Landscape

Physic garden - plan + organization
Hollyhock
Alcea
emollient, diuretic

Dianthus
Dianthus
astringent, tonic
diuretic

Poopy
Papaver somniferum
opium, opiate derivative

Garlic
Allium
expectorant, stimulant

Foxglove
Digitalis
cardiac stimulant, diuretic

Mayapple
Podophyllum
low pteridoids, purgative

Bugloss
Anchusa
inflammation, kidney stones

Echinacea
Echinacea
expectorant, antipyretic, immunity booster

Jacob's Ladder
Polemonium
antibacterial, expectorant

Chamomile
Anthemis
anti-septic, antispasmodic

Betony
Stachys officinalis
headache, nausea

Self Heal
Prunella
stomachic, tonic

Snapdragon
Antirrhinum
antiseptic, tumours, ulcers

Liverwort
Hepatica
astringent

Lungwort
Pulmonaria
anti-inflammatory, lung problems

Columbine
Aquilegia
astringent, diuretic

Lettuce
Lactuca
diuretic, sore throat, gout

Rosemary
Rosmarinus
astringent, diaphoretic

Wild Ginger
Asarum
astringent, toothache

Tobacco
Nicotiana
irritant, cathartic

Sage
Salvia
astringent, tonic

Wild Indigo
Baptisia
sore throat, purgative

Evening Primrose
Oenothera
astringent, sedative

Salad Burnet
Sanguisorba
anti-septic, tonic, diaphoretic

Mountain Mint
Agastache
stimulant, expectorant

Peony
Paeonia
antispasmodic

Golden Rod
Solidago
stimulant, carminative

**Medicinal herbaceous plants**
3rd Floor Cafeteria + View into Organic Synthesis Laboratory

3rd Floor Roof Terrace + View of Boston Harbor
Sun Angles at the Site

Elevation = 70.67 deg
Azimuth = 199.78 deg

Elevation = 47.72 deg
Azimuth = 184.4 deg

Elevation = 24.12 deg
Azimuth = 183.14 deg

Summer Solstice  Spring + Autumnal Equinox  Winter Solstice

Sectional Daylighting Strategy
// Simulation + Computational Analysis

In the absence of user evidence the design tries to provide for the human subjective intentions for the space. An extension to the issues of materiality is the way that the design seeks to improve occupant comfort through environmental sensitivity. Extending Duffy's ideas about evidence-based design, this thesis used several computational analysis tools to simulate circulation, lighting, and thermal systems. Through iterative rounds of simulation, the design was modified and adjusted to maximize daylighting and shading systems and begin to minimize the contribution of these systems on the environmental impact of the design.
DAYLIGHT AUTONOMY SIMULATION

Measurement from 0% to 100%, with the building occupied from 8am to 6pm annually. 4 ambient bounces. 2m grid.

Daylight Autonomy (DA) is the percentage of working hours when a minimum work plane illuminance is maintained by daylight alone.
Continuous Daylight Autonomy (CDA) is the summation of continuous daylight autonomy (DA) values. A CDA > 40% equates to 1 credit, continuous DA > 60% = 2 credits, and continuous DA > 80% = 3 credits for 60% of the work plane and DAmax < 1%.

Measurement from 0% to 100%, with the building occupied from 8am to 8pm annually. 4 ambient bounces. 2m grid.

Third Floor: CDA = 67.98%
Second Floor: CDA = 50.49%
First Floor: CDA = 62.74%

CONTINUOUS DAYLIGHT AUTONOMY SIMULATION
USEFUL DAYLIGHT FROM ILLUMINATION SIMULATION

Measurement from 0% to 100%, with the building occupied from 8am to 6pm annually, 4 ambient bounces, 2m grid.
Useful Daylight Illuminance (UDI) divides the working hours into three groups: ≤100 lux (insufficient daylight), 100 lux < x ≤ 2000 lux (useful daylight), and x > 2000 lux (too much daylight with potential heat gain issues)
DAYLIGHT AVAILABILITY SIMULATION

Measurement from 0% to 100%, with the building occupied from 8am to 6pm annually. 4 ambient bounces, 2m grid.

Daylight Availability is the percentage of the occupied hours of the year when a minimum illuminance threshold is met by daylight alone.
Third Floor
DF = 56.2%

Second Floor
DF = 32.54%

First Floor
DF = 4.92%

DAYLIGHT FACTOR SIMULATION
Measurement from 0% to 100%. 4 ambient bounces. 4 ambient bounces. 4m grid.
The Daylight Factor is the ration between exterior sky illuminance on an overcast day and illuminance inside a building.
RADIATION SIMULATION

Measurement from 0% to 100%, 24 hrs annually, cumulative sky method. 4 ambient bounces. 2m grid.
A representation of annual surface irradiation.
### Analysis Zone

<table>
<thead>
<tr>
<th>Analysis Zone</th>
<th>Daylit Area (DA&lt;sub&gt;300 lux&lt;/sub&gt; [50%])</th>
<th>Mean Daylight Factor</th>
<th>Daylight Factor (DF) Analysis (DF &gt;2%)</th>
<th>Daylight Auto (DA) Analy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor 1 - skylights</td>
<td>84%</td>
<td>9.9%</td>
<td>75%</td>
<td>77%</td>
</tr>
<tr>
<td>Floor 2 - skylights</td>
<td>85%</td>
<td>4.9%</td>
<td>72%</td>
<td>75%</td>
</tr>
<tr>
<td>Floor 3 - skylights</td>
<td>97%</td>
<td>52.7%</td>
<td>97%</td>
<td>92%</td>
</tr>
<tr>
<td>Floor 1 - no skylights</td>
<td>41%</td>
<td>2.6%</td>
<td>29%</td>
<td>37%</td>
</tr>
<tr>
<td>Floor 2 - no skylights</td>
<td>40%</td>
<td>1.8%</td>
<td>22%</td>
<td>36%</td>
</tr>
<tr>
<td>Floor 3 - no skylights</td>
<td>62%</td>
<td>5.0%</td>
<td>41%</td>
<td>55%</td>
</tr>
</tbody>
</table>

**DIVA Simulation Metrics**

- Location: Boston - 42.37N / 71.02E
- Occupancy: 3650 hrs/yr
- Illumination Target: 300 lux
- Ambient Bour
The above table compiles the output of the daylighting simulations. A base condition with only standard curtain wall glazing provides a substantial amount of daylighting for most of the occupants. However, quality daylight is rather limited to either the beginning or end of the day. The installation of skylights and corresponding cuts into the floor plates to create the solization study mezzanines substantially increases the floor area that is daylit. There is a doubling of both daylight autonomy and continuous daylight autonomy (300 lux target using four ambient bounces) with the skylights.

The failure of the design to qualify for LEED-NC 2.1 Daylighting Credit reflects the inclusion of the light safe service cores and lab support space in the simulations as a control to ensure that simulation parameters were precise. The cores consistently appear as dark blue indicating no light entering the service space.
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The rate of pharmaceutical development has steadily decreased over the last 30 years as a result of the failure to discover more efficacious pharmaceuticals. This situation has created a culture in which economic growth is achieved through mergers and acquisitions rather than innovation through internal research and development. This has created economic conditions in which the rate of increase in the investment capital required to develop new medical treatments outpaces the approval of drugs more efficacious than the previous generation of drugs. The ultimate result has been the instantiation of a cycle in which innovation is suffocated due to the need for immediate return on the investment. The greatest growth in new drug development comes from the development of biologically-derived treatments rather than the traditional system of small-molecule treatments.

McKim BioPharma is a leader in the development of lifestyle drugs such as Foliculin for treatment of male-pattern baldness, and Focusin for the enhancement of cognitive acuity. McKim now wants to make a push for the development of anti-aging agents. This research endeavor requires the creation of 150,000 square feet to house wet labs, technical facilities, a vivarium, and office space.

As a company striving to better the human condition, McKim requires an architecture that reflects this vision for the betterment of humanity by creating a more humane and stimulating working environment for its researchers and seeking to better co-exist with the environment by adapting on short timescales to local environmental changes and on longer timescales to changes in the spatial needs to the research programs.

A competitive hiring market necessitates that the laboratory will be sited in either: Cambridge, MA, San Francisco, CA, or Raleigh-Durham, NC. All three of which require active heating and cooling seasons.

The architectural design of this project will preference the social element within the laboratory spaces. The adaptability of the laboratory will occur at several different scales. An active facade will adapt to optimize energy waste due to changes in the external environment. Designed casework and service elements will allow for future spatial changes while minimizes the impact of the changes to the laboratory experience.
Design Precedents

The Richards Laboratory

The Richards Laboratory designed by Louis I. Kahn in 1961 for the University of Pennsylvania is an early attempt to give the laboratory space over to the served elements such as the researchers. This is accomplished by moving all of the service elements to the periphery of the building, providing flexibility and openness to the layout of the laboratory space.
Genzyme Headquarters

The Novartis campus in Basel, Switzerland was master-planned by Studio di Architettura in 2003. The masterplan pushes the notion that research spaces can promote a humane lifestyle for its researchers at the urban scale. Each space and mass within the masterplan has been calibrated to maximize day-lighting and the environmental and experiential comfort of the researchers. The design of the masterplan treats the arts as an integral component of the overall design.
The Dynamic Tower sited by not built for Dubai was designed by David Fisher in 2007. The building allows each floor to optimize its orientation based upon environmental or view parameters. That is, a given floor can continually privilege an angle that says minimizes solar heat gain or glare.
The Stata Center at MIT was designed in 2004 by Frank Gehry and houses research groups from the artificial intelligence, computer science, bioengineering, and molecular biology departments. The project served as a testing platform for the holistic and volumetric BIM design approach. The object and sculptural nature of the project succeeds in providing the building's scientists and research groups with a unique identity. However, the design has been plagued with significant leakage issues created by the complicated structure and titanium skin. The deconstructed space of the laboratories also has created problems for the reconfiguration of the research spaces.
Established to research and disseminate information about the Arab world and its cultural and spiritual values. The shutters function as a sophisticated brise soleil. 240 photo-sensitive motor-controlled apertures. To some extent replicates the filtered light of typical Islamic architecture.
//Payette - Theoretical Physics

Infill as technical engine
Treehouse for contemplation and interaction
Wilson Hall, the central research building of the Department of Energy Enrico Fermi Laboratory in Batavia, Illinois was designed in 1967 for a 6,700 acre site to house a powerful synchrotron particle accelerator used by both particle physicists and structural biologists. The project was managed by director Robert Wilson (after whom the building was named). Like the Salk Institute much of the projects success is derived from a strong and clear singular design voice. The overall massing directly references the design of Gothic cathedrals. However, like Bell Labs, the remote suburban location and monumental verticality do not reflect the spatial trends of highly collaborative research organizations.
// Process Models
// 1:200 Model
// 1:200 FinalModel
// 1:75 Final Sectional Model
// 1:75 Final Sectional Model
// 1:75 Final Sectional Model
// Process - Desk Disarray

Summer - August 31, 2013

Design Review 1 - September 12, 2013

Design Review 2 - October 4, 2014

Mid - Review - November 1, 2013

Penultimate review - December 6, 2013  Final Review - December 19, 2013
Reassembling The Laboratory

Design Review 2 - October 4, 2014
Continuous Daylight Autonomy
Envelope Radiation
Cellular 3 Model - Design A
North Elevation - Design A
Perforated Deep Floor Plate - Design A

Typical Section - Parking Level At Water Edges

Programmatic Specialization

Massing Strategies
Alexander Forley

Site Documentation
Alexander Forley
Searchscapes: Reassembling the Laboratory Module

Mid - Review - November 1, 2013
Penultimate review - December 6, 2013
Laborlandschaft: Redesigning the Industrial Laboratory Module

Abstract

Final Review - December 19, 2013
Final Review - December 19, 2013

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