

ADAPTIVE ARCHITECTURE IN A REGENERATIVE MEDICINE RESEARCH FACILITY

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ADAPTIVE ARCHITECTURE IN A REGENERATIVE MEDICAL RESEARCH FACILITY

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By

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ABSTRACT

The proposed regenerative medicine facility, in downtown Rochester, MN is the platform for investigating how a building can adapt with the expansion of human knowledge. The realization of adaptability in architecture can provide an increase in the lifespan of a building. Numerous benefits are achieved in this architectural process, which include a lessening of a building's environmental impact, client profitability, and the facilitation of continual knowledge growth. The design provides space for explorative and collaborative research into growing human organs and tissues.

keywords:
adaptability, regenerative medicine

statement of intent

PROBLEM STATEMENT

How does the growth of human knowledge impact the longevity and usefulness of a building?

TYPОLOGY:

A regenerative medicine research facility. The National Institute of Health defines regenerative medicine as “the process of creating living, functional tissues to repair or replace tissue or organ function lost due to age, disease, damage, or congenital defects” (Hunziker, 2010).

CLAIM:

Architecture that responds adaptively to human knowledge growth will increase the usefulness and longevity of a building.

SUPPORTING PREMISE:

The human knowledge base is directly related to Moore’s rate of technology growth (Hiremane, 2005).

Architecture is not permanent.

The life-span of a building is directly related to how well the space can be adapted for future, unpredictable use.

Increasing the longevity of a building lessens its environmental footprint.

THEORETICAL PREMISE:

Architecture must adapt to change. This ability to adapt, to the current context in which it is used, plays a significant role in a building’s lifespan. With an ever-increasing demand for cures to chronic illnesses, adaptable architectural solutions are needed to further medical research.

PROJECT JUSTIFICATION:

With an aging population, regenerative medicine is a timely issue that must be faced. In recent years, the Mayo Clinic announced that one of their major focuses of emergent research is regenerative medicine (Hansel, 2010). Also, the Mayo Clinic has recently allocated funds to develop their Center for Regenerative Medicine in Rochester, MN. To accommodate this, and future research, an architectural solution that will fit their needs for generations is needed.

proposal

NARRATIVE

When does a building lose functionality? Is there a correlation between functionality and knowledge? Architecture needs to adapt to numerous programmatic needs within a lifespan of a building.

Many factors contribute to the longevity of a building, however, poor design choices should not prematurely age a building. A building needs to simultaneously adapt to current demands while allowing for a “plug-and-play” functionality.

Recently, I became aware of the possibilities and the implications of regenerative medicine. Researchers are able to create organs in a laboratory and transplant them into a patient with a chronic illness and/or disease. It is not a question of *if*, it is a question of when regenerative medicine will impact society in the future. With an increasing life expectancy, many people face issues with organ failure, disease, and/or trauma. The research conducted will ease the impact of being placed on long wait lists for organs or tissues that will save their life. I have no background in medical sciences; however, my deep interest lies in the instinctive nature of humans to implement solutions for altering their future through technological advances.

Regenerative medicine is an ideal platform for exploring how the expanse of human knowledge database relates to architecture. Laboratories are chiefly static in nature, unable to easily change. Permanence in laboratories stems from the

need for expensive/specialized mechanical equipment, standard furniture, and repetitive, defined spaces. Adding avenues for adaptability to design solutions will add to the usefulness and ultimately the lifespan of the proposed building.

Regenerative medicine is controversial. Typically, human embryos are used to obtain the stem cells that are needed for research. Another methodology that is being explored is using adult stem cells which are reprogrammed back into specific organs/tissues. The Nobel Prize in Physiology or Medicine this year was awarded to Sir John B. Gurdon and Shinya Yamanaka for their work in the later method for stem cells extraction that has a significant impact on regenerative medicine (Nobel, 2012).

The Mayo Clinic recently dedicated significant resources for their Center for Regenerative Medicine in Rochester, MN. The financial backing needed for the expansion of research and facilities has a high potential for a substantial return on investment. The Mayo Clinic stands to be the pioneer in the field of regenerative medicine.

This is just the beginning for regenerative medicine. There is still an abundance of research to be done. Architects have the responsibility to create adaptable spaces which facilitate space for answering scientific questions. The architectural response will impact generations of scientists and the public.

USER/CLIENT DESCRIPTION

OWNER:

The owner of this project will be the Mayo Clinic in Rochester, MN. The client will be staffing the facility and maintaining the building and the grounds.

USER(S):

The primary users of this facility will be researchers/employees of the Mayo Clinic. These users will require laboratory space, offices and high-tech equipment. There is an assumption that these individuals would work on an 9-5 basis, with the possibility of late nights.

This building may be used by the Mayo Clinic as a vehicle to inform the general public, outside scientists, and students about the implications and new knowledge discovered in the field of regenerative medicine. Seminar space and direct visual access to a research lab are vital to this program.

MAJOR PROJECT ELEMENTS

LABORATORY:

location for hands-on research/experiments

OFFICES:

individual spaces for scientists/researchers

COLLABORATION SPACE:

critical location where discussions about research taking place

MECHANICAL

PARKING:

not feasible underground for a laboratory building, but underground parking will be available under non-research space.

SEMINAR ROOMS:

space for the public or outside medical teams to listen to lectures about the process of regenerative medicine and what the Mayo Clinic is currently investigating.

MEETING SPACE:

researchers/scientists will be able to discuss their findings with investors or their supervisors



Figure 1: *Minnesota*. Retrieved from maps.google.com

SITE INFORMATION

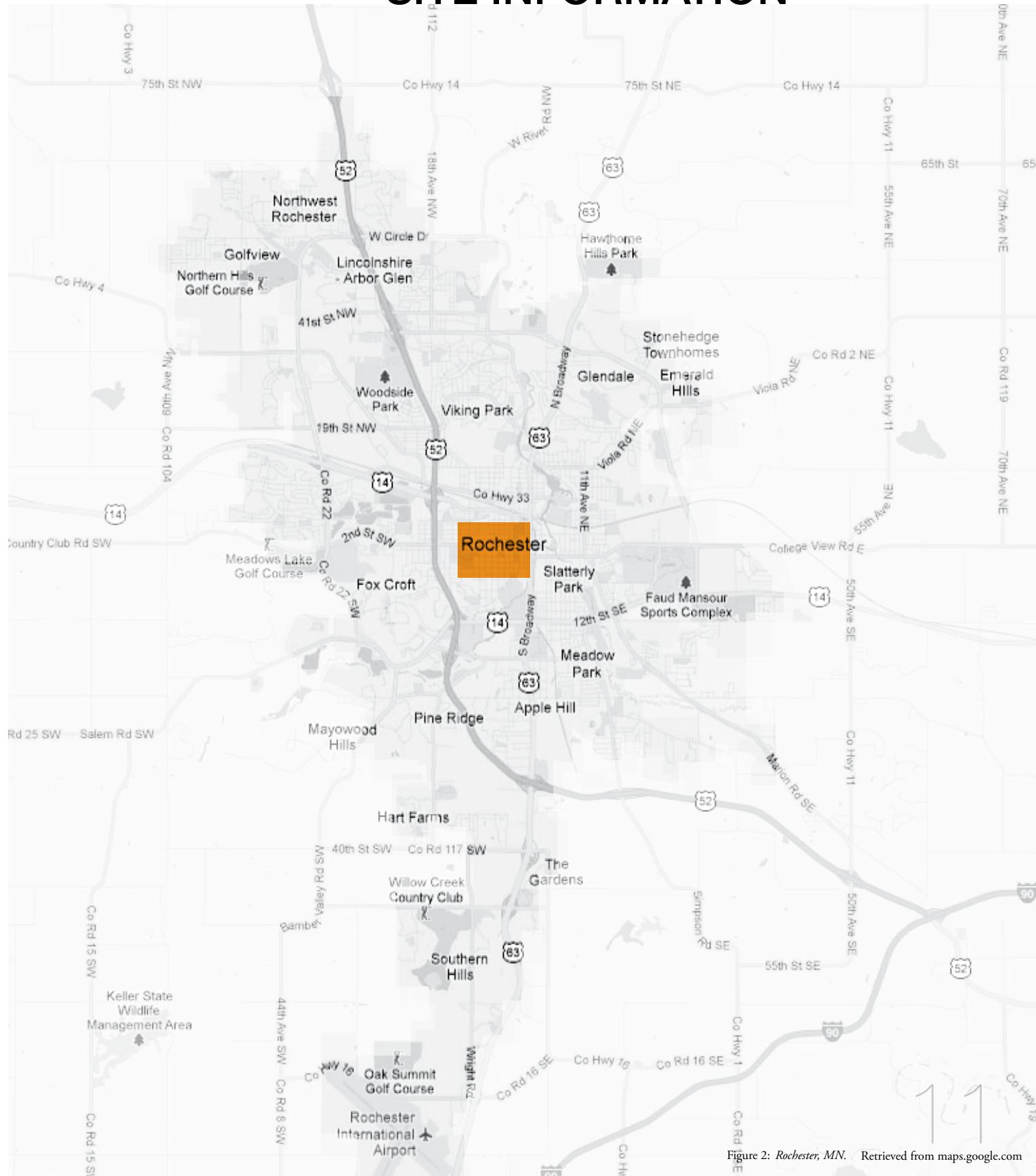


Figure 2: Rochester, MN. Retrieved from maps.google.com

The new regenerative medicine facility for the Mayo Clinic in Rochester, MN is located two blocks south of the Mayo Clinic's main facility, the Gonda building. The selected site is in the medical research and education zone of downtown Rochester's future zoning map ("Downtown rochester: master," 2010). Positioning this new laboratory within this zone is critical for collaboration between various medical research disciplines.



Figure 3: *site selection*. Retrieved from maps.google.com

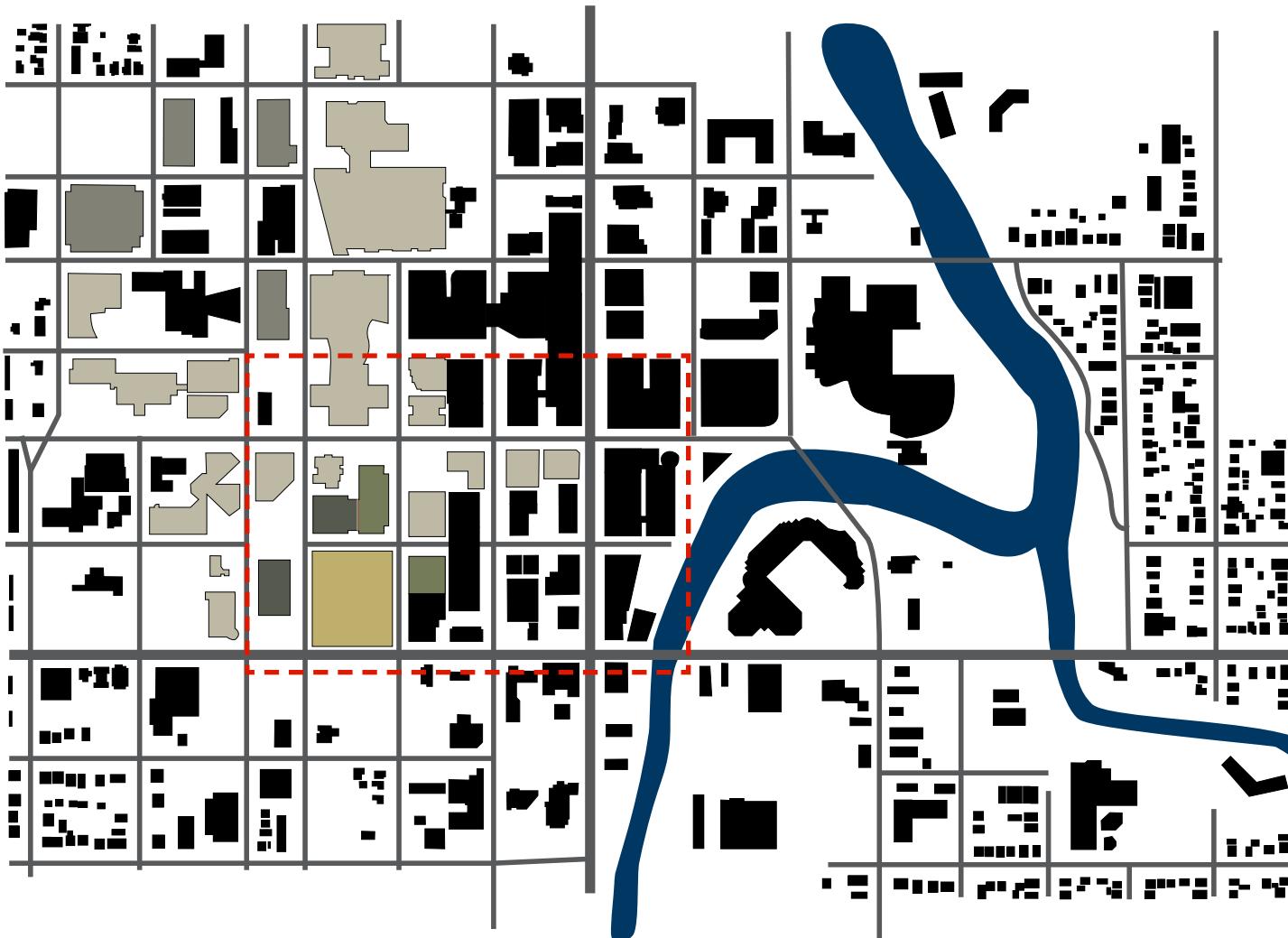
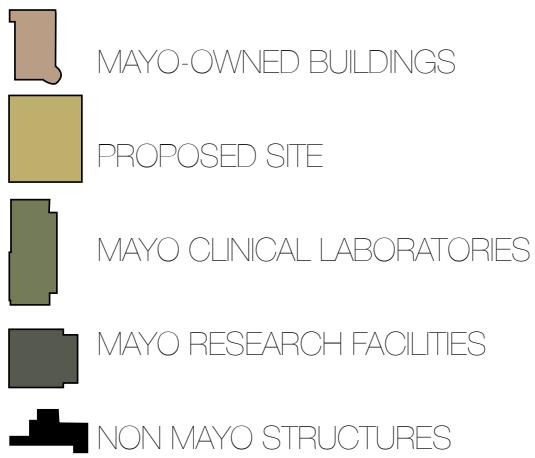


Figure 4: Rochester downtown figure ground. Retrieved from maps.google.com

PROJECT EMPHASIS

Exploring how the growth of human knowledge affects architecture. How can architecture adapt to new, unforeseeable situations?

PLAN FOR PROCEEDING

RESEARCH DIRECTION:

Research will be conducted on the theoretical premises of biomedical research, the Mayo Clinic, typology history, historical site information, site analysis, and programming.

DESIGN METHODOLOGY:

The design methodology will employ quantitative and qualitative analysis, graphic analysis, digital analysis, and programmatic analysis. Research will follow the Concurrent Transformative Strategy, which is guided by the theoretical premise/unifying idea.

DOCUMENTATION:

Documentation will be provided in the form of photos, sketches, writing, and research. Weekly, the data will be stored and compiled online for scholars to follow. It will accessed for final presentations.

SCHEDULE



Figure 5: spring semester schedule

program

THEORETICAL PREMISE RESEARCH

THEORETICAL PREMISE:

Architecture must adapt to change.
This ability to adapt, to the current context in which it is used, plays a significant role in a building's lifespan. With an ever-increasing demand for cures to chronic illnesses, adaptable architectural solutions are needed to further medical research.

Charles Darwin proposed, “the problem of survival always depends upon the capability of an object to adapt in a changing environment” (Zuk, 1970). Architecture needs to adapt to constantly changing environments and uses to allow for continued usefulness. Recently, buildings have been perceived to contain a high permanence value, contrary to the idea that the context in which a building is placed in is never static. Knowledge growth is fundamental in today’s society and contributes to the world’s altering context. This growth places a strain on the built environment; this strain can be alleviated by planning for flexibility.

KNOWLEDGE GROWTH

The rate of knowledge growth is not directly measurable. There are many components that contribute to the growth of knowledge. Three specific factors possibly attribute to this change may be people, technology and problem solving.

The growth of knowledge depends on an interactive process with numerous actors. Specific knowledge gain usually cannot be sourced back to how hard a single individual tried, but more often the contributions of a collection of people. Knowledge depends on “not only how hard people are trying, but also on the differences in what they know: if all of us know the same thing, we cannot learn from each other” (Jovanovic & Rafael, 1989). Therefore, it is important to recognize knowledge growth as a collaborative process.

Technology and knowledge are inseparable. Moore’s Law is a trend that was discovered by Gordon Moore in 1965. The

law states that the number of components used in integrated circuits will double every two years. At the time of his published paper, he observed this trend from the years 1958-1965, but he predicted that this trend would carry at least ten years into the future. The law is still accurate to this day. This almost perfect nature of this law stems not necessarily from the law, but from the actors in the technology industry. Since this trend was discovered in 1965, companies have used Moore's Law to meet expectations. The industry sets goals to meet this annual doubling of circuitry and if they are falling behind on expectations, they ramp up research to meet their goal. There is a debate among scientists and futurists alike that at some point Moore's Law will not be applicable because the technology will reach its singularity (Kurzweil, 1999).

Ray Kurzweil, a futurist, has tracked the recent evolution of computers and noticed that once a technology has been developed to its fullest potential it is replaced by a new technology. He has proposed that Moore's Law may reach a singularity, but a new technology will replace it (Kurzweil, 1999).

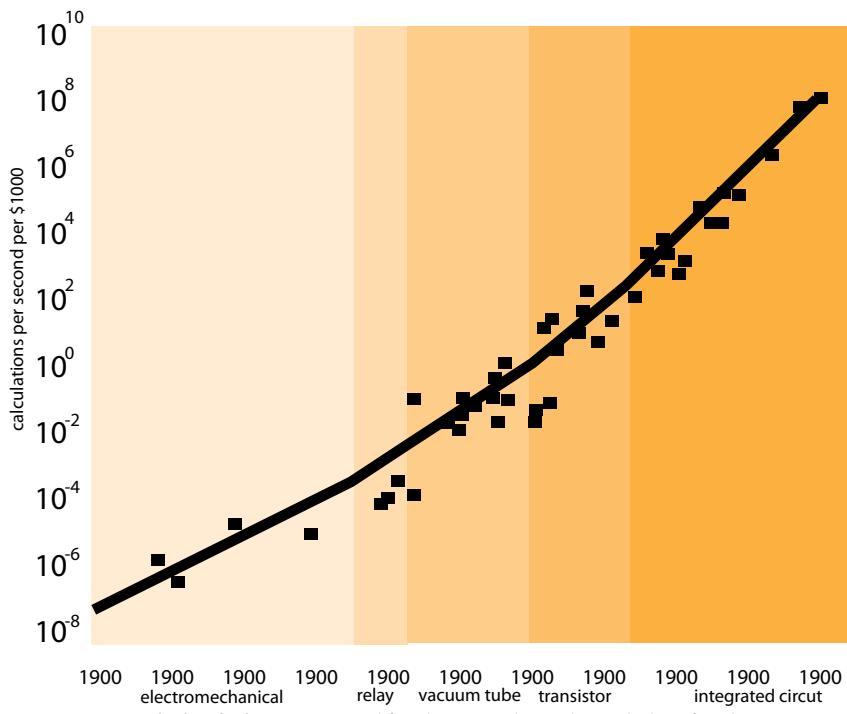


Figure 6: Technology development. Retrieved from <http://www.kurzweilai.net/the-law-of-accelerating-returns>

While Moore's Law appears only applicable to integrated circuit development, it has an farther reaching importance. Technology growth impacts the growth of human knowledge, and vice versa. Most new technologies are not the result of a spontaneous solution. Rather, knowledge is compounded for many years to culminate into a new technology. The invention of the personal computer follows this logic. Technologies to build the computer were first invented in the 1950's and it was not until the 1980's that the first personal computer was available to the public (Jovanovic & Rafael, 1989).

This trend is important to investigate for this thesis. It establishes the concept that there is an exponential growth in technology and knowledge. Buildings need to respond to the changes in program due to knowledge and technology growth in order to remain useful.

ADAPTABILITY IN ARCHITECTURE

Adaptability in architecture is not a new concept. Historically, architecture and adaptability were one in the same. Most primitive housing was able to shift, move, and be recycled. It is only recently that a trend towards permanence developed. Research laboratories are greatly benefited from the realization of diverging from permanence towards a new flexibility.

Architecture of the past developed in direct relation to the creative nature of humans. Humans were able to use architecture as a problem solving method to fit their current needs. This flexible nature of primitive buildings was vital to the survival of the human species. Mobility and adaptability were necessary with limited building resources, moving with animal herds, and surviving long, harsh winters (Kronenburg, 2007).

The history of flexible architecture has diminished over time as more specialized programs have been demanded by the population. One of the first building typologies set in permanence were religious structures. The specific rituals that were conducted required a very specific program. The

religious structures of the past were lavishly detailed with no expense spared in their creation. Robert Kronenburg, in his book *Flexible: Architecture that Responds to Change*, states, "...it is these permanent, static structures that have created the legacy that, until recently, has formed the main source for architectural history" (2007). In *Kinetic Architecture*, William Zuk suggests that most of architectural history classes present buildings that are of a permanent nature, such as churches and monuments, which have endured centuries. Zuk believes this teaching process is what contributes to much of the architect's motive to be a monument builder (1970).

"Architecture has traditionally been perceived as enduring, permanent structures. For centuries the architect has aspired to permanence...[T]here is little consideration given by the architect or the client to the life of any building other than to assume that it will always stand" (pg 4).

Since the Industrial Revolution, the population has seen an increasing sense of mobility -- especially in the forms of communication and transportation. This change in human activity has had little effect on architecture. Architecture is still mostly regarded as static and monumental. Kronenburg suggests, "The reason is circumstantial and, it would seem, has more to do with recent economic cultural history than with the character of how human personality or the responsive requirements that we can now identify in contemporary architecture" (2007).

The context in which a building is set is not static. It is sometimes perceived that the backdrop to a building, i.e. surrounding buildings, roads and services, are immovable or will never change. However, buildings are torn down, roads are re-routed and services are upgraded. This change within a particular site can be linked to the changing context of the social environment. Society is set in perpetual change, which usually facilitates progression and improvement (Kronenburg, 2007).

The population has adapted to living and working in environments that are static and unable to change. “They are built to the lowest common denominator for (apparently) standardized people, carrying out standard functions” (Kronenberg, 2007). If progress is to be made, users of a building must not be inhibited by the space around them. In Schneider and Till’s book, *Flexible Housing*, they cite Mies van der Rohe as an example to support this theory. Most of Mies’s buildings were supported by outside walls and a minimal amount of columns, placed on a grid, to facilitate a highly flexible use (2007).

If it is essentially economic influences and capital gain that are prohibiting adaptable change, what can break this cycle? Legislation and cultural views may sway investors toward an adaptable future. People are increasingly aware of our impact on the environment. The public is demanding a shift in our sustainability practices and promoting legislative reform on how buildings should perform. To meet these high-performance demands, clients and designers are looking towards increasing the lifespan of their buildings (Kronenburg, 2007).

Humans seem hard-wired to adapt and change to altering circumstances. We are fundamentally problem solvers and it is within our ability to create new built landscapes that foster change. When defining flexible architecture, Kronenburg says, “This is architecture that adapts, rather than stagnates; transforms rather than restricts; is motive, rather than static; interacts with its users rather than inhibits” (2007, pg. 10).

DESIGN SOLUTIONS FOR AN ADAPTABLE LABORATORY

Research laboratories require a set of specialized spaces with a requirement for expensive mechanical, electrical and plumbing services. These requirements lend themselves to static objects without the possibility of adaptability. The main exploration in this thesis is how far flexibility can be pushed in an extremely specialized program.

Laboratory spaces are a large investment for the client. They must be able to adapt to future generations needs and values

with the least amount of fiscal impact on the client. Daniel Klaus, in his book *Low Tech, Light Tech, High Tech*, speaks on the importance of this utility value (1998).

'Optimizing user values' means creating values for the users in consideration of future requirements, targeting investment to this end. At any rate, securing utility and thus profitability must be the main goal of each investor, who is therefore intent on creating buildings with the highest utility value - and the longest possible life cycle (Daniels, 1998).

If laboratories are designed to meet the needs of only the current user, the next group of scientists will not be able to perform to their highest level. It is costly to purchase new laboratory furniture and a burden to store the old furniture. Designing at a "generic" level ensures that the next set of users can comfortably investigate scientific questions (Griffin, 2005).

Klaus Daniels also outlines a way in which the services of a generic building may be thought of to meet the needs of new uses. He suggests that the "basic fit-outs" of a building are heating, water supply and disposal and electrical supply. In the book, *How Buildings Learn*, Stewart Brand discusses how building should not be thought of as a single unit; they are comprised of many layers. Brand cites Frank Duffy, former president of the Royal Institute of British Architects, as saying, "Our basic argument is that there isn't such a thing as building. A building properly conceived is several layers of longevity of building components." These layers can be thought of as the "shell, services, scenery and set" (Brand, 1994). In figure 7,

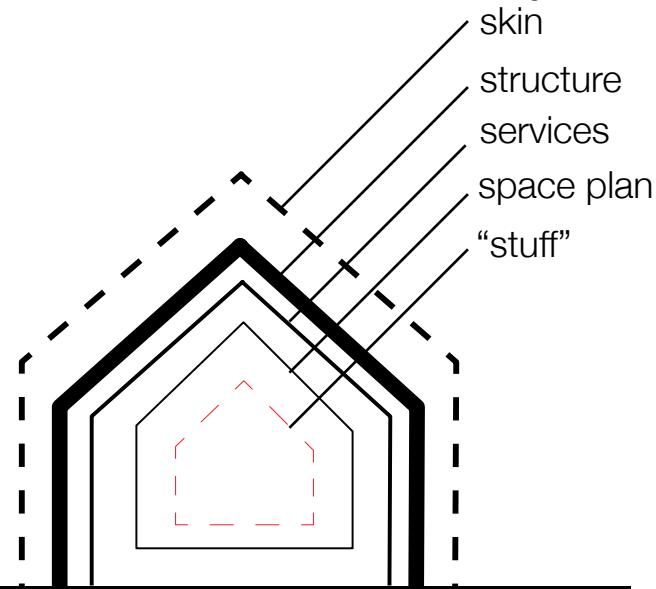


Figure 7: Building's layers. (Brand, 1994 pg. 13)

Brand "peels" apart the layers of a building (1994).

Brand expands Duffy's four S's into site, skin, structure, services, space plan, and "stuff." According to Brand, the structure of a building is able to survive as long as 300 years if the services of the building are not embedded too deep to replace, thus requiring demolition.

Laboratories can benefit from the layered building approach. The Eli and Edythe Center for Regenerative Medicine on the University of Southern California (USC) campus is a great example of the benefits of this approach. The center benefits from the inherent flexibility of the mechanical and structural system. The narrow depth of the building decreases the need for columns; therefore, the research space is open to allow for altering needs (ZGF, 2010). The mechanical system (heating and cooling) utilizes chilled beam technology thus reducing ductwork and even heating and cooling in all areas. The outer layers are well designed to allow flexibility within the space plan and furnishings.

A team of visionaries for the laboratory help to facilitate the design process for architects. They suggest what the laboratory may be doing in the future and what space will be required for this new function. However, it is still important to get feedback and to collaborate with current laboratory staff (Griffin, 2005).

LIFESPAN

In our current information-driven society, buildings must be planned with maximum efficiency. Klaus Daniels states in his book, *Low-tech, Light-tech, High-tech*, "The lifespan of buildings will have to be specifically planned for, with an absolute minimum of material expenditure, a minimal consumption of "grey energy" and a maximum of recycling" (1998). He suggests that we will remain a society set in real life, not virtual reality, because social interaction and innovation would be nonexistent. A building must be flexible enough to see several usage cycles throughout its lifespan (Daniels, 1998). The usage cycles in question need not be a total typological shift. Specifically, for a research laboratory, these usage cycles may be that the architecture needs to accommodate every new generation of scientists and/or new investigations.

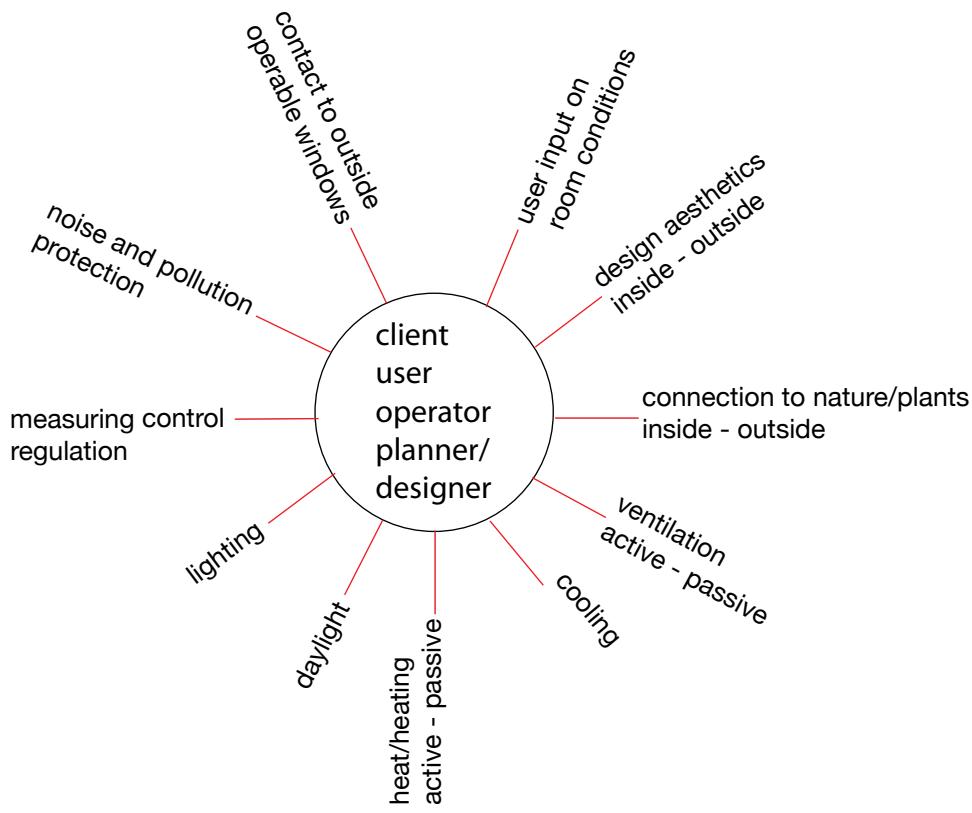


Figure 8: *Client needs.* (Daniels, 1998 pg 219)

Generally, clients have a set of needs that influences the longevity of a building. Figure 8 demonstrates the basic needs of clients and occupants would utilize to judge the usefulness of their building. Daniels has also developed what he calls a “Product life-cycle concept”. This concept breaks down the possible phases a building goes through during a typical lifespan (Daniels, 1998).

- Shell cycle, lasting over 50 years
- Building envelope, lasting over 30 years
- Technical fit-out (general), lasting over 10 years
- Fit-out of information and communication tools, lasting over 5 years

Inevitably, most buildings will be demolished. Why are buildings terminated? Many factors contribute to their end. Jennifer O’Connor, a research scientist, for the Forintek Canada Corp, conducted a survey to find what leads to the demolition of buildings. She chose the cities of Minneapolis/

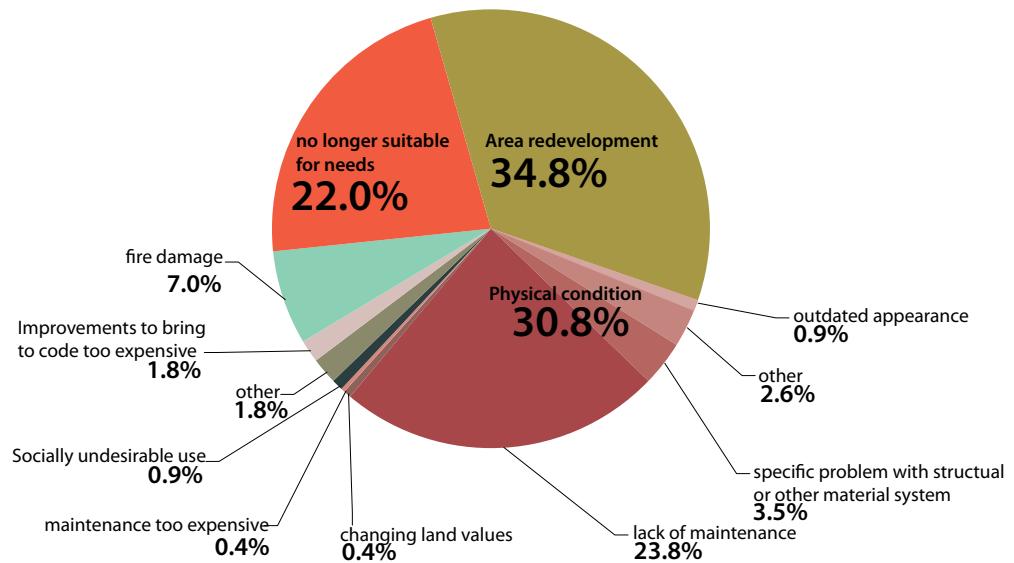


Figure 9. Reasons for demolition of buildings, 2004)

St. Paul and surveyed the owners of the buildings that had demolition permits.

Surprisingly, almost a quarter of the buildings surveyed were torn down because they did not fit the needs of the occupants. The other interesting percentage is the lack of maintenance that contributes to the diminished longevity. Architects can play a role in either reducing maintenance required or making this task easier (O'Connor, 2004).

The study also found that there was little to no connection between the structural system used and longevity. On average, many of the wood buildings that were surveyed actually had the longest lifespan (O'Connor, 2004).

ENVIRONMENT

“[...] the capacity to accommodate change could be the most important factor in determining economic efficiency and performance in sustainability terms” (Kronenberg, 2007).

Adaptability in architecture is a sustainable approach to design. If buildings were to survive twice as long as they currently do, there would be half as much construction and demolition waste (Organisation, 2003). By allowing a building to easily transform to the needs of the current users, the building could be in use longer. Predicting the longevity of buildings can be measured in three distinct ways (2003).

1. Durability -- how long the structure will survive under normal conditions.
2. Maintenance -- proper maintenance of mechanical systems.
3. Adaptability -- “[...] buildings will be used for longer period of time only if they can be adapted to other or new needs.”

The methodology for “Green Building” must take into consideration the future inhabitants of the building. It is a limited view to just consider materials and passive systems (O’Connor, 2004).

The sustainability of buildings are about the adaptability of the space and the materials. Materials that are adaptable to new buildings are also of high importance. For example, if a material in a building is used that has low embodied energy but has to be replaced every year does not make sense from a sustainable stand point. Materials that have a higher embodied energy that are used in a building may exceed the life span of a building. These materials may be adapted to fit into a new structure, like a masonry unit or reclaimed wood (O’Connor, 2004).

THEORETICAL PREMISE RESEARCH SUMMARY

If a building is to remain useful to its inhabitants, it must be able to be realized in multiple usages. Future buildings users will require unforeseeable “fit-outs” to accomplish their tasks in answering life-saving medical questions. It is a designer’s and client’s task to create a space that will last longer than a typical building’s lifespan of 50 years in order to save money, reduce environmental waste and energy, and for user comfort.

Knowledge growth is a continual process that has no end. Knowledge and technology growth have a cyclical relationship and compound on each other. The collaborative process is an essential building block of this progress. It is imperative that a medical research building has spaces in which scientists and researchers have a common space to foster the exchange of information.

The history of adaptable architecture dates back to some of the first structures. As humans developed a need for more specialized functions, such as churches, the monumental nature of architecture appeared. As William Zuk said, generations of architects have been trained to idolize these monumental structures and are designing without the realization that the buildings have an “expiration date.”

It is important to note the limitations of flexible buildings. They must still exude a sense of stability, create meaning and establish purpose. Kronenburg (2007) summarizes this as -

Though change is driving [a building's] development, it must still respond in a balanced way to the constant theatres in which human activity takes place - in our private and public lives, at home and in the community - each of which contributes to our sense of how we dwell in the world (pg. 19).

Laboratories can directly benefit from implementing adaptable strategies. This typology of buildings require large fiscal

investments. Adaptability is essential in laboratory buildings because of the large amount of fiscal investment that is required. Strategies to attain flexibility may come about by creating easily convertible mechanical systems, such as chilled beams; a structured grid, void of columns, to allow for changing needs; and structural systems that are well designed to last longer than 50 years. If a building is looked at through Stewart Brand's layered approach, it seems within reach to construct a structural system with an open space plan to alter to changing needs. Mies van der Rohe was a recent pioneer in this strategy where most of his buildings were supported by the exterior with minimal columns in the interior.

Lifespan of buildings can be increased by adding flexibility to spaces. Jennifer O'Connor's survey of why building owners demolished buildings found that almost a quarter of buildings were demolished because they could no longer meet the demands of the client. It is helpful to lay out the phases of what a building might go through, whether this is a technical fit-out change or a fit-out of new communication tools. Adding to the lifespan of buildings is not only potentially profitable for the client but also the environment.

The application of adaptability in architecture benefits the environment. With a longer lifespan realized by these new, flexible buildings there is the potential for reducing landfill waste and for reducing energy expediter. Highly adaptable buildings, with consideration to the environment, may even be constructed of adaptable materials. It is one thing to choose a material due to its low-embodied energy, but if it has to be replaced frequently, it could add up to more energy expenditure. It may be a better approach to select materials that can be transplanted to new structures so they can realize a longer lifespan than their original buildings. These materials may be masonry units or reclaimed wood (O'Connor, 2004).

With our changing society, we are at a pivotal moment in architecture. It is within reason to demand from buildings a sense of adaptability and change. We must not forget the limitations of flexibility and continue to create buildings that are deeply planted in the context of which they are designed, but also realize the building will be set within many contexts during its lifespan. These context shifts may be partly due to the continual increase in human knowledge.

THEORY + TYPOLOGY

When a scientist is in the lab constructing an organ, he/she creates a scaffolding of an organ and applies the patient's cells to this framework. Once the new organ is transplanted into the patient this framework created by the scientist slowly disappears and the body takes over. Such as a scientist develops this framework, an architect can design a framework for a building that satisfies the programmatic requirements now, but when placed into the client's hands the building can learn, transform, and grow to fit their needs, while the framework is allowed to disappear.

CASE STUDIES

COLLABORATIVE

ELI AND EDYTHE BROAD CIRM CENTER
FOR REGENERATIVE MEDICINE RESEARCH
LOS ANGELES, CA

AUTHENTIC

METLA FOREST RESEARCH CENTRE
JOENSUU, FINLAND

PERMANENCE

SAINSBURY LABORATORY
UNIVERSITY OF CAMBRIDGE
CAMBRIDGE, UNITED KINGDOM

COLLABORATION

ELI AND EDYTHE BROAD CIRM CENTER FOR
REGENERATIVE MEDICINE AND STEM CELL RE-
SEARCH AT USC

PROJECT TYPE

Regenerative medicine and stem cell research

LOCATION

University of Southern California

SIZE

91,485 square feet/5 stories

COST

\$65 million

FLOOR-TO-FLOOR HEIGHT

16'

MATERIALS

Black granite

Stainless Steel

Glass

Flagstone

CONSTRUCTION METHOD

concrete flat plate floor slab, supported by reinforced concrete columns and walls

The CIRM facility is chosen for its context and typology. Being a building dedicated to regenerative medicine research it was of particular interest. The campus of USC is much larger than that of the Mayo Clinic's campus, but the CIRM facility has a clear interaction with buildings around, that are all owned by the same institution. USC also built this facility as a hub for collaboration between scientists at different facilities scattered around the site.

information from ZGF Architects zgf.com



The San Pablo Street elevation reveals the sloped site. Mechanical spaces were placed in a partially submerged end of the building to maximize natural light in the lobby, the offices, and the 1,000-square-foot

PHOTOGRAPHER Nick Mamack © Hochricht Blessing

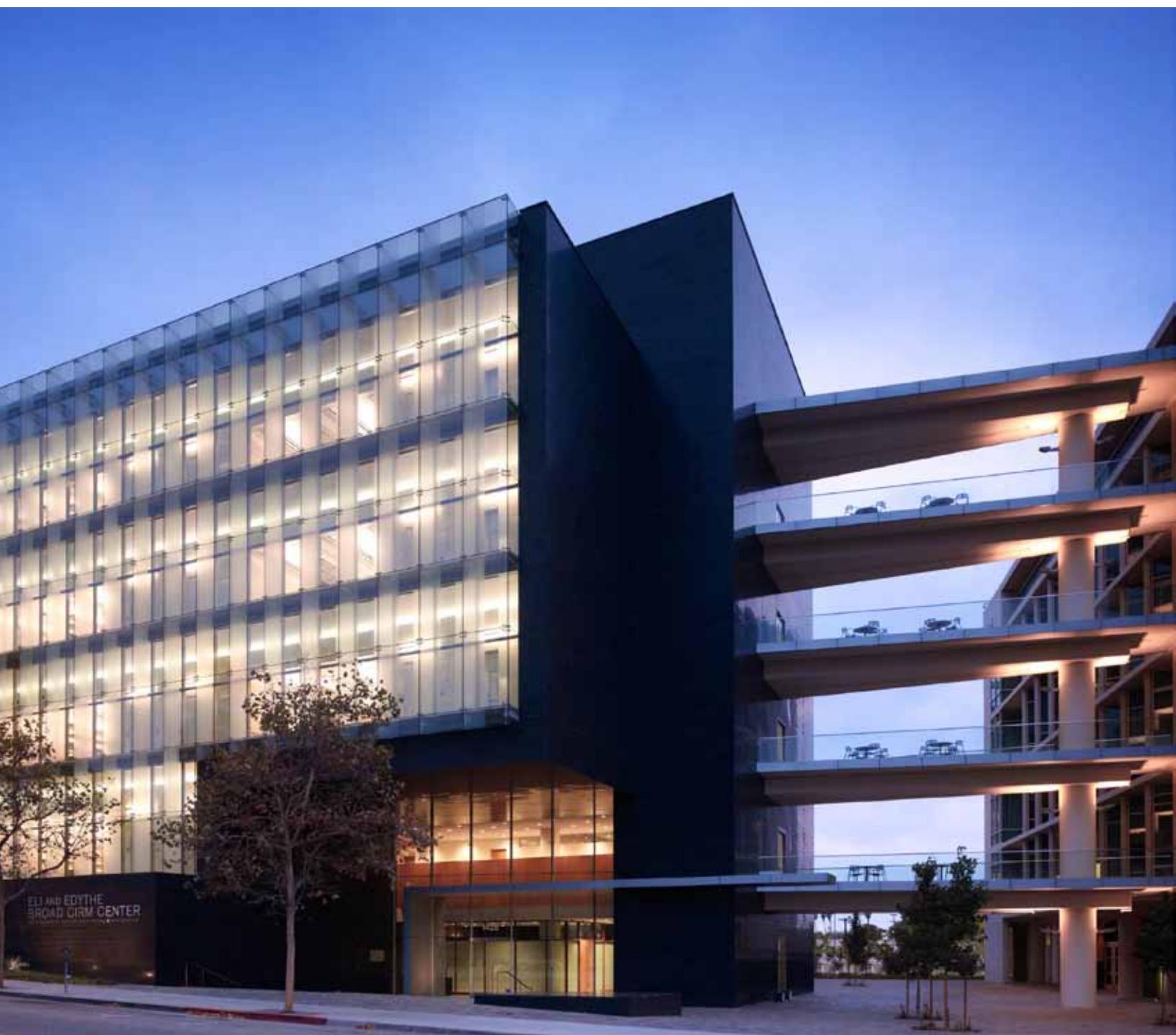


Figure 10: *Eli and Edythe Broad CIRM Center*. Retrieved from zgf.com



Figure 11: CIRM interior. Retrieved from zgf.com

The CIRM Center's design objective was to create unique and new discoveries inside, just as in science. The program is broken up into private and public space. The first floor is mostly public space with a large, 100 person, seminar room and a reception area. The second through fifth floor is dedicated open lab space. The public does not have viewing access to the laboratories. Common spaces are scattered throughout the top floors to accommodate interaction between scientists across all disciplines. Flexibility is important in this design. Laboratory benches are configured in such a way to allow an easy conversion between "wet and dry" (ZGF, 2010).

The CIRM Center is located in the center of the main research facilities on the University of Southern California's Campus. This requirement furthered the need to increase flexibility and provide ample collaboration space. No columns are used inside the research laboratories, which increases the flexibility of the spaces. This structural configuration allows for no obstructions between the lab desks and allows for no visual noise (ZGF, 2010).

Sustainable design was implemented throughout the CIRM Center. The majority of the east facade is composed of a double skinned wall, which also acts as a privacy barrier into laboratory space. The solar gain on the west side is controlled through vertical fins. The space is cooled by a chilled beam system. Flexibility was one of the main driving factors for selecting this system (ZGF, 2012). ZGF states many reasons, "The use of chilled water, rather than chilled air, as a means to remove thermal loads from the laboratory, reduces ductwork sizes, air handling sizes, fan energy, and potentially the floor-to-floor heights" (ZGF, 2012).

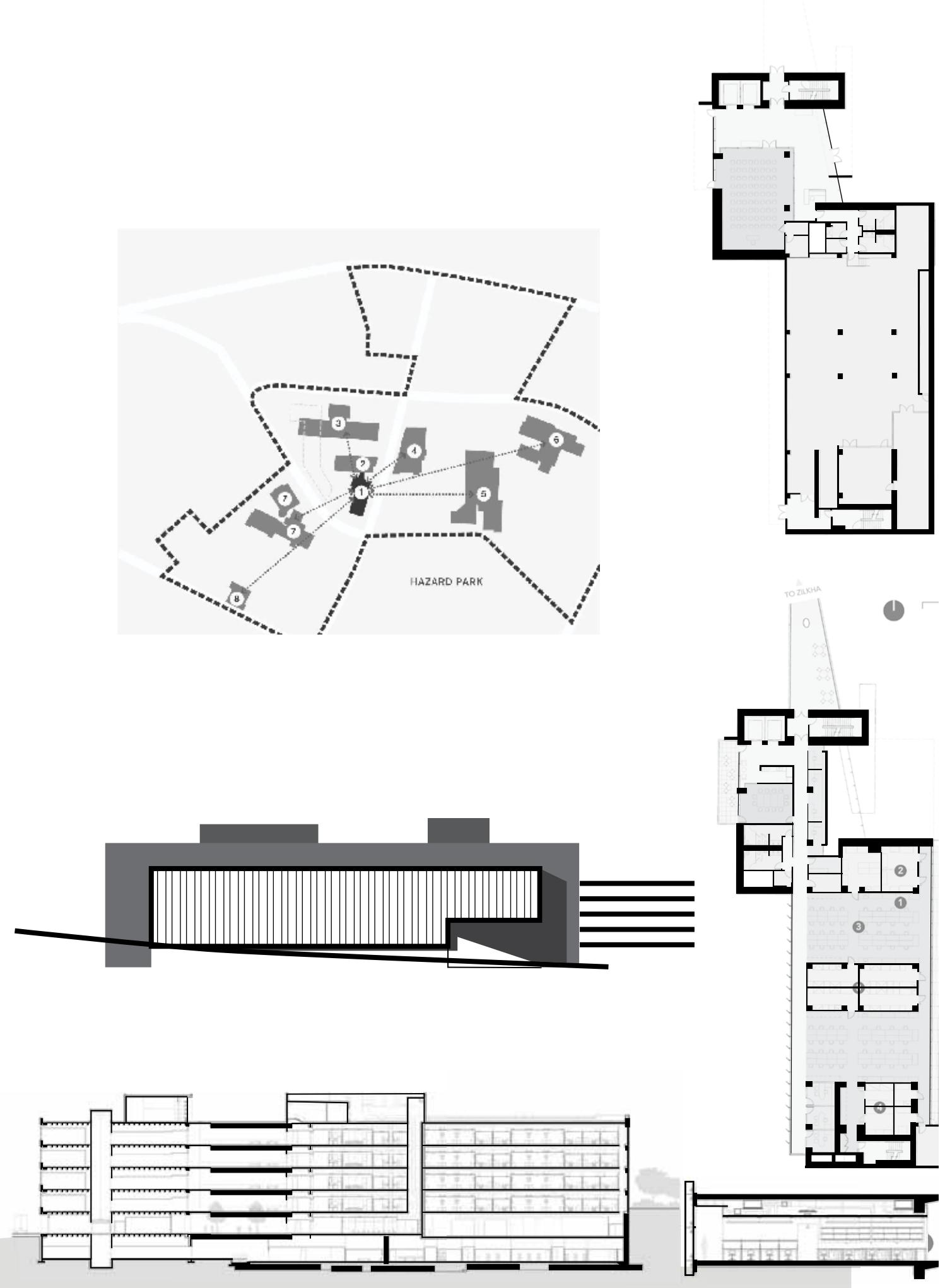


Figure 12: Eli and Edythe Broad CIRM Center drawings. Retrieved from zgf.com

This case study is the tallest at five-stories above ground and one below ground. The basic floorplan does not change on any of the floors. This may help in creating an expected layout for the scientists that conduct research on multiple floors.

The building is very compact in width. This allows for a lot of natural light to get inside. There are light control systems on the windows to reduce glare and avoid excessive heat gain.

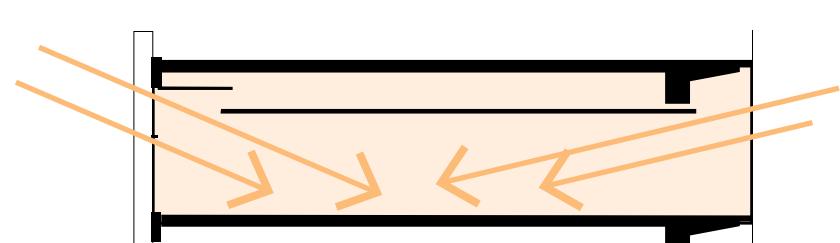
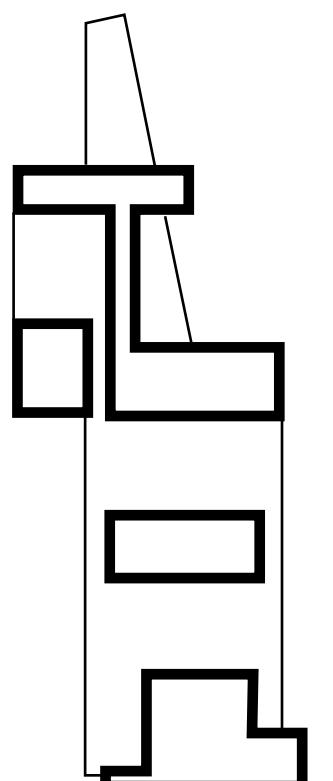
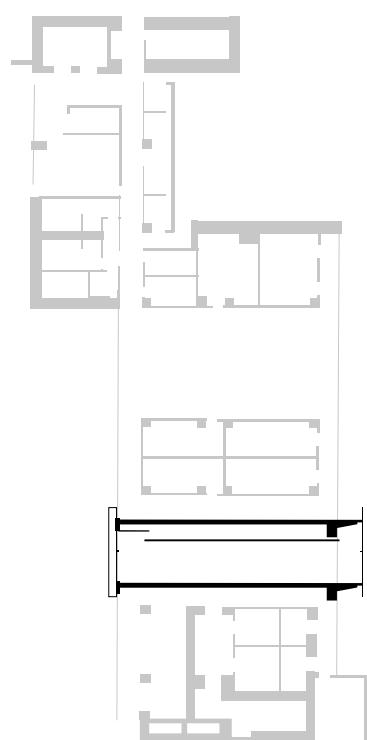
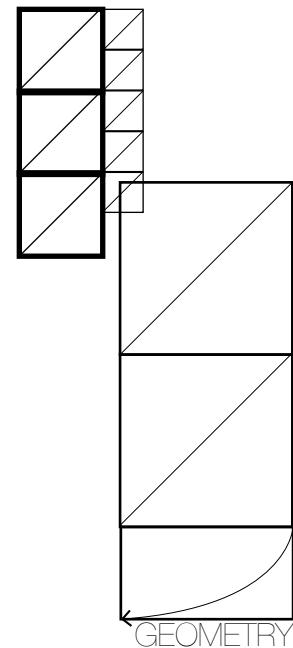
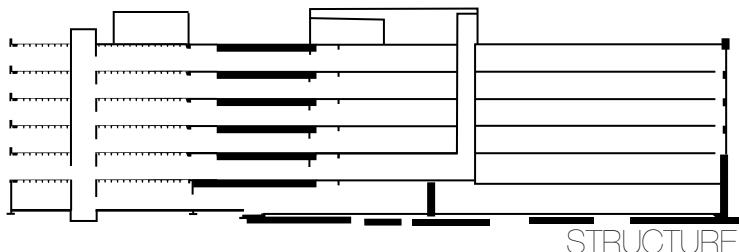


Figure 13: Eli and Edythe Broad CIRM Center analysis.

AUTHENTIC

METLA FOREST RESEARCH CENTRE
JOENSUU, FINLAND

PROJECT TYPE

Forest Research Centre

LOCATION

Joensuu, Finland

SIZE

82,343 square feet

MATERIALS

Wood

Glulam fir-ribs

Fir planks

CONSTRUCTION METHOD

Wooden column-beam-slab system

The METLA Forest Research Centre was chosen for investigating the innovative use of materials, building configuration and flexibility. The grid system for movable walls and ability to change the exterior were of interest. Building a research center on the Mayo campus made almost entirely out of wood would not be appropriate, but the METLA building reinforces the concept of fitting a building into its context.





Figure 14: *METLA Forest Research Centre exterior*. Archdaily. Retrieved from <http://www.archdaily.com/15951/metla-forest-research-centre-sarc-architects/>

The METLA Forest Research Centre in eastern Finland is a proving ground for the use of wood construction in a large scale building. One of the many areas of research METLA conducts is using wood in innovative ways. This is the first modern wood building in Finland. It is also the first building of this size to use a wood column-beam-slab system.

The building is laid out in a concise 7.2 m grid for flexibility. There are supplementary grids that are set at 1.2 m. This secondary grid allows for the addition of movable walls and facade changes. For additional flexibility the laboratories are placed on the ground level. This placement also helps control the dampness the lab produces as to not disturb the wood structure.

The METLA facility, in relation to scale, ties in harmoniously with the neighboring structures. The wood material selection is what makes it unique. The interior courtyard to offer protection from the wind. The interior courtyard is largely dominated by a unique conference room that breaks up the rectilinear pattern of the building. It is a representation of a boat that has capsized.

This new facility was constructed to accommodate a growing staff that was not able to work efficiently in their previous location. Currently, the research institute can employ up to 170 people at a time.

Inside the entry space, among the tree-like columns, visitors are granted views into the research space. This view is also accessible from the conference room located in the middle of the building. This relationship seems beneficial during conferences so there is a direct link between research discussions and research implementation.



Figure 15: METLA Forest Research Centre materials. Archdaily. Retrieved from <http://www.archdaily.com/15951/metla-forest-research-centre-sarc-architects/>

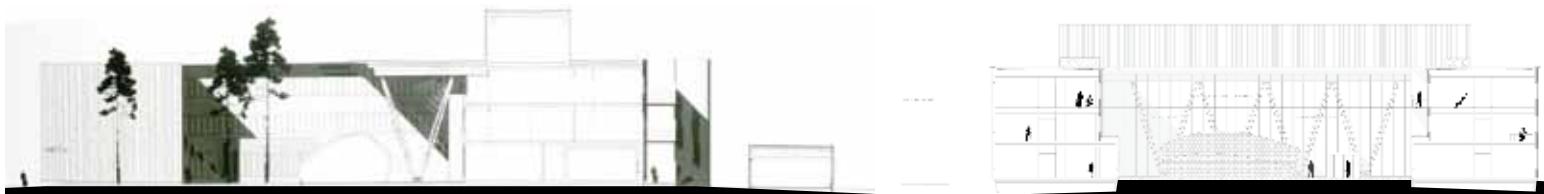
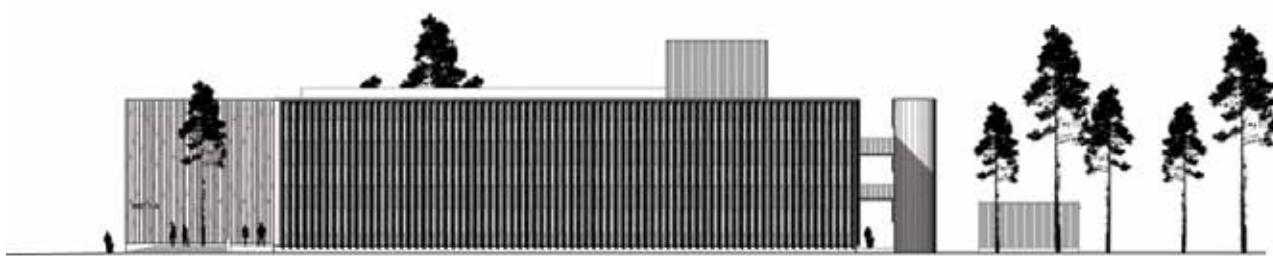
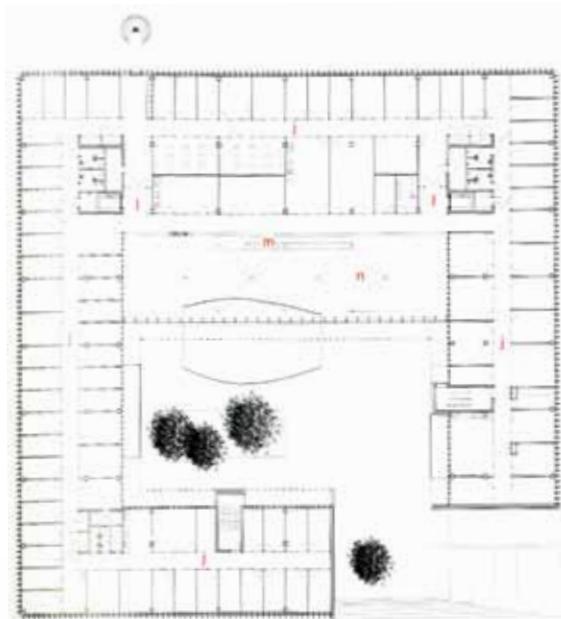
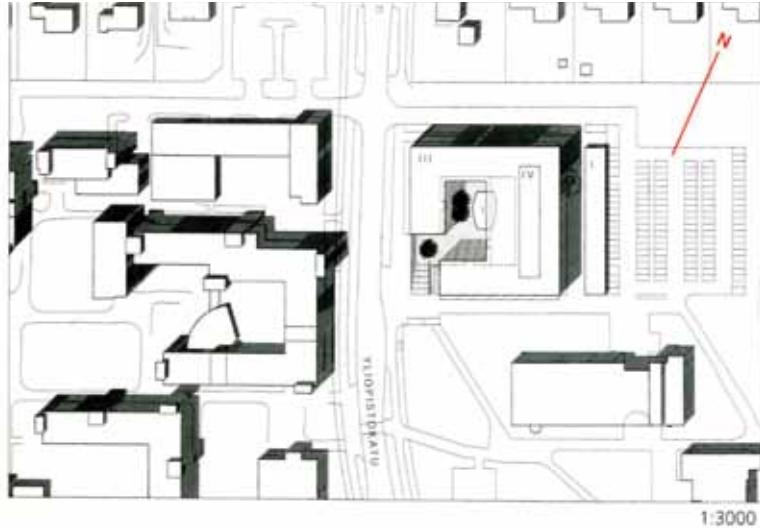


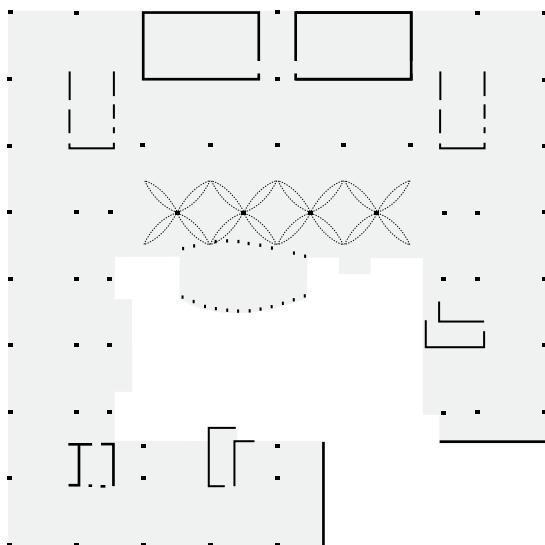
Figure 16: METLA Forest Research Centre drawings. Archdaily. Retrieved from <http://www.archdaily.com/15951/metla-forest-research-centre-sarc-architects/>



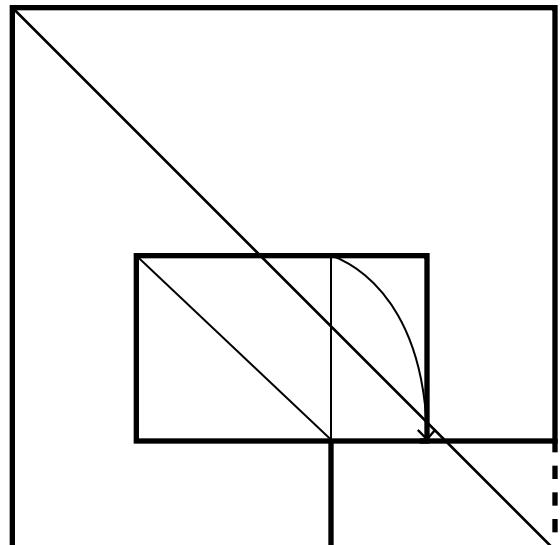
Figure 17: *METLA Forest Research Centre overview*. Archdaily. Retrieved from <http://www.archdaily.com/15951/metla-forest-research-centre-sarc-architects/>

The almost completely “O” shaped floorplan offers an extensive amount of surface area for glazing. The width of the building at any point is small enough to let the light penetrate deep within the building.

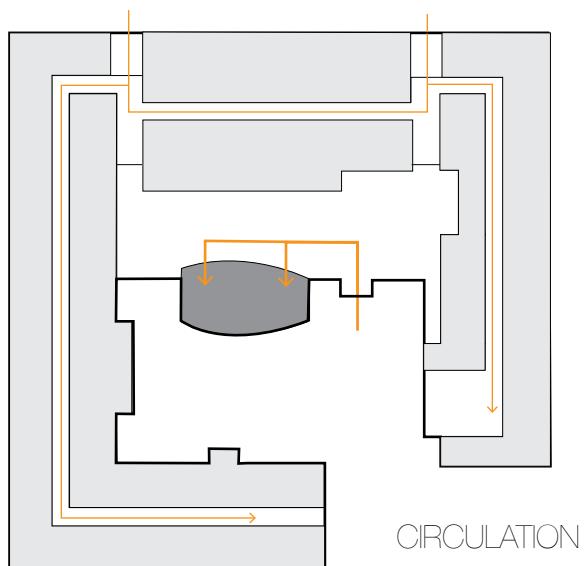
The overall shape is that of a square with a rectangle cut from the middle. The structure’s strict grid system assists in the layout of the program.



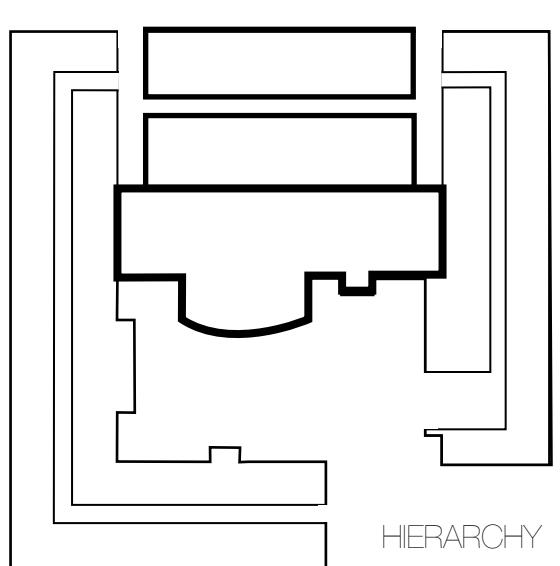
STRUCTURE



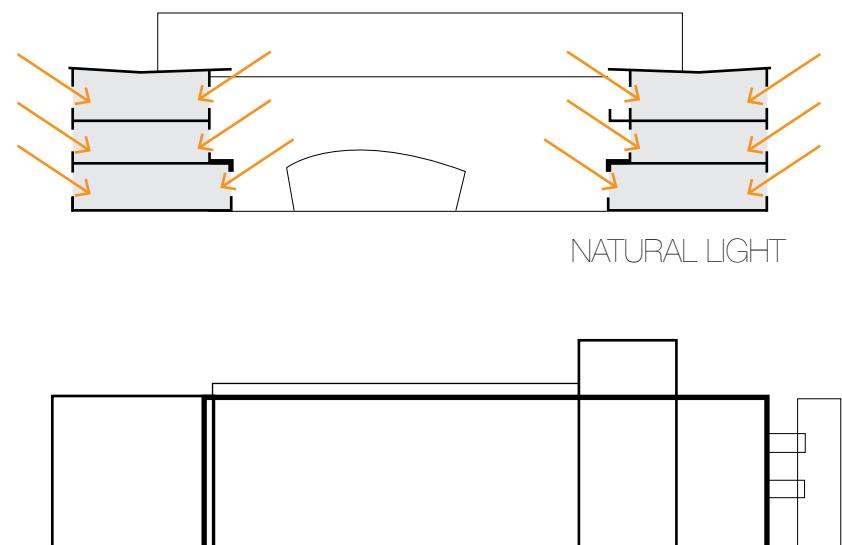
GEOMETRY



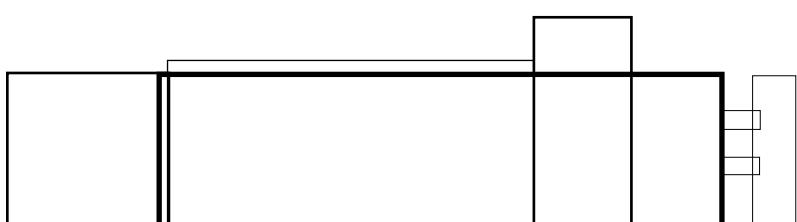
CIRCULATION



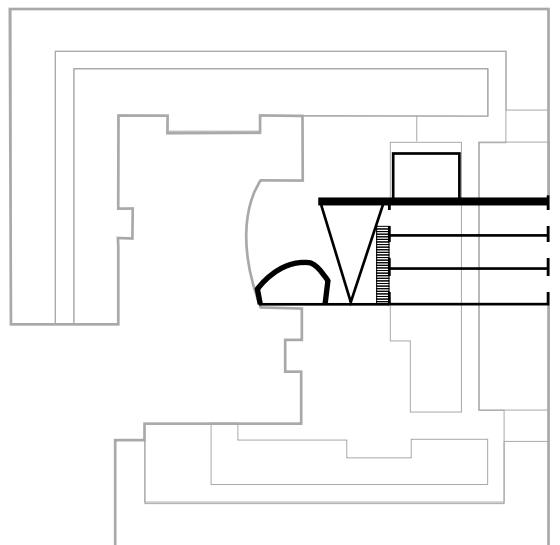
HIERARCHY



NATURAL LIGHT



MASSING



PLAN TO SECTION

Figure 18: METLA Forest Research Centre analysis.

PERMANENCE

SAINSBURY LABORATORY

PROJECT TYPE

Plant Research Facility

LOCATION

University of Cambridge, Cambridge, UK

SIZE

118,403 square feet/2 stories

COST

\$132 million

COMPLETED

December 2010

MATERIALS

insitu concrete

limestone

PROGRAM ELEMENTS

Research Laboratories

Herbarium

Meeting rooms

Auditorium

Social spaces

Cafe

The Sainsbury Laboratory was selected as, what appeared at first sight, as the antithesis of adaptability. The material selection lends itself to monumental architecture. It was important to investigate the inner workings of this building to dissect any evident potential for adaptability. From the limited amount of information available about the innerworkings of this facility, it was apparent that room for alteration was established.





Figure 19: *Sainsbury Laboratory exterior*. Retrieved from <http://www.archdaily.com/154728/sainsbury-laboratory-stanton-williams/>



Figure 20: *Sainsbury Laboratory*. Retrieved from <http://www.archdaily.com/154728/sainsbury-laboratory-stanton-williams/>

The research conducted in this laboratory building seeks to understand plant diversity. The gardens at Cambridge University date back to 1831 when Charles Darwin's mentor Henslow planted the garden as a research tool. The Sainsbury Laboratory is constructed around this garden. Circulation in the building is focused around the garden, which facilitates a strong physical connection. Extensive glazing is utilized in the circulation areas. The arrangement of glazing is flexible in nature and will allow for alteration in response to future needs (Sainsbury, 2011).

The “pods” that line the circulation windows are pivotal points in the program to allow for personal reflection, scientific collaboration and transitional zone. On the other side of the circulation, openings allow for views into the laboratory to emphasize the relationship between the laboratories and the garden.

This case is uncommon to the previous case studies in the spatial layout. This building is the largest of the three, but maintains the connection with the ground and the garden. It achieves this connection by only having two stories above ground. This connection with the ground is also intensified with the use of long bands of material.

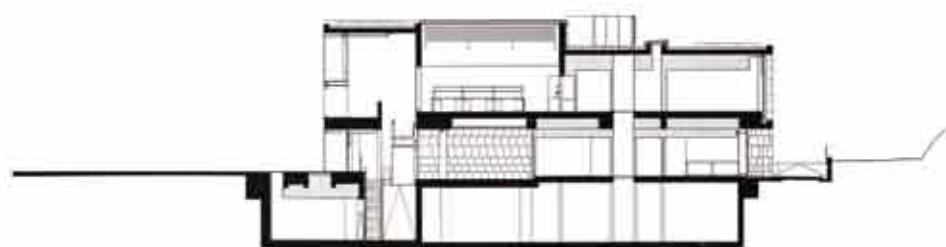
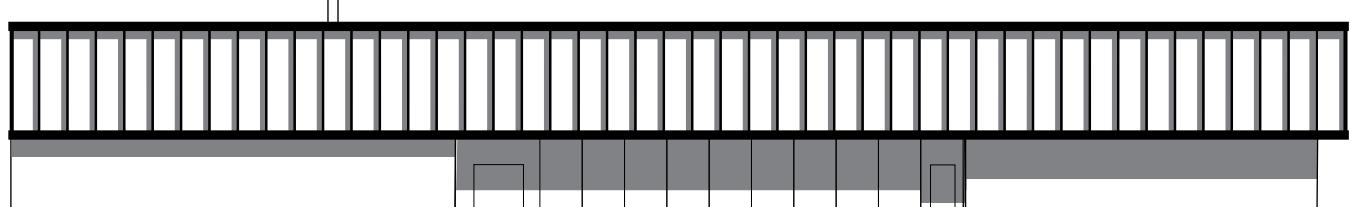
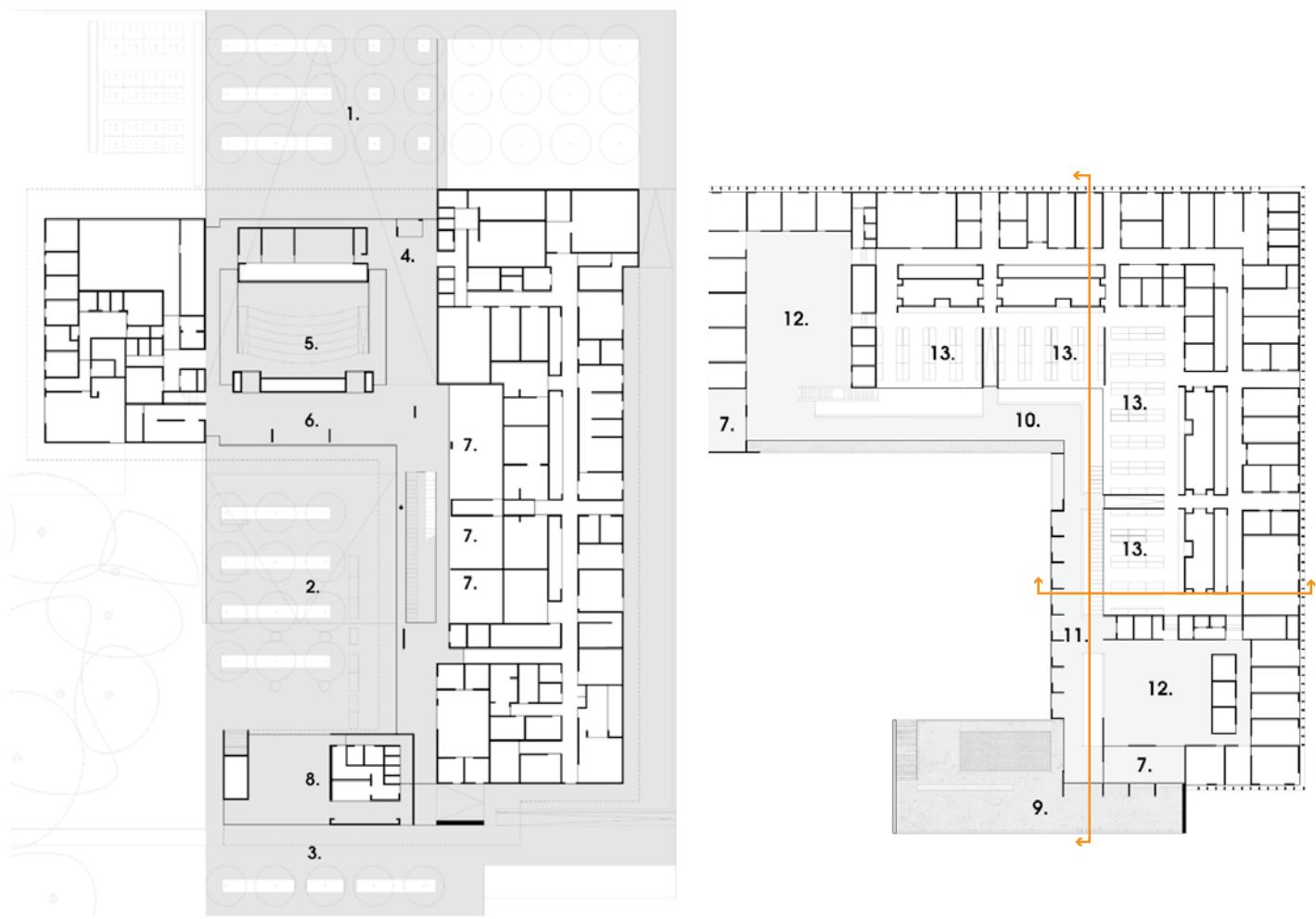


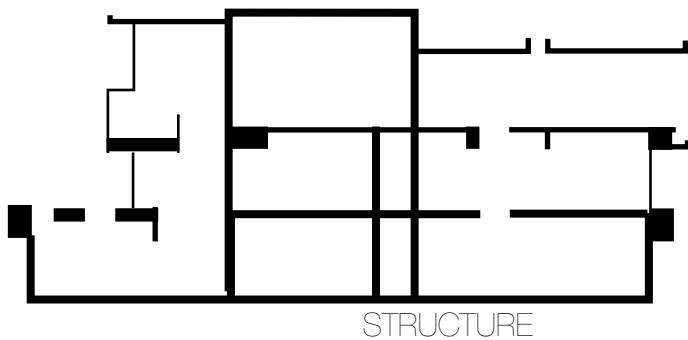
Figure 21: *Sainsbury Laboratory drawings*. Figures from The Architects' Journal 21 July, 2011 Pg. 36, 37



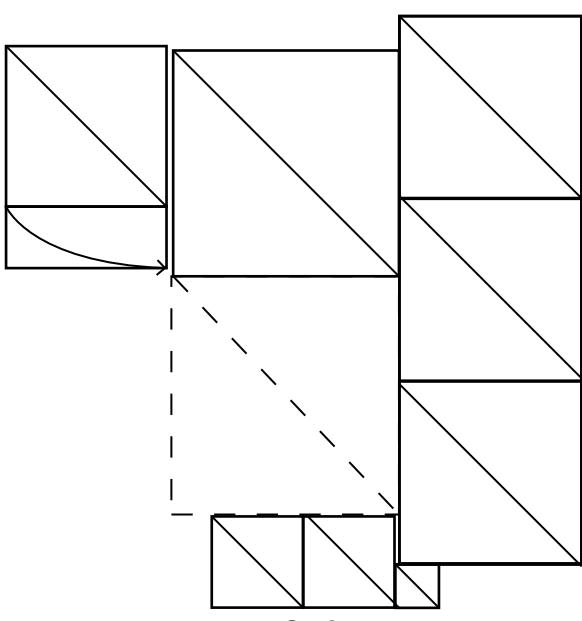
Figure 22: *Sainsbury Laboratory interior*. Retrieved from <http://www.archdaily.com/154728/sainsbury-laboratory-stanton-williams/>

The configuration of the floorplan is an L. The inside of the L faces the research garden, while the perimeter is flanked with laboratory space. The majority of the garden views are accessible by the public and the staff. Large fenestration inside the laboratories and on the exterior allow for the researchers' views to the garden. Natural light in the laboratories is also derived from extensive skylight system. The glazing is opaque to minimize glare. The necessary mechanical functions happen in the long, graceful "fins."

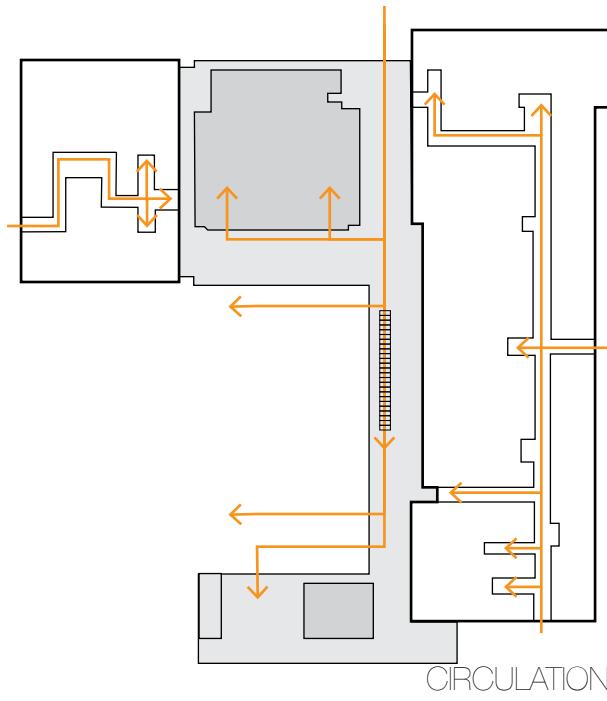
This building appears to be set more in permanence. It may be the materials selected that convey a strong sense of unflexibility. However the architects did implement flexible design strategies. One of these strategies was to allow for the alteration of the "pod" windows to fit future program demands.



STRUCTURE



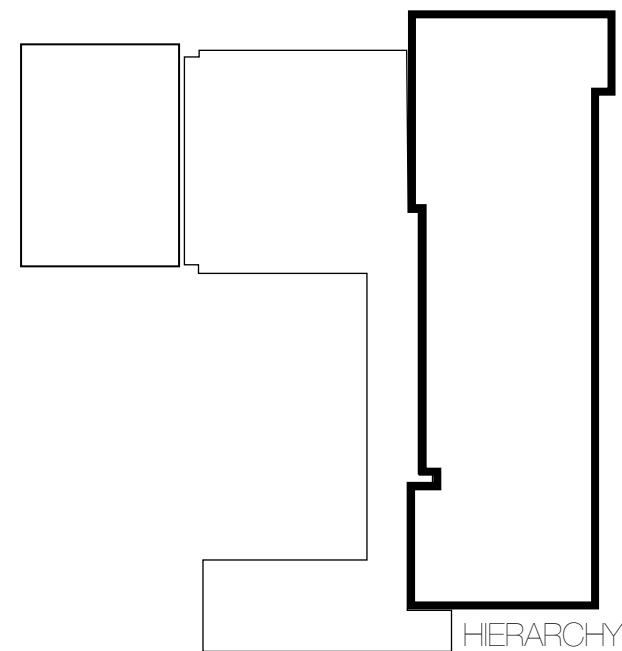
GEOMETRY



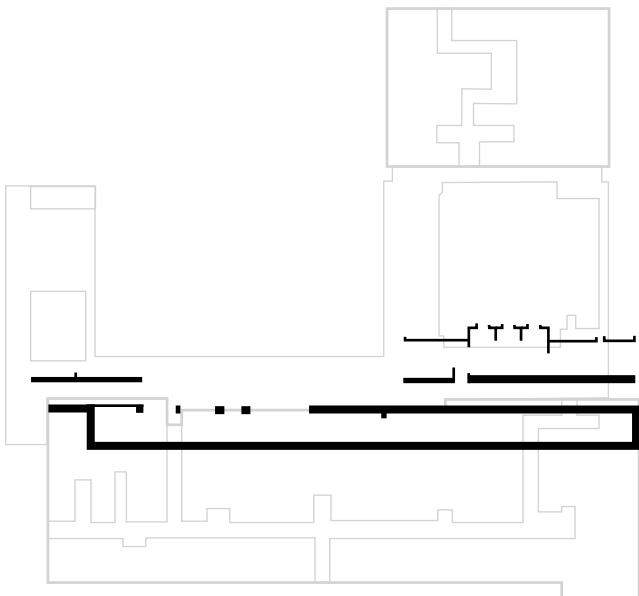
CIRCULATION



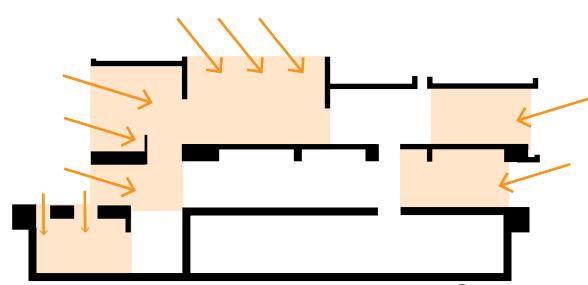
MASSING



HIERARCHY



PLAN TO SECTION



NATURAL LIGHT

Figure 23: Sainsbury Laboratory analysis.

CASE STUDY SUMMARY

This set of case studies represent three unique types of research facilities -- regenerative medicine research, wood construction research, and plant research. The exploration in the name of science unites the three cases. Another uniting theme throughout is the need for the creation of collaborative space within the program. This collaborative nature of science is critical to the expansion of knowledge. The theoretical premise of this thesis was not effected by the typological research.

All the case studies, in varying degrees, contribute to the theoretical premise that architecture must adapt to change. The research in the three case studies is bound to change and morph as exploration continues and the architects built in systems to facilitate this need. The CIRM Center is the most flexible of the three. The systems used in this building allow for flexibility by eliminating columns, using chilled beam technology, and convertible lab stations. The METLA building encourages flexibility by placing "sub-grids" within its strict gridded layout. Within these "sub-grids" it is possible to move walls and change the facade. The Sainsbury Laboratory is the least flexible of the three. There is room for additional flexibility in specific areas of the building, but it is not clear as to how flexibility could be achieved on a larger scale. From this typological research it is clear that flexibility within research space

is essential for increasing the usefulness of the building. Strong structural grids appear to help in this process.

While the last two case studies are not directly related to the typology used in this thesis project, they are valuable in investigating their unique approach to solving the evolving nature of scientific research. All the cases have highly specialized laboratory space, collaboration space and public space.

Besides their typological differences they respond differently in relation to their context. The CIRM Center, in Los Angeles, fits into a narrow plot of land and the surrounding buildings are of similar height. Also, the materials used may appear more "industrial" or what you may find in a large city. The METLA building is also of similar scale to the surrounding buildings. The materials are fitting to the context and the work explored within. The Sainsbury Laboratory also relates well to its context. It is long and low to the ground to strengthen its connection to the ground and the landscape; material selection reinforces this concept as well.

HISTORICAL CONTEXT

REGENERATIVE MEDICINE

Recently, regenerative medicine has been filed as a subheading under stem cell therapies. Research on regeneration has not always had this tight connection with stem cells. The regenerative nature of cells dates all the way back to Aristotle. He wrote about the generation of new lizard and snake tails after they were injured or severed.

In the 1700's, a renewed debate over regeneration ensued. The debates were about whether the organisms were given "internal predetermined instructions" or the growth of something that was already there but in a miniature form. Debates also centered on "fundamental metaphysical assumptions about such issues as whether life is nothing but material or also involves a vital force or entity of some sort (issues of materialism vs. vitalism) as well as core epistemological assumptions about the extent to which empirical observation can reveal the fundamental facts of living organisms" (Maienschein, 2011).

Continued research on regeneration was carried out in 1901 by T.H. Morgan who was able to see that organisms were able to regenerate in numerous ways. He expressed to the scientific community that the process of regeneration is responding to internal and environmental cues (Maienschein, 2011).

Transplantation of organs and tissues has had a profound impact on regenerative medicine. In the first half of the 1900's, the two areas of research seemed to be on completely divergent tracks (Maienschein, 2011). The first transplantation of tissues and bone happened in the early 20th century. In 1954, the first kidney was successfully transplanted (NIH, 2010). The National Institute of Health states that, "Approximately 500,000 Americans benefit from a transplant each year" and "As of August 2010, there were approximately 108,000 people on the waiting list for donor organs. Many of these individuals will die before a suitable organ can be found" (NIH, 2010). The convergence of regeneration and transplantation is apparent. The NIH also reported that bladders made in a laboratory, created from a patient's own cells, can be transplanted successfully (NIH, 2010). The large amount of people waiting

has caused an increase in research on regenerative medicine to solve the limited pool of transplantable organs and tissues.

Stem cells were first theorized in 1909 by Alexander Maximow who suggested that all blood cells originated from an “ancestor cell.” In 1981, Martin Evans and Gail Martin separately conducted research and were able to extract stem cells from mice embryos. In 1998, James Thomson and Jeffrey Jones extracted the first stem cells from human embryos. The two scientists found these cells could be converted into a variety of organs and tissues that could have a huge impact on medicines and transplantation. A lot of controversy surrounded this finding, due to ethical issues, and President George W. Bush signed an order that limited the research of embryonic stem cells to only the current supply (History, 2009). Recently, The Nobel Prize in Physiology or Medicine in 2012 was awarded to John Gurdon and Shinya Yamanaka, who both have discovered ways to take mature cells from an adult patient and “reprogram” the cells be used in various organs. Reprogramming allows the cells to be near or as effective as embryonic stem cells. This discovery can be the answer to the controversial use of embryonic stem cells (Nobel, 2012).

Now the study of regenerative medicine, stem cells, and transplantation medicine find themselves converging to offer many developments to prolong human life and improve the quality of life for sick patients. At the Wake Forest Institute, the researchers successfully made a kidney using an average ink jet printer by injecting the cartage with cells. This ingenuity of humans will drive regenerative medicine research to unfathomable heights.

HISTORY OF THE MAYO CLINIC

PAST

In 1863, W.W. Mayo, M.D. was transferred from his home in Le Sueur, MN to Rochester, MN after being appointed by President Lincoln, to be a Union doctor and surgeon. He quickly became accustomed to life in Rochester and made a permanent home. From a young age, William and Charles Mayo watched their dad perform surgeries on patients' kitchen tables, providing compassionate care and attentive service. William and Charles both attended medical school and returned to assist their father in his medical practice. W.W. Mayo had an early commitment to having the most advanced technology to serve his patients. During the course of his career, he had two microscopes, which was of great expense ("The mayo legacy," 2008).

In August 1883, a devastating tornado ripped through Rochester leaving 31 dead and hundreds of people injured. W.W. Mayo and his sons worked around the clock to care for the injured. They recruited the Sisters of Saint Francis to assist with care. Mother Alfred Moes persuaded Dr. W.W. Mayo to establish a community hospital. In 1889, Saint Mary's Hospital was complete and surgeries were underway. This new hospital was three-stories in height and made of red brick and rough hewn stone. The program consisted of a reception area, offices, dining room, and a kitchen. The operating room was on the second floor and was a mere 12-foot-square. All patients were welcomed to this hospital regardless of race, sex, religion, or economic circumstances (Nelson, 1990).

From the beginning of this first hospital, the Mayo brothers and their collaborators were at the forefront of technology. They were the first to implement sterilization of their operating tools. If they did not have a particular tool that suited them, they would construct it. Their pioneering spirit also led to the idea of collaborative care. The doctors freely traded knowledge with other medical professionals. They travelled the world for information on the latest medical care and brought in specialized doctors from around the country to learn from and teach. This idea of practicing medicine in a teamwork setting was unprecedented at the time. (Nelson, 1990).

The Mayo brothers retired from the hospital 1928 and left the hospital and a majority of their assets to the Mayo Foundation, which still to this day funds medical research and education at the Mayo Clinic. They set a policy in which Mayo Clinic employees receive a salary and any profit made from the Mayo Clinic would go to the Mayo Foundation ("The mayo legacy," 2008).

Laboratories have an early history at the Mayo Clinic. In 1905, three rooms were designated specifically for pathologic and bacteriologic work. Experimental surgeries led to further laboratory development, so that by 1908 there were six rooms for these surgeries in a doctor's barn not far from Saint Mary's Hospital. With the new Mayo Clinic building in 1914, laboratories were centralized to this location. By 1925, the clinic employed 263 scientists and had 135 rooms for research (Nelson, 1990).

The first, dedicated laboratory building was the Medical Sciences Building, which is still in use today. It was opened in 1941 to further medical research at the Mayo Clinic. The basic program of this building included "an auditorium for 180 people, a heart catheterization room, a human centrifuge, an engineering shop, pressure chambers, controlled temperature rooms, a mass spectrometer, radioactive isotope rooms, and other rooms for anatomy, biochemical research, biophysical electroencephalography, physiology, and surgical research" (Nelson, 1990).

MISSION/CORE VALUES

Currently, the Mayo Clinic's website states their mission as, "Mayo will provide the best care to every patient every day through integrated clinical practice, education and research" ("Mayo clinic mission"). This statement does not veer far from the beginning of the clinic. Dr. W.W. Mayo said the gathering of forces in the medical field provided advancing knowledge to benefit the sick. The value that has not changed at the Mayo Clinic is, "the needs of the patient come first" ("Mayo clinic mission"). The early doctors and Sisters at the Mayo Clinic

established strong commitments to patient care which are still implemented at the Mayo Clinic. The eight core values, as stated on the Mayo Clinic's website, are respect, compassion, integrity, healing, teamwork, excellence, innovation, and stewardship ("Mayo clinic mission").

BUILDINGS

One of the first partners at the Mayo Clinic was Dr. Henry Plummer. Dr. Plummer had a deep interest in architecture and technology. When a new building on the Mayo campus was to be built, Dr. Plummer took two weeks off and developed the drawings for this new building. He integrated one of the first intercom systems and a revolutionary system for storing patients' records. "Dr. Henry Plummer, the architect of many early Mayo innovations, thought of buildings as tools to help physicians provide efficient patient care. He believed in the importance of using good materials to build well-designed, well-constructed facilities that were planned for easy maintenance and kept spotlessly clean. Mayo Clinic's modern buildings are designed to provide a friendly and warm environment in which to continue Dr. Plummer's concepts. They are built with the intention of advancing the integrated model of medicine to the next level of excellence" ("Mayo clinic model," 2002).

During a recent interview with Tom Behrens, the head of facilities operations at the Mayo Clinic, said his department in one year spent \$50 million on minor maintenance and repair of the approximately 70 buildings on the Mayo campus (Behrens, 2012). The Mayo Clinic is amassing a lot of the buildings in downtown Rochester, and is constantly transforming. The Mayo Clinic is not a static organization, but one that is constantly striving for change so the public can benefit the most.

Mr. Behrens also spoke of the marble that is used on the Gonda Building. The Gonda Building is designed with the foresight of ten additional stories. The marble used on the building was quarried in Brazil, polished and finished in Italy and then shipped to Rochester. The material for the additional ten stories was quarried at the same time in Brazil and is aging in Italy (Behrens, 2012). The level of care and commitment given to the buildings is apparent.

HISTORY OF ADAPTABILITY IN ARCHITECTURE

A brief history of adaptability in architecture has already appeared within the theoretical premise research; however, it is important to investigate early human nonarchitecture and its ingenuity. Within this history is a potential for examination on how a population used space in such a way that reflected their processes of life and the changes their life required.

The first built structures were that of homes. These homes were rudimentary, but elegantly detailed for maximum efficiency. Humans in that context were directly responding to relatively simple demands with limited resources. Today's architecture may be viewed in response to permanence, these primitive structures were not built to last. In *Kinetic Architecture*, William Zuk states, "The admiration in this case is not for the permanence in these structures, as they had to be repaired and replaced often. Rather, it is the highly refined form that was produced that is esteemed" (1970).

Housing of the past was movable, recyclable, and replaceable. Nomadic people of the past relied on flexible nonarchitecture to shelter and to survive. One example of this flexible, movable living is the Tipi. According to the book *The Indian Tipi; Its History, Construction and Use*, by Reginald and Gladys Laubin, The traditional tipi was created by the American Indians in the Great Plains region. Tipi's are highly durable, are able to shelter inhabitants from large temperature variances, and are highly portable. The Native Americans in this region were highly mobile and needed a structure that would cater to this need. What makes the Native American's tipi different from other tent structures that existed around the world at this time was the innovation of the smoke flaps on top which allowed for a smoke-free living environment (1957).

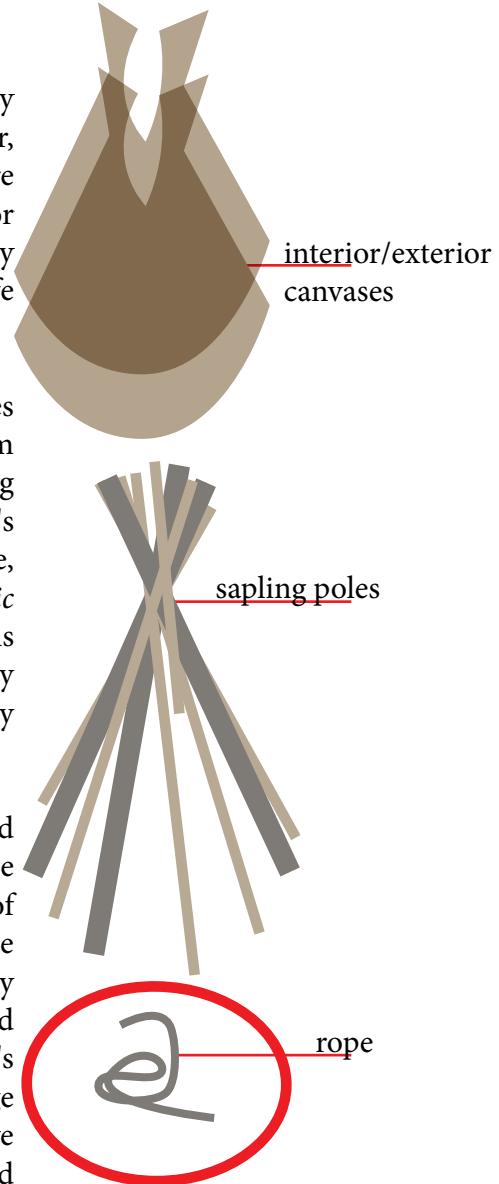


Figure 24: Tipi elements.

Traditionally, tipi's are comprised of five basic elements -- ten to fifteen sapling poles, canvas, an inner canvas, a canvas door and rope. The innovation that led to the success of the tipi is the flexibility of the interior space that had an opening flap on the top to allow for an interior fireplace. The skin on tipi's are highly flexible. In the warm months, the interior lining is removed and the exterior skin is rolled to create ventilation (Laubin, 1957).



Figure 25: *Tipi*. Retrieved from wired.com

GOALS FOR THE PROJECT

ACADEMIC

This project is an exploration into the limits of my design potential. It is an opportunity to compile all the information that has been collected over the last five years into a single project. A common thread throughout my previous projects is the lack of attention placed on how the building would actually be created. It feels as if the buildings I have designed are void of all detail. This thesis project is a chance to explore materials and structural systems.

Another goal of this project is to obtain greater knowledge of computer software. This has been a strength for me in the past, but I want to see how far I can push myself into this exploration.

Finally, it is vital that one of the goals of this thesis project is efficiency. Using my time ineffectively always leads me to “racing for the finish line.” The schedule that was set up will provide the structure necessary for a well thought out, complete project.

PROFESSIONAL

This will be the last project in my portfolio and it will need to effectively summarize the skills and information that I have acquired at NDSU. The typology of this project may be of interest to some employers. Being hired by a firm that specializes in healthcare and/or research laboratories would be an exciting career path.

PERSONAL

This thesis semester will be a filled with personal growth. It is a chance to hone the skills already in my toolbox. I am my own worse critic, so I believe the test for a successful project will be my own reaction. I have experienced many life altering changes in the last two years, and I know that working on this project I can make it through anything.

SITE ANALYSIS

AUGUST 12, 2012

I, somewhat begrudgingly, head south in quest of discovering another average American city. I look back to what prompted me into selecting such a “far away” site. The Mayo Clinic’s presence and their regenerative medicine department were the only reasons for selecting Rochester. After what seems like an eternity, or five hours, I arrive.

I now know exactly why I chose this beautiful city. It is summertime and the abundance of trees, vegetation and topography are a complete divergence from my starting point in the wee hours of the morning. When I enter downtown, the visitors and employees created a energizing bustle. Everyone seems to be on an important mission.

My first site selection is located in a parking lot to the north of the Mayo Clinic surrounded by two parking garages, one on the east side and one on the south. On the north side are single family homes. I approach the site at approximately 8:00 am and the lot is flooded with Mayo Clinic employees hustling to work. Exiting the car, I immediately feel I have lost all the energy that was present in the heart of the Mayo Clinic campus. It is as if the parking structures blocked the flow of this energy. I dutifully take my necessary pictures and climb to the top of the parking garages and take even more pictures to add to my collection. Feeling successful I proceed to leave this intriguing city.

NOVEMBER 10, 2012

I am now trusting my instincts and I am not proceeding with my original site selection. There is no energy to be harvested from that specific plot of land. It needs to be more connected to the heart of the Mayo campus. This time I have done my research and I will leave Fargo with a clear mission.

The new site is located two blocks south of the Mayo Clinic’s main building and is surrounded by four other medical

research buildings. It seems full of potential, at least that is how Google Maps makes it appear. Before embarking to Rochester, I studied the master plan for Rochester and found that the site selected was already slated as a research and education district.

Another student in the thesis process also has a site selected near the Mayo Clinic. With connections to the Mayo Clinic, he is able to set up a meeting with Tom Behrens, the head of facilities operations. We are going on an “exclusive” tour of the Mayo Clinic. Tom has access to every door on the campus. With excitement, we climb to the top of the Gonda building and can see in all directions for miles. Tom tells us that his department, in one year, spent \$50 million on minor maintenance, certain cleaning jobs, and painting.

Next, we are on top of the Hilton building. I am looking directly down at my site! I ask Tom if there are any current plans for developing this site. He says that the Mayo Clinic is planning on building a medical research building at this location. He expects construction to start within the next couple of years.

The main materials on the buildings surrounding the site are glazing and precast concrete, in different ratios. The building on the west side is a masonry building, obviously older than the other three buildings. Another parking lot is directly south of my new site.

I leave Rochester with more confidence in the site selected. The importance of the site being within close proximity to other research facilities, the importance of fitting into the master plan of Rochester, and the importance of satisfying myself with the site selection are all fulfilled.



Figure 26: Rochester, MN aerial photograph. Roger Thiemann. Retrieved from city-data.com

PHOTO RECONNAISSANCE

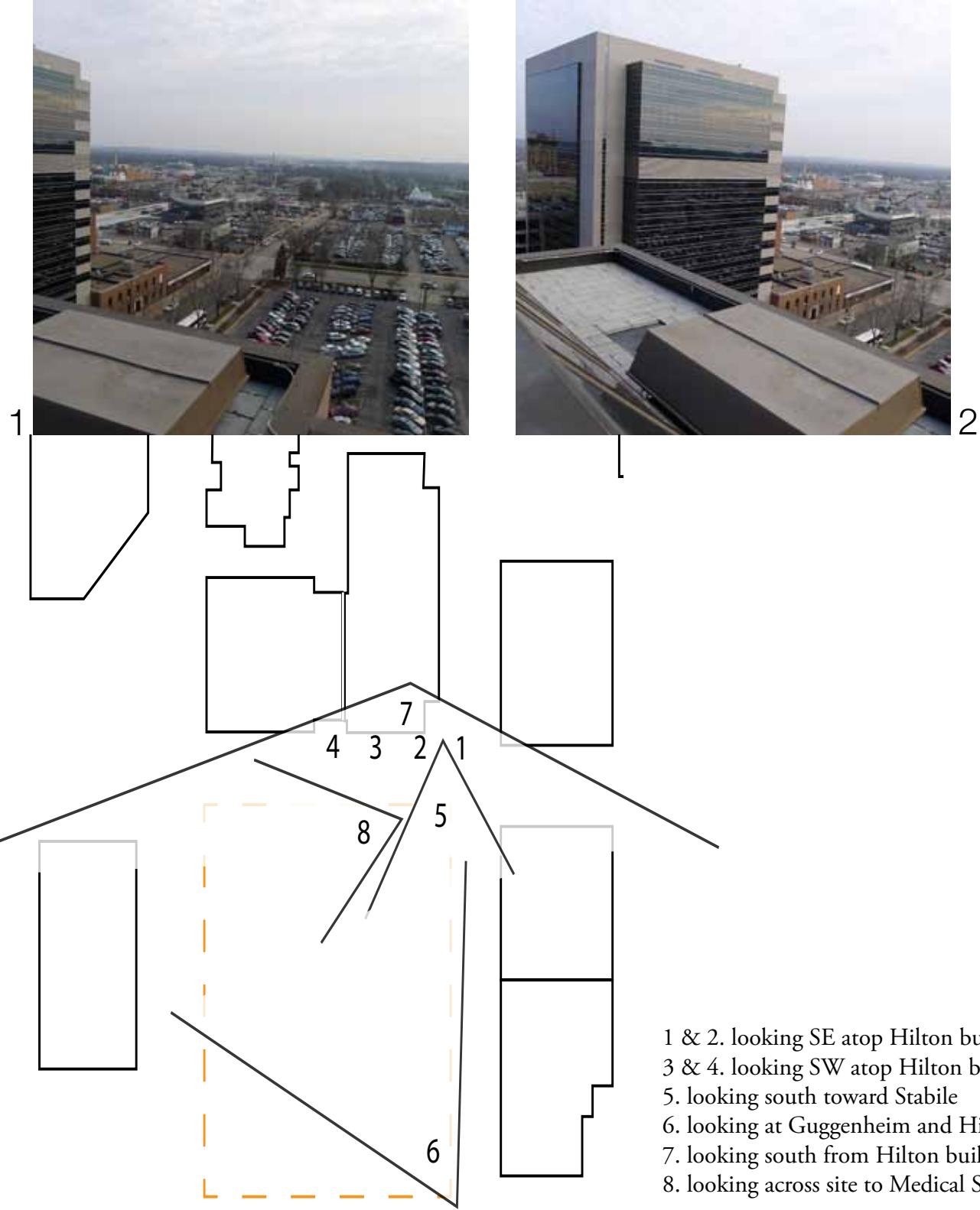


Figure 27: Photo reconnaissance.



3



4



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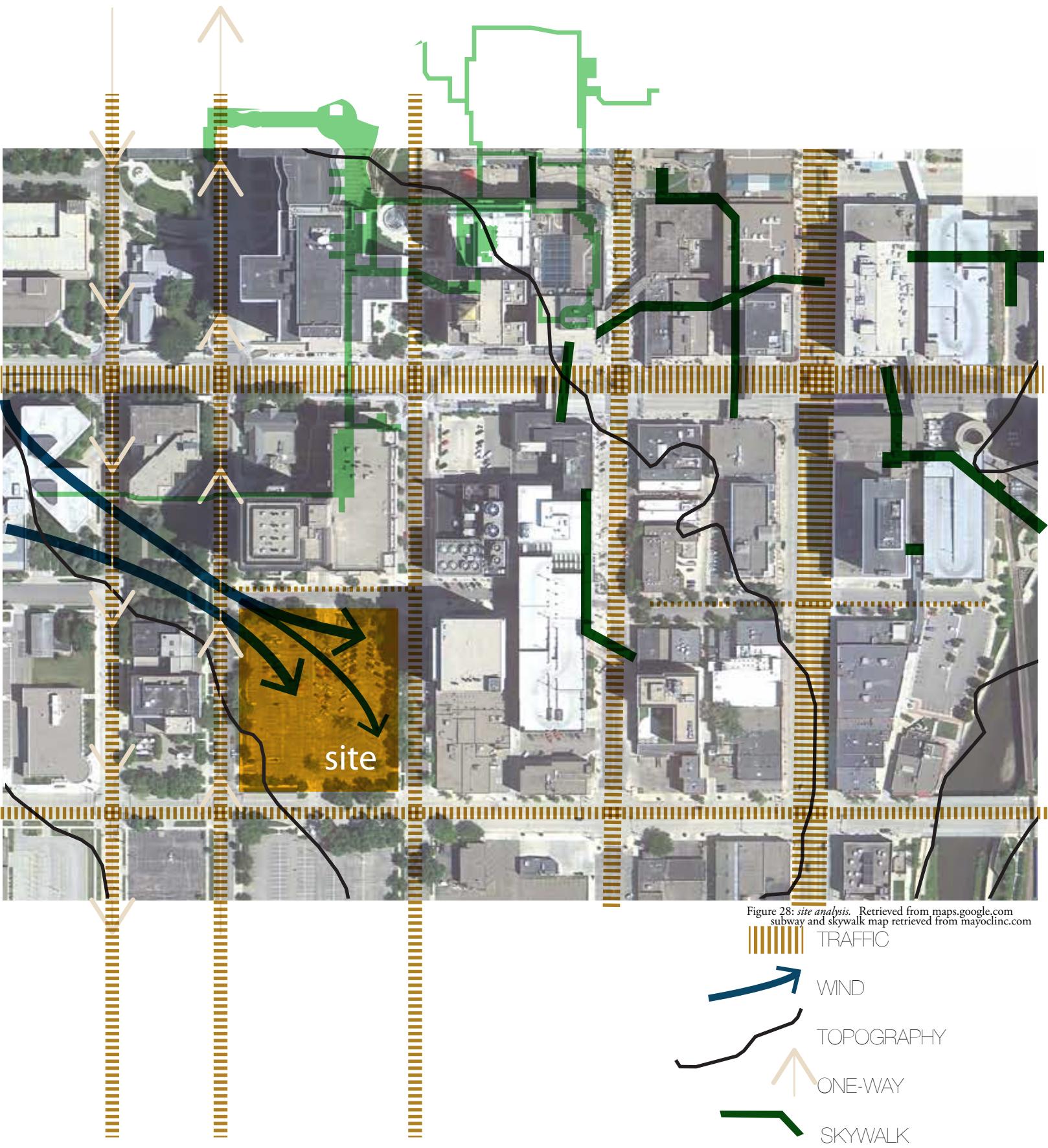
6



7



8



GRIDS

In Rochester there is a strong north-south road grid. Even close to the meandering Zumbro River, the road is unwavering. There are a few exceptions to the road, especially the block directly to the west of the site. It is composed of a block half as wide and twice as long in the north-south direction.

GEOMETRY

The geometry in the surrounding buildings, and most of Rochester, are predominately rectangular in shape.

SHADE AND SHADOW

Based on the shade and shadow study done in figure 38, there is little shade/shadow that falls on the site. The morning and evening produce the longest shadows and therefore do touch the site. If a structure were on the site, it would not take much height to penetrate the shadow.

LIGHT

With little shade from the surrounding buildings, the sunlight is strong on the site. The trees surrounding the parking lot offer relief from the sun. With the high amount of glazing on the surrounding structures, there is a strong potential from reflected light.

TRAFFIC

The main traffic is present on the streets of Second St. SE and S. Broadway. Second street is located one block north of the site. The site seems to be isolated from the majority of the congestion that happens. The street to the west of the site is a one-way going north.

PEDESTRIANS

A vast majority of foot traffic between buildings is seen in the extensive skywalk and “subway” system. The subway is the most extensive of the two and is tunnels connecting numerous Mayo buildings and its neighbors.

HUMAN CHARACTERISTICS

The site is highly impacted by human use. Currently, the land is utilized by the Mayo Clinic staff as a parking lot. At the time of last visit, the parking lot was at full capacity.

DISTRESS

There is no apparent distress located on this site or in close proximity. The vegetation surrounding the parking lot looks to be in good shape with no dying trees. All the structures surrounding the site are in use with no signs of dilapidation

WATER

Four blocks east of the site is the Zumbro River. At the river banks, the city has taken extreme measures to prohibit the flooding of the river with flood walls. There is no apparent smell emanating from the river. (See Figure 35 for precipitation amounts)

SOILS

1039 - Urban Land

This type of soil is unclassifiable because of the numerous alterations to the land. It is suitable for building (United, 2012).

UTILITIES

The site has access to all necessary infrastructures.

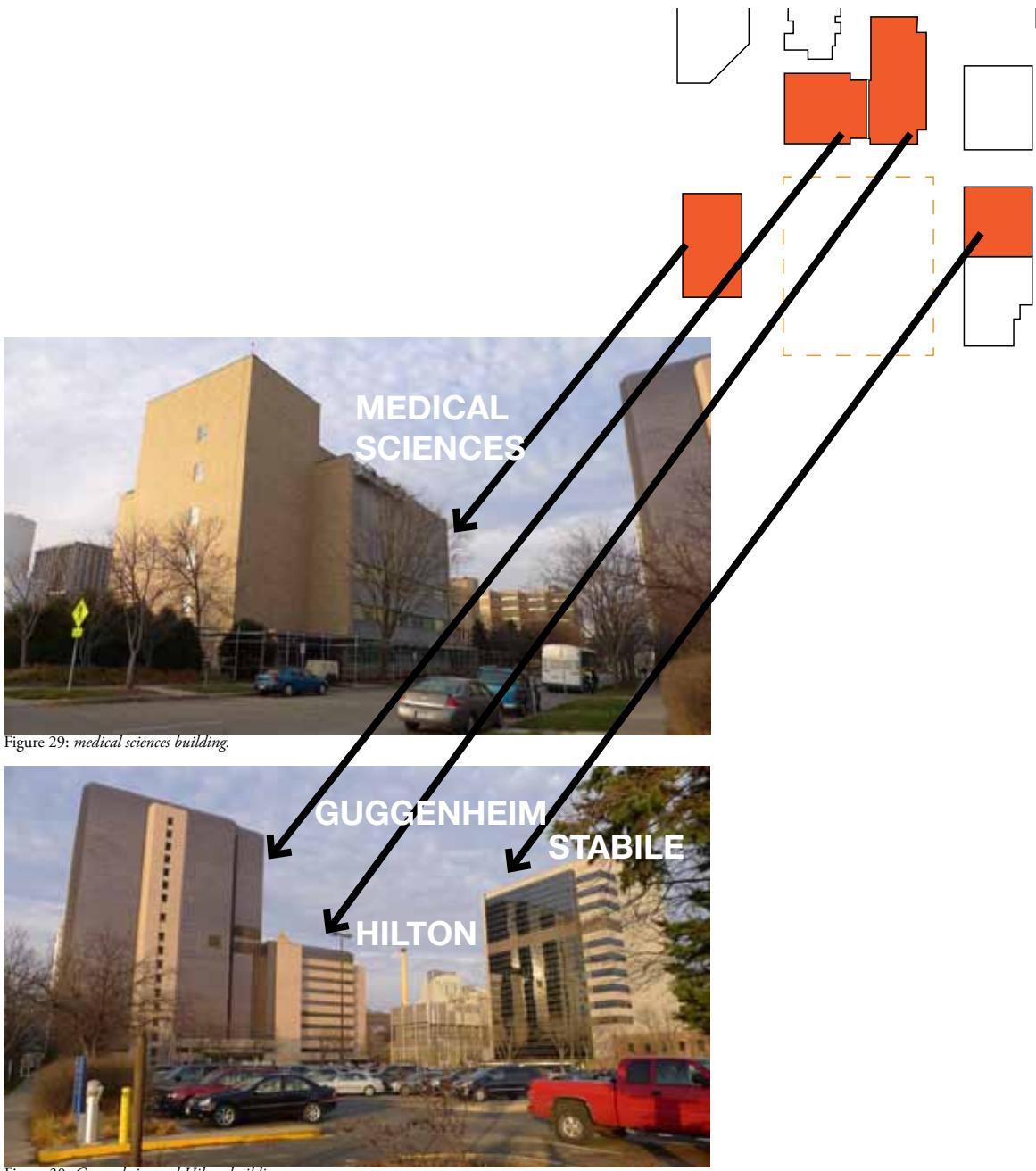


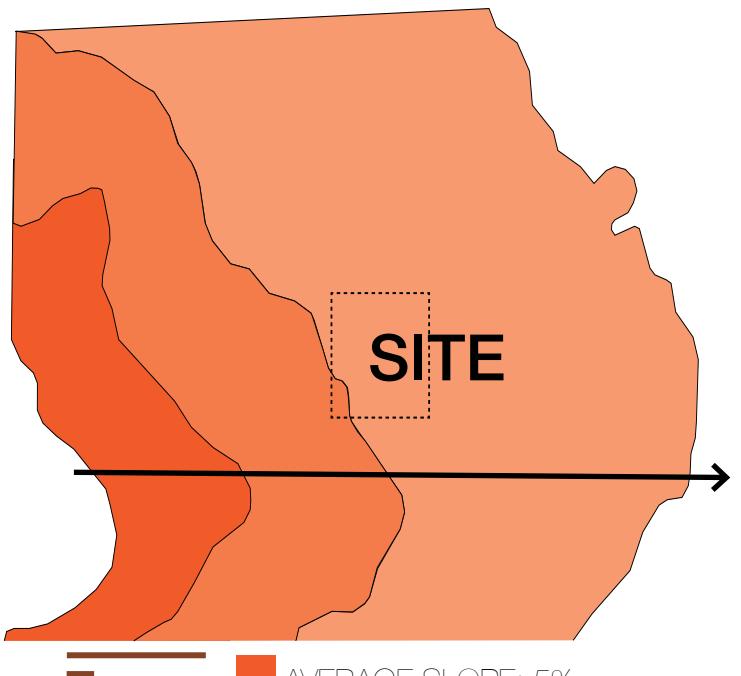
Figure 29: medical sciences building.



Figure 30: Guggenheim and Hilton buildings

EXISTING BUILT FEATURES

The four main buildings around the site are the Medical Sciences, Hilton, Guggenheim and Stabile. All these buildings are currently used as medical research facilities. The Hilton, Guggenheim and Stabile buildings are comprised mostly of glazing and precast concrete and appearing to be from the late 1980's to early 1990's. The Medical Sciences building is directly to the west and is comprised mostly of masonry, is five stories at the tallest and dates back to the 1960's. The tallest of the four buildings is the Guggenheim at approximately 260'. The Hilton and Stabile buildings are 150' and 200' respectively.



The primary slope on the selected site is 2%. This slope will allow for adequate water drainage on the site. The relatively small slope for the site is in contrast to the surrounding “hillier” neighborhoods. The 2% slope should not be a factor in excessive heat gain.

- █ AVERAGE SLOPE: 5%
- █ AVERAGE SLOPE: 4%
- █ AVERAGE SLOPE: 2%

Figure 31: *slope chart*. Retrieved from <http://websoilsurvey.nrcs.usda.gov/>

The closest buildings surrounding the site vary substantially from 85' to 260'. The larger buildings are more in context to the scale of the majority of buildings on the Mayo Clinic's campus.

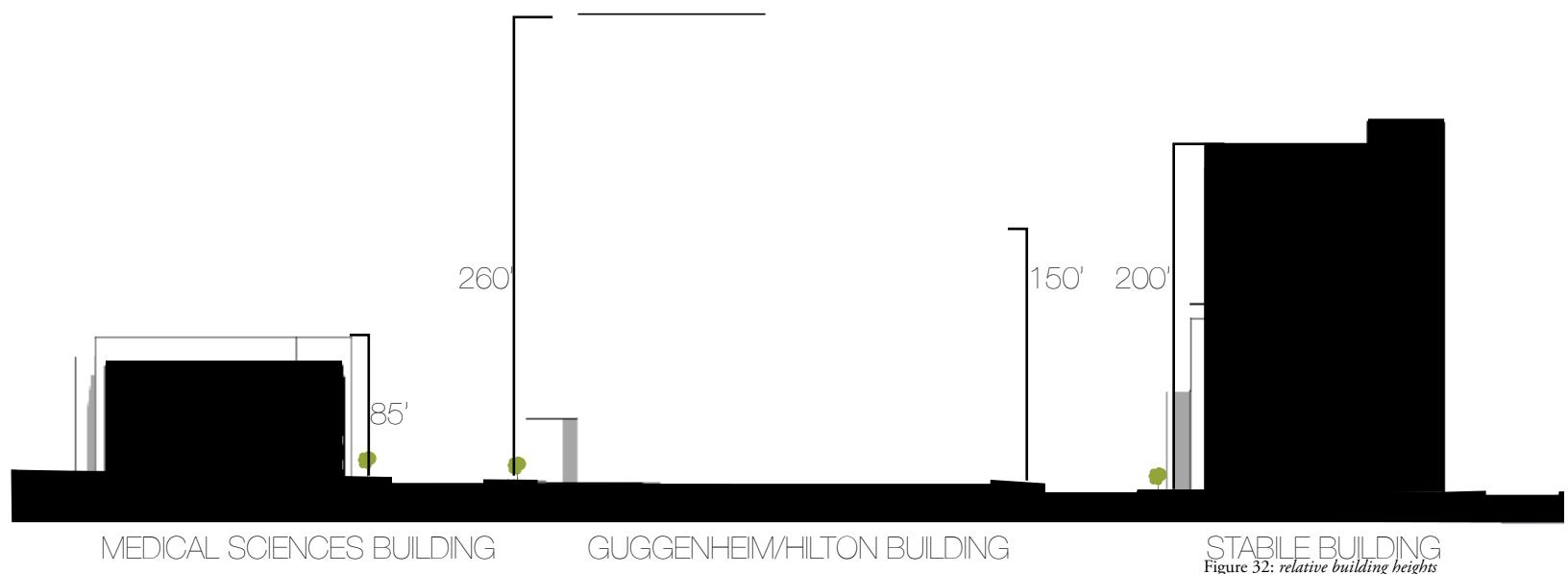


Figure 32: *relative building heights*

CLIMATE DATA

The National Weather Service classifies the city of Rochester, MN as “highly continental with mild summers and very cold winters” (Rieck, 2002). The four seasons are quite distinct. On average the temperature fluctuation between summer and winter is 52.3 degrees. Snow storms, tornadoes, freezing rain, high winds and hail occur on occasion. Flooding is rare, but the terrain can create pockets of flash flooding (Rieck, 2002).

WIND: AVG SPEED 13MPH

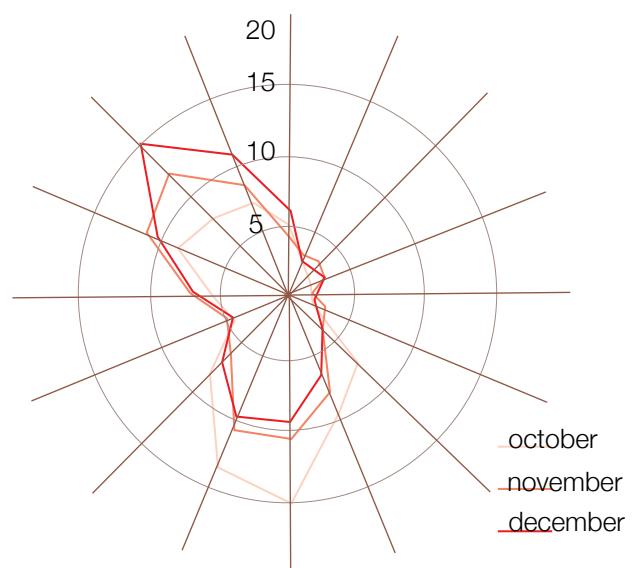
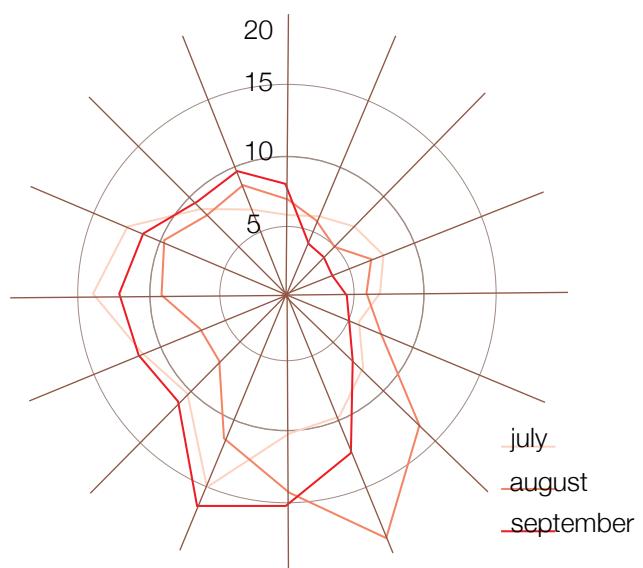
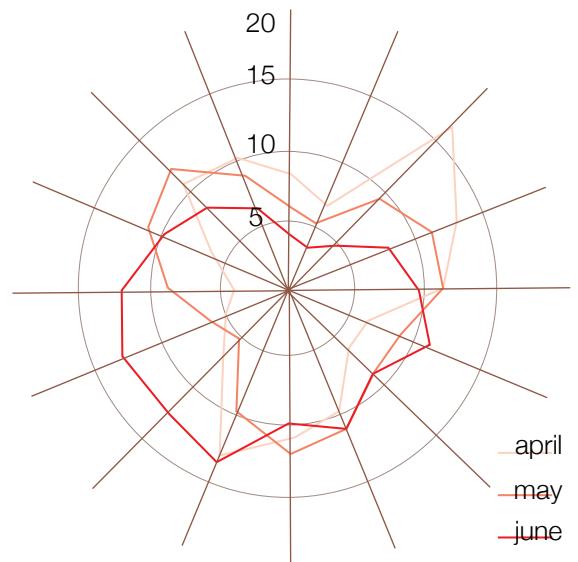
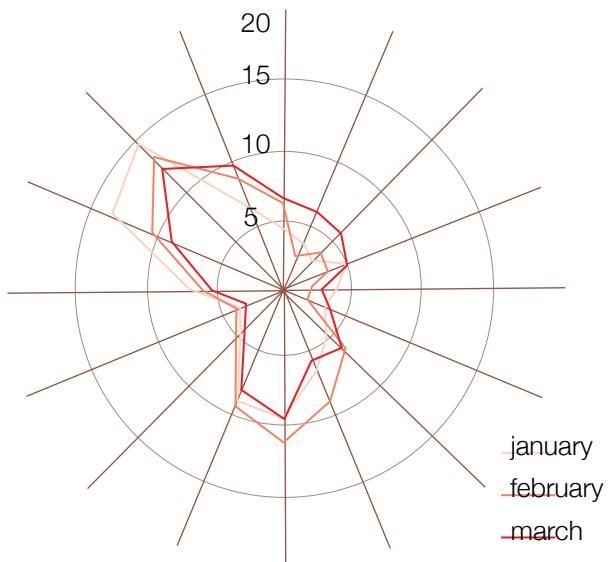
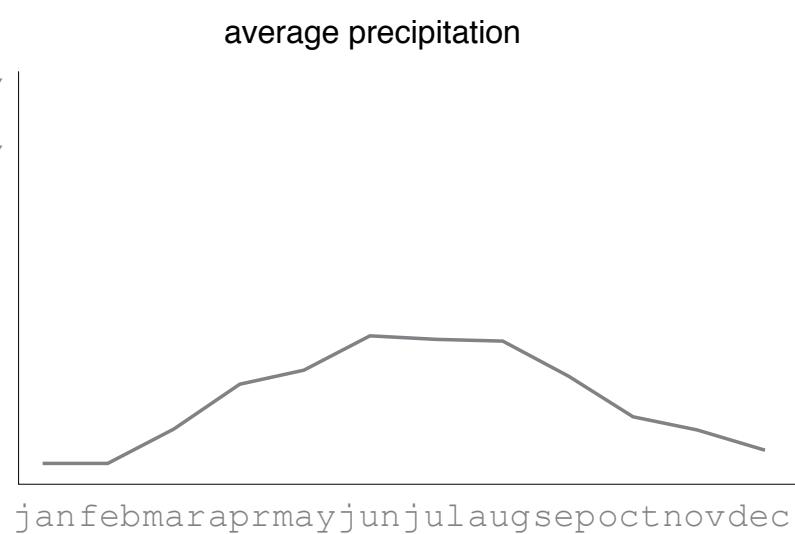
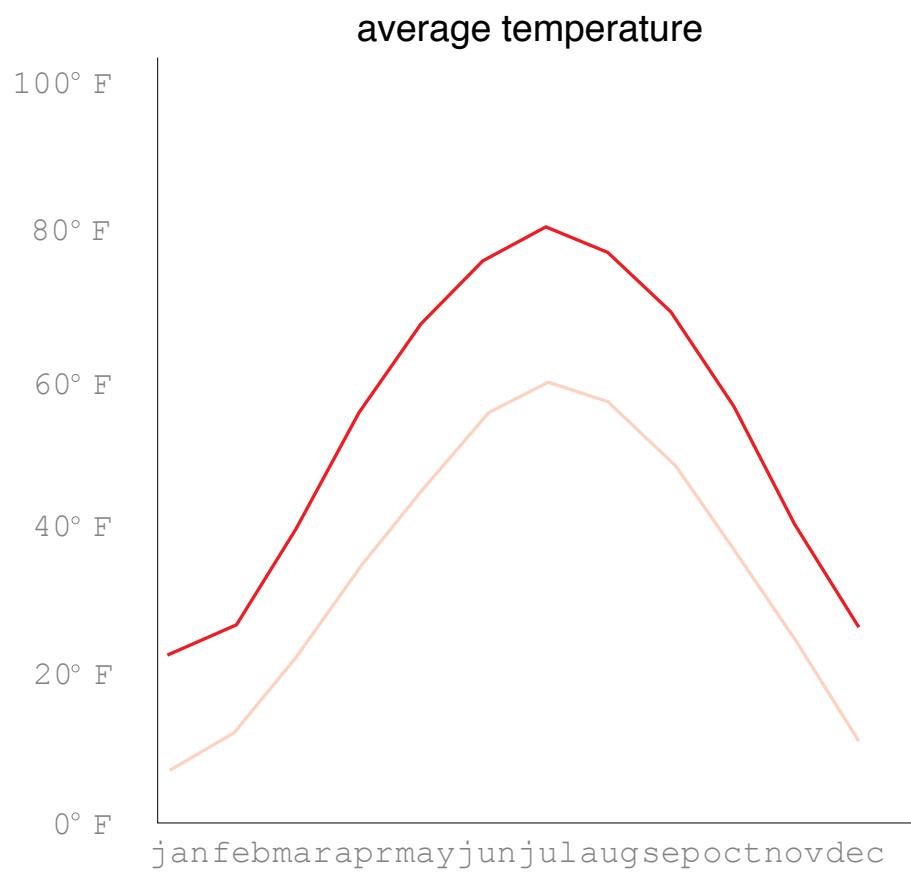


Figure 33: *wind roses*. Retrieved from <http://climate.umn.edu/wind/krst.htm>

The average wind speed in Rochester is 13 mph. The strong northwest winds, on average of 15 mph in December, are of most concern and the winds will need to be mitigated from this direction. The surrounding buildings may either offer protection or create a wind tunnel effect.



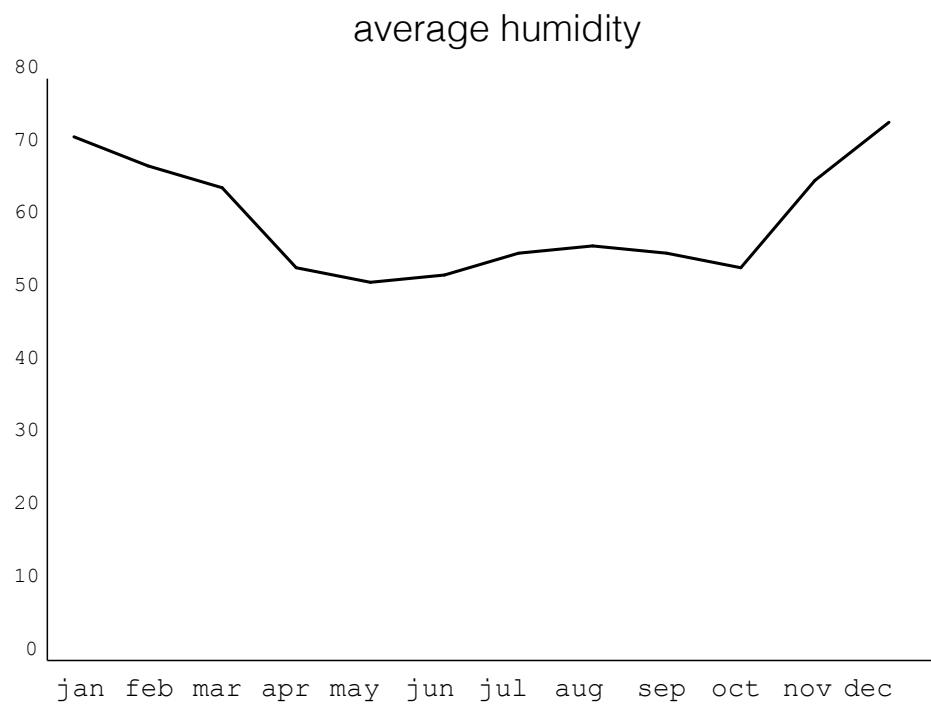


Figure 36: *average humidity*. Retrieved from climate-zone.com

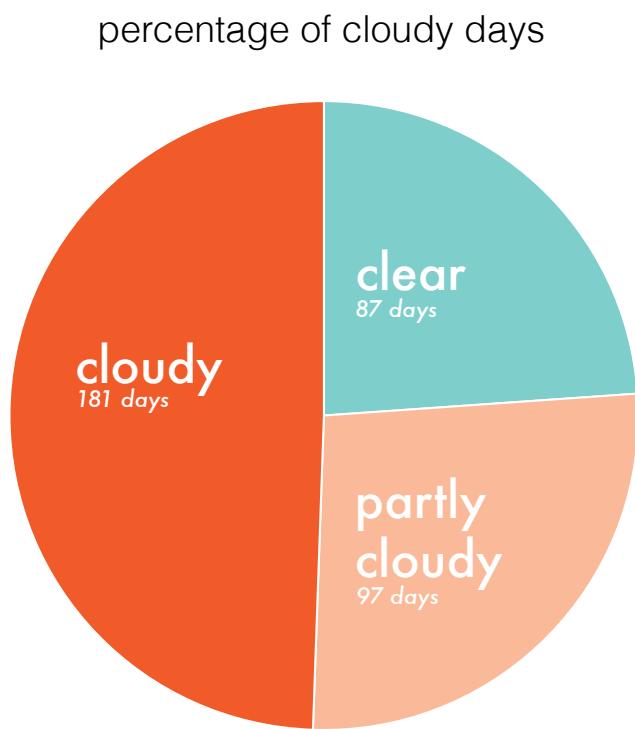
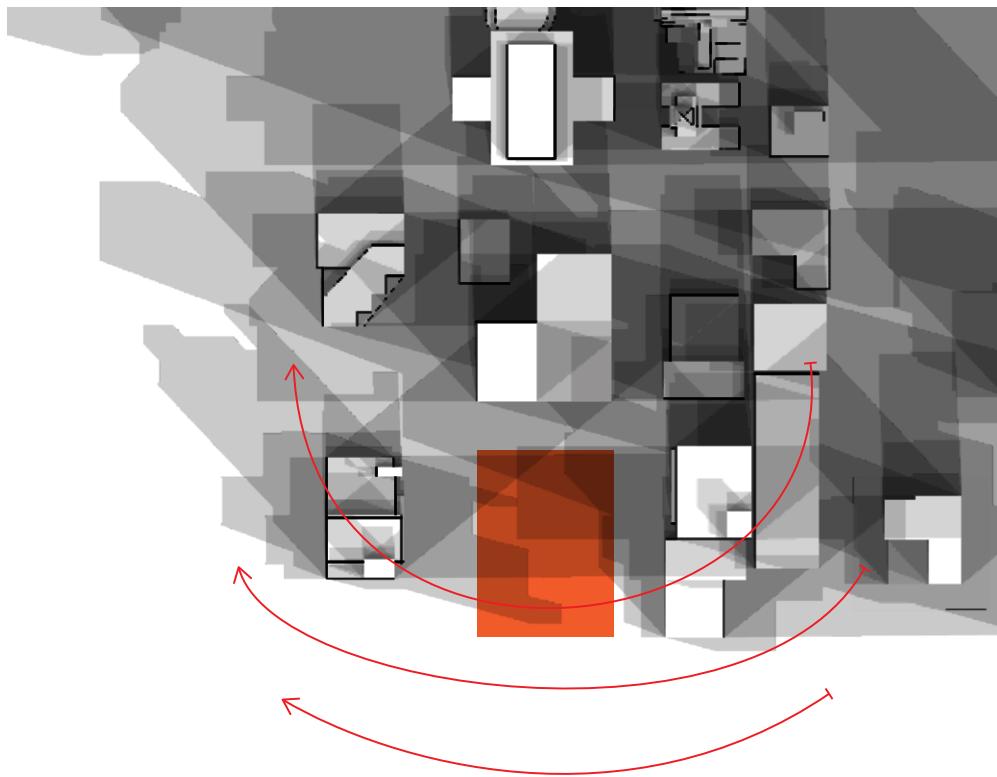


Figure 37: *percentage of cloudy days*. Retrieved from climate-zone.com



SHADOW DIAGRAM/SUN PATH

shadows from summer, fall/spring, and winter at 8am, 12pm, and 6pm.

Figure 38: *shadow diagram/sun path*. Sun path retrieved from www.gisma.com

The shadow diagram reveals a site that is lightly shaded along the perimeter during the summer months and is shadier in the fall/spring and winter. The southern end of the site has little to no protection from the built environment. With additional stories added to the site, there is a potential for excessive heat gain without proper detailing.

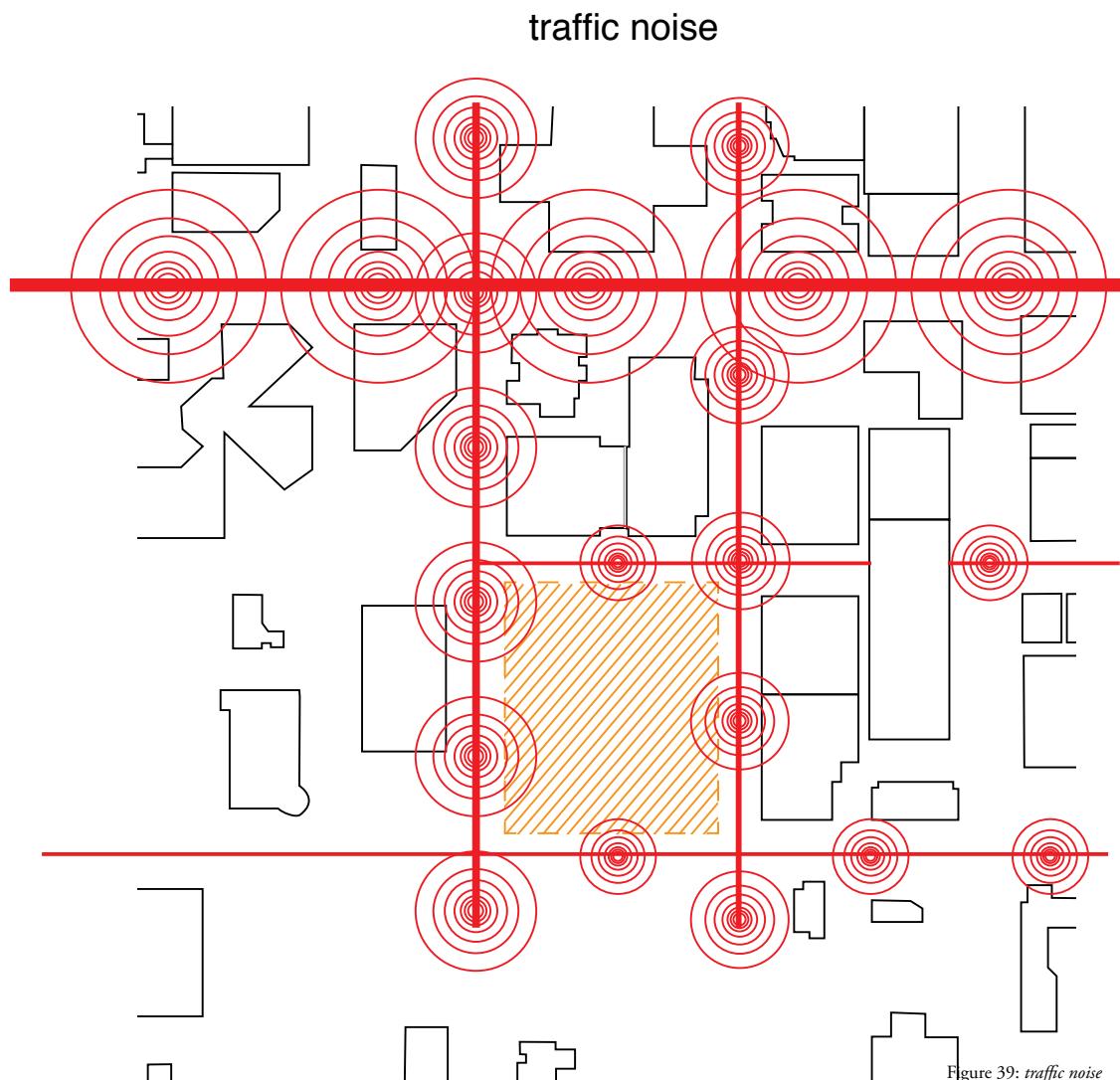


Figure 39: traffic noise

Roads located near the site are the main noise pollutants. The roads located directly next to the site do not have a heavy urban traffic flow, thus creating a relatively smaller noise. To the north is Second Street that is the source of the majority of traffic noise. When on the site, little of this noise is apparent. On the north-south streets on either side of the street are bus parking which provide transportation for employees to neighboring towns. This is a source of noise and congestion, particularly in the beginning and end of the work day.

PROGRAMMATIC REQUIREMENTS/ SPATIAL ALLOCATIONS

Atrium	2400
Seminar spaces	5700
Collaboration space	3000
Research labs	40,000
Core labs/support space	10,000
Vivarium	7000
Offices	2000
Conference rooms	1320
Common spaces/break room	1600
Mechanical	15,000
Circulation	22,000
<hr/>	
	total 110,020
Interstitial space 70,000	

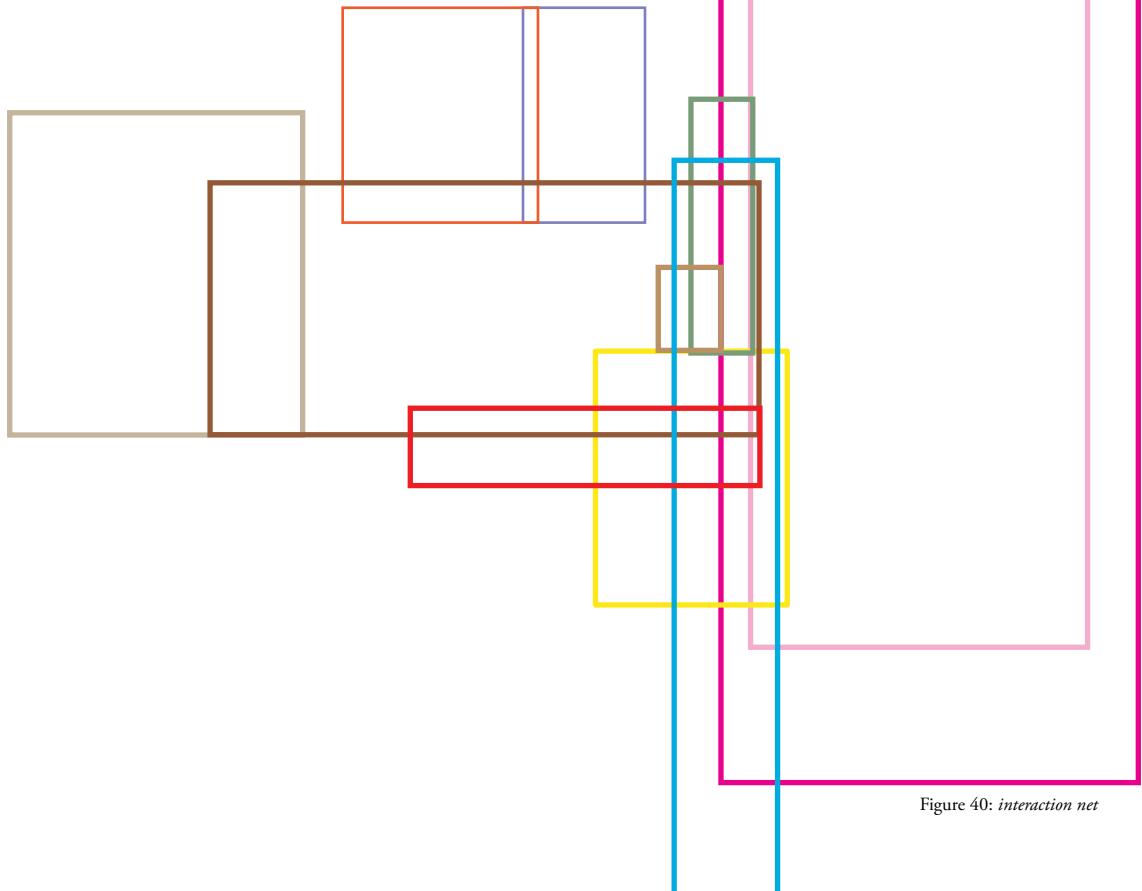


Figure 40: interaction net

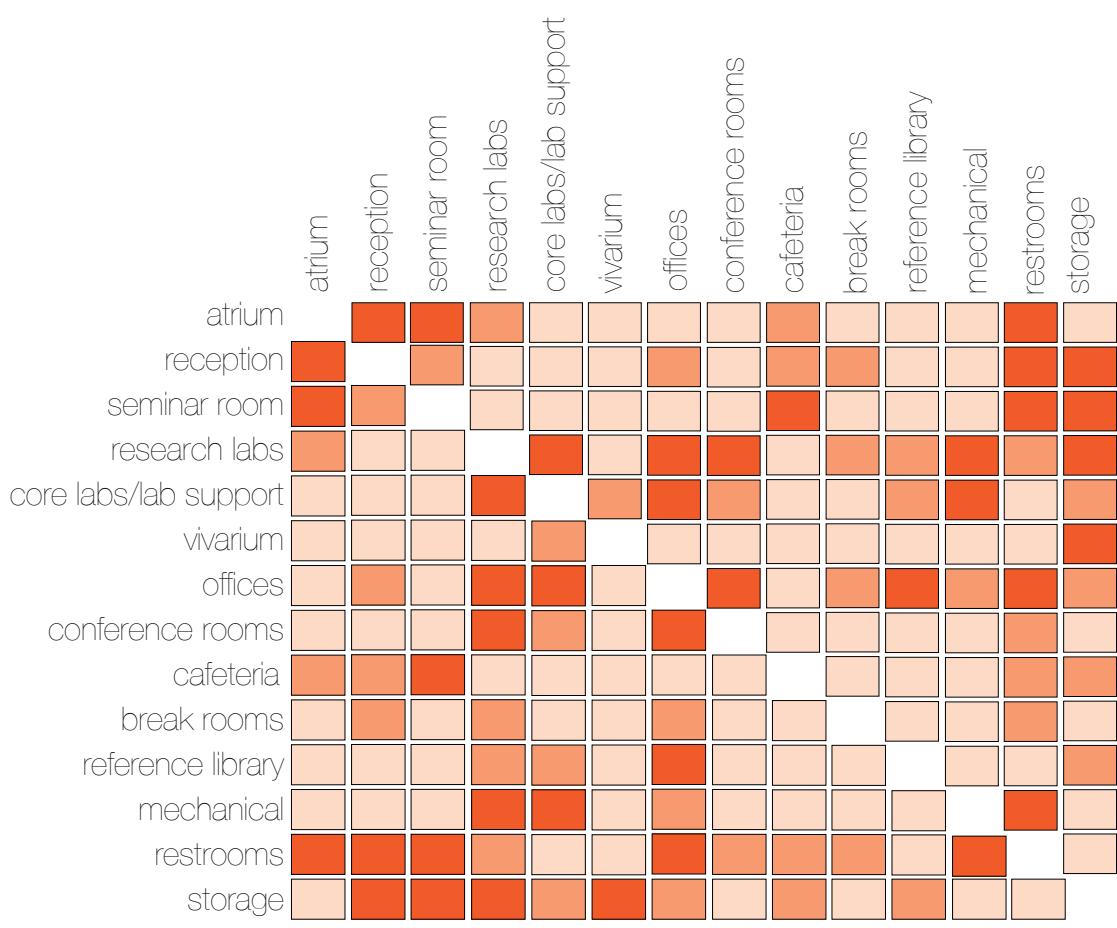


Figure 41: interaction matrix

seminar room - space for the public to see the inner workings of a highly specialized research facility, listen to guest speakers, and attend seminars. This room will have a viewport into a laboratory space to serve as a direct visual link to the processes conducted. Also, a view will be created upwards into the office space.

collaboration space (“collaboratory”)- Vital to the research process, these spaces are created to allow scientists from all disciplines to meet and discuss new research and form a team mentality.

research laboratory - At the heart of the program, the research labs are the locations for breakthrough discoveries for regenerative medicine. The arrangement of the research laboratories allows for a flexible work environment, which will be benefited from a largely open floor plan. Instead of separate research rooms, the laboratory space is open and broken up into “communities.”

laboratory support - With the open space planning of the laboratory, shared spaces that allow for mechanical functions, such as freezers, small microscopes and fume hoods. These spaces are at a 25% ratio to the main laboratory space to allow for increased flexibility and expansion of research.

core laboratories - These laboratories house the expensive equipment in the facility. These laboratories are stacked, in a separate building structure, adjacent to the research laboratories. This relationship provides direct access for the scientists on that particular floor, and allows for surprise collaboration opportunities if the scientists must travel between floors.

vivarium - This is the location for the small animal containment. These creatures require a large amount of space and a large area for food storage. This part of the program is located in the basement to provide a comfortable living space with no windows. Also, smell can be an issue if located on higher floors.

offices - these spaces are reserved for more senior scientists. The need for collaboration among this group is still high, so the offices are largely grouped together and visible from all floors. Collaboration space flanks all the offices to allow more connections to be made.

reference library - a small branch library from what is already located in the Plummer building. This space will be accessible to all researchers from the other four buildings.

conference rooms - These rooms offer scientists and administration to gather and have private meetings and discussions.

break room - vital to any office building, this is an area in the building for relaxation and casual interactions.

PREVIOUS STUDIO EXPERIENCE

Fall 2009

Professor Darryl Booker

Teahouse -- Concordia College, Moorhead, MN

Boathouse -- Minneapolis Rowing Club, Minneapolis, MN

Spring 2010

Professor Joan Vorderbruggen

Montessori School -- Fargo, ND

Dwelling -- Cripple Creek, CO

Fall 2010

Professor Cindy Urness

Food Co-op -- Fargo, ND

Snow Symposium -- Winnipeg, Manitoba

Wellness Center -- Fargo, ND

Spring 2011

Professor Ronald Ramsey

Hotel -- Chicago, IL

Performing Arts Center -- Pennsylvania

Fall 2011

Professor Bakr Aly Ahmed

Sustainable High-Rise -- San Francisco, CA

Spring 2012

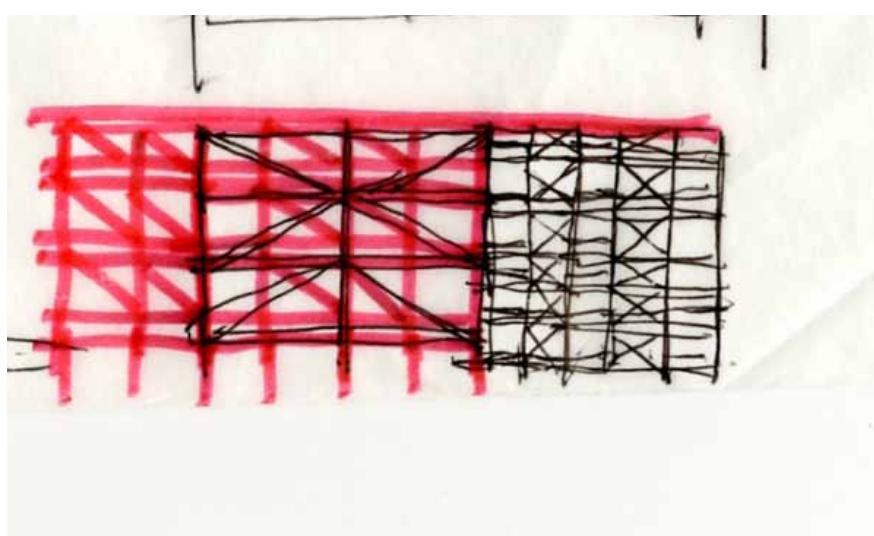
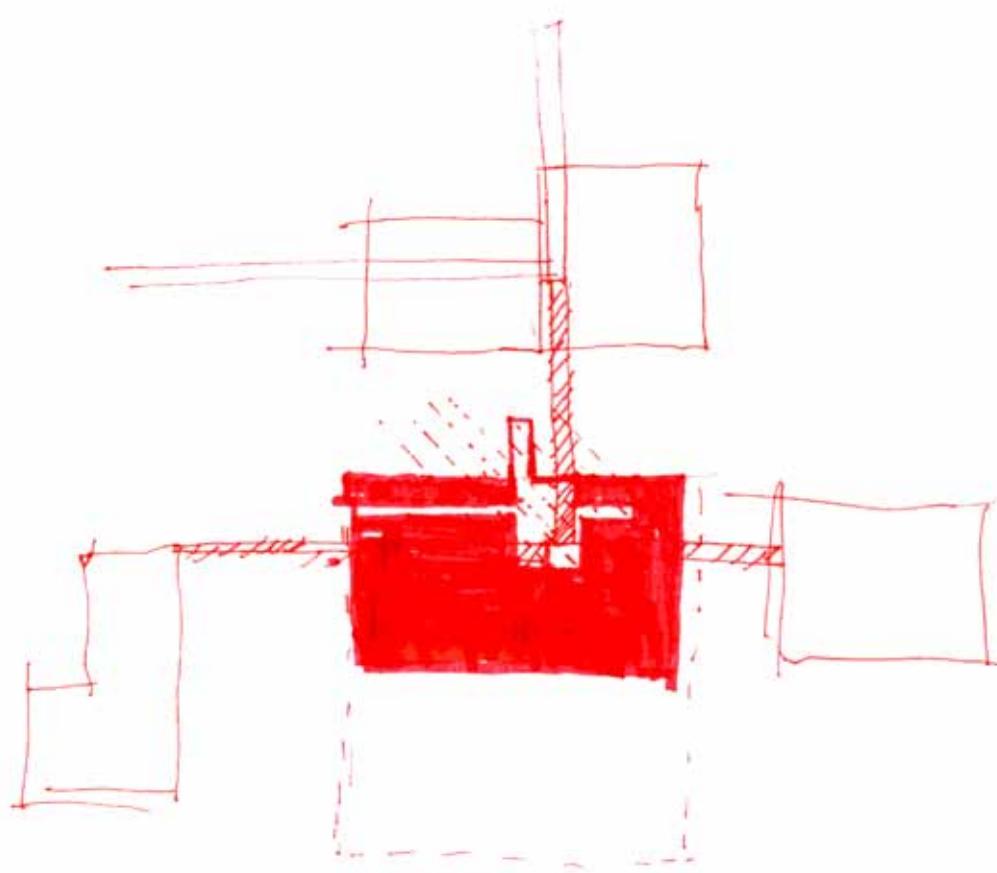
Professor Paul Gleye

Square Foch Urban Design Project -- Lille, France

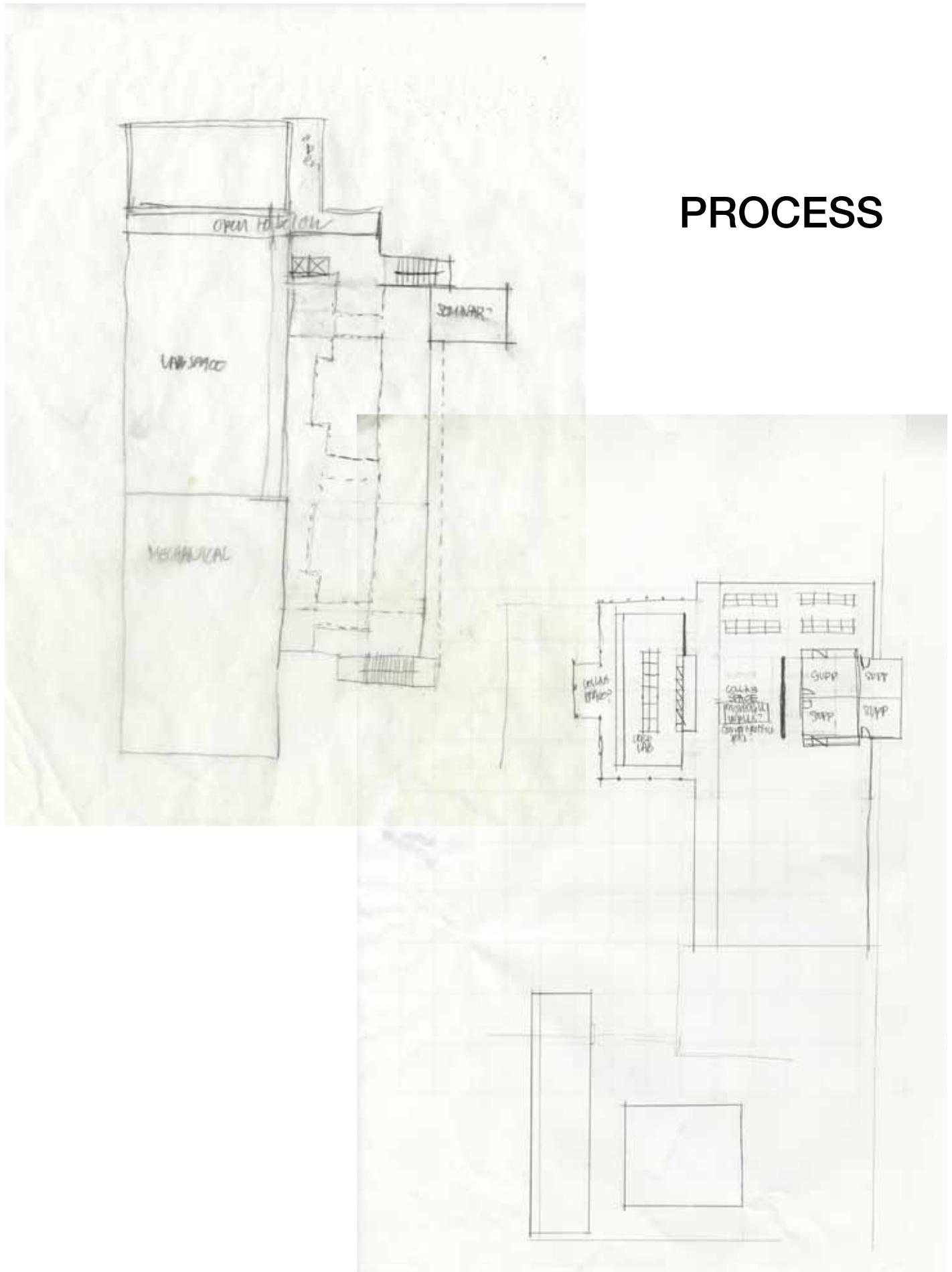
Fall 2012

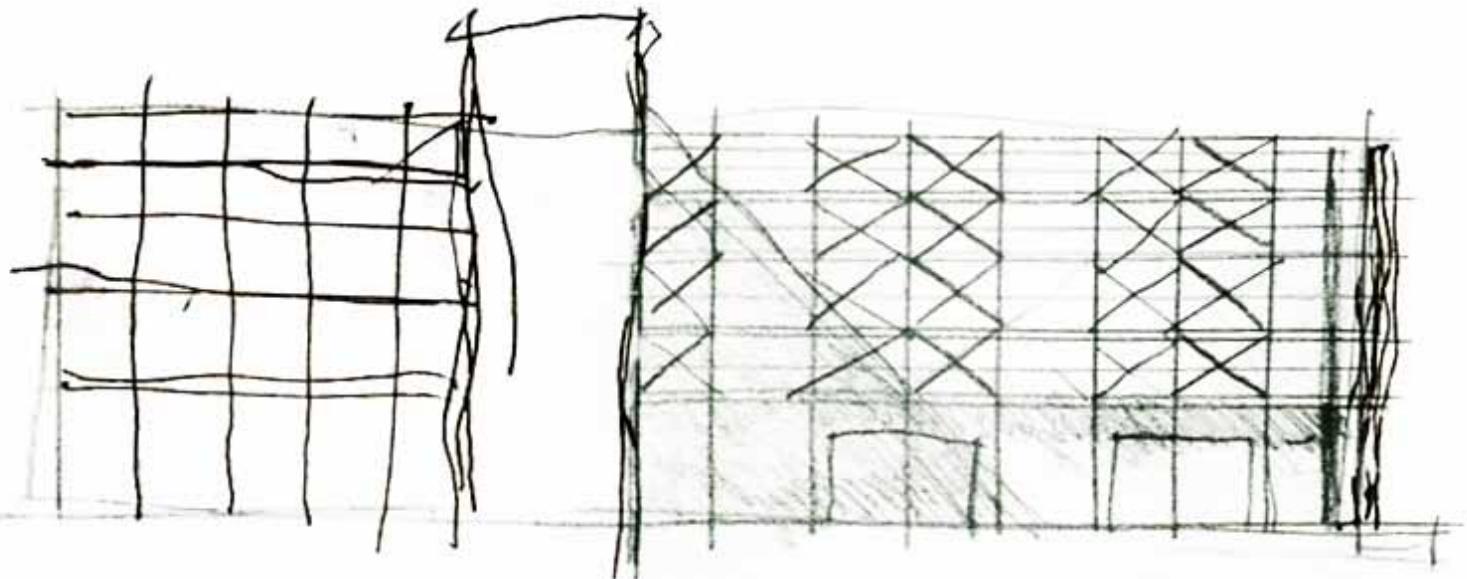
Professor Mark Barnhouse

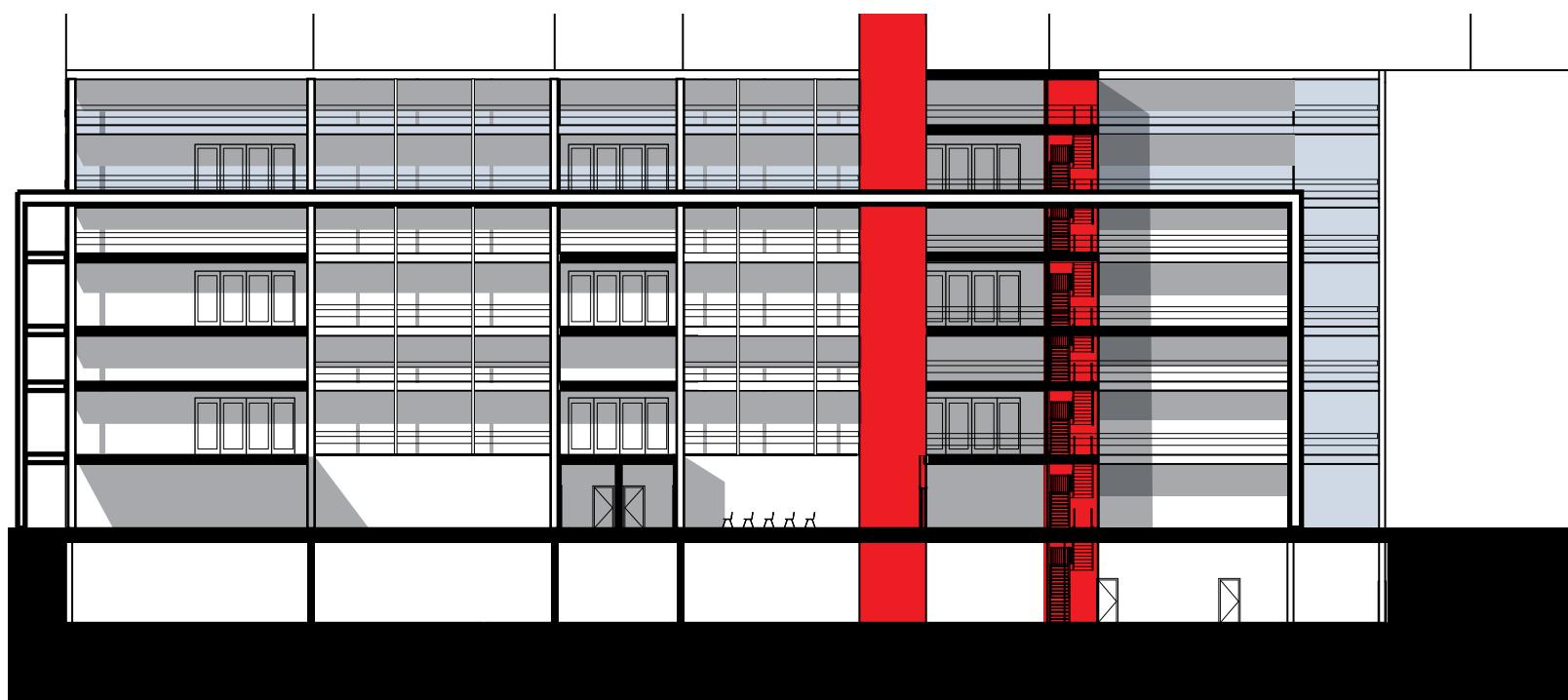
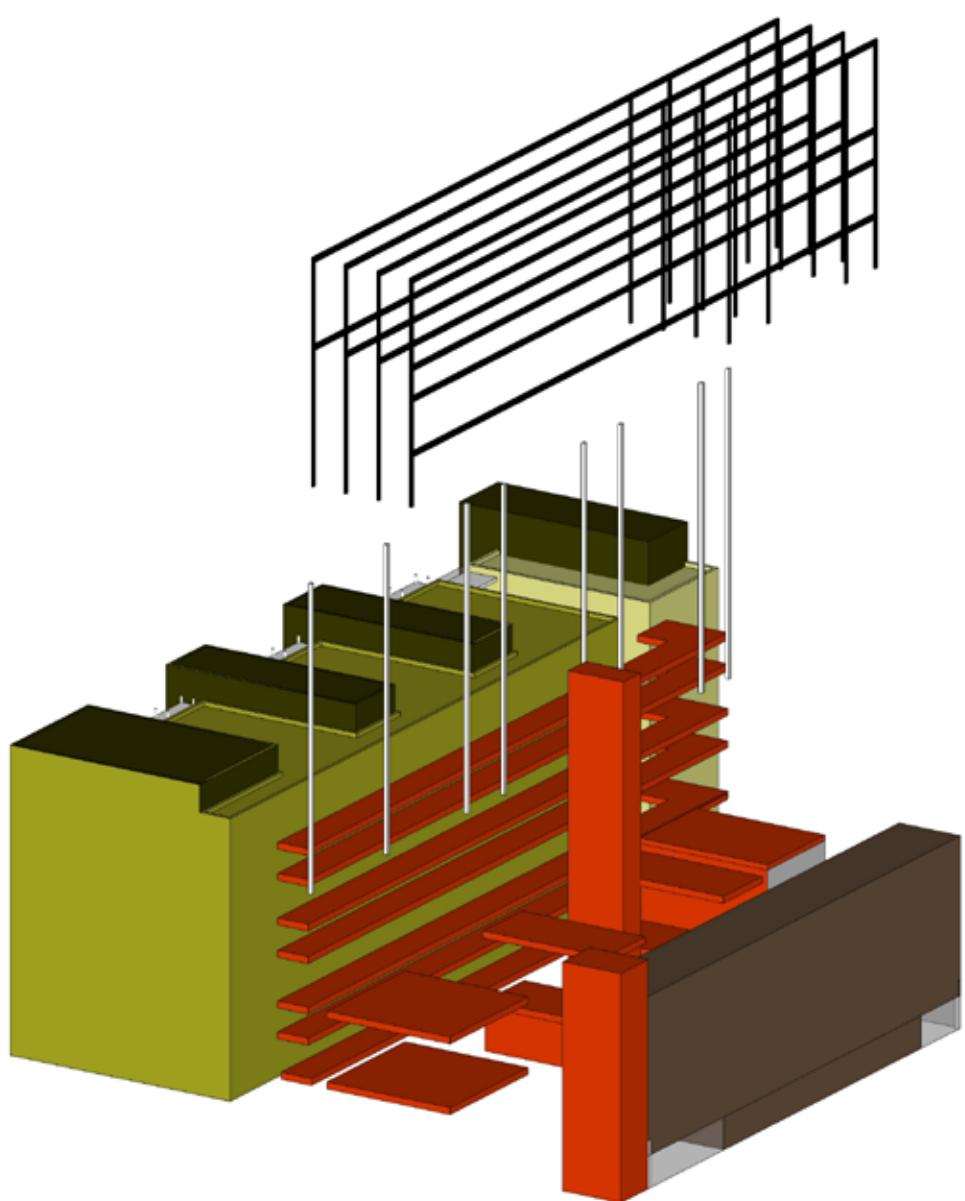
Water Research Facility -- Linton, ND



PROCESS







ADAPTIVE ARCHITECTURE

in a regenerative medicine facility

BOARD LAYOUT

problem statement

How does the growth of human knowledge impact the longevity and usefulness of a building?

theoretical premise

Architecture must adapt to change. This ability to adapt, to the current context in which it is used, plays a significant role in a building's lifespan. With an ever-increasing demand for cures to chronic illnesses, adaptable architectural solutions are needed to further medical research.

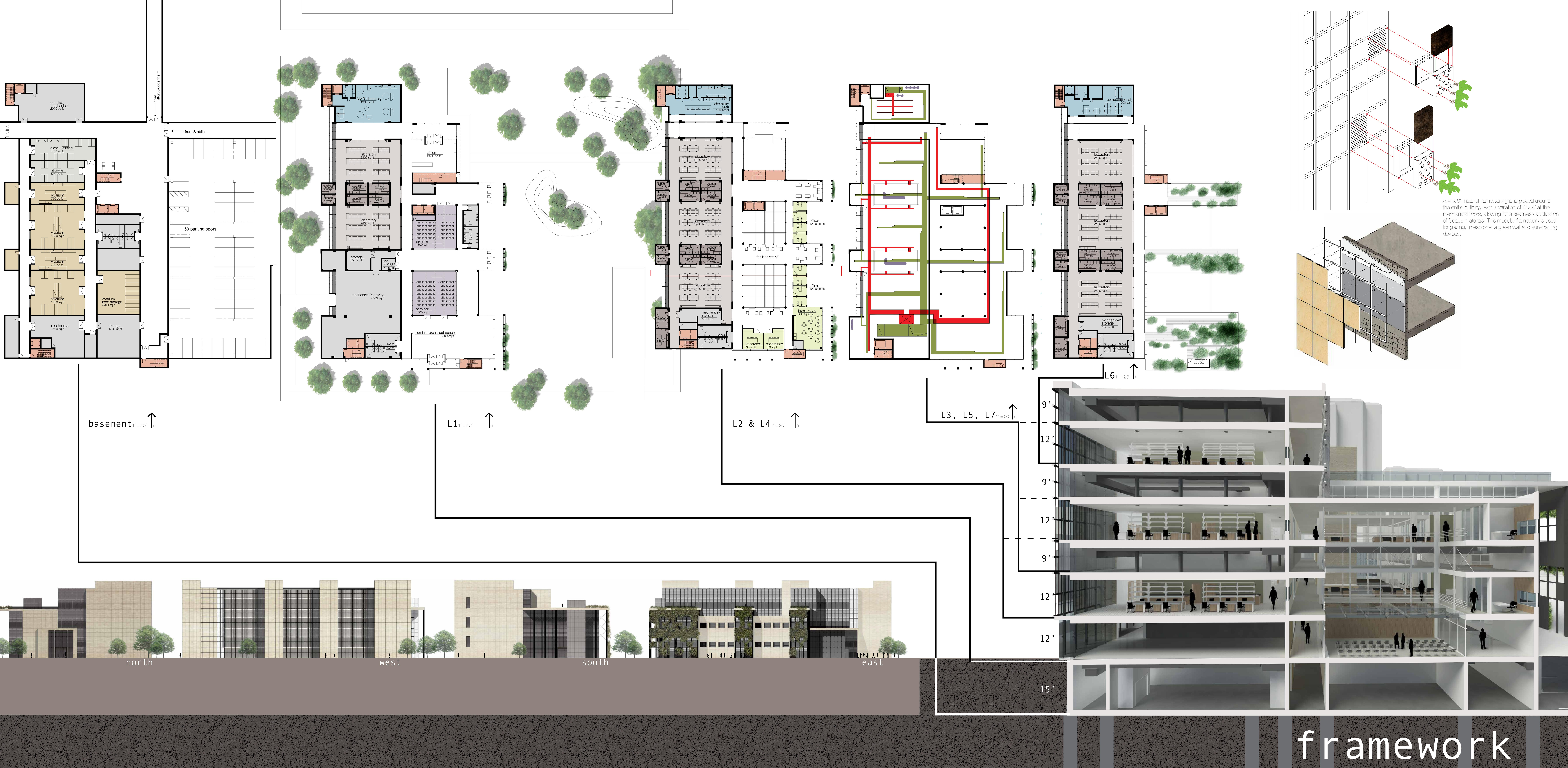
typology

Regenerative medicine is a field of scientific research which aims to help patients heal themselves. Scientists use a **framework** of non-human cells and coat it with a patient's own cells to create a new organ. This framework idea is applied in architecture by creating a building that is designed for the current needs of the users, but also designed for **learning**, **transforming**, and **growing**.

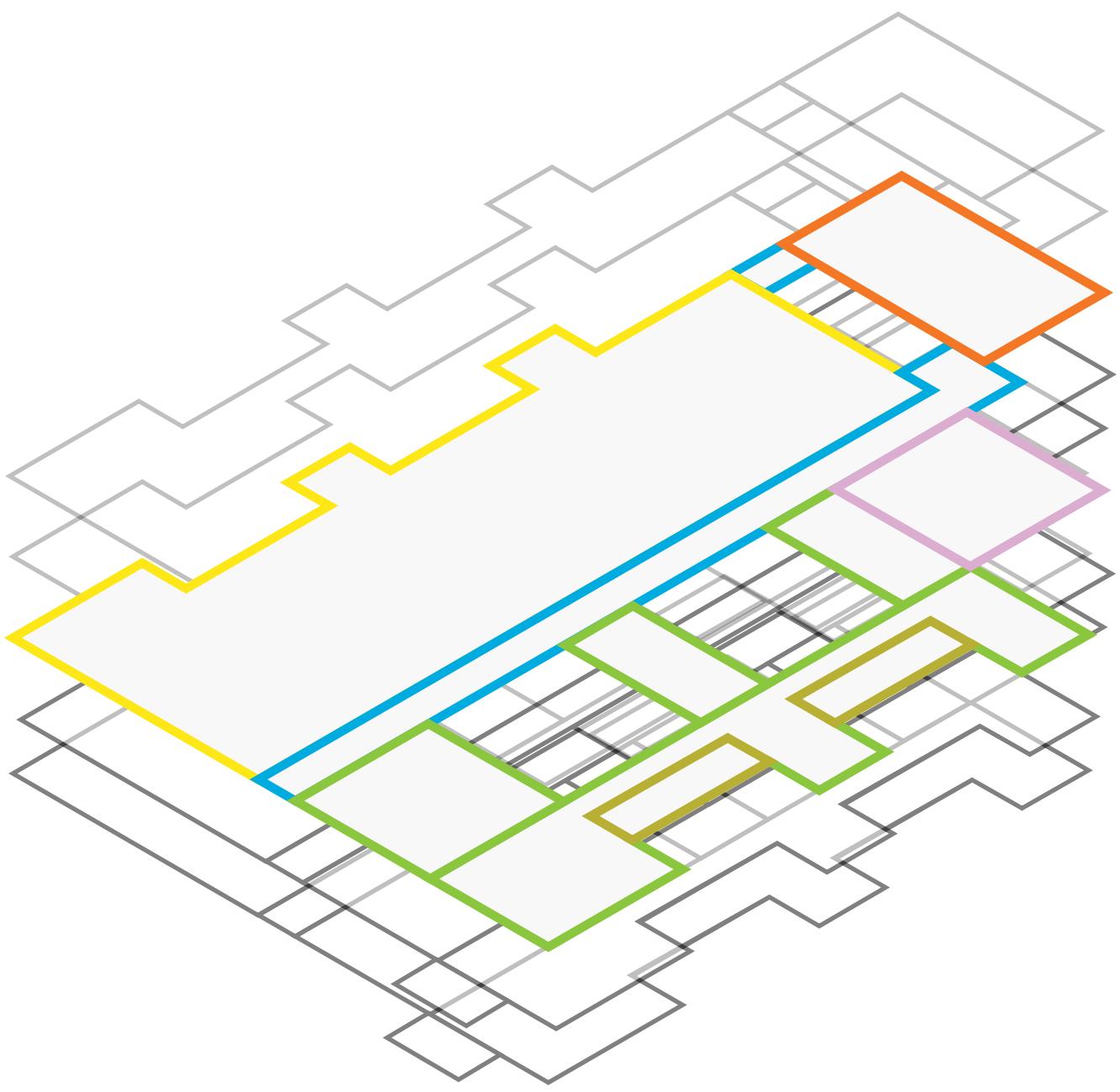


Mayo Clinic
Mayo Clinic existing research facilities
new site



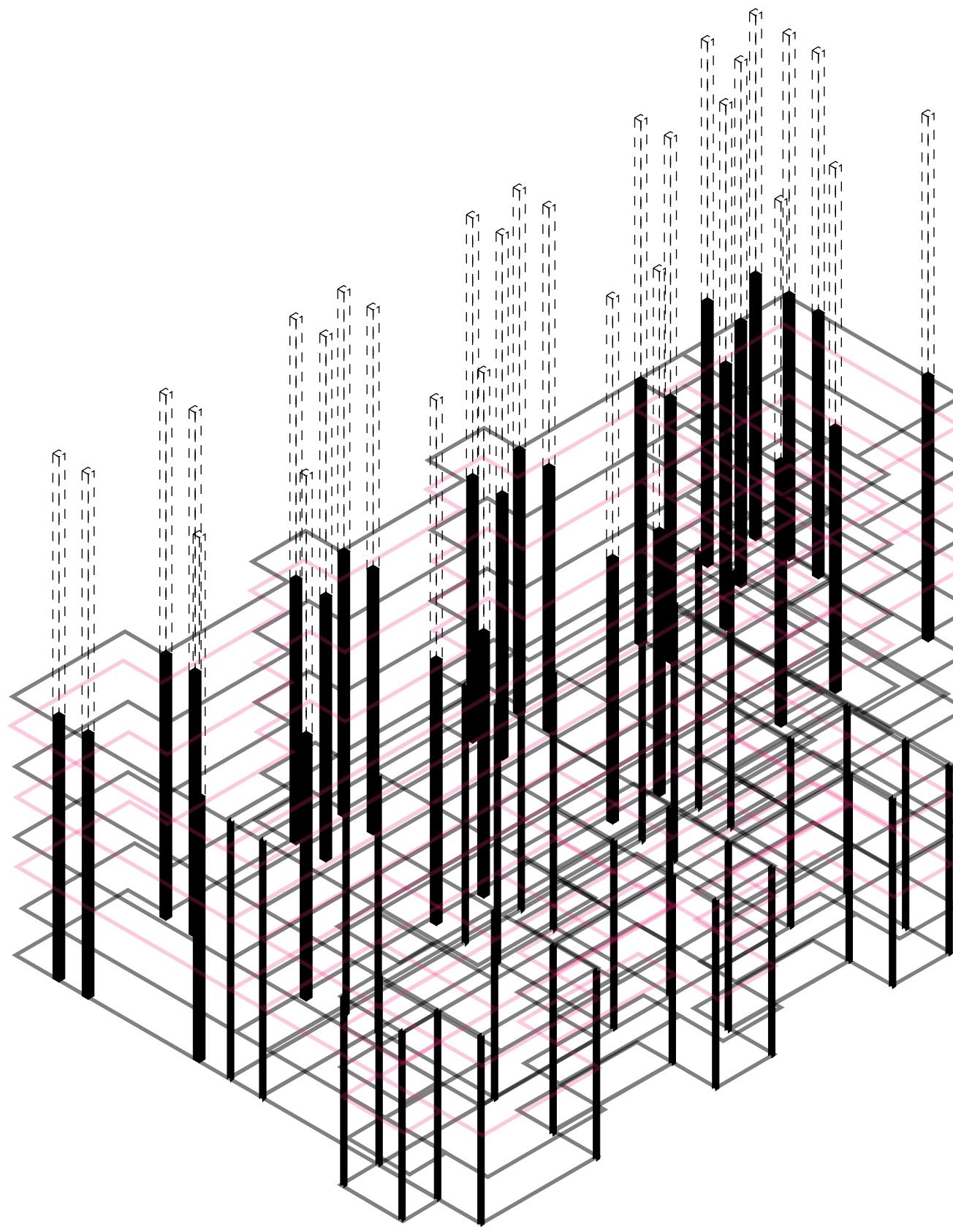


framework



space plan

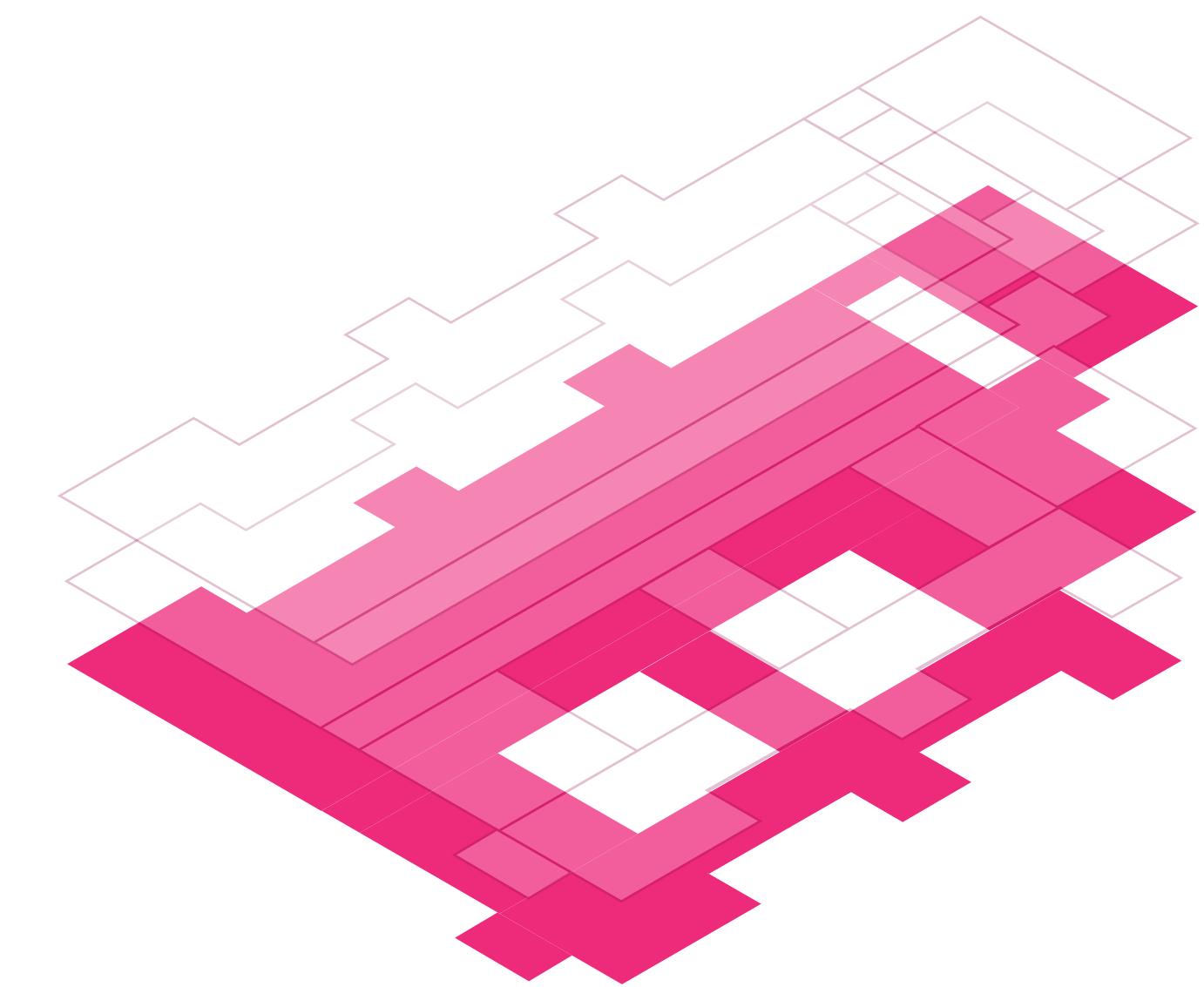
As the scientists and users of this building learn, their need for altering spaces increases. It must acknowledge this change in human knowledge growth and adapt to its occupants needs. To achieve adaptability within the space plan, it is configured to allow for each primary programmatic element to learn independently in conjunction with its users. An open space plan is used in the design to allow for the occupants to freely designate spaces as the knowledge growth demands new spaces, the organization grows or as the direction of research changes. This ease of adaptability within the space plan allows for an increase of closed space plan to increase "useable" square footage, without having to expand vertically or horizontally.



structure

When the space planning approach can no longer sustain the need for more space, this building is able to increase vertically within the building's lifespan. Structure in buildings, when properly designed, often outlive the occupants desired usefulness. Allowing the building to learn how tall it needs to be increases the longevity and purposefulness, saves money, and is an environmentally sound idea.

The structure is separated into three main parts, each housing a primary programmatic element. The laboratory and core laboratory are site-cast concrete, with columns that can support a doubling in height. A steel joisted system is used for the office portion, due to lighter loads.

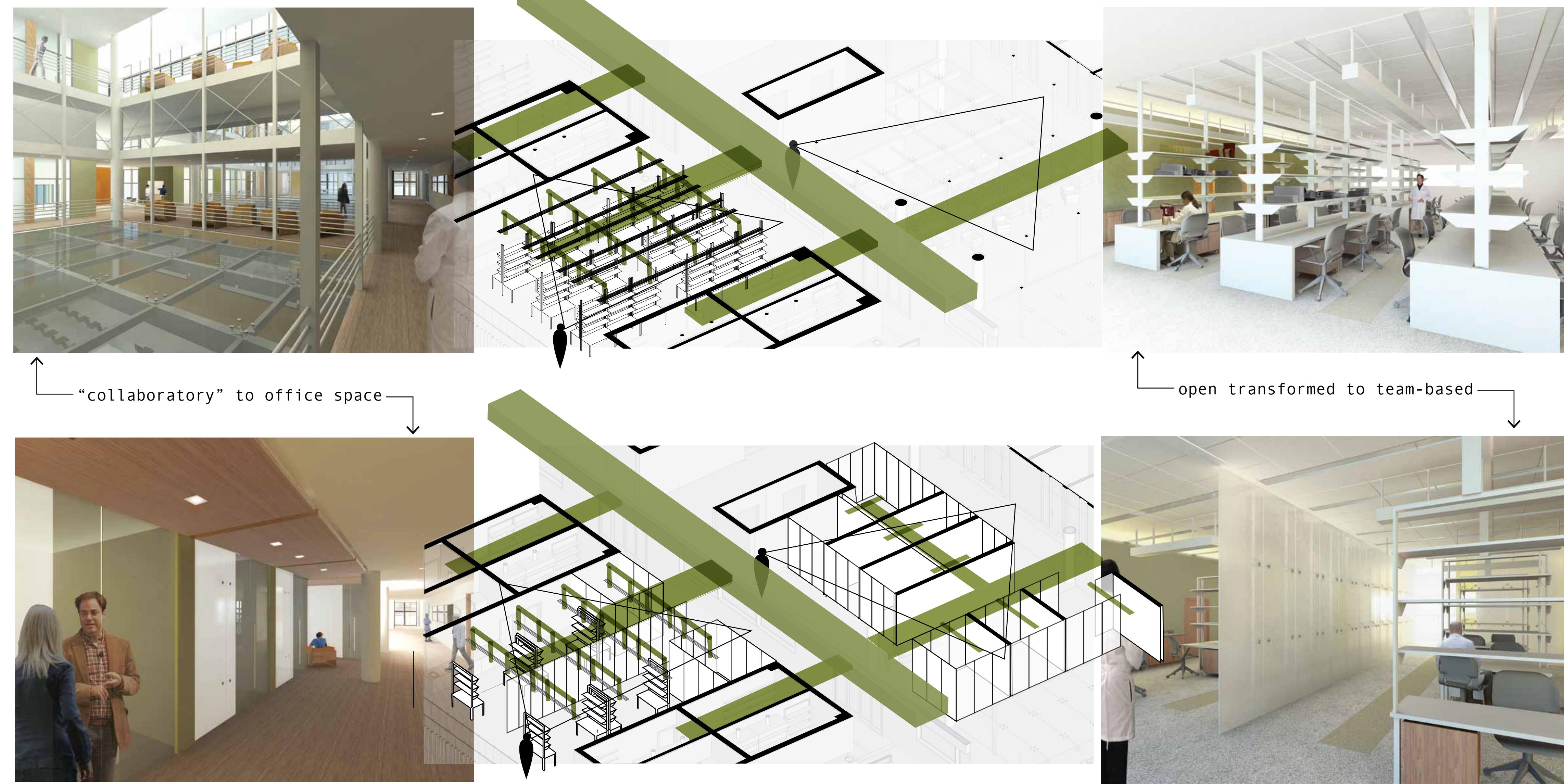


services

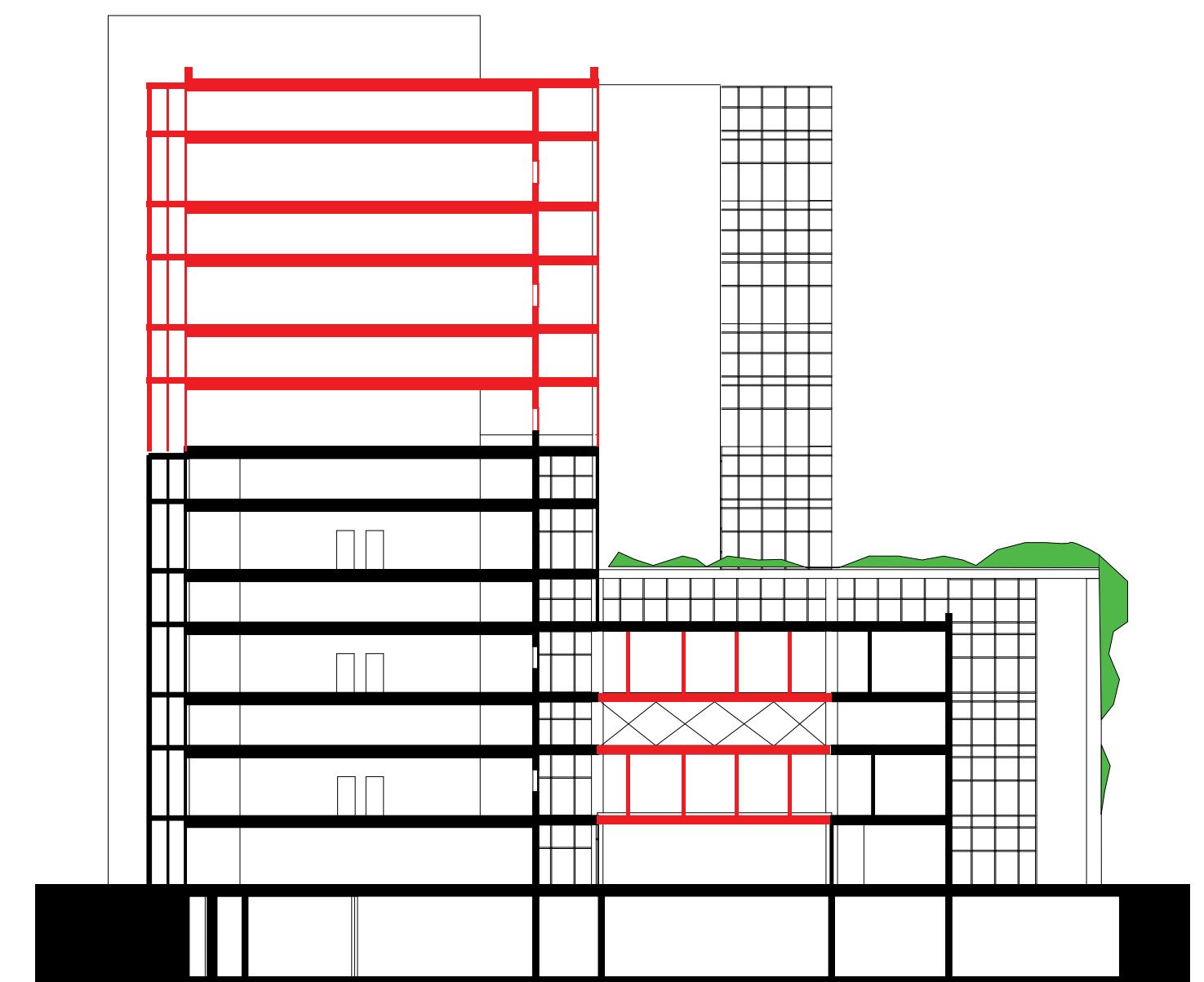
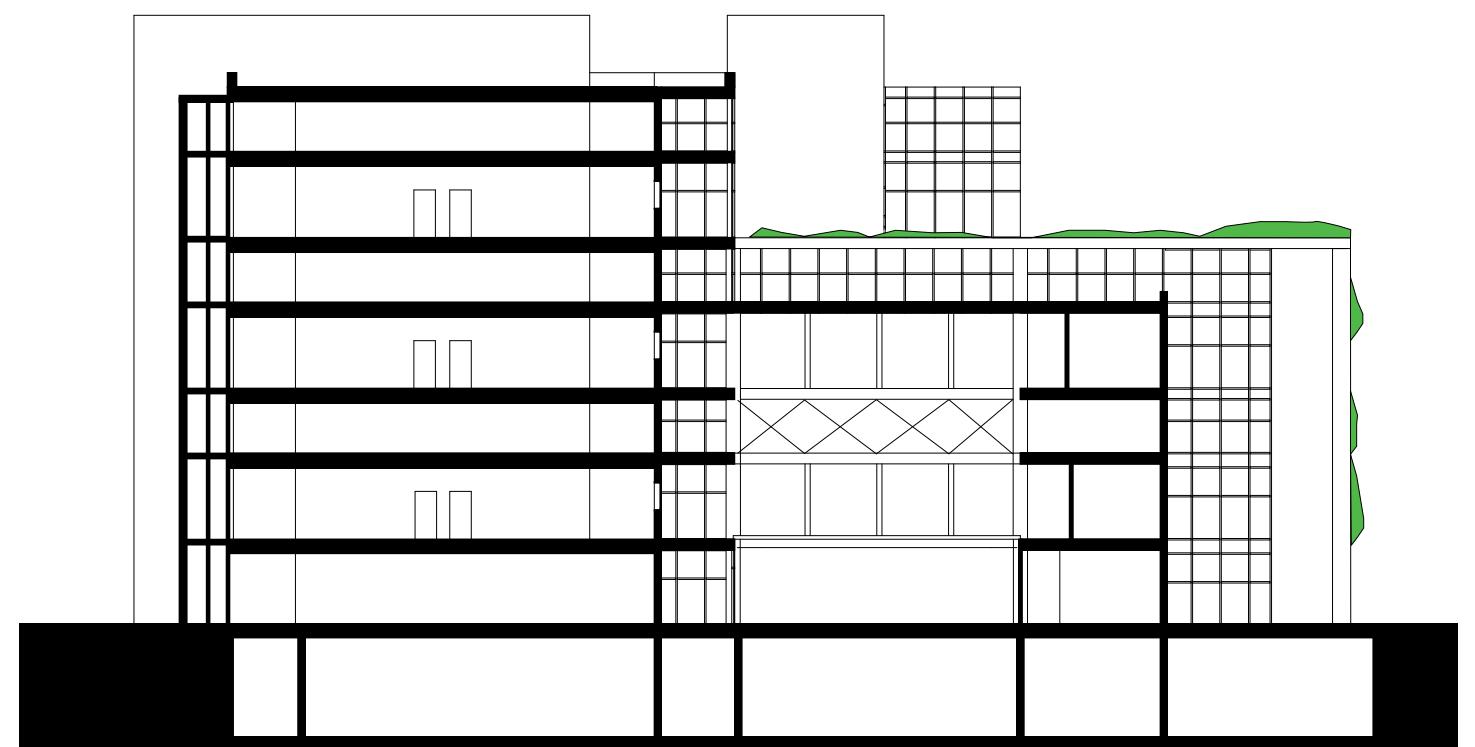
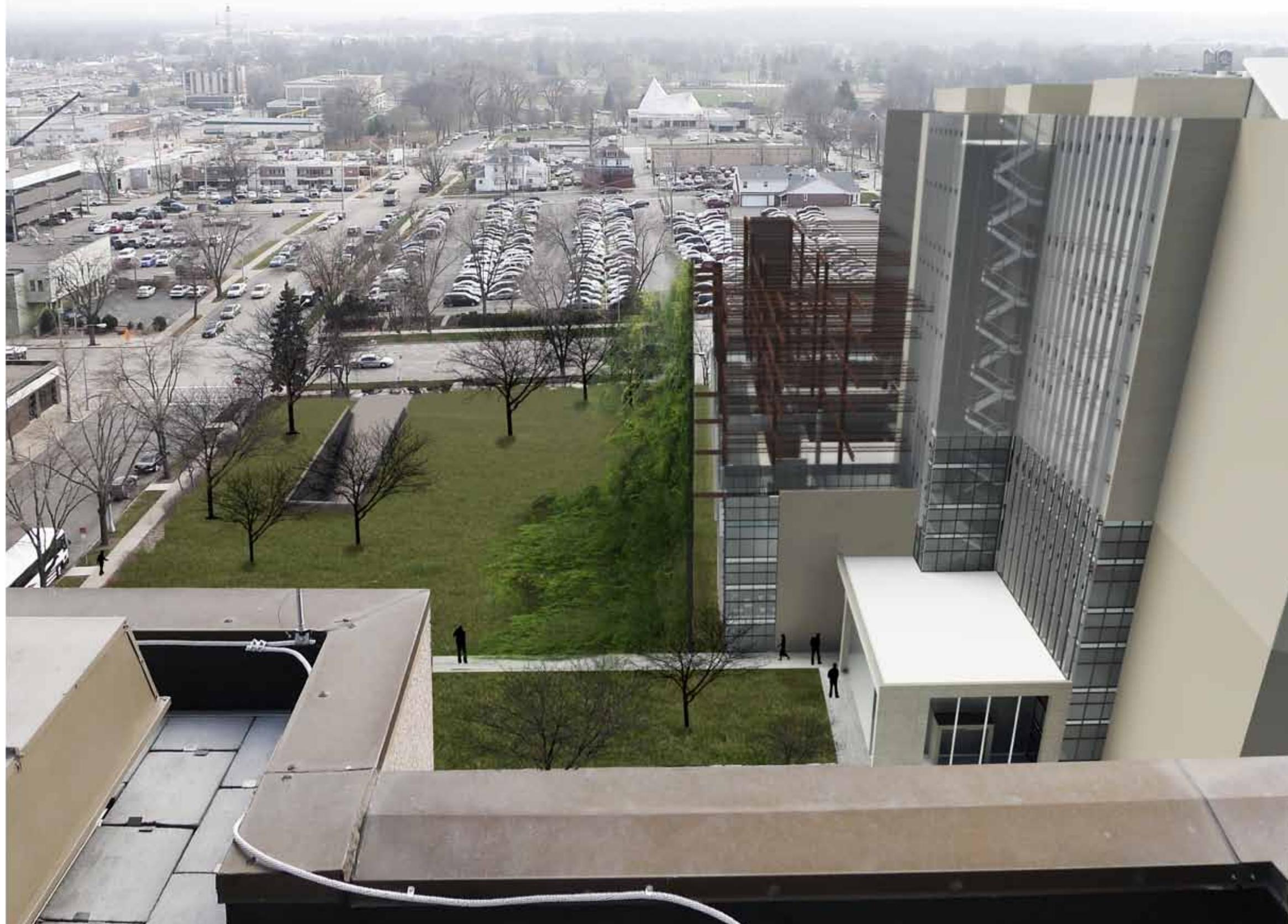
The building is able to learn with its occupants through its services. Services within a building must be upgraded regularly, and when a mechanical scheme allows for easy access to these systems, a building's usefulness increases. The approach within this building is to use interstitial floors, floors which are dedicated solely to mechanical equipment and storage overflow. Services are able to be upgraded without shutting down research operations on the main levels. If a spatial re-configuration is deemed necessary, the mechanical system is able to learn what the occupants need and easily shift to the new needs.

*adapted from Stuart Brand's book *How Buildings Learn*

learn



transform



grow

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“NDSU has facilitated my learning
and growth as a person.”

