Spatial separation in scientific laboratory design : a design for a chemistry and biology laboratory building on the campus of Georgetown University in Washington, DC

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Spatial separation in scientific laboratory design:

A design for a chemistry and biology laboratory building on the campus of Georgetown University in Washington, DC

by

Darlene Alberta Gluck

A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the degree of

MASTER OF ARCHITECTURE

Major: Architecture

Program of Study Committee:
Thomas Leslie Major Professor
Clare Cardinal-Pett
Marc Porter

Iowa State University

Ames, Iowa

2005

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This is to certify that the master's thesis of

Darlene Alberta Gluck

has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy
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I. Thesis Statement

The impact of spatial separation (i.e. "enclosure" and the "wall") is significant in the design of research buildings. An exploration of major aspects of "enclosure" and the "wall" will be conducted to expose and validate assumptions about the nature of spatial separation in scientific research buildings today. A building's enclosure acts to define the space it encloses. For this thesis, a building's enclosure will be defined as the barrier that separates the external climate environment from the interior engineered climate. The "wall" is difficult to assign a precise definition because it can be examined from a number of different perspectives. In architecture, it can be defined in terms of functional relationships, as an aesthetic object, as a conceptual representation or as a construction system. For the purposes of this thesis "wall" will be defined in a very wide sense as a vertical, horizontal, diagonal or curved partition either physical or virtual. Walls connect, filter, interrupt, control and direct the passage of people and things like water, air and light. Several case studies will be evaluated and wall sections will be analyzed to test assumptions. The analysis will result in a design for a Chemistry and Biology Laboratory building on the campus of Georgetown University in Washington, DC incorporating valid assumptions and discoveries. In addition, the building will be designed using low-energy design principles and high performance standards. The use of drawings, personal interviews, models and other documentation will reveal the role enclosure and "wall" play in the success of a laboratory building and the influence these factors have on the building occupants and their work.
II. Introduction

The research laboratory is an increasingly important and interesting architectural building type. It is the stage for advancement in many areas of knowledge, the environment in which many creative minds must function, the location for extremely valuable and often dangerous equipment, it represents significant financial investment and is an important part of many architectural practices. Yet it has maintained a low profile as a design problem and vehicle for distinguished architecture. The design of research laboratories highlights the architectural debates of form vs. function and the intellectual idea of “Two Cultures”, the separation of “intellectual” and scientific cultures, articulated by C.P. Snow.¹ There is still debate about whether the quality of our science architecture really enhances the quality of our science. To create truly great architecture I believe we must design to meet the aspirations of both cultures. This challenge is no more evident than in the design of scientific laboratories. “Today there remains a chasm between the two cultures of architecture and science. ...In the nineteenth century, however, both professions

were emerging from that broad and somewhat undifferentiated field that was the "arts and sciences".²

The history of the research laboratory as a specialized building type begins with the alchemist cell. Paintings of the alchemist's work often show a room of picturesque gloom with crucibles on the floor and ceilings and walls cluttered with mysterious objects leaving an impression somewhere between magic and madness. An assistant does most of the work while the alchemist sits in contemplation.

![Image](http://www.liebig-online.com/1383g.jpg)

When chemistry began to appear as science rather than magic, rooms were depicted more objectively. In drawings from the early eighteenth century, apparatus can be seen clearly, the scientist dictates notes and careful observation is evident.

As utilities like gas and electricity became available the laboratory began to be planned around immovable benches. The first laboratories were built as conversions of rooms in existing buildings with buildings built specifically for laboratories coming much later; but even these early laboratories exhibited the kind of planned geometry we often see today.

As long as most laboratory work was bench-based, the evolution of the fixed bench as dominant made some sense but today new methods of work and new devices have made the traditional fixed bench obsolete. The development of electronic devices of all types has completely revolutionized the way scientific laboratories are used. The benches have become obstructions.

The design requirements of
the laboratory have come full circle. The need for the user to be able to configure and reconfigure the work environment has become a measure of architectural success. Further, increased interest in sustainability requires us to re-examine fundamental building issues including building systems and the nature of separation between the laboratory and the outside environment and between functions within a building.

Some key issues involved in the design of modern scientific research laboratories include:

- **Flexibility** - rapid and unpredictable changes in research activity
- **Resource efficiency** - building lifespan, resource efficiency, sustainability
- **Human environment** - intellectual productivity, social contact, innovation, interaction, computerization, individuality (mobility, space and resource consumption)
- **Global trends** - world wide information networks, cultural differences, technological innovation
- **Safety** - chemicals, biologicals, terrorism, activism

Spatial separation is an important factor in all the above issues. Interstitial space has been a widely studied concept but only addresses some of the more mechanical issues. A study of the “wall” in terms of enclosure is a good vehicle for
understanding research issues in terms of the architecture of scientific buildings because enclosure drives so many other building elements.

"Enclosure has many meanings; it represents a fundamental construct in architectural design pertaining to the representation of spatial arrangements. Through the materialization of basic geometric entities – points, lines, planes and volumes – architecture arranges program across a rich spectrum of expression...Listening to any discussion of architectural design, virtually all of the terms used to describe spaces, places and their connections are premised on the concept of enclosure. The architectural design intent must be sufficiently declarative to guide the selection and manipulation of enclosure elements so that aesthetics are harmonized with sustainability criteria both for the building envelope and the whole building system".

Our bodies can handle only a narrow range of environmental conditions. The designer of research buildings must be concerned not only with the external environment but also with the diversity of health and safety conditions existing in the laboratory. N.B. Hutcheon in his Fundamental Considerations in the Design of Exterior Walls, defined a basic set of performance requirements which extend from the Vitruvian parameters of "firmness, commodity and delight" the needs and desires of humans have essentially remained constant as have their reasons for, and methods of, constructing enclosures." One aspect that has changed is sustainability. We are now more concerned with managing our resources and the

4 Kesik 2.
health and safety of building occupants than people were in the 1950's when Hutcheon wrote.

Probably more than any other building type, scientific laboratory enclosure requirements caused by occupancy type and use often conflict with building systems. For example, research activity that combines microelectronics and biology laboratories, as in some bioinformatics and machine-organism interfaces work, will find a conflict between the need for positive air pressure in microelectronics spaces and negative pressure required for some biological work.

Building enclosures can be classified by examining their composition including structure, cladding and interior finishes. Enclosures consist of: natural formations, stacked units, frames, shells and plates, and air supported fabrics. Cladding and interior finishes include: coatings, units or panels, fabrics, films, sheets or rolls or the incidental outcome of monolithic construction.\(^5\)

\(^5\) Kesik.
The tradition of hut construction has many conceptual similarities to our present day system of frame and enclosure. "A wigwam built with a pole frame structure and a bark cladding is very similar to a steel frame structure of glass and metal cladding like the Chrysler building."

"Modern curtain walls rely on similar methodology to wattle and daub wall construction but use different materials."

---

6 Kesik.
7 Kesik.
Many factors influencing wall and enclosure design are site-specific and vary considerably. The following table outlines some of the influences.

<table>
<thead>
<tr>
<th>Site Influence</th>
<th>Factors to Consider</th>
<th>Impact on Building Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil</td>
<td>Soil type, bearing capacity, percolation rate</td>
<td>Foundation design and drainage</td>
</tr>
<tr>
<td>Topography</td>
<td>Hilltop, bottom of valley, side of slope, level site</td>
<td>Foundation design and drainage, site drainage and access</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Depth of water table</td>
<td>Foundation design and drainage</td>
</tr>
<tr>
<td>Sunlight</td>
<td>Building orientation, seasonal sun paths, shading from adjacent plantings and buildings</td>
<td>Passive solar heating, cooling loads, daylighting, fenestration &amp; shading devices, pedestrian comfort, landscaping</td>
</tr>
<tr>
<td>Wind</td>
<td>Seasonal magnitude, direction &amp; frequency, extremes, orientation &amp; geometry, arrangement of interregional openings (ventilation)</td>
<td>Structural design, separator design, natural ventilation, pedestrian comfort, landscaping</td>
</tr>
<tr>
<td>Rain</td>
<td>Seasonal precipitation, storm intensity, frequency and duration, extreme values</td>
<td>Separator design, site grading/landscaping, foundation drainage</td>
</tr>
<tr>
<td>Snow</td>
<td>Same factors as above</td>
<td>Snow loads, snow accumulation (removal), snow melt (runoff)</td>
</tr>
<tr>
<td>Outdoor Temperatures</td>
<td>Seasonal temperatures, heat/cold intensity, freq. &amp; duration, extremes</td>
<td>Separator design, heating/cooling, pedestrian comfort, landscaping</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Seasonal variations, intensity, frequency and duration, extremes</td>
<td>Separator design, humidification/ dehumidification, ventilation</td>
</tr>
<tr>
<td>Seismic Activity</td>
<td>Magnitude and level of risk</td>
<td>Structural design, separator design</td>
</tr>
<tr>
<td>Noise and Vibration</td>
<td>External &amp; internal sources</td>
<td>Structural design, separator design</td>
</tr>
<tr>
<td>Organic Agents</td>
<td>Insects, rodents, birds, reptiles, fungi, moss, mold</td>
<td>Landscaping, separator design</td>
</tr>
<tr>
<td>Inorganic Agents</td>
<td>Radon, methane, heavy metals</td>
<td>Separator design, bldng air press.</td>
</tr>
</tbody>
</table>

Fire, explosions, and impact may represent an external site condition or an internal phenomenon related to occupancy. These situations require special design considerations for the separator or enclosure.

Source: Architectural Science Forum, Principles of Enclosure: March 2002
III. Process

The impact of enclosure and the wall is significant in the design of scientific buildings. An exploration of major aspects of enclosure and the wall will be conducted to expose and validate assumptions about the nature of the wall in scientific research buildings today. A typology of laboratory and wall characteristics will be established. The resulting matrix will provide parameters to construct a study of wall sections from several specific case studies both historical and current. Both technical and non-technical factors will be identified and analyzed. This exploration will lead to a design for a Chemistry and Biology Laboratory Building incorporating research discoveries. This exploration will lead to some ideas about the significance of the wall to the success of scientific buildings. The research will look at walls as boundaries and spatial dividers, walls as representational devices, walls as points of exchange, walls as definers of hierarchies and exclusion, walls as acoustic devices, walls as texture and surface, walls as building circulation control, and walls as visual devices.

Initially, three buildings have been selected for analysis, The Center for Clinical Science Research (CCSR) and The Clark Center at Stanford University both by Architects Foster and Partners, completed in 2000 and 2003 respectively and “Old Building 20” at MIT built in 1943 as a “temporary” building. (See Section V. of this thesis “Analysis of Precedents”) An analysis of these three buildings along with elements of several others should result in a clearer picture of the significance of architectural form and function for the cases in addition to providing a diverse look at the significance of “wall” and spatial separation on scientific activity. The use of drawings, personal interviews, models and other documentation will reveal the role
enclosure and "wall" play in the success of a scientific building and the influence these factors have on the building occupants and their work.

Learning from the above analysis and other research will then be incorporated in a design for a Chemistry and Biology Laboratory building on the campus of Georgetown University in Washington, DC.

A. Typology Matrix

Typology of Walls

The terms "wall" and "enclosure" have many meanings in architecture. Concerns for sustainability have brought into focus issues of spatial separation and how the idea of enclosure impacts not only design but also building performance. The following typologies help structure a discussion of spatial separation issues in architecture.

Typology of Walls

- **Interior**
  - Wall as Boundary/Spatial Divider
  - Wall as Acoustic Devices

- **Exterior**
  - Wall as Representational Device
  - Wall as Texture & Surface
  - Wall as Points of Exchange
  - Wall as Circulation Control
  - Wall as Definers of Hierarchies
  - Wall as Visual Devices
Wall as Boundary/ Spatial Divider- One of the most basic functions of a wall is as a boundary or spatial divider. Classic examples of walls as boundaries are the Great Wall of China and the Berlin Wall.

Both of these monumental walls were built for political reasons. These walls were not only physical; they also represented social and cultural boundaries. These types of walls are becoming obsolete with the advent of the computer and the WEB. Today, the notion of boundary is changing. The boundaries that define space are often the effect of visual and sound media. Virtual environments are becoming increasingly common. Historically and in modern times, however, walls continue to represent cultural ideas about privacy and personal space. Walls create a sense of spatial boundaries that contain people and things and create a sense of space.

Wall as Acoustic Device- Properly designed architectural acoustics is fundamental to quality communication within and around buildings. Architects attempt to control and direct both wanted and unwanted sound. The acoustic design of internal spaces has a major bearing on the successful operation of a building. Consideration of privacy, intelligibility and all aspects of room acoustic design allow
a building to be used to its full potential, whether for music, conferences or other activities. Key concepts in architectural acoustics include:

**Reverberation:**

The prolongation of the sound in a room caused by continued multiple reflections is called reverberation. Reverberation time plays a crucial role in the quality of music and the ability to understand speech in a given space. When room surfaces are highly reflective, sound continues to reflect or reverberate. A high reverberation time will cause a build-up of the noise level in a space. The effects of reverberation time on a given space are crucial to musical conditions and understanding speech. It is difficult to choose an optimum reverberation time in a multi-function space, as different uses require different reverberation times.

**Reflections:**

Reflected sound strikes a surface or several surfaces before reaching the receiver. “Although reverberation is due to continued multiple reflections, controlling the Reverberation Time in a space does not ensure the space will be free from problems from reflections. Reflective corners or peaked ceilings can create a megaphone effect potentially causing annoying reflections and loud spaces. Reflective parallel surfaces lend themselves to a unique acoustical problem called standing waves, creating a fluttering of sound between the two surfaces. Reflections can be attributed to the shape of the space as well as the material on the surfaces. Domes and concave surfaces cause reflections to be focused rather than dispersed which can cause
annoying sound reflections. Absorptive surface treatments can help to eliminate both reverberation and reflection problems."\(^8\)

**Noise Reduction Coefficient (NRC):**

The Noise Reduction Coefficient (NRC) is a single-number index for rating how absorptive a particular material is. It is the average of the mid-frequency sound absorption coefficients (250, 500, 1000 and 2000 Hertz rounded to the nearest 5%).

**Sound Transmission Class (STC):**

The Sound Transmission Class (STC) is a single-number rating of a material's or assembly's effectiveness as a barrier. Higher STC values are more efficient for reducing sound transmission. "For example, loud speech can be understood fairly well through an STC 30 wall but should not be audible through an STC 60 wall. The rating assesses the airborne sound transmission performance at a range of frequencies from 125 Hertz to 4000 Hertz. This range is consistent with the frequency range of speech. The STC rating does not assess the low frequency sound transfer. Special consideration must be given to spaces where the noise transfer concern is other than speech, such as mechanical equipment or music. Even with a high STC rating, any penetration, air-gap, or flanking path can seriously degrade the isolation quality of a wall. Flanking paths are the means for sound to transfer from one space to another other than through the wall. Sound can flank over, under, or around a wall. Sound can also travel through common ductwork, plumbing or corridors."\(^9\)

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\(^9\) "Education: Acoustics 101."
Wall as Representational Device – *Interior with Mirrored Wall* by Roy Lichtenstein is an example of a mirrored wall being used as an illusionist representational device.

Another well known example of a wall as a representational device is the Vietnam Memorial in Washington, D.C., built 1982. Designed by American sculptor and architect Maya Ying Lin, it is a sloping, V-shaped, 493-ft (150-m) wall of highly polished black granite that descends 10 feet (3.05 meters) below grade level at its vertex. Often called simply The Wall, it is inscribed with the names of the more than 58,000 Americans killed or missing during the Vietnam War. The austere, abstract nature of Lin's design at first made it a controversial way of memorializing the war's casualties. In the years since its construction, however, the simple, evocative, and starkly dramatic wall has become a national shrine, drawing more annual visitors than the Washington Monument or the Lincoln Memorial.10

Wall as Texture & Surface—A successful environment combines both well resolved functional relationships and also a sensitive integration of colors, textures and a feeling for space. The character and delight of a building wall is the result of the materials chosen and the way they are related. Observed color and texture are governed by the ability of a surface to reflect light. It is important to determine the density of light on each surface in all conditions. Texture and surface color can be used to balance the amount of daylight and light density required. Architects must analyze materials not only for their aesthetic quality, but also for their ability to become dynamic elements within building systems.

One new material that is changing our definition of wall is Lumisty Film. *Lumisty* first drew widespread attention when it was used on the windows of Pleats Please, Issey Miyake’s clothing boutique in SoHo. “Walking past a window with *Lumisty* applied, a perfectly clear, transparent glass surface becomes, in a step or two, partially fogged. Two or three steps later, the same window is completely
fogged. Walk backward or forward, and it's clear again. As the viewer’s angle shifts, so does the transparency or translucency of the film.”

Wall as Points of Exchange- Architects are currently faced with an increasing demand to address building efficiency and the relationship between the constructed and the natural environment. Materials must be reconsidered to produce and support sustainable and passive building systems. It is now possible to create structures where walls and roofs are made of membranes that selectively allow light, sound, and heat to either pass through or be reflected. Walls historically meant rigid boundaries but they can also become soft interfaces for social and physical interaction. These three-dimensional “skins” represent a new materiality.

Products which are inherently smart by design have been called “intelligent.” “Intelligent” is a catch-all term for materials that are designed to improve their environment and which also take inspiration from biological systems. They can act actively or passively, and they can be high-tech or low-tech. One example is pollution-reducing cement John Harrison, an Australian inventor, has developed which is based on magnesium carbonate rather than calcium carbonate, and absorbs carbon dioxide from the atmosphere. Fiber Cement Façade Systems are another example of “intelligent” systems. These reinforced cement panels make up a ventilated façade system designed for rainscreen cladding applications.

Ventilated Curtain Walls utilize an “air-loop” principle to neutralize the effects of both wind and rain by incorporating separate air and water seals. Other “intelligent” systems include: solar shading systems, texlon roof systems, light-

diffusing glass, smog-fighting and water repelling paints, solar walls and solar cell innovations, SmartWrap and meso-optics.

“The Texlon Foil System is an intelligent and dynamic cladding system that has the capability to adjust its shading, thermal, and aesthetic characteristics as the sun moves across the sky, responding to specific program and climatic requirements. Made of fluoroplastic film, Texlon is self-cleaning and will not deteriorate with UV exposure. It is designed to withstand local snow and wind loads, in addition to hail.”

A temporary pavilion structure made of SmartWrap, constructed for an exhibition at New York’s Cooper-Hewitt National Design Museum

A close-up of an active panel of SmartWrap.
Source: www.kierantimberlake.com

Source: www.transstudio.com, March 2005

Art Center College of Design - South Campus Pasadena, California, USA

The architectural firm of Daly Genik Architects was selected to transform this complex into new studio and gallery spaces for the school. Above the studio spaces DGA designed three sculptural skylights utilizing a Texlon Foil System to clad the faceted forms. The Texlon System is a skin comprised of three layers of ETFE foil with two layers incorporating custom patterns designed by renowned graphic designer Bruce Mau. These patterns are integral in the system's dynamic/variable technology which allows the skin to actively transform visually while altering its light transmittance.

Source: www.foiltec.de/projects/ArtCenter/ accessed 4-6-05
Wall as Circulation Control/Security - As we navigate through the built environment and interact with it, we are continuously involved in the processing of spatial information. When we begin to think about circulation or security, "wayfinding" comes in to play. Wayfinding is, generally, the aspect of design and architecture that directs how an individual moves through a physical space. J. Weisman, in his study, *Evaluating Architectural Legibility: Way-Finding in the Built Environment*, found that "while many people expect familiarity with a site to be the biggest factor in determining ease of wayfinding around that site, simplicity of site design is in fact the largest factor in wayfinding." 13 A person's pathway experience can be given a sense of continuity and direction through wall elements like cornices, corners, and paving patterns on floors.

Surveillance and security systems have taken over perhaps the most important historic function of the wall - protection. The solidity of the wall has been replaced by electronic surveillance zones of cameras and sensors. Architects have the greatest control over how secure a building will ultimately be. Decisions concerning pedestrian circulation, access control, building materials, fenestration, along with various other features are determined by architects. While architects resist the fortress mentality, many security professionals believe architects take security and safety concerns too lightly. 14

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Wall as Definer of Hierarchies- Often architecture reveals the social elitism of an economically privileged class and how art is used by those with economic power. Palatial architecture is a sign of economic and political power. Construction of walls to limit and control the flow of people and ideas has been a mainstay of architecture since ancient times. Historic Chinese architecture is a good example. In Chinese architecture and urban planning the wall has always been an important means to underline the social structures and to make them tangible. “From the sequential courts of imperial China to the homogeneous strips of the communist work units (danwei), the neighborhood has been demarcated as the elementary component of society. The pre-communist city consisted of communities of members of the same clan, the same position or the same occupation. Every individual was part of this walled society. The life of the nobleman unfolded within the confinements of the courtyard, life for the commoner was part of the crammed quadrants of the hutongs and every Chinese farmer was surrounded and protected by the Great Wall.”

Today there is a resurgence of the phenomenon of fortification around the world. Gated communities are sprouting everywhere and walls, fences, gates and other “security measures” are being erected at an alarming rate in both public and private architectural realms.

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A notable feature of the courtyard house is that the complex is fully enclosed by buildings and walls. There are no windows on the outside walls, and usually the only opening to the outside is through the front gate.

Courtyard houses epitomize traditional Chinese architecture. In Beijing, depicted here, such courtyard residences have been typical since the Yuan dynasty.

Wall as Visual Device- The 'wall' can be a device to create a number of different effects. In its various guises - solid wall, projection screen, canvas, window to the outside - the wall is a primary space-making device. For example, by running extensively across a site, lines can traverse inside and out. Deviations from the Classical composition of the “wall” can emerge as incidents where the walls become floor, or twist to become ceiling, or are voided to become a large window looking out. By constantly changing dimension and geometry, they adapt themselves to whatever role is needed.

What is it that the roof, the floor and the wall do? As a motion, the roof rises or falls. The walls stand up or sink, the floor spreads out, climbs or descends. In this way, weight is also implied. That which rises is light, that which falls is heavy. And if the roof is bright and
soft as a sail, it is open. If it is dark and of stone, it is closed. If the openings in a wall are tall and narrow, they ascend, if they are short and wide, they sink. A soft and fine floor is warm and open, but if it is hard and coarse, it closes and is heavy.\textsuperscript{16}

In addition to these more traditional approaches to walls as visual devices, interactive mechanical surfaces are becoming available. These surfaces introduce the possibility of dynamic form since they allow real-time deformation based on environmental stimuli including the sounds and movements of people, weather, and other electronic information.\(^{17}\) The image above is an example of a dynamic surface.

**B. Laboratory as a Design Type**

In order to apply the typologies of walls to laboratory buildings we must first look at the different ways in which the term laboratory is applied. *Webster's Collegiate Dictionary tenth edition* defines it as “a place equipped for experimental study in a science or for testing and analysis; a place providing opportunity for experimentation, observation, or practice in a field of study.” The term laboratory as related to architecture can be used in the following ways:

- a room used for scientific testing, experiments or research
- a building used for scientific testing, experiments or research
- a classroom where practical learning and demonstration take place
- a worksite at a single geographic location where research occurs under the direct supervision of a single principal investigator/researcher

• A group of spaces and people in one or more buildings all devoted to conducting related research. For example: Ames Laboratory, Fermi National Laboratory or the Salk Institute

For the purposes of this thesis, a laboratory will be defined as a room used for scientific testing, experiments, or research or a classroom where practical learning and demonstration take place. Laboratories can be public, private or educational in nature.

Science education and laboratory design are going through a dynamic period of change. The traditional boundaries and distinctions between scientific disciplines is eroding and evolving leading to changes in laboratory design. Change is being driven by developments like:

• Building and material technologies that remove the limits of traditional classroom and laboratory walls.
• Lecture based learning is being replaced by discovery-based learning.
• "Sustainable" design methods for construction and use of buildings.
• Biological and genetic discoveries have lead to multidisciplinary research and marriages of biological and physical sciences research.

The boundaries of laboratory design are being questioned and changed. The creation of laboratory architecture has been historically about creating spatial separation. In thinking about laboratory design the limits of flexibility, sustainability and permeability must be reconsidered. Dave Barista, of Building Design and Construction Magazine, has identified six trends in laboratory design:

1. "Workspaces moving out of the laboratory
2. Keeping cost down
3. Speed of delivery

4. The laboratory as a recruitment/retention tool

5. Multidisciplinary interaction and collaboration

6. Flexibility and adaptability”¹⁸

In keeping with the above trends in laboratory design, flexibility and adaptability should be major considerations in laboratory creation. Jerry Koenigsberg, retired principal of GRP Planners suggests the following to improve long-term flexibility and adaptability:

• “Develop a generic lab structure where all rooms are multiples of a universal module in terms of size, shape, and utility requirements.

• Adopt an open-lab approach with limited use of partitions.

• Specify flexible casework that can be reconfigured by lab users without relying on facility personnel.

• Localize lab cooling with chilled water spot cooling.

• Replace central-piped services for gas, vacuum, reagent-grade water, and hot water with point-of-use generators or local delivery containers.”¹⁹

Larger mechanical/electrical rooms and vertical chases are also required to insure flexibility. These issues will be considered in the evaluation of precedents and in the design for Georgetown University.


¹⁹ Barista.
IV. Analysis of Precedents

The following section provides an analysis of three university research buildings. The purpose of the analysis is to come to an understanding of the characteristics of exemplary laboratory architecture in terms of the formal implications of the building program, sustainability objectives, social and cultural implications of the design and spatial separation implications of the architectural design.

The Center for Clinical Sciences Research (CCSR) was selected because it was recently constructed and has received acclaim as exemplary laboratory architecture. The Clark Center was selected for its leading-edge architecture, flexibility and integrated scientific programming. Finally, Old Building 20 at MIT is analyzed due to its apparent contributions to the creative success of its occupants.

A. Center for Clinical Science Research

Stanford University, California

Completed 2000

Architect: Norman Foster
Interior shading with grill-like shading system

- Formal implications of the building program

The Center for Clinical Science Research (CCSR) was designed to respond to emerging trends for interdisciplinary biomedical research and to provide flexible, light filled working spaces in which teams could expand and contract. The design provides natural lighting in office and laboratory spaces and is based on modules that allow intercommunication between functional areas and research groups. Two symmetrical wings unite around a central courtyard.
Screen louvers connect the wings at the roof and shade the courtyard from direct sunlight. Offices overlook the courtyard through bay windows. A screen of bamboo at ground level provides privacy for office occupants. The offices can be naturally ventilated for most of the year. Horizontal louvers on the exterior facades provide shade and are aligned with the third floor cornices on the building next door.

The metal and glass vocabulary of the CCSR challenges Stanford’s historic architectural vocabulary of Spanish colonial architecture.
The following section sketch as well as plan drawings in Appendix B help illustrate the simple traditional structural layout of the building that works well with the modular design.

Source: Foster and Partners

- **Sustainable objectives compared to actual experience**

For the most part, sustainability objectives for the project have been met and the building is well liked by users and occupants. Faculty members express great pleasure with their offices. In a few areas, interior window shades were found to be inadequate and a material with less opacity was successfully substituted without negative visual impact.

Although the semi-circular office window bays are elegantly designed and are operable and shaded, occupants of the office spaces seldom open the windows and
the screens are nearly always closed. These windows offer interesting potential in terms of spatial separation and sustainability. Why are these windows not being fully utilized? Direct observation suggests that the units operate easily as designed. Further observation over the course of several days reinforces the hypothesis that the offices are quite comfortable without opening the windows. In a less stable thermal environment these features might be used more heavily. Further study is warranted to determine if this type feature might be successful in a Georgetown building.

The modular approach to design (Appendix B – CCSR Drawing A2-1A) and the adjacencies of lab, office and support space all seem to be working well but the laboratories are falling short in meeting the biomedical trends of more molecular work and less chemistry, and increases of computers and equipment.

![Typical CCSR laboratory bench](image)

The following illustration show the sustainability features intended by the architects.
• The social and cultural implications of the architectural design

The courtyard that separates the two wings brings to mind the outdoor courtyard of the Salk Institute in La Jolla, California by Louis Kahn. Like the Salk courtyard the CCSR courtyard is a vast long open space but it is not as austere. The geometry of the courtyard at CCSR is emphasized by the dense tall bamboo plantings through the length of the space. Lively small birds live among the bamboos. The shade provided by the tubular overhead screen and the attraction of the café and patio furniture ensure the hoped for interaction between scientists who can be seen in groups along the courtyard at all times of the day. The courtyard is also the site of formal get-togethers and a convenient meeting place for staff and
guests. It will be interesting to see if the opening of a much larger eatery in the new Clark Center two buildings away will dampen the activity at CCSR.

- **Spatial separation implications of the architectural design**

  Although the CCSR is laid out modularly in both plan and elevation, walls still provide a significant barrier to flexibility and define boundaries in a traditional sense. The design of the walls in plan assures a quiet pleasant office atmosphere. The materiality of the laboratories and the volume of the modules meet laboratory requirements. The modular and lineal plan design provides a very legible circulation system. The open central atrium defies traditional ideas of enclosure and provides a pleasant place for contemplation or discussion with colleagues.

![Diagram of CCSR](image)

The curved, sliding office window screens help provide varying degrees of light, privacy and enclosure. The office space is well liked by occupants.
The building design does not use the "intelligent" materials sighted above, but it does utilize a sophisticated mechanical sun shading system.
**B. James H. Clark Center**

Stanford University, California, Completed 2003

Architects: Foster and Partners and MBT Architecture

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- **Formal implications of the building program**

The James H. Clark Center at Stanford University was created to house the Bio-X program. The building was designed to house state-of-the-art core shared facilities for joint work in biosciences, bioengineering, biomedicine and related fields. The intention is for Bio-X to create opportunities for discoveries by facilitating connections between people in traditionally separate disciplines. The building was located and designed to form a geographic focus for bringing together scientists and engineers from the greater Stanford community. This connectedness is illustrated by the red arrows on the map above and the diagrams that follow.
The concept, of the Clark Center as a campus hub, lead to Foster and Partner's unique inside-out design. Unlike traditional laboratories, the circulation in the Clark Center is pulled to the exterior of the building in the form of balconies. The open laboratories face the middle and have floor-to-ceiling glass exposure.
The three story building takes the form of three wings of mixed offices and laboratories wrapped around and open courtyard with overlooking balconies. This seems an abstraction of the old Stanford central campus vocabulary. The materiality of the building also echoes the red tiled roofs and limestone facades typical at Stanford. A walled forum area sits atop an underground auditorium in the central courtyard area.

Structurally the building floor plates and walkways are supported by a limited number of major columns. Floors, walkways and canopies are cantilevered from these columns. The structure is expected to provide both rigidity for sensitive equipment and flexibility.
The Clark Center uses a plenum type HVAC system that is already showing signs of balancing type problems between the wide variety of laboratory types and their opposing requirements. Utilities are distributed overhead and exposed for flexibility.

Lab benches and most furniture are on rollers. Lab benches designated for visitors or "hotelling" are painted bright yellow to help prevent "squatting".
• **Sustainable objectives compared to actual experience**

The Clark Center meets all of Stanford University’s sustainability objectives which include LEEDS standards.
• The social and cultural implications of the architectural design

"Stanford’s objectives for the building included:

• Facilitate interactive, interdisciplinary research by creating large, flexible zones for both faculty labs and hotel lab space.

• Design spaces that allow maximum customization, either by users themselves or with the help of building management.

• Develop numerous specialty support and non-lab spaces, including imaging, central glass wash and media rooms, a laser facility, classrooms, conference rooms, an auditorium, a large cafeteria, a coffee shop, and administrative offices.

• Provide a generous amount of social and educational spaces throughout the building, as well as outdoors.

• Create a new “hinge” on campus between the historic science and engineering core and a developing medical hub clustered around Stanford Hospital."

It appears that Foster and Partners have met most of Stanford’s objectives for the building although it may be too early to tell if the desired “hinge” has been created. As evidenced by Stanford news releases, the outdoor auditorium/meeting area is used frequently for casual meetings, gathering and performances.

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• **Spatial separation implications of the architectural design**

There is a noticeable reduction in the number of walls in the Clark Center over other research laboratories. Even the “exterior” glass walls in the center of the building seem to disappear in the transparency of the glass curtain wall. The exterior walkways seem to accentuate this feeling. Sound transmission is accentuated in the large laboratory spaces but an attempt has been made to reduce sound in the office areas with the installation of acoustic ceiling tiles.

The local climate makes it easy to take advantage of outside air temperature and sunlight most of the year reducing the need for artificial light and HVAC capacity in the laboratories. No special “intelligent systems were used as enclosure materials for the Clark Center. Passive systems like the walkway overhangs serve both light control needs and the need to disguise mechanical equipment on the roof.

Navigation and wayfinding are simple in this building do to its reduced number of opaque walls and the large exterior circulation walkways. The Clark Center has high architectural legibility but the transparency may compromise security and secrecy for certain potential commercial and government projects.

It is interesting to note that an attempt has been made to maintain hierarchies by color coding equipment. For example, visiting researchers are assigned bright yellow lab benches.
C. Building 20

MIT,
Completed 1943

Originally built in 1943 as a temporary building for part of the Radiation Laboratory, the building was supposed to be demolished immediately following World War II. It remained the home to a variety of research labs, academic departments, student clubs and machine shops until it was demolished in 1998 to make room for the new Stata Center. It is said that Building 20 was designed in one day. The barracks style was plain and in the 1980’s and 1990’s many people described the building as shabby and dilapidated. However, as Stewart Brand points out in his book, How Buildings Learn: What Happens After They’re Built, building 20’s lack of style allowed its occupants free reign to be creative and successful within its walls.21

21 "Celebrating the History of Building 20,”
"Building 20 was comprised of six wings. The structure didn't have a basement; it was built on concrete slabs. Building 20's horizontal design was emphasized by the length of its wings and the fact that it stood only three stories tall."
• **Adaptable Space**

“At the time of its construction, steel was scarce, and Building 20 was mainly made of wood. Although the building appeared weathered, it was not rickety; the building was capable of supporting loads up to 150 pounds per square foot. Over the years, depending upon their projects, Building 20’s occupants have reconfigured their workspaces, sometimes by changing the interior of their rooms or labs, sometimes by expanding into adjacent rooms. Small sheds and other structures that are signs of expansion were visible in the courtyards between wing. On at least one occasion, one professor expanded his lab space vertically. (When Jerrold Zacharias was developing the world’s first atomic clock, he arranged to have sections of two floors removed so he could assemble a tall cylinder that was part of his design.) The exposed duct-work and wiring that was clearly visible above most of the hallways was accessible to those who needed to rewire computer networks or work on some of the service functions of the building.”

• **Working atmosphere in Building 20**

“Many people believe that the horizontal layout of Building 20 encouraged collaborations. People who met in the lobby or in one of the long hallways, or on a wooden staircase could easily share information and ideas. Although the unpretentiousness of Building 20 made some people feel like they were being overlooked, it was liberating for other professors who felt freer to be creative and make the most out of the available space. MIT never seemed overly concerned about Building 20 (quite possibly because everyone knew it was a "temporary" building), and MIT generously gave space to new student clubs and new departments. These
same units might not have ended up with as much space had they been assigned space in a building located in a heavily-trafficked area of campus.”

Building 20 has recently been replaced by the new Stata Center designed by Gehry Partners.


V. Design Component

The design component of this thesis is a Chemistry and Biology Laboratory building on the campus of Georgetown University in Washington, DC. The design program is based on a 2003-2004 competition administered by the Association of Collegiate Schools of Architecture (ACSA) and sponsored by the Labs21 program, a joint program of the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE) and the Public Works Government Services Canada.

A. The Institution

Georgetown University, founded in 1789, is the oldest Catholic and Jesuit University in the United States. Today Georgetown is a major international research university. Georgetown has the nation’s oldest school of international affairs and has a strong Law Center and Medical Center. Georgetown University has a student

body of 6,400 students. Approximately fifty-four percent of the students are Catholic.

The campus is situated on a hilltop north of the Potomac River in a park-like setting just north-west of the Washington, DC Capitol Complex.

The building will be used jointly by the Biology and Chemistry departments for office and undergraduate teaching laboratories typically in preparation for more advanced study in medicine and life sciences.

The historic port city of Georgetown is known for its early federalist period architecture. Its historic brick and frame row houses and cobblestone streets adjoin the university and building site. The architectural character of the university is dominated by many historic Gothic Revival structures some of stone and some red brick. Most buildings are arranged as city blocks with buildings organized around the street perimeters and interior courtyards. The buildings act as a wall protecting the courtyards from the street.

B. Program Description

The program for a Chemistry and Biology Laboratory Building for Georgetown College, Georgetown University in Washington, DC, requires a building of approximately 30,000 gross square feet (gsf).

<table>
<thead>
<tr>
<th>1.0 Public spaces</th>
<th>4,200 net square feet (nsf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 Undergraduate Teaching Laboratories</td>
<td></td>
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<tr>
<td>2.1 Chemistry Laboratories</td>
<td>3,500 nsf</td>
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<tr>
<td>2.2 Biology Laboratories</td>
<td>10,500 nsf</td>
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<tr>
<td>2.3 Support areas</td>
<td>1,800 nsf</td>
</tr>
<tr>
<td><strong>Total area requirements</strong></td>
<td><strong>20,000 nsf</strong></td>
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<tr>
<td>3.0 Building operational areas</td>
<td>4,300 nsf</td>
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<tr>
<td>4.0 Building services and systems</td>
<td>5,700 nsf</td>
</tr>
<tr>
<td><strong>Total area requirements</strong></td>
<td><strong>30,000 gross square feet (gsf)</strong></td>
</tr>
</tbody>
</table>

B.1.0 Public Spaces 4,200 nsf

The Lobby, Foyer and Lecture Halls will visibly communicate the University's commitment to sustainability. Seating areas will be provided in the Lobby and Foyer.

- **Lobby** 1,200 nsf
- **Foyer** 300 nsf

The Foyer is a place for meeting and carrying on spontaneous conversations before and after activities held in the Lecture Hall.

- **Lecture Hall** 2@1,200 nsf 2,400 nsf
Each Lecture Hall will accommodate 100 people in fixed seats with provisions for the physically-challenged. A standing area or gallery of 150 square feet should be located behind the seating area. It should provide for a video projection booth of 50 nsf.

- **Women’s Restroom** 150 nsf
- **Men’s Restroom** 150 nsf

### B.2.0 Undergraduate Teaching Laboratories

Each Laboratory should provide bench space for eighteen to twenty-four undergraduate students. A minimum clear interior vertical dimension of 10’- 6” should be maintained throughout the space. Laboratory spaces should have at least two means of egress. Laboratory spaces should be designed for maximum flexibility and adaptability and for shared use among disciplines.

#### 2.1 Chemistry Laboratories 3,500 nsf

- Each laboratory should have 100% outside air ventilation.
- **Laboratory** 2@ 1200 nsf 2,400 nsf
- **Laboratory support** 300 nsf

The laboratory support should include prep, storage, equipment, and chemical and glassware supply areas.

- **Storage room** 300 nsf
- **Faculty office** 2@ 150 nsf 300 nsf
- **Teaching assistant office** 150 nsf
- **Student lockers** 2@ 25 nsf 50 nsf
2.2 Biology Laboratories 10,500 nsf

In designing the biology laboratories the following should be provided: two fume hoods per laboratory, space for incubators, freezers and refrigerators, equipment and student storage space and chemical and flammable storage.

Laboratory 6@ 1,200 nsf 7,200 nsf
Laboratory support 3@ 300 nsf 900 nsf

The laboratory support should include prep, storage and equipment supply areas.

Storage room 3@ 300 nsf 900 nsf
Faculty office 6@ 150 nsf 900 nsf
Teaching assistant office 3@ 150 nsf 450 nsf
Student lockers 6@ 25 nsf 150 nsf

2.3 Support areas 1,800 nsf

Seminar/ Conference Room 4@ 300 nsf 1,200 nsf

A 25 square foot locked storage room should be provided for equipment, chairs and supplies as part of this space.

Lounge 2@ 300 nsf 600 nsf

Each lounge should include a 25 nsf food preparation area.

B.3.0 Building operational areas 4,300 nsf

Circulation 3,000 nsf

Circulation space should include corridor seating near laboratories.

Women’s Restroom 300 nsf
Men’s Restroom 300 nsf
Security office 150 nsf
Maintenance office 150 nsf
Loading dock 200 nsf
Shipping/ receiving 200 nsf

B.4.0 Building services and systems 5700 nsf

Building services and systems include rooms for electrical and mechanical systems, communications equipment and environmental controls. Utilities and services will be zoned and provide maximum flexibility.

C. Analysis of Program

Analysis of the stated program begins with a building concept that relates key elements of the building program. The Building Concept Diagram outlines the relationship of these elements. Teaching Office Clusters include private faculty offices with seminar and meeting space. Teaching Laboratory Clusters include pairs of laboratories with related teaching assistant offices, support, storage, supply and mechanical spaces in support of the laboratories. Central Social Space includes all commonly used spaces including lounges, restrooms, lobby, foyer, and circulation and general student space. By clustering these major functions, an orderly and simple flow of people through the spaces is established simplifying wayfinding. The clusters also facilitate simplified routing of fume hood exhaust and other mechanical and electrical system routing in support of the laboratories.
C.1.0 Adjacencies and separations between activities.

Program relationships are further developed in the following relationship diagram. The diagram suggests space adjacencies and a logical ordering of the program elements.
C.2.0. Possible Laboratory Configurations

Most chemical and biological laboratories are organized in modules. The CCSR at Stanford utilizes a similar methodology.
C.3.0. The Relationship of the Georgetown Building program to Precedents

Learning

One of the first things about the Georgetown program that raises concerns as related to precedents is that it appears to follow a very traditional model of laboratory teaching space. The space that has been requested may be too specific and may lack flexibility for potential future multidisciplinary work (For example: incorporating physical science activity.). Storage and mechanical space may not be sufficient for necessary human interaction or for significant sustainable design features or future flexibility. The National Science Foundation (NSF) recommends about 50 square feet more per laboratory than the program requests. NSF also recommends 1600-1800 net square feet (nsf) teaching laboratory space for 18-24 students to insure future flexibility. This is greater than the 1200 square feet requested. Interviews with occupants need to occur to gain a better understanding of how the space will be used. Given the small laboratory size, I am assuming discussion and recitation will take place outside the laboratories.

One hundred percent "outside air" may not be necessary to meet environmental requirements or comfort if some of the precedent air handling features are incorporated. Also, there is no accommodation in the program for a copier, mail or faculty administrative support.

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D. Site Description

The site consists of an L-shaped parcel on the eastern side of the block defined by O, P, 36th, and 37th streets. Located on the western side of the block are Poulton Hall and a row of University-owned townhouses. (See-site map for more information on the immediate neighborhood.)
The Graduate School of Arts & Sciences is located in Room 302 of the International Center (ICC). map key 📊
E. Site Analysis

Source: http://data.georgetown.edu
E.1.0 Analysis of Significant Site Relationships

- **Formal ordering principles**

As can be seen on the Georgetown Main Campus map, the project site is part of the south-east section of the Georgetown Campus. This section of campus reflects the organized blocks of the adjacent urban neighborhood. These blocks are organized with structures on their perimeters and more private open or green spaces on the interior. The structures provide spatial separation and act as a wall separating the noise and activity of the street from the more tranquil interior.

The project site is located on the extreme east edge of the main Georgetown campus and is bordered on the east primarily by multi-unit two story simple red/orange brick structures and on the north by surface parking and similar structures.
On the west there is Poulton Hall and a row of university owned townhouses followed by 37th Street.

Across 37th Street is a stone wall that provides a barrier for the major green space to the west.

The University Gatehouse is the core of the green space. This entire section of the Georgetown Campus is the historic heart of the University and contains a number of architecturally significant structures including:

White-Gravenor Hall

Copley Hall
Riggs Library in Healy Hall,
One of the few remaining cast iron libraries in the nation.


Healy Hall and Gatehouse

http://data.georgetown.edu/graphics/images/
The Quadrangle is the oldest part of the Georgetown University Campus and is bordered by the Old North and Maguire buildings.
Brick and stone define spatial separations throughout campus and adjoining neighborhoods as illustrated by the following photographs:
M and Prospect Street Stairs
Source: http://exorcist-revisited.blogspot.com/

35th and O Street Cobblestone

36th and Prospect Streets

www.bestfouryears.com/Georgetown.htm
Interiors reflect the traditional Gothic Revival exterior. Arches are a dominant feature as well as large volume public spaces conveying heaviness.

- Relationships between architectural typologies and urban morphology

Spatial order and hierarchy are evident in the site plan for Georgetown University and surrounding neighborhoods. (Refer to the maps in Section IV.D) As mentioned earlier, the buildings are typically organized around the perimeter of square blocks and are connected by narrow cobblestone or asphalt streets. For example, the gatehouse, street walls and the size and organization of green space around Healy Hall and White-Gravenor Hall clearly show that this area of campus
is elevated in the hierarchy of campus structures. These buildings are also taller and larger in volume than any of the surrounding structures on campus or in the nearby neighborhoods. Like most other American towns, the “town” area historic charm is compromised by “mall-like” shops and chain stores.

- **Material, Cultural and Experiential Context Characteristics**

  Formal gardens and brick paved courtyards characterize campus “green” spaces. Other than athletic fields, the only significant grassy space is located between the old campus gate and Healy and White-Gravenor Halls and on the steep banks of the Potomac River. Since streets are very narrow, traffic is generally slow and noise from traffic is less than anticipated. Traffic on campus is primarily pedestrian but the building site is on the edge of campus and borders city streets. The experience of Georgetown University is generally one of being in an old walled and fortified town.

- **Movement Systems**

  Parking is very limited and not recommended on the Georgetown University Main Campus. Free public transportation is available on campus and Washington, DC Metro bus service is available and convenient to the project site with a stop at the corner of O and 37th Streets. Since the project site is on the edge of campus, extra consideration will be given to the significance of vehicular traffic and congestion around the site.
Project site as related to Wash. D.C. Metro System bus stops
Source: exploregeorgetown.edu
- **Climatic Relationships**

Wind patterns are predominantly from the south as indicated by the diagram below. Since the project building faces south, care must be taken to ensure roofs and overhangs are secure and advantage is taken of natural ventilation opportunities.

Temperature and precipitation information from the charts in Appendix A suggest a moderate, humid climate on the Georgetown campus.

**E.2.0 Preliminary parti studies**

Preliminary analysis of potential design impact on site context and the impact of potential designs on the extended geographic areas of Georgetown University and surrounding neighborhoods is significant. Because the project site is on a corner of the historic section of Georgetown campus the building could have a major visual
impact on the campus and community. Care must be taken to insure the new structure adds rather than detracts from the neighborhood fabric. The materiality and design of the building will reflect the historic campus while addressing the advanced technical nature of the activities inside the building. The structure needs to be scaled so that it does not compete unfavorably with the large gothic revival structures nearby. In addition, the site development should be sensitive to the needs of the childcare center next door by providing safe play space and sensitive to the safety and security of people utilizing the Metro bus stop near the project site.

When comparing the CCSR and the Clark Center at Stanford University to the project at Georgetown, aspects of both designs are compatible but key architectural features including outdoor formal and informal meeting areas and exterior primary circulation are not as useful in the Georgetown climate.
VI. A Design Solution for the Georgetown University Chemistry and Biology Laboratory Building

A. Site Plan

The above plan shows the relationship of the laboratory building to the immediate surrounding area, landscaping, and pedestrian and vehicular circulation patterns. The plan addresses the street in a similar way to nearby street blocks but deviates on the north where the site faces landscape and parking lot. This deviation opens the block to provide vehicular access that will be useful to both the project building and the adjacent childcare center.
B. Description of the design concepts of the project

The design component of this thesis creates a design for a Chemistry and Biology Teaching facility on the Georgetown University Campus in Washington, D.C. The design is based on a program developed for the 2003-2004 Labs 21 Program student design competition. The design incorporates elements of sustainability, and provides long-term flexibility and adaptability by:

- Developing a generic lab module that is repeated along a single corridor.
- Adopting a flexible, moveable casework and equipment plan limiting the use of opaque walls.
- Providing large vertical mechanical/electrical chases to insure flexibility.
- Adopting passive solar strategies.
- Incorporating a geothermal heat-pump system to improve energy efficiency.

Geothermal Systems provide heating, cooling, and dehumidification, all important considerations at Georgetown. They can also provide virtually free hot water when supplied with a heat recovery system. Geothermal Systems work by removing heat from a space and rejecting it into the earth or in the reverse cycle.
mode absorbing the heat from the earth and supplying it back to a space. Because of site limitations, a vertical loop system is recommended.

A Vertical Loop System is installed in vertical bore holes 150 to 500 feet deep depending on the design considerations. Each hole contains a single set or a dual set of pipes. After the pipe is inserted, the hole is grouted. The number of loops required depends on ground conditions, air conditioning and heating load and the depth of each hole. This type system is well suited to applications with minimal space and where minimum soil disruption is desired. It also requires no roof-top equipment. This system is located in the grassy area north of the building.

- Incorporating a double-skin system for the auditorium and south façade.

It was decided to use a double-skin for the auditorium and south façade only due to the cost of these systems which can be four to five times the cost of a traditional cladding system. Examples of Double-Skin Façade Buildings

(From left to right) The RWE Building, Berlin, Germany, Das Düsseldorfer Stadttor, Düsseldorf, Germany, and The Tjibaou Cultural Centre, New Caledonia

Source: Univ. of Waterloo School of Architecture


"The Double-Skin Façade is essentially a pair of glass "skins" separated by an air corridor. The main layer of glass is usually insulating. The air space between the layers of glass acts as insulation against temperature extremes, winds, and sound (Lang and Herzog, 1999). Sun-shading devices are often located between the two skins. All elements can be arranged differently into all numbers of permutations and combinations of solid and diaphanous membranes." 27

- Incorporating leading-edge communications technologies like meeting rooms equipped with real-time living wall systems.

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C. Passive Solar Strategies

The following illustrations demonstrate the sustainable characteristics of the design solution.
D. Modular Design

Generic Laboratory Modules were developed to maximize long-term flexibility and provide easy re-configurable laboratory furniture for innovative teaching. Floor plans that resolve building program needs follow.
Floor plans were based on the program requirements outlined earlier in this document and previously developed program relationships.

As you can see on the following laboratory plan and elevation drawings, mobile casework is provided that allows for different teaching environments and for different types of classes to be taught in the same space.
Overhead storage is limited in the center of the rooms to maximize sight lines for teaching and learning. Utility connections are distributed by an exposed unistrut type system. Teaching laboratory student casework is also adjustable vertically to allow both sitting and standing activity. As an alternative to lectures in the laboratories, the shared meeting rooms across the corridor can be used for occasional classroom activity.

Teaching Assistant (TA) office space is provided between sets of laboratory modules. These spaces utilize “window walls” for easy viewing of the laboratories while in the office area. Sound monitors are also provided to aid TA’s in their oversight of the laboratories. These window walls also double as projection surfaces in the laboratories.

The Priva-Lite windows between the TA offices and the laboratories double as laboratory projection surfaces.

Source: http://www.komfort.com/glass/priva-lite.asp

Basic design of electrochromic layers:
1. glass;
2. transparent conductor;
3. ion storage film;
4. ion conductor (electrolyte);
5. electrochromic film;
6. transparent conductor;
7. glass.

The chemical reaction takes place when the ions are shuttled forwards and backwards through the application of an electrical field.

Micro-encapsulated liquid crystals: without an applied voltage the molecules are randomly orientated and the system scatters light. When a voltage is applied, the molecules align themselves with the electrical field and the system transmits light.

Example of a glass partition with liquid crystals in opaque and transparent states: Priva-Lite®.
E. Double-Skin Façades

- South Laboratory Walls

The Double-Skin Façade is based on the notion of exterior walls that respond dynamically to varying ambient conditions, and can incorporate a range of integrated sun-shading, natural ventilation, and thermal insulation devices or strategies.

Double-Skin Façades reduce heat gain and lower air conditioning loads in the summer. Daylight, fresh air, and views connect occupants with the outside, while direct sun, heat, and cold are kept out with this design.

As can be seen on the laboratory elevation drawing, a simple, pressure equalized, vented curtain wall similar to curtain walls available from *Commission Permasteelisa Cladding Technologies* has been employed on the south exterior.
The system is a double-façade common in Europe, but not yet employed much in the U.S. Because of the efficiency provided by the double façade, the glass requires no tinting or reflective coatings allowing a great deal of transparency. The transparency translates to a lighter more open feel inside and outside the laboratories.

Schematic diagram of heat extraction double-skin façade

Source: gaia.lbl.gov/hpbf/techno_c.htm

Heat extraction

Heat recovery
• **Auditorium Walls**

A hybrid double facade system is proposed for the auditorium walls. The system consists of a conventional thermal wall system inside a single glazed building skin. The system has openings in the skin to allow for natural ventilation. The internal skin provides insulating properties to minimize heat loss. The outer glass skin is used to block or slow wind and weather and allow interior openings and access to fresh air without associated noise or air turbulence. The use of windows can allow for night-time cooling of the interior of the auditorium while minimizing humidity effects in the rest of the building and reducing HVAC building loads. To help control sound, the openings in the outer skin are staggered relative to the openings in the inner façade.

The undivided auditorium façade benefits from the stack effect. On warm days hot air collects at the top of the space. Openings at the top allow warm air to escape and cooler air is drawn in from below.
F. Faculty Office Light Wall

A three dimensional light wall has been incorporated into the design of the faculty office clusters. This wall utilizes a “Texlon Foil System” skin with custom scientific patterns as part of the system’s dynamic/variable technology. The wall will introduce light to an otherwise dark area and provide separation from the main traffic flow for faculty office privacy. The wall will have digital displays build-in where faculty can post problem solutions, exam results, and other student communication directly from their office computers.
G. Three-dimensional representation of the design solution
VII. Implications of Research

In the course of this thesis I have explored the impact of spatial separation (i.e. “enclosure” and the “wall”) on the design of research buildings. Through research, precedent analysis, design experimentation and application, this thesis demonstrates how spatial separation impacts the design of laboratory spaces.

By developing a Typology of Walls Matrix, spatial separation factors were identified and used to explore three science laboratory buildings: the Center for Clinical Sciences Research (CCSR) at Stanford University; the Clark Center at Stanford University and “old” Building 20 at MIT. Learning from this analysis was used to develop a design for a Biology and Chemistry Building at Georgetown University.

The thesis design incorporates many of the wall typology concepts developed early in this thesis. Through the building’s passive solar design Wall as Point of Exchange is exhibited by permitting maximum daylight while minimizing the effects of other environmental conditions.

The thesis results in design ideas that incorporate sustainability, flexibility, and adaptability. Passive solar concepts are included by utilizing a unique roof and window design that minimizes the bad effects of the sun and optimizes the use of daylight. Flexibility and adaptability are maximized by utilizing “cluster” programming, modular mobile casework, and exposed flexible utilities distribution. Energy savings are realized by including a geothermal heating system and double wall façade systems. The double wall facades not only improve energy consumption, they also function to improve acoustics. In keeping with the scientific nature of the activities inside the building, high technology materials will be
incorporated in selected interior walls including TA office walls and the faculty cluster light wall.

Finally, the faculty office cluster wall functions as a boundary/spatial divider, a point of exchange, circulation control, and as a visual device.

More work needs to be conducted to evaluate the success or failure of new strategies to meet scientific laboratory needs. This thesis did not address the trend of integrating physical science research with biology and chemistry. This integration presents some very real technical challenges and potential future research work. In addition, new building material technologies are revolutionizing how we view spatial separation. The proper function of many of these materials is very complex. How will architects address this complexity to insure functionality? Will the rift between Snow's "Two Cultures" be mended out of necessity because art and architecture will no longer be able to avoid science? The line between real and virtual is beginning to blur. How will the practice of architecture be affected? How will architecture for science be affected?
APPENDIX A - Design Support Documents

- Wind Rose Diagrams
- Temperature Tables
- Rainfall Data
- Floor Plans
- **Wind Rose Diagrams**

Source: [http://www.weblakes.com](http://www.weblakes.com)
### Monthly Averages for Washington, DC

**Average Temperature (°F)** | High | Low | Minimum Period of Record: 30 years
---|---|---|---
**Jan** | 43°F | 24°F | Jan 43°F 24°F 33°F 3.57 in. 80°F (1950) -10°F (1982)
**Feb** | 47°F | 26°F | Feb 47°F 26°F 36°F 2.84 in. 80°F (1985) -1°F (1961)
**Apr** | 66°F | 42°F | Apr 66°F 42°F 54°F 3.26 in. 94°F (1976) 18°F (1982)
**May** | 76°F | 52°F | May 76°F 52°F 64°F 4.29 in. 98°F (1991) 25°F (1966)
**Sep** | 80°F | 57°F | Sep 80°F 57°F 69°F 4.08 in. 102°F (1953) 34°F (1989)
**Oct** | 69°F | 44°F | Oct 69°F 44°F 57°F 3.43 in. 94°F (1954) 20°F (1966)
**Nov** | 58°F | 36°F | Nov 58°F 36°F 47°F 3.32 in. 87°F (1950) 10°F (1987)

Source: [http://www.weather.com](http://www.weather.com)
APPENDIX B - Precedents Support Documents

- Center for Clinical Sciences Research (CCSR)
  - Selected Drawings and Sketches
  - Program Information

- James H. Clark Center
  - Selected Drawings and Sketches
  - Program Information

- MIT Old Building 20
Center for the Clinical Science Research, Stanford University

Exterior view of the south façade from the adjacent parking lot

Detail of the shading device on the south façade

Linear atrium with grill-like shading system

North façade

Interior atrium façade with operable windows

Source: http://gaia.lbl.gov/hpbf/casest_k.htm
Cited References


“Laboratory Architecture Exemplars.”


“Plan a Lab.” *National Science Foundation.*
“Remembering Building 20.” Photos by John F. Cook.


Acknowledgements

I would like to thank Robert Gluck and his family of Herndon, Virginia for their assistance in gathering site information and photographs of Georgetown University.