



# GREEN FURNITURE:

The Implementation and Teachings of the Usage of  
Biodegradable Materials in Furniture Design

LEILA CURTISS

ADVISOR: BRIAN NEWSWANGER

INTERIOR ARCHITECTURE AND DESIGN

THESIS DESIGN BRIEF

SPRING 2022

# TABLE OF CONTENTS

---

## TOPIC

CONCEPT

LITERATURE REVIEW

## DESIGN AGENDA

PRECEDENTS

PROBE 1

PROBE 2

PROBE 3

MATERIALS

## SITE

CONTEXT AND HISTORY

DOCUMENTATION

IN-SITE DIAGRAM

## PROGRAM

MASTER LIST OF SPACES

CASE STUDY

## FINAL PRESENTATION

FLOOR PLANS AND REFLECTED CEILING PLANS

SECTION CUTS

PERSPECTIVE VIEWS

FURNITURE DESIGNS

## BIBLIOGRAPHY



# CONCEPT

By researching and using both biodegradable and recycled materials in furniture design, the objective would be to leave a smaller carbon footprint based on components used to produce each material, travel time of materials to the manufacturer to the consumer, manufacturing process, and form of energy used for manufacturing.

Additionally, these elements will be included in offered courses to the public, in hopes of raising awareness for sustainable practices within furniture design.



# Transitioning to Biodegradable and Sustainable Materials in Furniture Manufacturing

Leila Curtiss  
Drexel University  
Fall 2021



## **Introduction**

Throughout the last century, mass production in furniture manufacturing has become the norm. This started with the Industrial Revolution over two-hundred years ago and has continuously increased. The materials used in this process have become predominantly manmade and synthetic, shifting away from elements that can be gathered from nature. This literature review will explore material use in the manufacture of furniture, and how it can be done more sustainably through reducing waste and using organic materials. The review takes into account both scholarly research and contemporary vendors and suppliers of green materials. The goal of the review, and my thesis, is to increase awareness of the harm of synthetic materials and waste, while providing a more sustainable alternative to minimize the carbon footprint.

### **Issues with the Production and Consumption of Synthetic Materials**

Over the last two hundred fifty years consumer demand has increased greatly and manufacturing has expanded its use of synthetic materials (Hounshell, 1997). Utilization of plastic, for example, became popular during World War II at which time a variety of plastic materials, such as nylon and Plexiglas, were used to create cheaper military equipment that could be produced rapidly and in large quantities for the United States army (Gonzalez, 2018). After years of war time rationing, consumers were ready to spend money. Leading to the post World War II economic boom (Hounshell, 1997). Much of the money they spent was on new products, predominantly made of plastics. Since the 1960s, many people around the world have had concerns about plastics and other synthetic materials, even so, this has not stopped or slowed down production of these materials (Obermeyer, 2021).

As we have come to learn, one major downside to synthetic materials is that they have a limited useful life and they do not reenter the manufacturing process easily. This has led to a huge issue: consumer waste. Landfills, recycling facilities, and oceans are overflowing with non-biodegradable materials and debris from humans (Environmental, 2021). Despite this, it is drilled into the consumers mind that more is more and more is still not enough (Barbaritano et al, 2021). I will turn now to discuss materials in the current furniture manufacturing process (Environmental, 2021).

## **Current Materials Used in Furniture Manufacturing and the Harm of Synthetic Materials to the Earth and Human Health**

In this section I will briefly review a number of the most commonly used materials in furniture manufacturing, discussing the problems with each as they have shifted toward the use of synthetics.

### Wood

While wood itself is an organic material, many contemporary manufacturing processes introduce synthetic ingredients into the process. Many cheaply made pieces of furniture use wood veneers to cover MDF (medium density fiberboard) or particle board. Both of these options are made of left-over woodchips from hardwoods being cut down to size (Gul, 2019). Using this leftover material is a positive in terms of sustainability; however, in creating both MDF and particle board, large amounts of greenhouse gases are released (Wang et al, 2018). Additionally, the majority of products that use MDF and particle board are being shipped overseas from China and other Asian countries. Not only are these materials emitting greenhouse gases in the manufacturing process, but also releasing emissions while being shipped to stores and consumers (Wilson, 2008). Another large problem is that countries are not keeping track of who is buying and using their woods. This leads to illegal trade of protected species which could be stopped with proper oversight (Hub, 2021).

### Plastic

Plastics, today, are used for everything from adhesives and furniture finish to medical and military equipment. Plastic was first developed in 1869 by John Wesley Hyatt, who was trying to create a substitution for ivory. It was then produced because manufacturers wanted a material that was strong, lightweight, "pliable and easily shaped." (History, 2019). Plastics have been advertised as an alternative to save elephants and tortoises, confusing consumers into believing plastic would, "protect the natural world from the destructive forces of human need." (History, 2019). Subsequently people have become more concerned and critical of the use of plastics. However, while these concerns are still considered, businesses around the world still use plastic in their products and packaging. In fact, about 50% of people are either allergic or sensitive to epoxy resin, specifically when handling it during the manufacturing process (Akarslana, 2015). Using plastic in furniture manufacturing is largely unsustainable unless there is a clear and easy process for recycling (History, 2019).

## Foams used in Upholstery

---

The most commonly used foam for furniture is a petroleum-based foam. Historically, petroleum foam could contain any number of potentially toxic chemicals. "For example, diisocyanates can irritate the mouth, nose, and eyes, and TDI in particular may be carcinogenic" (Is Memory, 2021). Many companies have claimed to be moving away from using such harmful chemicals and ingredients, yet choose not to "divulge the exact ingredients they use to make their memory foam," claiming these blends are a trade secret. (Is Memory, 2021). These chemicals also contribute to off-gassing. When unboxing a new mattress, the foam will release a certain odor. The odor that is inhaled by the consumer is the release of all the chemicals used during the manufacturing process (Foam, 2009).

## Adhesives

---

Glues and adhesives have been used for over 6,000 years, however, most of the technology of adhesives has been developed during the last 100 years (Frihart, 2015). Up until the Industrial Revolution, natural glues were used around the world. A technical breakthrough, cellulose nitrate, a thermoplastic derived from the cellulose of wood, resulted in new and stronger adhesives (Pyne, 2016). Further development of plastics and elastomers has led to the evolution and a diversification of adhesives. Glues can be created for different needs such as flexibility, toughness, curing or setting times, temperature, and chemical and water resistance (Autopedia, 2021). Synthetic adhesives can be placed into two categories: reactive and non-reactive. Reactive adhesives include ingredients like epoxies, urethanes, and cyanoacrylates, which harden through a chemical reaction through a combination of two elements, or exposure to heat and/or air. Non-reactive adhesives can be solvent-based which harden as the solvent evaporates, including white glue, contact adhesive, and rubber cement; or polymer dispersion adhesives, which are polyvinyl acetates and most commonly used in the woodworking and packaging industries (The History of, 2021). Technical advancement continues to expand the use of synthetic adhesives; however, these products are largely unsustainable.

## Metal

---

The sustainability of metal is complex and has both positive and negative aspects. It takes a large amount of resources to extract natural metals from the Earth, and is starting with but not limited to the mining process. Processing metals for use in furniture also has a large impact on resource use, emissions, and waste generation. Looking specifically at steel, this material requires a large amount of energy to create, but has a small amount of waste in production because scraps can be put back into the production line (Raabe, 2019). While steel is not necessarily sustainable by certain definitions, its durability and lengthy lifecycle show its benefits. Once steel is made it will virtually last forever because it can be continuously recycled with no downgrade in quality. Conversely, the fact remains that energy used to produce and/or recycle it, is typically coal and fossil fuels (Explainer, 2018). While changes in production could lower resource consumption and the emissions of producing metal, there is no current process that would make it fully sustainable (Raabe, 2019).

## Textiles

---

The textile industry is one of the most water consuming, chemicals-consuming and energy-consuming industries. From fabric and garment production to dyeing, all aspects of textile creation are extremely wasteful. Additionally, the chemicals used to manufacture textiles are detrimental to human health, especially those working in the factories and breathing in toxins all day. These chemicals can be acquired through the skin, bronchially, or through digestion. They can also be carcinogenic, mutagenic, and allergenic (Akarslana, 2015). Additionally, it is commonly believed that if a textile is made with a natural material, it is good for the Earth. However, this is not always the case. An example of this is cotton, which is a staple in the fashion and textile industry. Although cotton is a naturally occurring material, to grow it in the quantities that we require, take large amounts of water and chemicals. This becomes harmful to the Earth, as well as the people coming into close contact during the farming and harvesting phases (What are, 2021).



## Sustainable and Biodegradable Alternatives

### Wood

---

There are a variety of green alternatives for synthetic materials in furniture manufacturing. This section will discuss the more sustainable ways to source, manufacture, and create a fully recyclable wood product (Hub, 2021). However, "There is very little literature available yet," (Goldhahn, 2021) so it is difficult to fully grasp every aspect of the matter.

Wood, in general, is one of the most sustainable materials available. Using native locally sourced hardwoods is the most sustainable way to create furniture (Sustainable, 2017). However, unless we slow down consumption, no matter what materials are used, we are using more than the Earth can naturally supply and replenish. A good way to be sustainable, in terms of wood, is to use the scraps, leftovers, or recycled pieces. While these elements are currently used to produce particle board, the downside to this was explained previously. However, these parts could be used in other ways, or if a less harmful production process is discovered to produce particle board. To address issues with transportation and distribution, it is important for wood species to stay in their native land to reduce the carbon footprint created from shipping, as well as reducing the harm caused by invasive species (Goldhahn, 2021)

### Plastic

---

While plastic is extremely harmful to the Earth, it does make products more affordable and diverse, and a valuable place in our lives. Scientists are exploring bio-plastics which are made from plant-based ingredients making them biodegradable, as opposed to plastic made from petroleum which is estimated to take four-hundred fifty years to begin breaking down (History, 2019)

## Foams used in Upholstery

---

There are many alternatives to standard plastic-based foams for upholstered furniture. These include options such as feather and down, coconut fiber, organic wool, and cotton, natural latex, and horse hair (Avinc, 2020). However, these are all stuffing, which will not give the same shape as foam does. Foam continues to bounce back to shape, whereas stuffing gets matted after some time, leaving your cushion flat and hard. These organic options are better suited for pillows as opposed to seat cushions. One alternative to plastic foams is a natural latex foam. It holds the same shape without being made with several harmful chemicals and adding more plastic to the Earth (Marchant, 1972). Natural latex is safely harvested from rubber trees and the tree does not need to be cut down to harvest this material, as it is produced from the tree's sap, also called milk. A rubber tree will be tapped, the sap from the rubber tree will be collected and then taken to a facility and baked at a high temperature to become a solid, dense foam (Parker, 2011). Latex foam is naturally resistant to mold and is 100% biodegradable (Foam, 2009). It is a viable option to replace plastic based foams and has a much more sustainable harvesting and manufacturing procedure, without releasing harmful chemicals in the process.

## Adhesives

---

Glues have been used by civilizations for thousands of years, and there are organic options that could be reconsidered. Egyptians, Romans, and Greeks used animal and fish glues, and later developed adhesives using ingredients such as: egg whites' blood, bones, hide, milk, cheese, vegetables, grains, tar, and beeswax. (GLUES, 2011). Glues fell into disuse for about a thousand years, only beginning use again for furniture and cabinetry in about 1500 A.D. Some of the greatest makers such as, Chippendale and Duncan Phyfe who are still recognized today, used organic adhesives in their work. In 1700, the first commercial glue factory was started in Holland, manufacturing glue from the hides of animals. In 1750, England issued the first glue patent for a fish glue (Autonopedia, 2021).

## Metal

---

Metals are not biodegradable, which leads some to believe that it is not sustainable. However, this is not necessarily the case, being that metal is a renewable material because it has a “virtually unlimited lifespan and the potential for unlimited recyclability.” (Norgate, 2002). An important detail is that metal extraction should be stopped and manufacturers should focus solely on recycling what metal is already available to us (Gleich, 2007). Much less energy is used to recycle metal versus new metal production. There is not one metal that is significantly better than another, it is more a matter of where it is sourced from and the energy used to recycle it. Some metals that are regularly used in furniture design are steel, copper, nickel, and zinc. Along with recycled metals, there are also unlimited options when looking at restoration. Using restored elements, such as hardware, can greatly decrease a designer’s carbon footprint by lowering production for these materials (Gleich, 2007). “The challenge that lies ahead is to devise policies and actions that will help society to optimize the efficient use of metal resources and stocks while at the same time minimizing their environmental impacts.” (Norgate, 2002).

## Textiles

---

An alternative to standard cotton would be using organic cotton which has a substantially reduced effect on the Earth, but it is important to ensure that it is GOTS-certified. Additionally, finding ways to incorporate recycled cotton into fabric could reduce the amount of harvested cotton annually (Sustainable Fabrics, 2021). Another alternative is organic hemp textiles. This material has been used for hundreds of years, and can be grown around the world due to its adaptability and versatility, being that it demands little water, no pesticides, it naturally fertilizes the soil it grows in, and it does not require a particular climate to grow. Hemp fabrics are breathable for warmer months but also insulate in the winter, it also becomes softer the more it is washed, making it one of the most sustainable fabrics available (What are, 2021). Organic linen holds many similar properties to hemp fabrics and is another positive option (Sustainable Fabrics, 2021). Interestingly, synthetic fibers can also be considered sustainable. An example of this is Tencel. This material is made by dissolving wood pulp and while it requires certain chemicals to produce, this process is a closed-loop system, meaning the chemicals are reused for the next batch. While Tencel and some other synthetic textiles are man-made, they are produced from naturally occurring materials and manufactured in more sustainable ways (What are, 2021).

## **Conclusion**

Since the beginning of civilization, humans have been makers. Thousands of years ago, humans created what they needed with natural materials by hand, but now mass production uses synthetic, manmade materials for all manufacturing possibilities. This has added drastically to the waste on Earth, creating unhealthy habitats for all living things. Continuing the use of synthetic materials will worsen an already damaged planet, so it is crucial that designers and manufacturers consider what materials they are using in their products. Shifting to organic and biodegradable materials is a necessary step to reduce environmental damage.

Company: **PP Mobler**

Company Elements:

**Pros:** Small scale mass production  
Multi-material  
Locally sourced woods  
Sustainable finishes  
Uses scrap wood to heat building

**Cons:** Ships worldwide  
Unsure of sourcing locations  
Distance to / from source



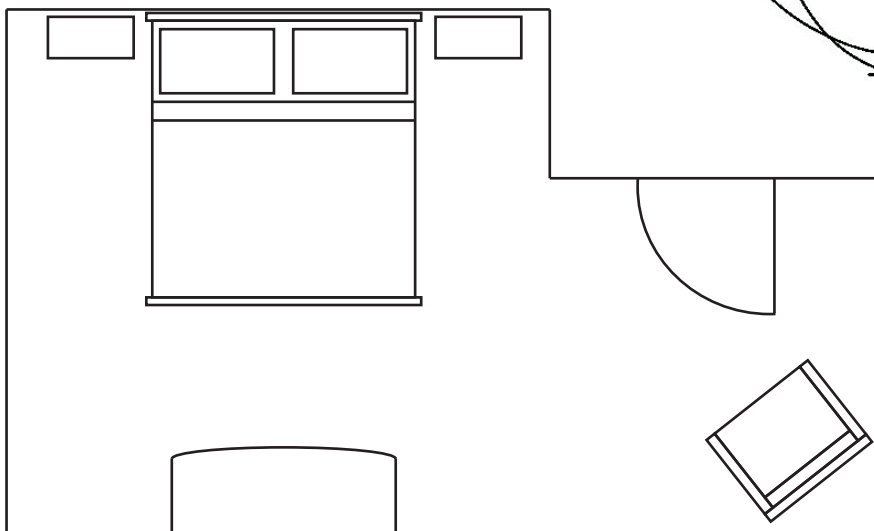
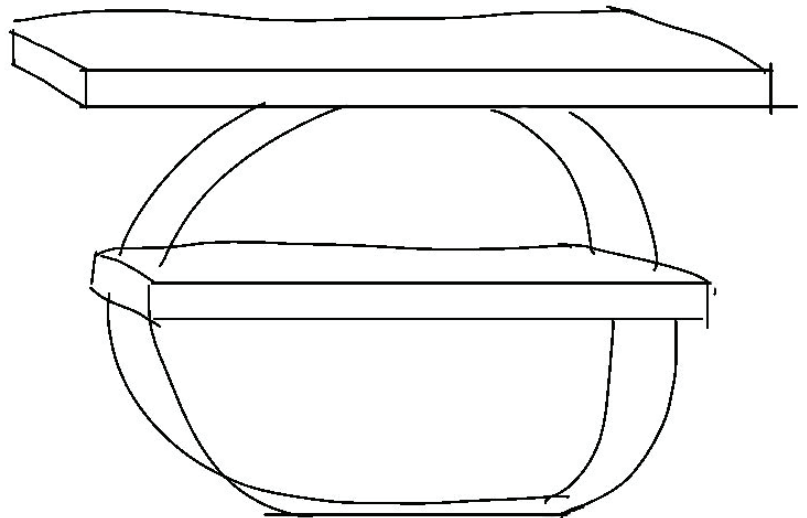
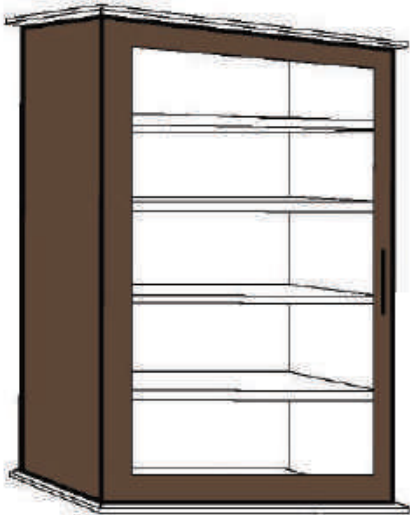
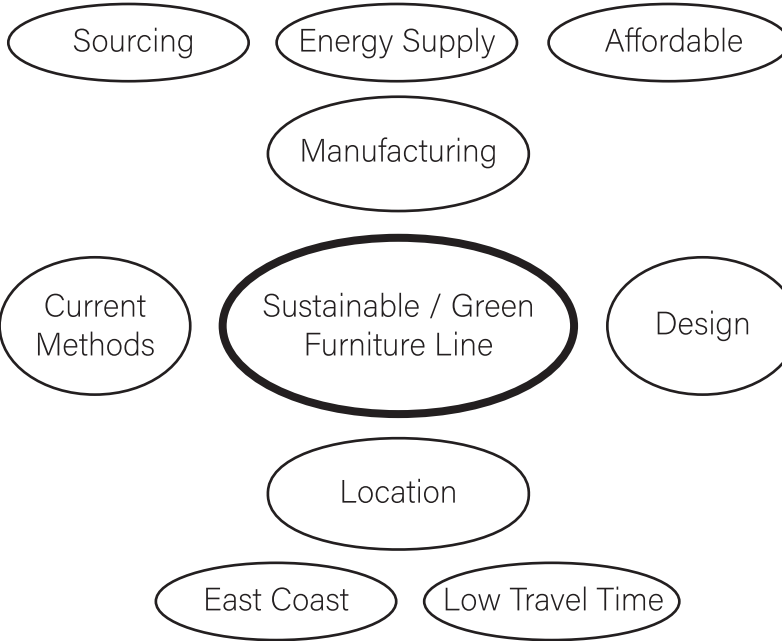
Company: **Bok Building**

Company Elements:

**Pros:** Rental space for designers  
Restored building  
Partnerships  
Building amenities

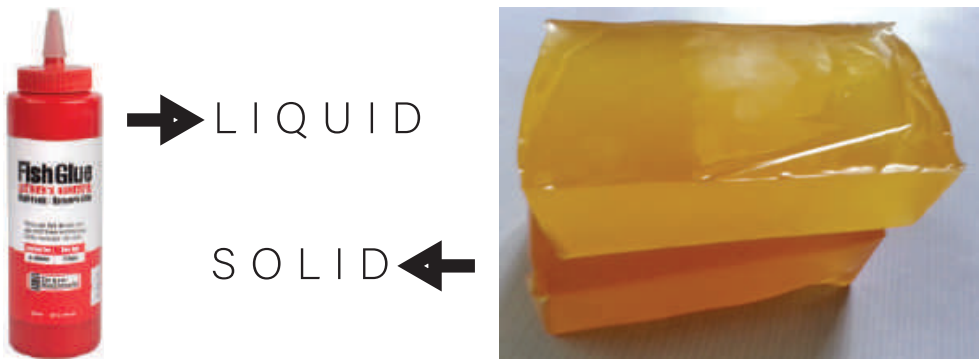
**Cons:** Central in city (difficult for deliveries)







# FOAM GLUE METAL FINISH WOOD





## Interview Questions:

Do you use furniture on a daily basis?

. Yes

Do you find it important to have a fully furnished home?

Yes

Hypothetical situation: If you are moving into a new apartment with nothing, would you choose option 1 or 2? Option 1: you live in an empty apartment until you can buy good quality furniture one piece at a time Option 2: you furnish the entire apartment from Ikea (or another cheap brand)

I would buy the essentials, a bed, mattress, table and chair from cheap brand but I wouldn't get any unnecessary things until I could invest in a nicer piece

What piece of furniture in your house do you use the most?

Bed

What aspects of a bed are most important to you?

Natural looking, wood, sturdy

What about a piece of furniture makes you want to buy it/ display in your home?

Intricate woodwork, engravings, wood tones need to match

When you buy a piece of furniture, do you pay attention to where it was made?

Yes, generally buys American made or French antique. nothing from east Asia

Why do you choose not to buy Asian furniture?

They don't dry the wood properly so the furniture doesn't last long

Does manufacturing location sway your decision to purchase?

Yes (ex. China, other cheap places)

If you were presented with 2 seemingly identical dining tables, one made in China for \$40 vs one made in the US for \$200, which would you buy?

Depending on quality, but most likely the US table because everyone knows things manufactured in China are meant to be throw away pieces. I'd rather invest in a table that will last

What functional qualities are important to you in a piece of furniture?

Drawers need to open and close smoothly, I don't like wasted space

If you had unlimited money, would you spend it on an unusable piece that is purely decorative?

Maybe if I really loved it, but I would rather not waste money on something that I can't even use

What material do you prefer your furniture to be? A variety of materials? All matching?

Wood

For upholstery, what do you prefer in your home? Do you care about plastic-based fabrics?

Leather, cotton, any other naturally biodegradable fabrics

Would you put metal pieces in your home? Do you care what kind of metal it is?

If it is made well and matches my aesthetic. I don't know a ton about metals so I don't necessarily pay attention to that when buying furniture

How do you feel about refurbished pieces? or refurbished elements on a piece such as hardware?

I love antiques, so refurbished is not a problem for me. I've gotten a lot of pieces for the house from Olde Good Things Antique Store NYC

## Design Experience:

Have a showroom display furniture from many centuries (antiques should be refurbished and in good condition to look "new"). High end pieces from today as well as cheap pieces from China/ Ikea. Do not display when it was made or where it is from etc. Have staff standing around showroom for people to ask questions (more likely that people will ask if there is someone right there to speak to).

Invite a variety of people to view the display. Observe which pieces people gravitate towards. See who asks questions about the piece. As people leave, they will be given an anonymous questionnaire to fill out, not knowing ahead of time. Giving some feedback on favorite piece, style, etc. and why.

Would people offer to buy a piece without knowing anything about it ahead of time?

What is the main factor when people buy furniture? Or opt for a cheaper option?

Is it money?

A lack of caring (environment, what is in their home, materials)?

Style preference?

Do people flock to one particular piece or style? Or does everyone have different taste?

# MATERIALS

All American made products or recycled products.  
Biodegradable

Locally sourced woods

Large discontinued fabric samples

Bio-plastic

Foam and stuffing

Natural latex foam

Wool, cotton, coconut fiber stuffing

Metal

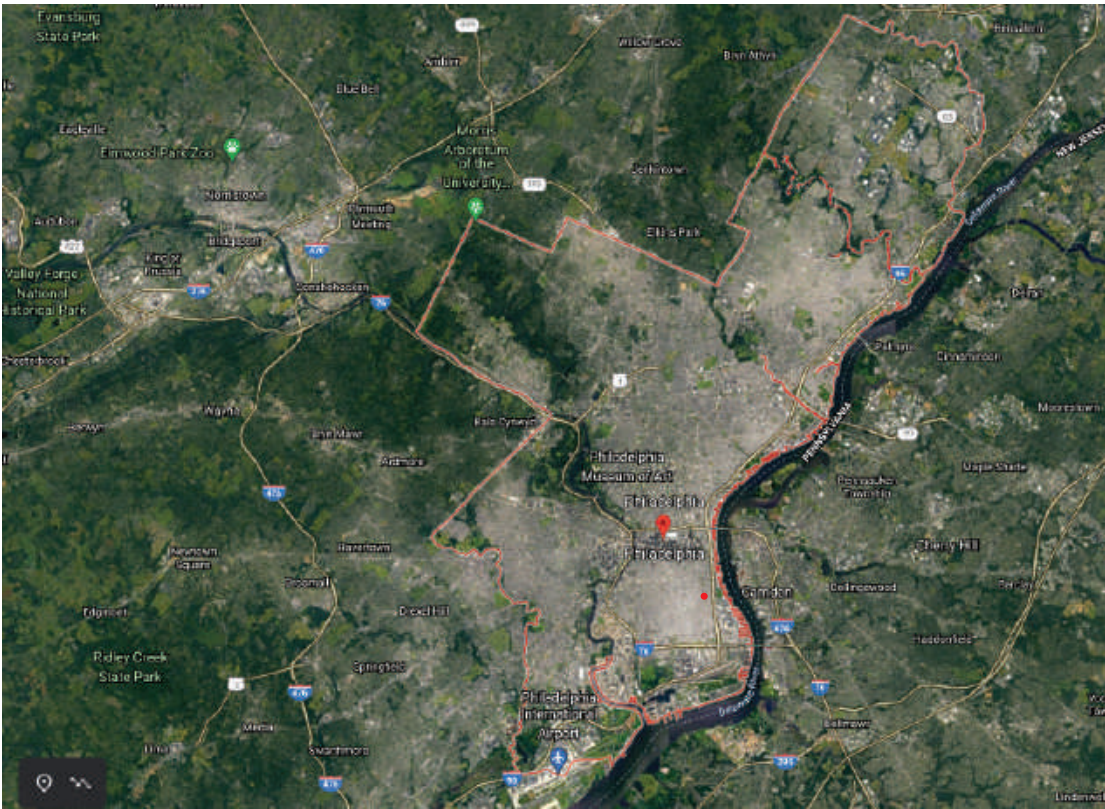
Steel or recycled

Hide or fish glue

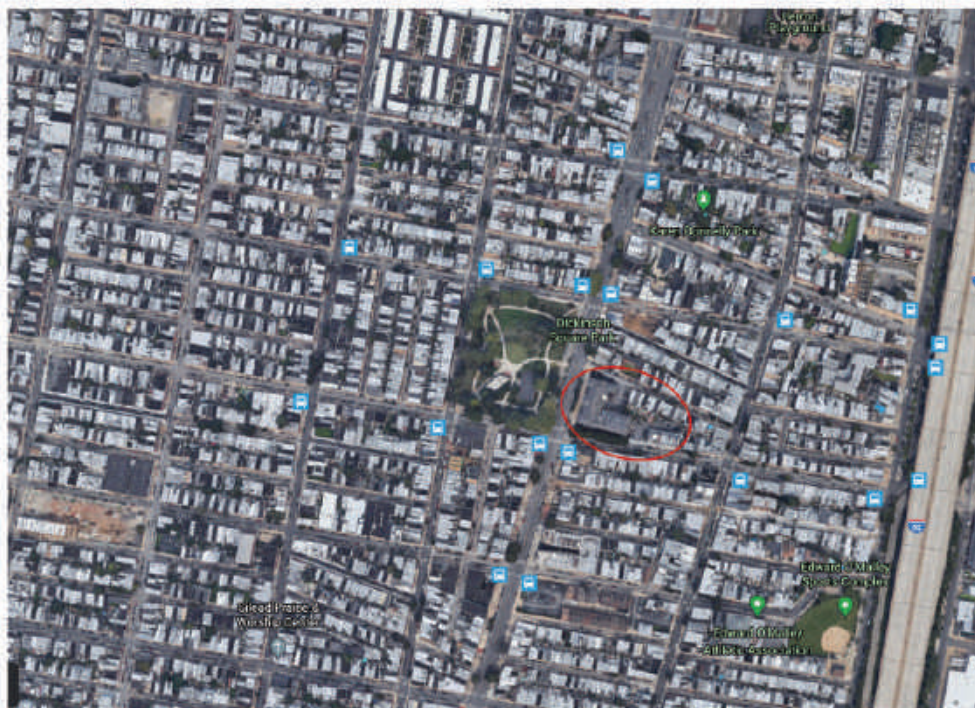
Beeswax or soap finish







Abigail Vare School  
1619 E Moyamensing, Philadelphia, PA 19148



Transportation:  
~12 blocks from broad street line  
~2 blocks from I-95  
~Bus Lines: 7, 29, 57  
~Uber / Lyft: \$20  
~Bike: 25 minutes  
~Walk: 1 hour 20 minutes



**1903:** Built

Three stories, basement, outdoor space

**1986:** Added to the National Register of Historic Places

**2013:** Vare School moved into the Washington School's building in 2013

**2014:** Sold to real estate developer









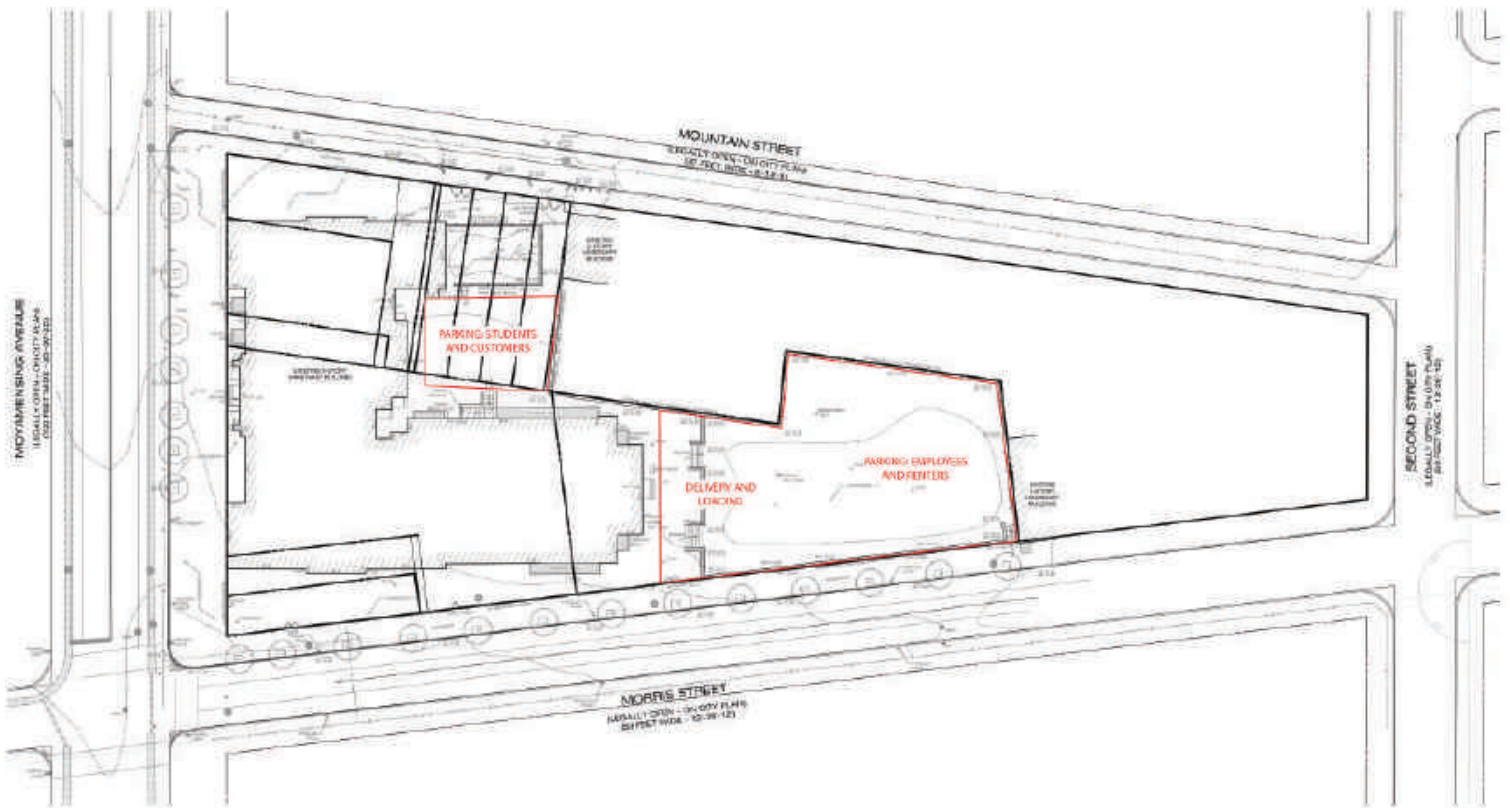
## OUTDOOR AMENITIES:

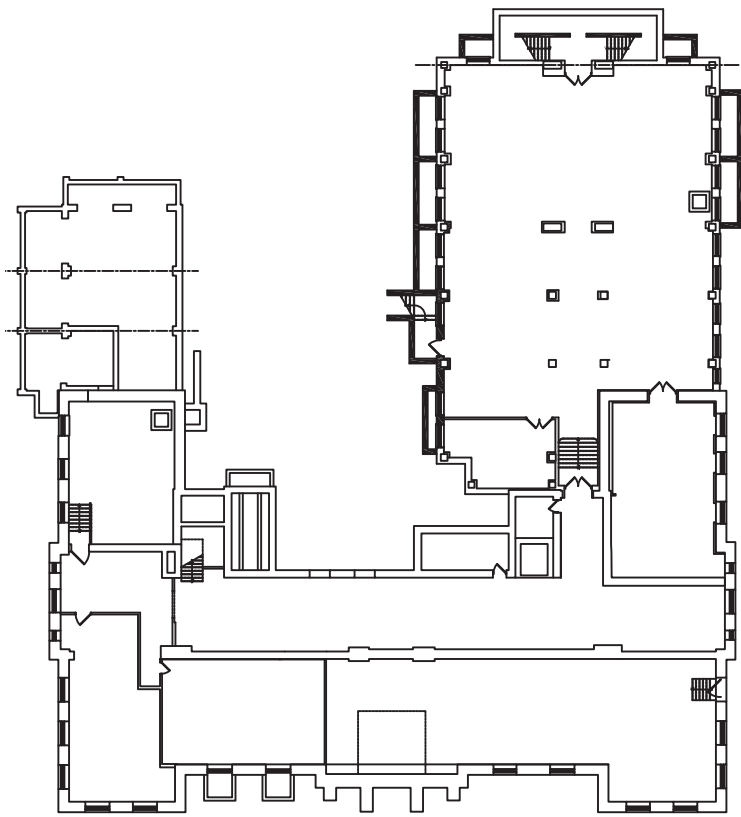
PARKING OFF MOUNTAIN STREET FOR STUDENTS  
AND CUSTOMERS

PARKING AND DELIVERY OFF MORRIS STREET FOR  
EMPLOYEES AND TENANT

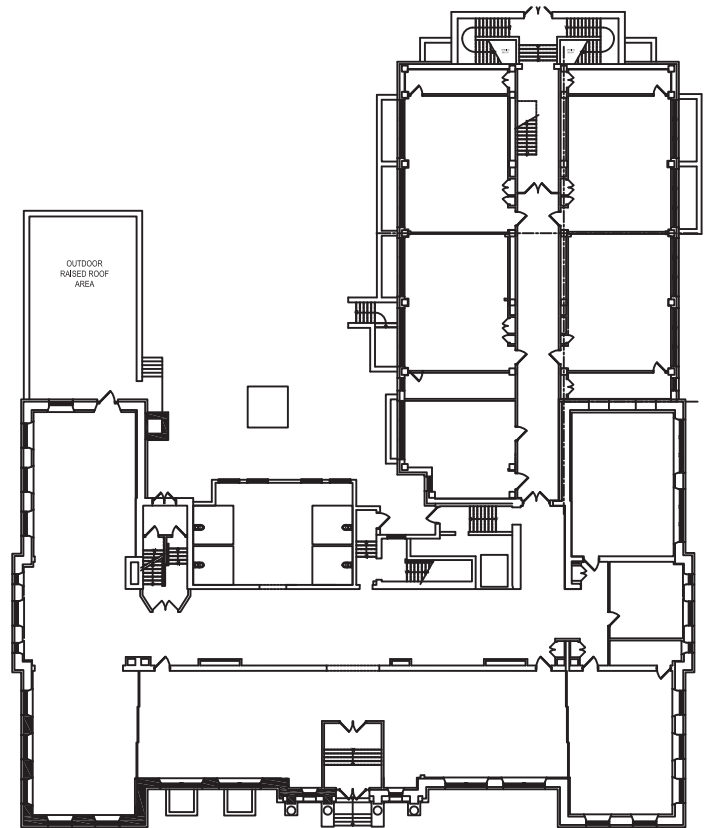
OUTDOOR SPACE TO KEEP BEES (FOR BEESWAX  
POLISH)

OUTDOOR SEATING FOR CAFE

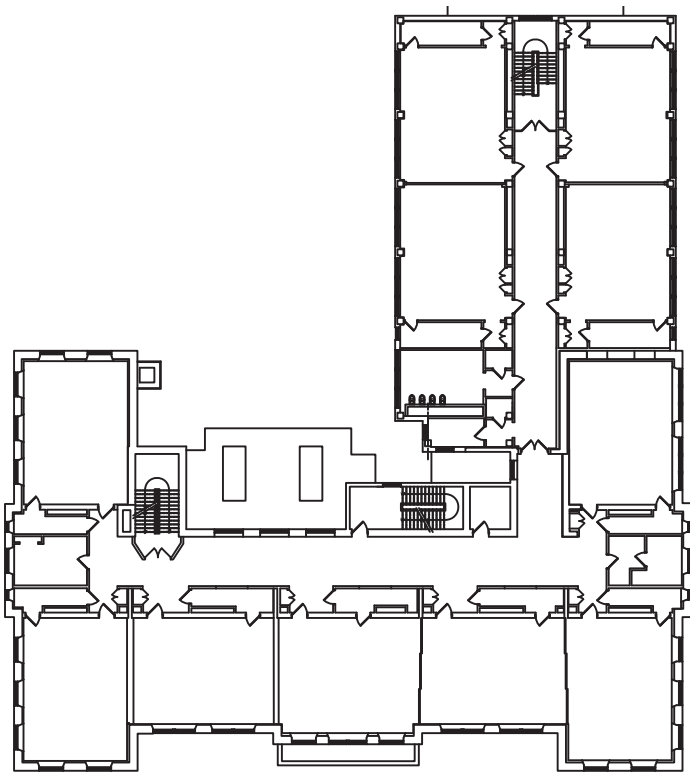




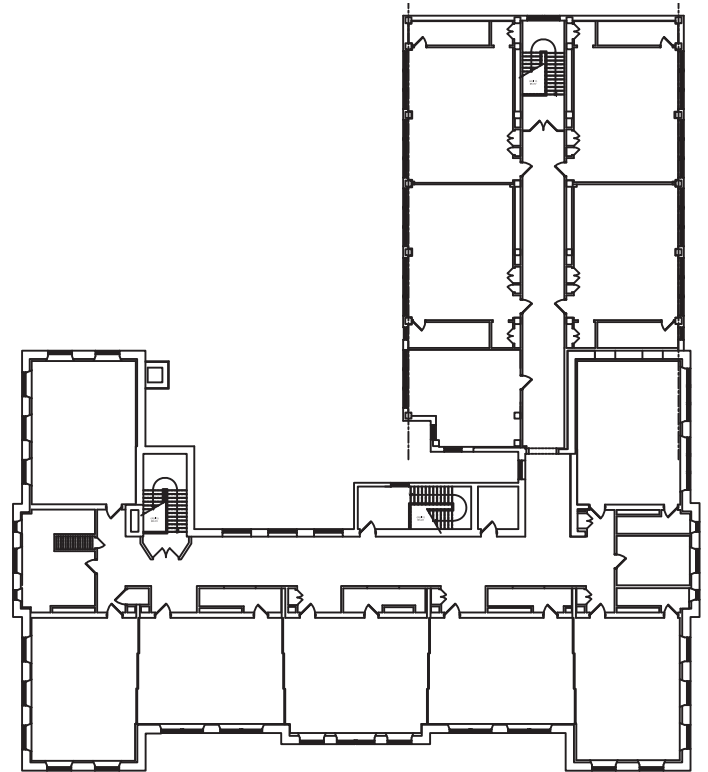
BASEMENT FLOOR



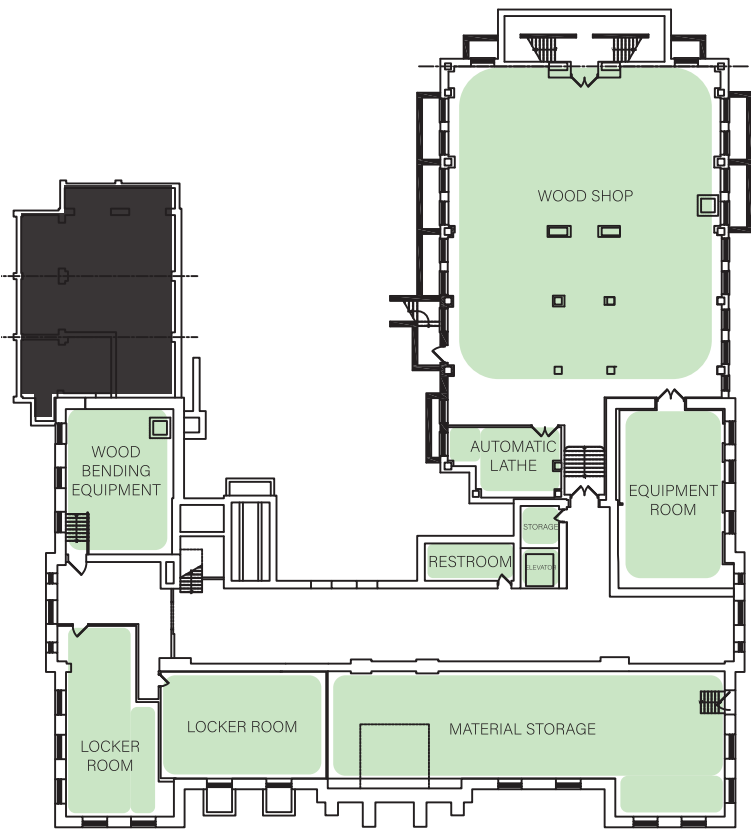
FIRST FLOOR



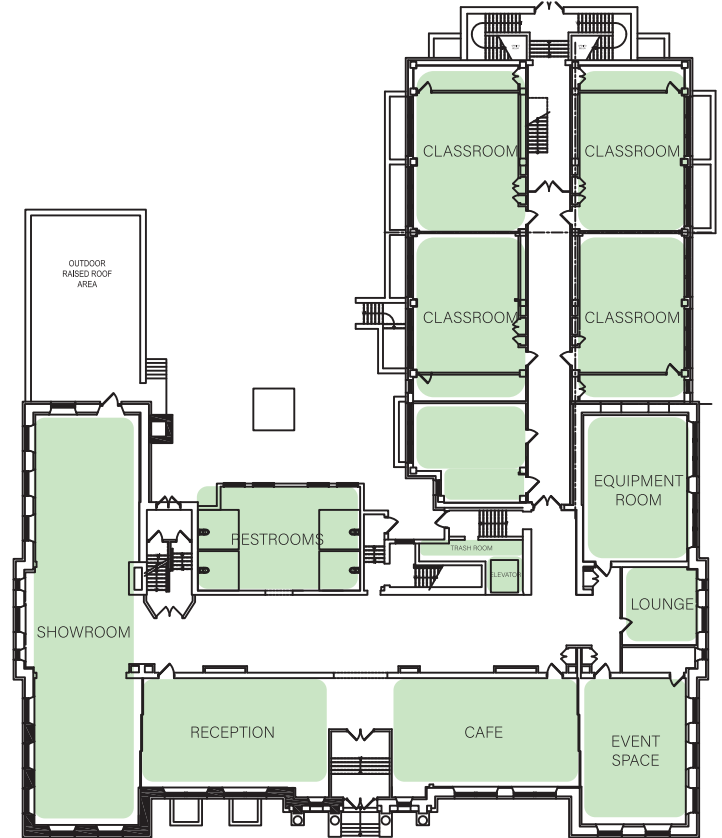
SECOND FLOOR



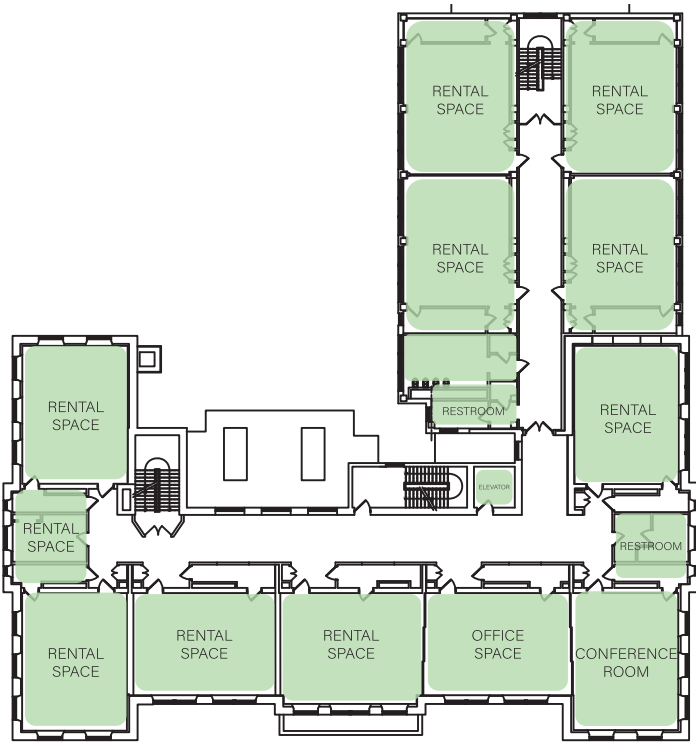
THIRD FLOOR



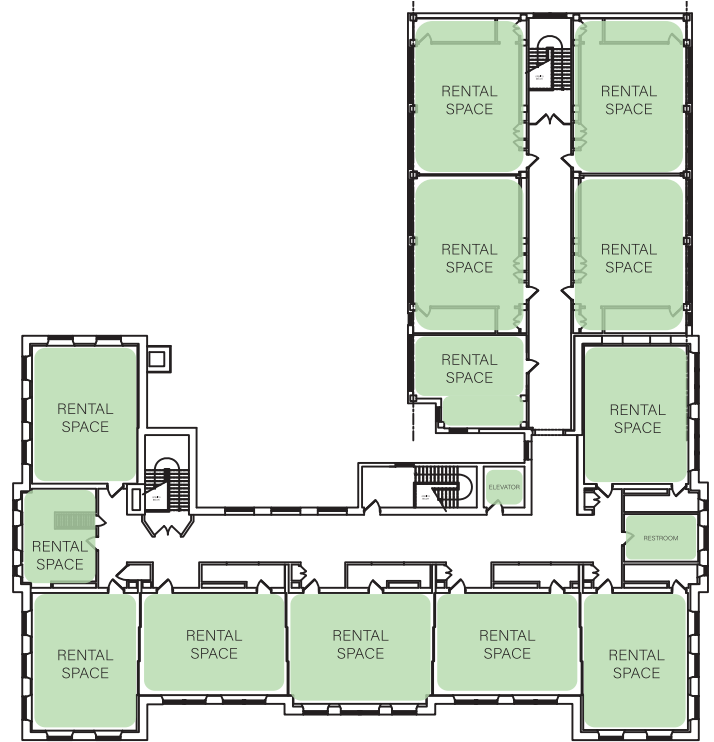
BASEMENT FLOOR



FIRST FLOOR



SECOND FLOOR



THIRD FLOOR

## BASEMENT

WOOD SHOP	4000
LOADING/DELIVERY	350
EQUIPMENT	1250
MATERIAL ROOM	2000
LOCKER ROOM X2	800
ELECTRICAL CLOSET X2	100
MECHANICAL CLOSET	120
DATA CLOSET	60

## FIRST FLOOR

RECEPTION	100
SHOWROOM	2400
CAFE	400
EVENT SPACE	720
CLASSROOM X4	650
RESTROOM X4	80

## SECOND FLOOR

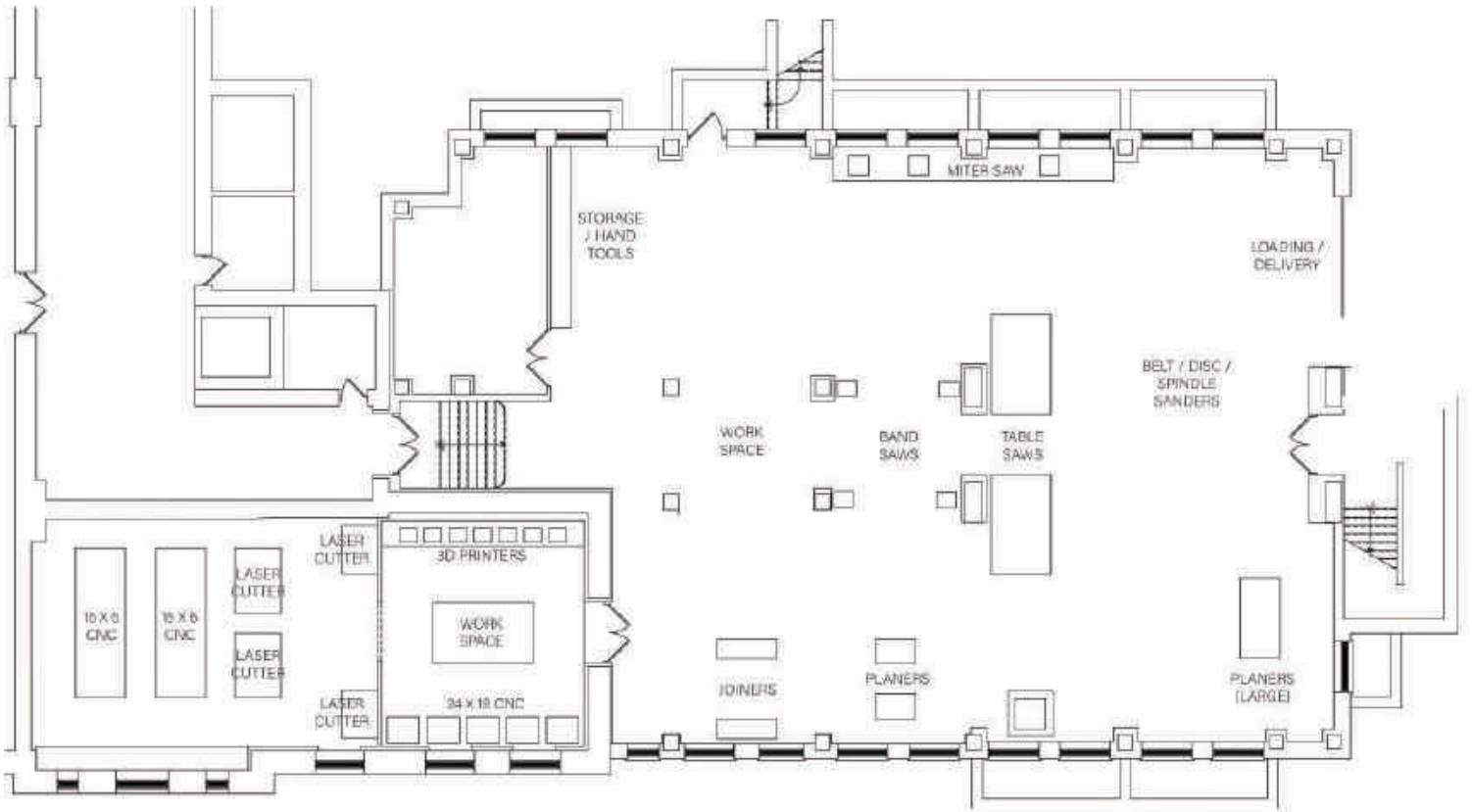
OFFICES	700
CONFERENCE ROOM	400
LOUNGE	200
RENTAL SPACES	9000

## THIRD FLOOR

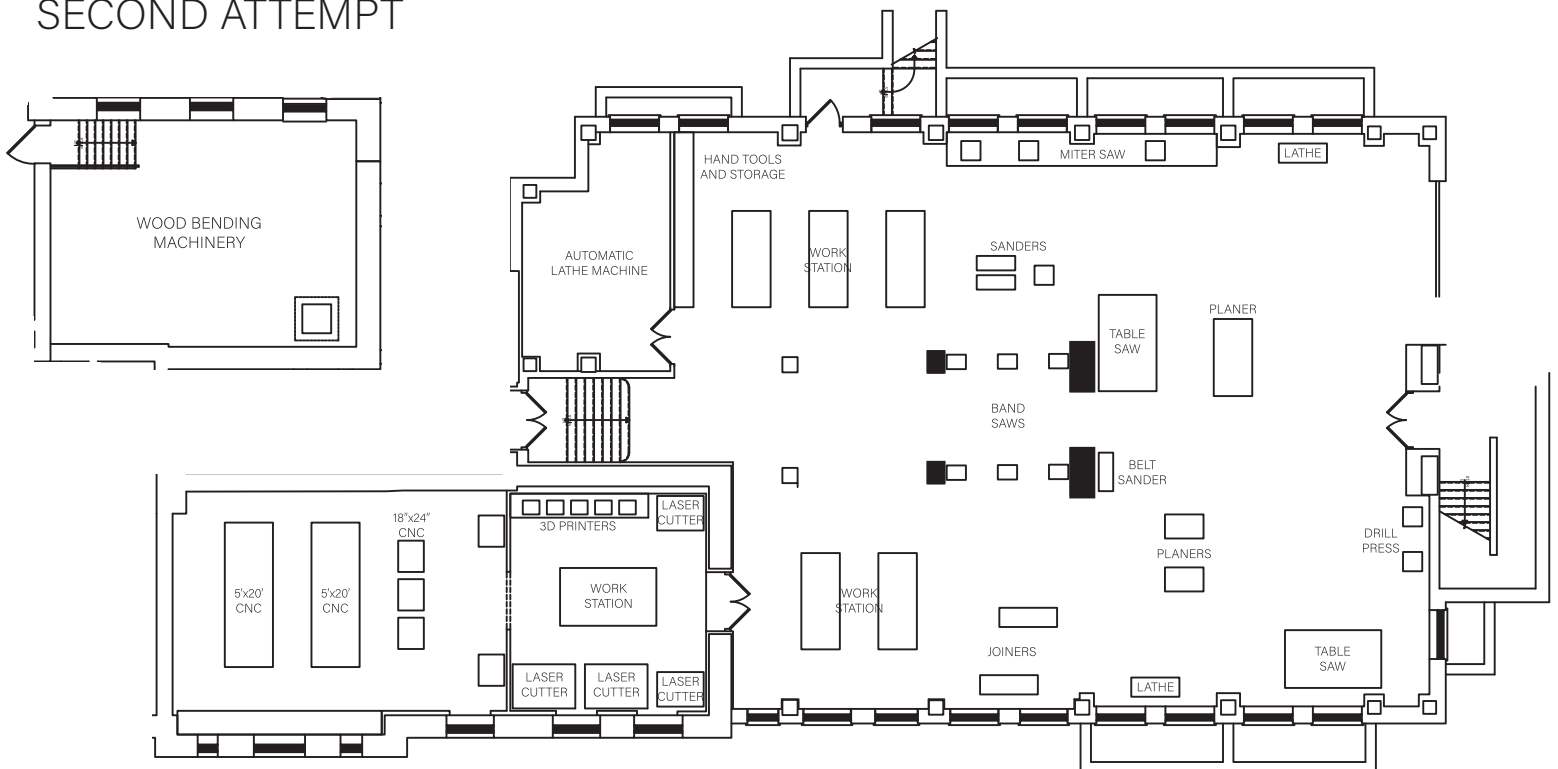
SPACES AVAILABLE 10500  
FOR RENT BY LOCAL  
DESIGNERS AND  
MAKERS:

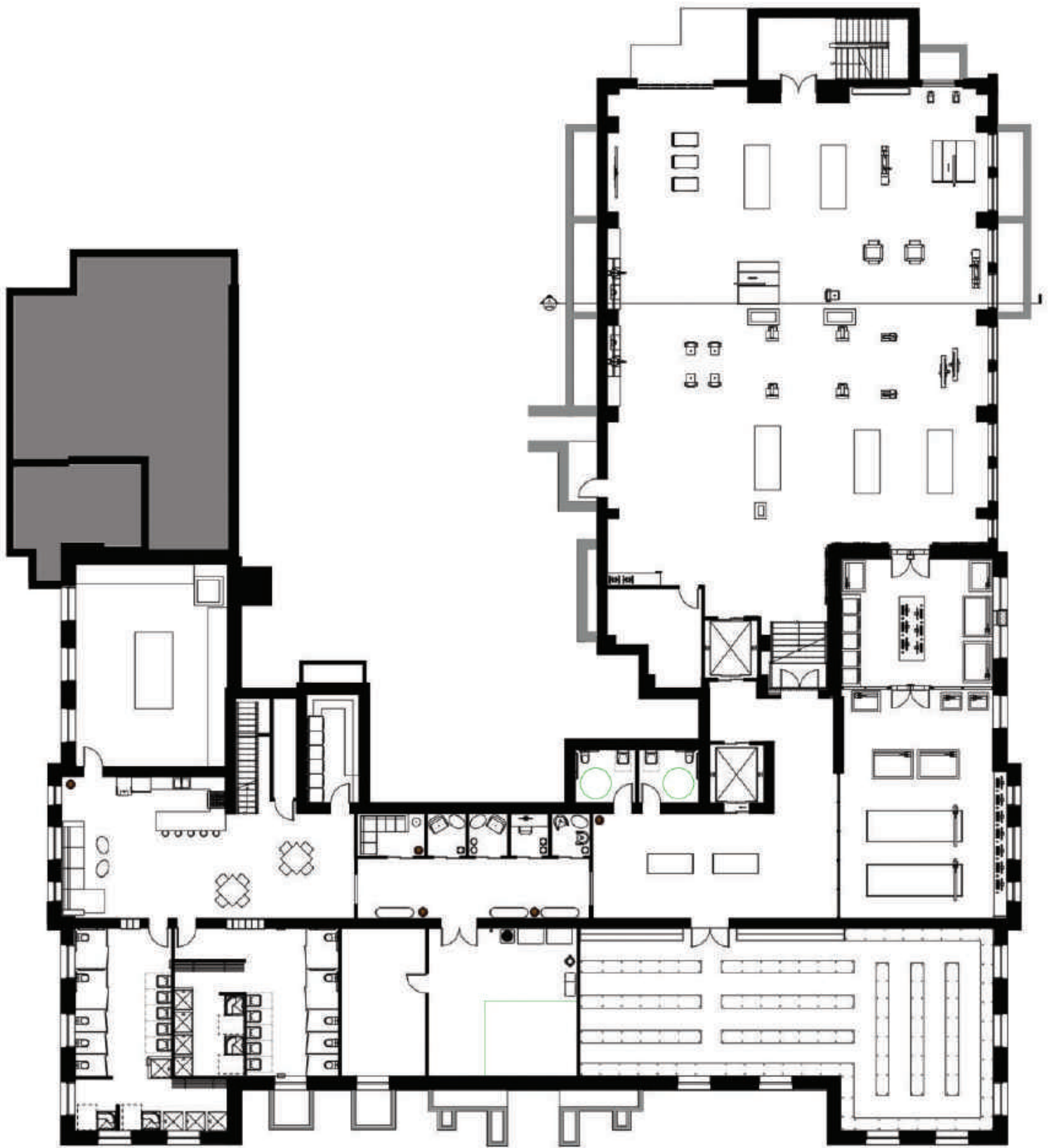
100  
300  
500  
700

# FIRST ATTEMPT

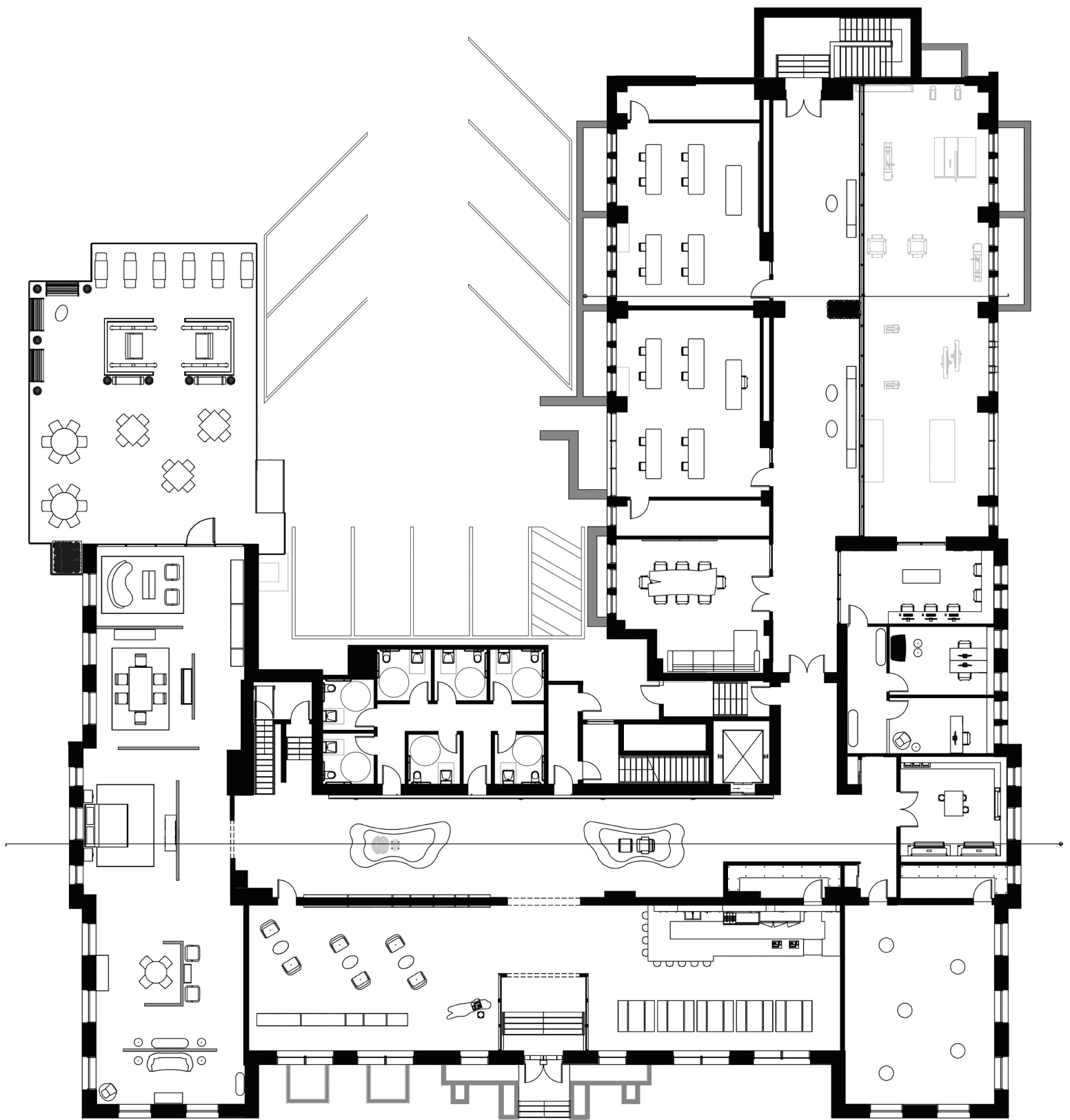


# SECOND ATTEMPT



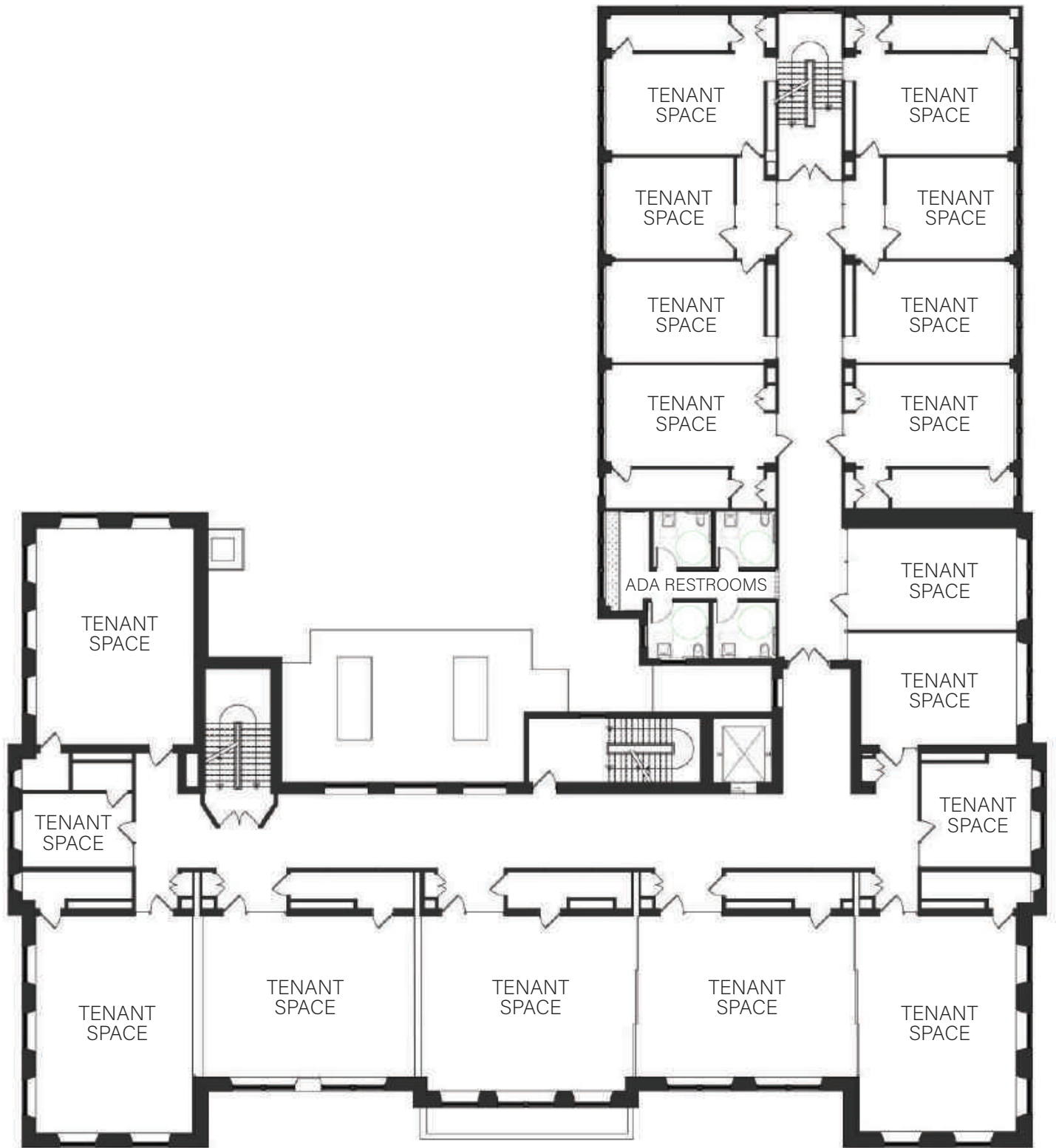


BASEMENT FLOOR PLAN  
NOT TO SCALE



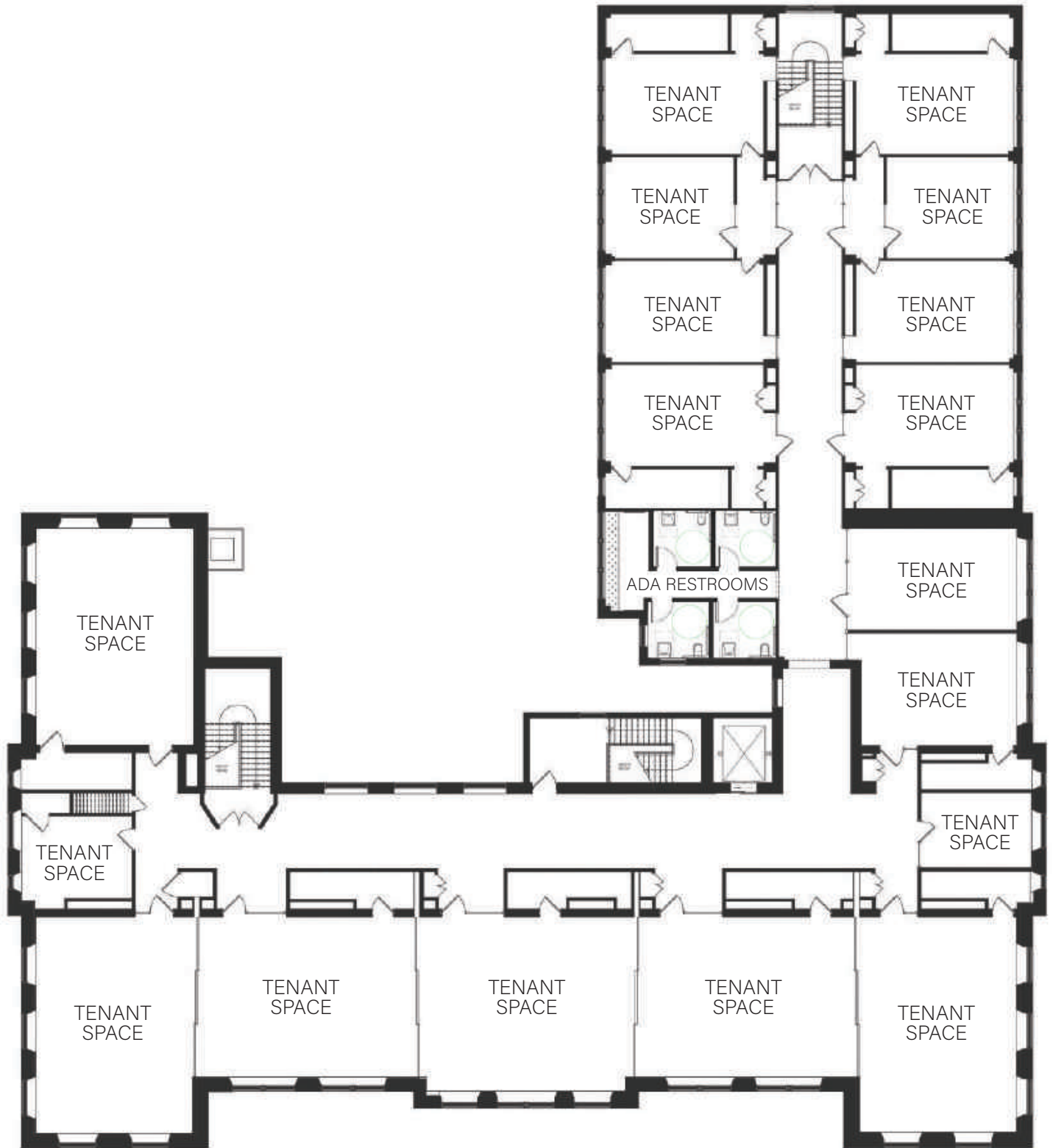
FIRST FLOOR PLAN  
NOT TO SCALE



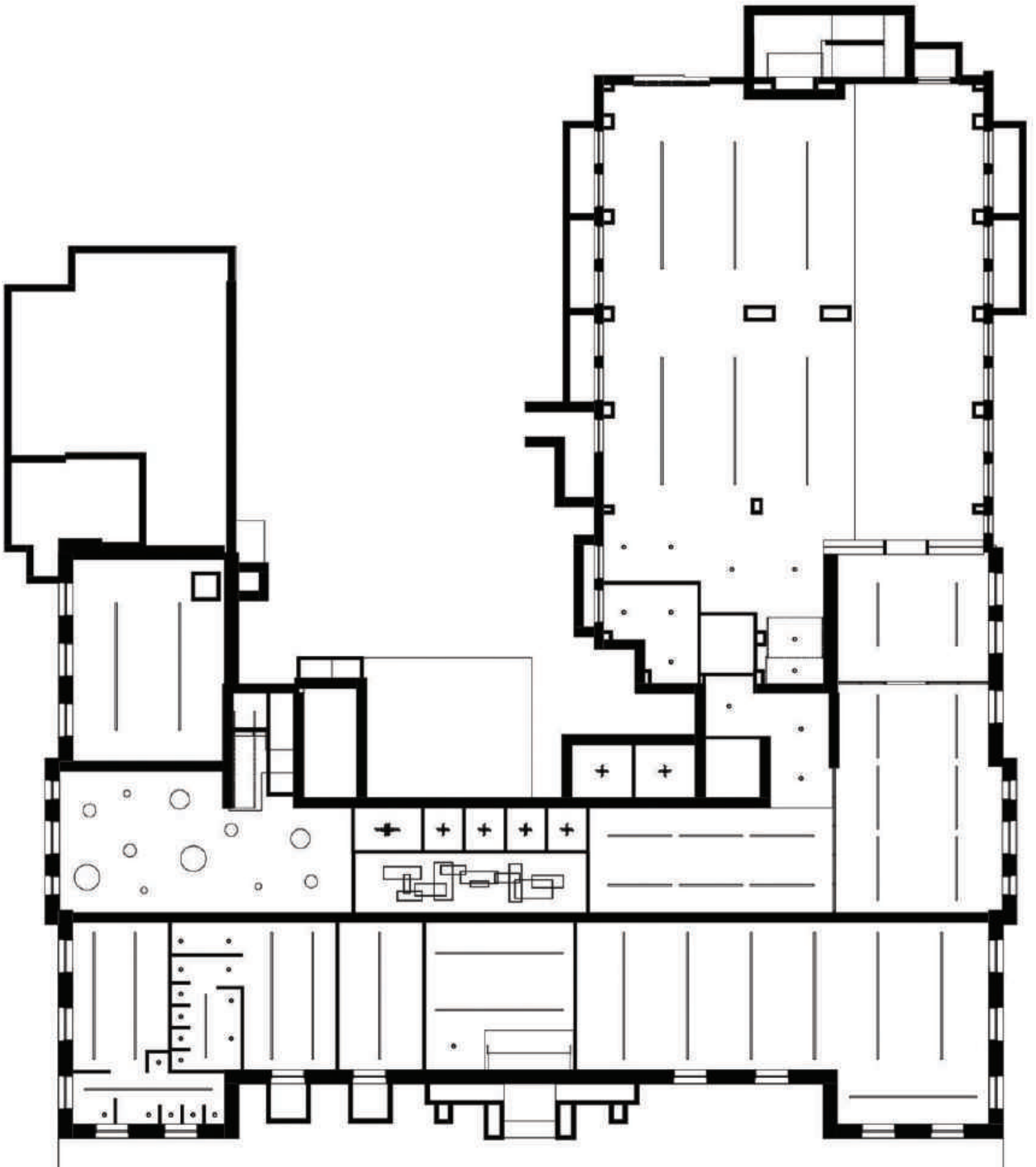


SECOND FLOOR PLAN  
NOT TO SCALE

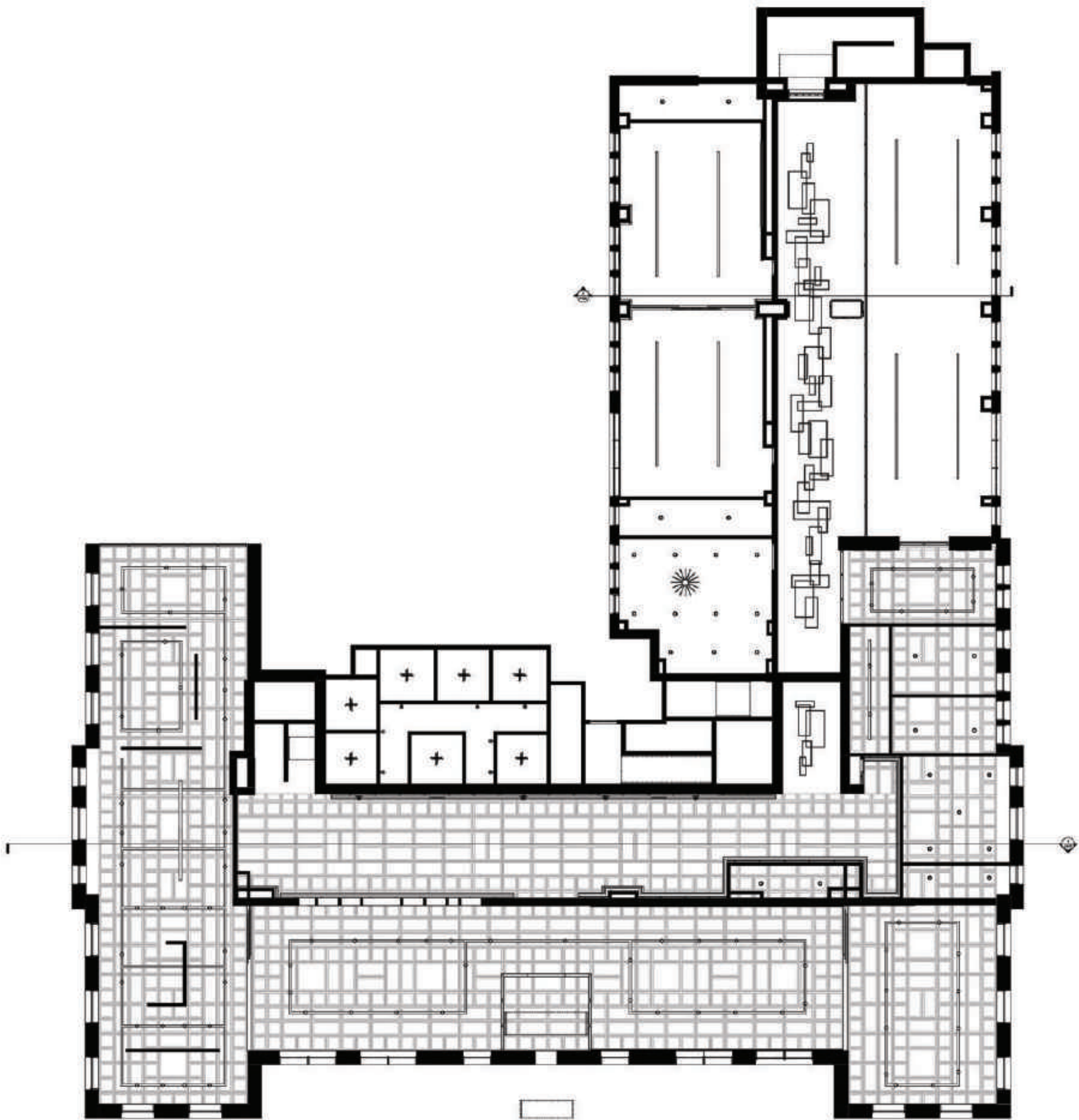




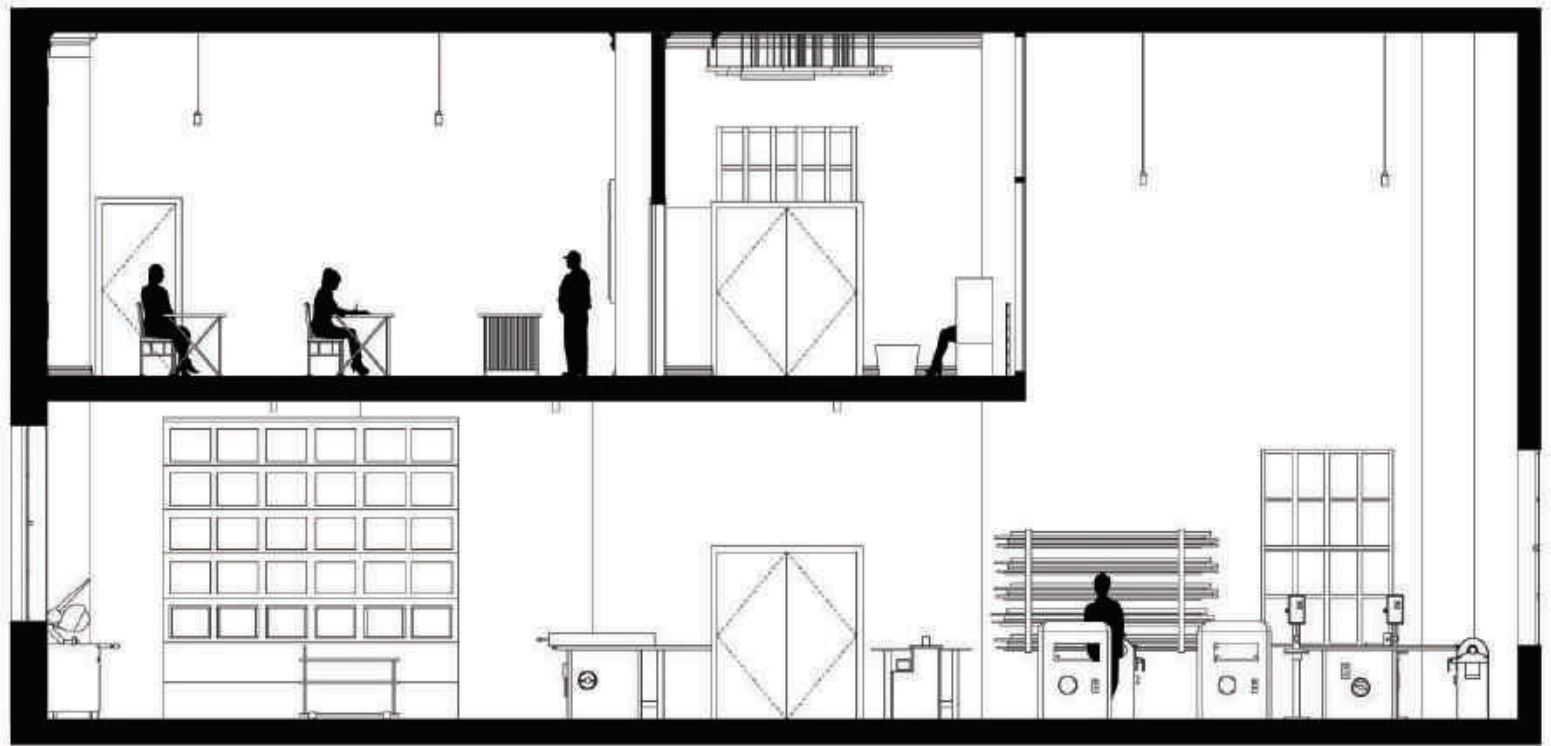
THIRD FLOOR PLAN  
NOT TO SCALE



BASEMENT REFLECTED CEILING PLAN  
NOT TO SCALE



FIRST FLOOR REFLECTED CEILING PLAN  
NOT TO SCALE



EAST SECTION  
NOT TO SCALE



WEST SECTION  
NOT TO SCALE





RECEPTION PERSPECTIVE



CAFE PERSPECTIVE



FIRST FLOOR HALLWAY PERSPECTIVE



SHOWROOM PERSPECTIVE





OUTDOOR SEATING PERSPECTIVE



CLASSROOM PERSPECTIVE

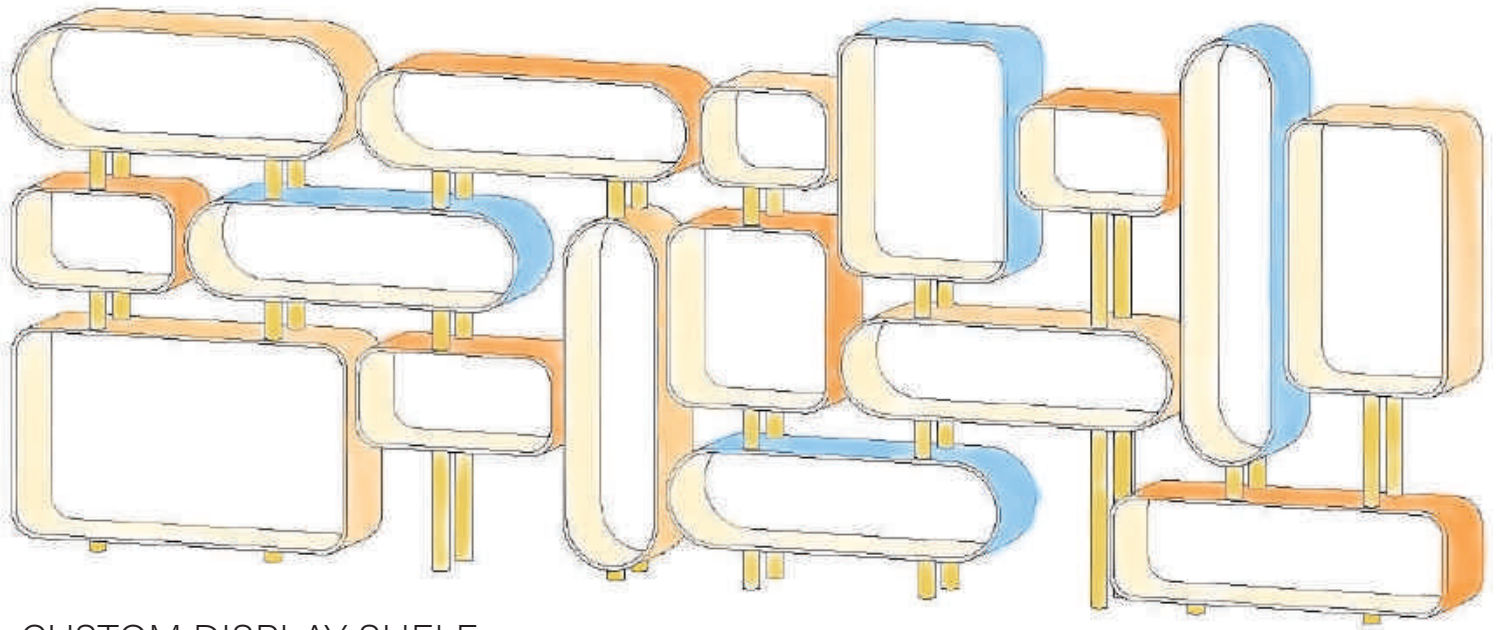


CLASSROOM HALLWAY PERSPECTIVE

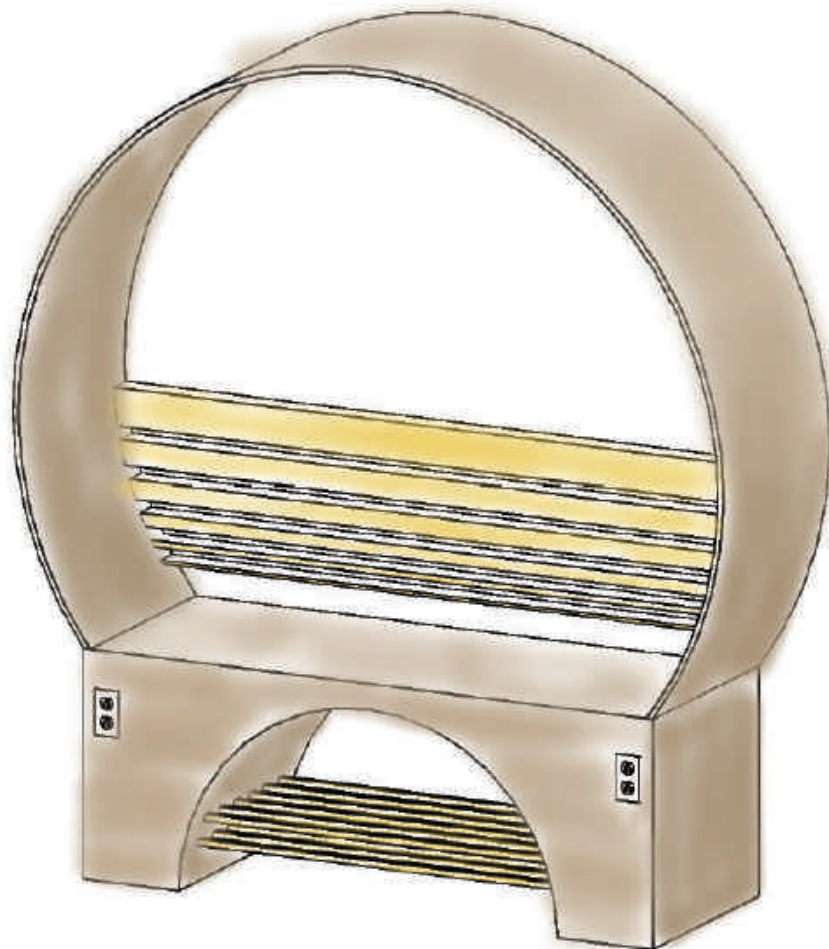


WOOD SHOP PERSPECTIVE





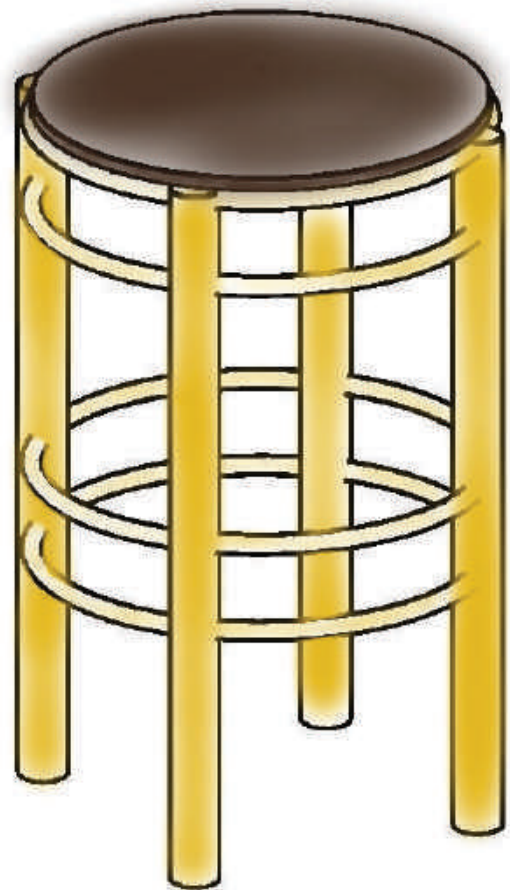
CUSTOM DISPLAY SHELF  
NOT TO SCALE



CUSTOM CAFE BOOTH SEATING - W/ OUTLETS FOR GUESTS  
NOT TO SCALE



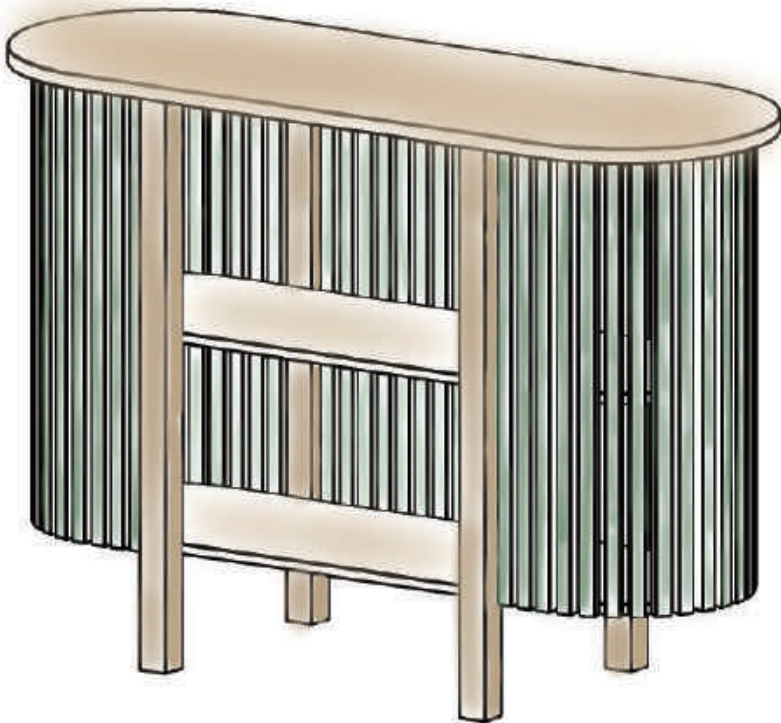
CUSTOM COCKTAIL TABLE  
NOT TO SCALE



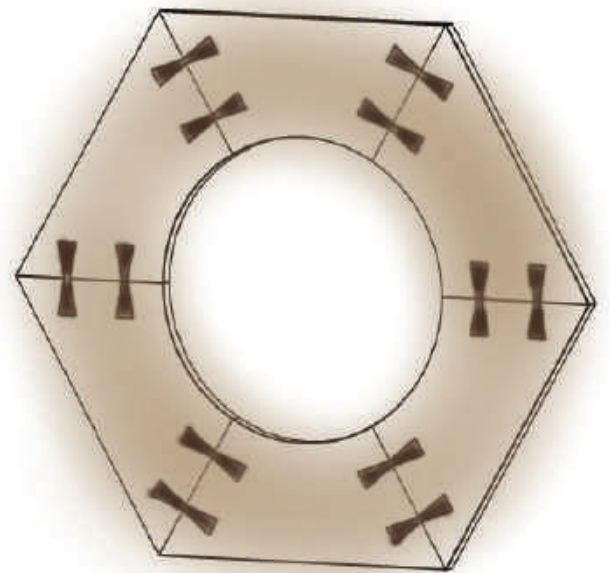
CUSTOM CAFE STOOLS - W/ METAL STRUCTURE  
NOT TO SCALE



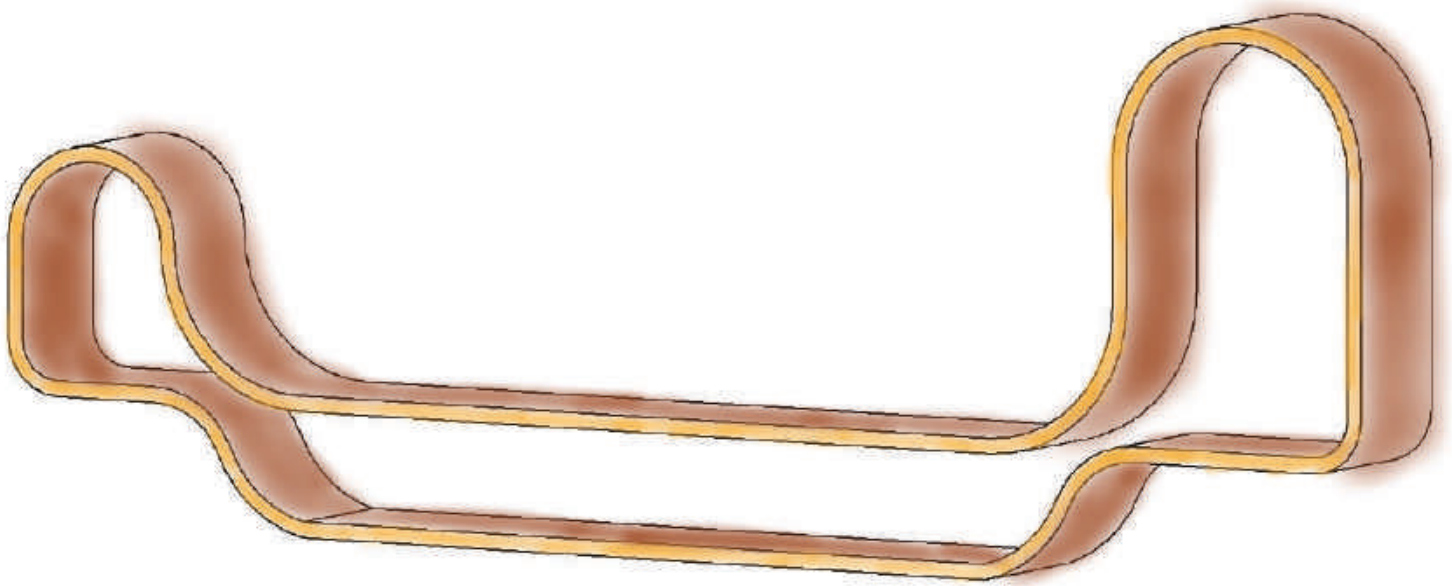
CUSTOM WALNUT AND POPLAR BED FRAME  
NOT TO SCALE



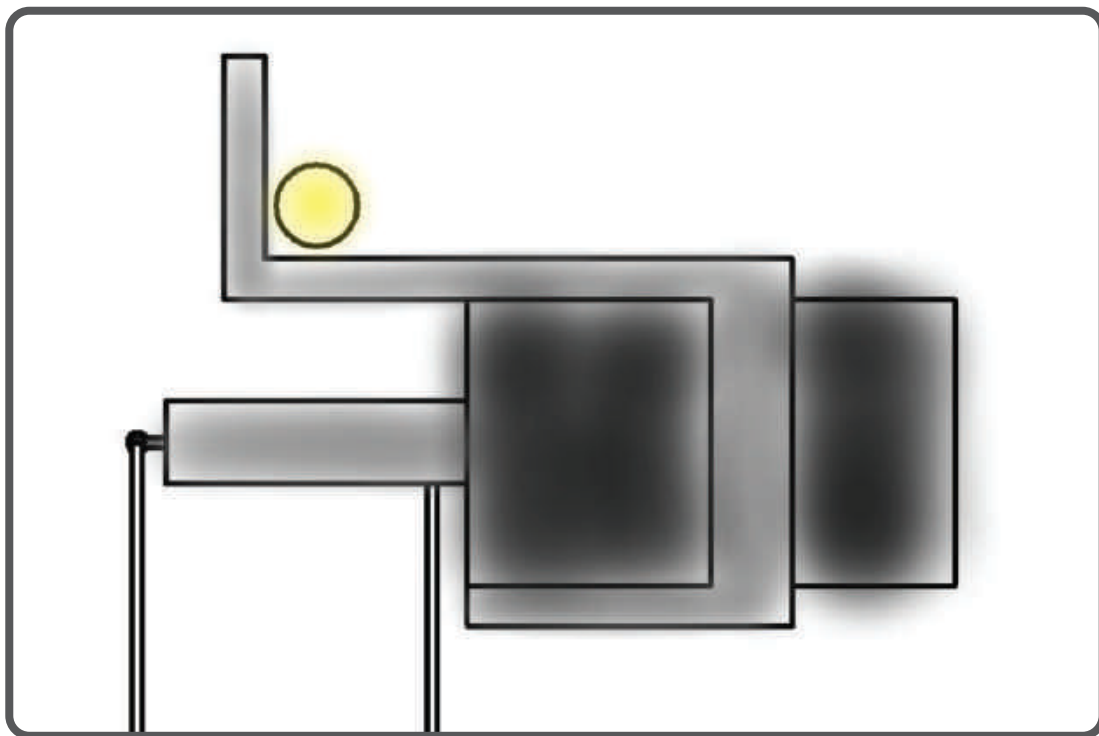
CUSTOM CONSOLE TABLE  
NOT TO SCALE



CUSTOM WHITE OAK AND  
WALNUT MIRROR  
NOT TO SCALE



CUSTOM CHERRY BENT LAMINATION BENCH  
NOT TO SCALE

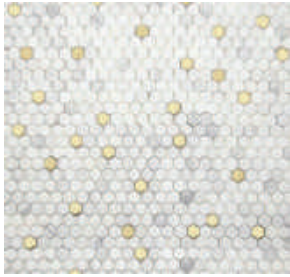


DETAIL: LIGHTING RUNNER  
NOT TO SCALE

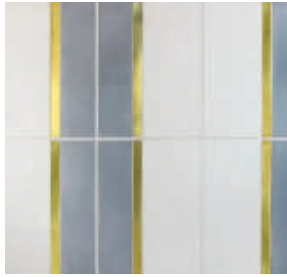




Arcadia Bonsai Tint Glass & Slate Tile TileBar



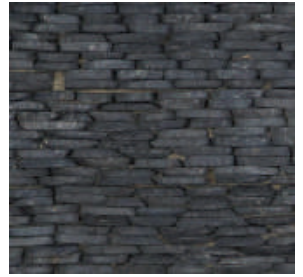
Fairmont Brass Mini Hex Mosaic Realstone Systems



Kavim 4 White / Gray Tabarka Studio



Inara Kentucky Haze Brass & Marble Tile TileBar



Nature Alor Black Stacked Slice TileBar



Iconic Metal Tile Architectural Systems



Cozy Day Dreamer Architectural Systems



Island Weaves Cork Maya Romanoff



Cork Textile Wolf-Gordon



Cork Wallcovering Wolf-Gordon



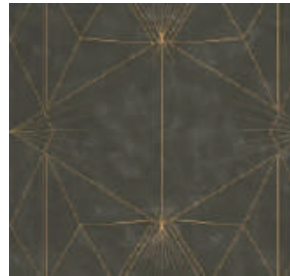
Wildspitze Himmelblau Organoid



Maharam Cork & Felt by Danskina



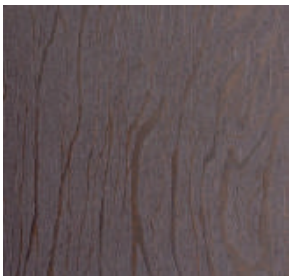
Mural Wallpaper Geometries and Stripe LitFad



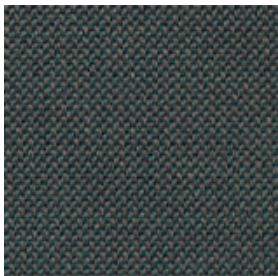
Skins Dreamland Porcelanosa



Roscommon Wolf - Gordon



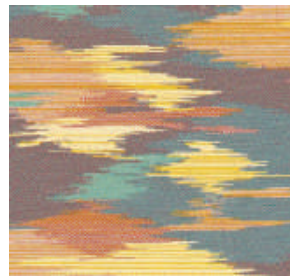
Cortex Momentum Textiles & Wallcovering



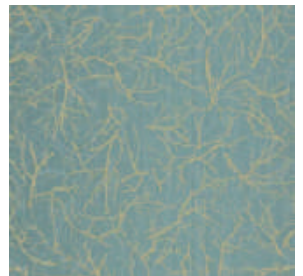
Mikro Momentum Textiles & Wallcovering



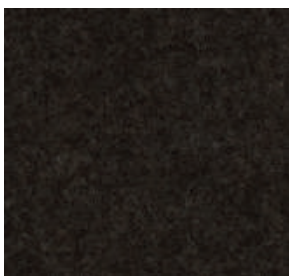
Adelaide Weitzner



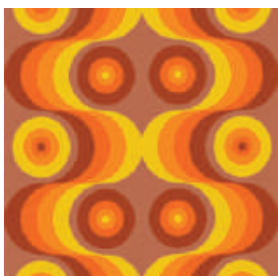
Ilsa Brentano



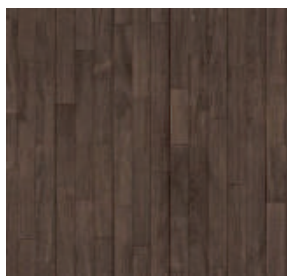
Skins Sheffield Porcelanosa



Alpaka Filzfelt



Ceiling Mural



Original Wood Flooring Throughout Building

Work Cited:

- Akarslana, F., & Demiralayb, H. (2015). Effects of Textile Materials Harmful to Human Health. ACTA PHYSICA POLONICA A, 128, B-407-B-408.
- "Autonopedia." History of Adhesives. Accessed October 30, 2021. [https://web.archive.org/web/20100326160721/http://autonopedia.org/crafts\\_and\\_technology/Adhesives/History\\_of\\_Adhesives.html](https://web.archive.org/web/20100326160721/http://autonopedia.org/crafts_and_technology/Adhesives/History_of_Adhesives.html).
- Avinc, O., Yavas, A., & Kalayci, E. (2020). USAGE OF HORSE HAIR AS A TEXTILE FIBER AND EVALUATION OF COLOR PROPERTIES. ANNALS OF THE UNIVERSITY OF ORADEA FASCICLE OF TEXTILES, LEATHERWORK.
- Barbaritano, Marica, and Elisabetta Savelli. How Consumer Environmental Responsibility Affects the Purchasing Intention of Design Furniture Products. 13. Vol. 13. Basel, Switzerland, 2021.
- Burt, L. (2018, July 21). MDF or solid wood furniture: Advantages and disadvantages. Parade of Homes. Retrieved December 10, 2021, from <https://www.paradeof-homes.org/blog/mdf-solid-wood-furniture-advantages-disadvantages/>.
- EPA. Environmental Protection Agency. Accessed October 29, 2021. <https://www.epa.gov/ghgemissions/overview-greenhouse-gases>.
- Environmental Protection Agency. (n.d.). EPA. Retrieved December 10, 2021, from <https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials>.
- "Explainer: These Six Metals Are Key to a Low-Carbon Future." Carbon Brief, April 20, 2018. <https://www.carbonbrief.org/explainer-these-six-metals-are-key-to-a-low-carbon-future>.
- Foam Types Used in Cushioning. (2009). Sustainable Furnishings Council.
- Frihart, C. R. (2015). Introduction to Special Issue Wood Adhesives: Past, Present, and Future.

Gillah, P. R., Irle, M. A., & Maher, K. (2000). Properties of a novel three-layer MDF panel made with wood and sisal nonwoven mattresses. *International Forestry Review*.

Gleich, A. von, Ayres, R. U., & Gößling-Reisemann, S. (2007). *Sustainable Metals Management: Securing Our Future - Steps Towards a Closed Loop Economy*. Springer Science & Business Media.

GLUES History, Preparation, Use and Disassembly, December 9, 2011.

Goldhahn, Christian, Etienne Cabane, and Munish Chanana. "Sustainability in Wood Materials Science: An Opinion about Current Material Development Techniques and the End of Lifetime Perspectives." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 379, no. 2206 (2021). <https://doi.org/10.1098/rsta.2020.0339>.

Gonzalez, D. (2018). *Economic development after World War II*. Researcher at Valley College.

Gul, W., Khan, A., & Shakoor, A. (2019). Impact of Hot Pressing Temperature on Medium Density Fiberboard (MDF) Performance. *Advances in Materials Science and Engineering*.

"History and Future of Plastics." Science History Institute, November 20, 2019. <https://www.sciencehistory.org/the-history-and-future-of-plastics>.

"The History of Glue." BayneBox.com. Accessed October 30, 2021. <https://baynebox.com/news/the-history-of-glue/>.

Hounshell, D. A. (1997). *From the American system to mass production, 1800-1932: The development of Manufacturing Technology in the United States*. Hopkins Univ. Press.

Hub, IISD's SDG Knowledge. "Guest Article: Greening the Wood Industry: Sustainability from Production to Consumption: SDG Knowledge Hub: IISD." SDG Knowledge Hub. Accessed November 1, 2021. <https://sdg.iisd.org/commentary/guest-articles/greening-the-wood-industry-sustainability-from-production-to-consumption/>.

Is memory foam toxic? sleep foundation. Sleep Foundation. (2021, May 14). Retrieved December 10, 2021, from <https://www.sleepfoundation.org/mattress-construction/is-memory-foam-toxic>.

Marchant, R.P. "Comparison of Polyurethane and Latex Foams for Furniture." *Journal of Cellular Plastics* 8, no. 2 (1972): 85–89. <https://doi.org/10.1177/0021955x7200800205>.

Norgate, T. E., & Rankin, W. J. (2002). The role of metals in sustainable development.

Obermeyer, C. (2021, February 18). The history and proliferation of single-use plastic products. *CleanUp News*. Retrieved December 10, 2021, from <https://www.cleanupnews.org/home/history-of-plastics-and-recycling>.

Parker, Kate, Jean-Philippe Garancher, Samir Shah, and Alan Fernyhough. "Expanded Polylactic Acid - an Eco-Friendly Alternative to Polystyrene Foam." *Journal of Cellular Plastics* 47, no. 3 (2011): 233–43. <https://doi.org/10.1177/0021955x11404833>.

Pyne, L. (2016). The sticky history of adhesives. Retrieved December 10, 2021, from <https://daily.jstor.org/the-history-of-adhesives/>.

Raabe, Dierk, Cem Tasan, and Elsa A. Olivetti. "Strategies for Improving the Sustainability of Structural Metals." *Nature News*. Nature Publishing Group, November 6, 2019. <https://www.nature.com/articles/s41586-019-1702-5>.

Sustainable American Hardwoods A guide to species. (2017). American Hardwood Export Council.

Sustainable Fabrics • Guide on the most ethical materials [2020]. SustainYourStyle. (n.d.). Retrieved December 10, 2021, from <https://www.sustainyourstyle.org/en/fiber-ecoreview>.

What are the most sustainable fabrics? Good On You. (2021, February 3). Retrieved December 10, 2021, from <https://goodonyou.eco/most-sustainable-fabrics/>.

Wilson, J. B. (2008). Medium Density Fiberboard (MDF): A Life-Cycle Inventory of Manufacturing Panels from Resource through Product . CORRIM: Phase II Final Report.