Design Process and Issues in New Interdisciplinary Science Research Buildings

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Abstract
The purpose of this paper is to introduce and analyze the design process and issues of a new interdisciplinary science laboratory building. Unlike conventional science buildings that focus on one type of discipline, new interdisciplinary science buildings are a combination of two or more different disciplines. By illustrating a specific example of the design and construction of the Biogeochemistry (BGC) building and the Marine Research Facility (MRF) building at Woods Hole Oceanographic Institution (WHOI), the main issues pertaining to the new lab design will be covered. In discussing the development of the project, campus planning, laboratory planning, public space planning, cladding design, Mechanical Electrical and Plumbing (MEP) system coordination, interior design, laboratory bench design, and inherent design issues in interdisciplinary science labs will be reviewed.

Keywords: interdisciplinary lab design; wood cladding; casework design; MEP coordination; Woods Hole

1. Introduction
The purpose of this paper is to introduce and analyze a recent interdisciplinary science building design work by Ellenzweig. Ellenzweig is ranked as the top lab design firm, and the detail analysis of their work illustrates what type of thought and design process was involved in the recent science research building.

[1] Campus planning is discussed. Most interdisciplinary labs are situated in an academic or research setting. Hence, enhancing the quality of the existing site structure with new building form and shape is critical.

[2] Laboratory planning is discussed. Lab typology has evolved over the years. Unlike prior generation labs, current interdisciplinary labs are efficient and communicative.

[3] Public space planning is discussed. Public spaces in interdisciplinary laboratory buildings are critical spaces for leisure discussion. Furthermore, from the exterior, public spaces occupy an important position in the overall appearance of the building. Often they perform an important aesthetic function. In the cases provided here, public spaces are located at the hinge point of the overall building.

[4] Exterior the cladding system is covered. The choice of cladding was a result of the system integration and the sustaining strategy of the local authority. Woods Hole is an area where houses are clad in cedar to resist the ocean air. Preserving the locality of the area, both in scale and materiality, was a sustaining strategy by the Cape Cod Commission authority.

[5] The MEP system and consultants coordination are discussed. The idea of system integration coincides with the idea of new scientific equipment. Recently, equipment has opened new doors to science in general. Highly sophisticated tools require a careful structure and MEP coordination to meet the requirements of equipment specification. Furthermore, interdisciplinary lab buildings require coordination of various consultants.

[6] The interior and laboratory bench design is examined. Labs are becoming more and more customized. Each faculty requires different lengths and types of benches to accommodate their cutting-edge research.

2. Campus Planning
When the project was offered by WHOI, Ellenzweig discovered at an early stage that the campus lacked hierarchy and traffic articulation. Buildings were dispersed, and pedestrian and vehicular circulation conflicted. To solve this problem, the design team divided the interdisciplinary science program into two buildings. Instead of one monolithic building, the architecture of two separated buildings could enhance the quality of the future campus landscape.

Conceptually, MRF was to become a "bridge" connecting the lower campus to the upper campus and BGC was to become a "bowl" finishing the unfinished loop of open space. Originally, both buildings were "L" shaped buildings, their size equal to the amount of...
By proposing the "bridge" and "bowl" idea, clear articulation was achieved on the site between the upper and lower campus. Furthermore, pedestrian access remained at the inner ring of the upper campus and vehicular access occupied the outer ring of the lower campus. This proposal also matched WHOI's earlier Core Campus Masterplan.

The actual idea of "interdisciplinary" depends upon the proximity of different disciplines. Hence, separating the program into two schemes seemed at first glance at odds with the idea of "interdisciplinary" design. However, the careful coordination of the disciplines within the larger framework of other labs on the campus enabled the design team to propose two-building scheme. As a result, the program was communicative both architecturally and inter-disciplinarily.

The Woods Hole area in Massachusetts is under the jurisdiction of the Cape Cod Commission (CCC). CCC is a regional planning authority regulating uncoordinated development that threatens the unique and valuable natural, coastal, historical, cultural features of Cape Cod. Hence the size of the building and its overall appearance were carefully scrutinized by CCC.

One unique aspect of the Woods Hole Institution is that entire laboratories were dispersed in hundreds of small cottages within the Woods Hole area. The campus design strategy is in line with that tradition, accommodating a village-like campus atmosphere.

3. Interdisciplinary Laboratory Planning

Modern laboratory planning stems from Louis Kahn's famous Salk Institute. Prior to Salk, lab typology was similar to that of classroom buildings, corridors with often windowless rooms.

The Salk Institute was innovative because Kahn fully understood the functional requirements of labs. Kahn included glass partitions to create an airy research space as he believed that the transparency would enhance research imagination and production. He placed lab support spaces (e.g., glassware and centrifuge equipment space) between research floors.

Following Salk, laboratories became faculty-based labs where the research and teaching labs of each faculty would enclose the offices. These cluster type labs hindered casual discussions between faculty members. Cluster-type labs resulted in the isolation of each lab.

Science labs recently became more interdisciplinary (Table 1.), where promoting discussion among faculty member is critical factor. Lab design typology has become flexible and efficient; and plans of laboratories are no longer cluster type.

The plans of both BGC and MRF (Fig.2.) are divided into the faculty office zone (light blue zone) and the lab zone (orange zone). BGC accommodated more chemistry labs, while MRF accommodated more marine biology labs.

To foster conversation and cross pollination between different disciplines, the linearity of labs and the articulation of programs were kept intact. Indentations within the corridor spaces also encouraged casual gatherings and broke the monotony of the double-loaded corridor system.

In contrast, earlier faculty-based labs such as the Joslin Diabetes Center (Fig.3.) illustrated the earlier laboratory model. The lab zone (orange zone) encircled...
individual the faculty office zone (light blue zone).

In this model, communication between faculty members is insulated and group dynamics and synergetic effects between different disciplines are discouraged.

In addition, building systems are inefficient in this model. The lab zone and the office zone require different type of HVAC system and the re-routing and cross-over of ducts is therefore inescapable.

Interdisciplinary science labs are typically a combination of two or more lab modules. A chemistry lab module differs from that of a biology or physics lab module.

Foster and Partners recent interdisciplinary science building, the Clark Center at Stanford University, consists of three wings surrounding a central courtyard and provides space for 700 researchers. The building is designed to facilitate collaboration between biology, physics, and chemistry as well as facilitate computation with medical education.

At WHOI, there was a combination of chemistry, biology, and marine research. Each distinctive area of research created common lab support spaces. For example, environment control rooms and tissue culture rooms facilitated collaboration by acting as linking points for interdisciplinary research.

4. Public Space Planning

Interdisciplinary science research labs are in most cases situated in an academic or research campus setting. Public spaces should be arranged to accommodate the circulation paths of the campus. Moreover, they should respond to the settings of their site.

At WHOI, this was particularly successful, where the public spaces were geometrically constructed in conjunction with the pedestrian circulatory path of the inner campus.

In Fig.2., the public spaces for BGC and MRF are shown in a dark blue color. Public spaces in both buildings occupied critical locations on the site. The public space in BGC looked over the lower part of the campus (Fig.4.), while the public space in MRF looked into the newly organized u-shape open space.

Due to the slope of the site, the public space of MRF was one story high, whereas the public space of BGC was two stories high. Robustness of architectural expression was sought after in these spaces, and the inward looking MRF and outward looking BGC therefore both served their role well with the play of scale.

The winning scheme for the Lab of the year 2007 was Rafael Vinoly's Carl Icahn Laboratory of the Lewis-Sigler Institute for Integrative Genomics at Princeton University.

Interestingly, Vinoly also used the public space as a circulatory path. Similar to the way exterior forms invite public space at WHOI, Vinoly creates an inviting exterior with the sustainable device of vertical fins. Furthermore, the structurally glazed atrium space invites researchers from other departments, promoting cross-pollination of discussions. (Fig.5.)

5. Exterior Cladding Design

Traditionally, white cedar cladding has been a
predominant exterior material used at Woods Hole as it resists the corrosive nature of salty wind from the Atlantic Ocean. To sustain the local traditional features, the design team searched from the very beginning for the right expressions for the wood siding.

Through design and mock-up studies, the design team proposed a shiplap wood siding profile and tongue & groove batten wood siding profile. In addition, the team used aluminum reveals on some of the design accents.

The word, 'interdisciplinary' suggests the notion of "innovation." An interdisciplinary approach seeks innovation through a combination of different branches of scientific knowledge. Architecturally speaking, innovation implies the use of new materials and a new structure that generates a new cladding system. In that sense, the buildings here could be considered non-innovative.

However, within the context of Woods Hole, and considering the context of local materials, and working within the CCC regulations, the dressing of the building was an outcome of an innovative use of the conventional materials of New England.

In this sense, the cladding design of BGC and MRF is in line with Moneo's commentary on Herzog De Meuron's use of wood cladding. It is not an innovative material per se, but an innovative use of materials. New ways of using materials facilitate the emergence of form and skin.

While typical residential structures in New England are of 2x4 platform framing construction, for the BGC and MRF buildings, steel was employed as the main superstructure with a metal stud framing back-up system for the wood siding. (Fig.7.)

Hence, the primary concern was not structural. The design team focused on the aging of the wood and termite resisting treatment. Cabot Clear Solutions and Olympic Weathering Stain were used for mock-up tests. The use of zinc panels was also pertinent to the mechanical penthouse. The air quality analysis performed by Rowan Williams indicated that the zinc panels would withstand the chemical exhaust fumes.

When this building was in the design phase, the LEED system by the Green Building Council had not been fully applied in practice. However, Ellenzweig was aware of its green strategy.

The development of the curtainwall system with the vendor (Kawneer) enabled us to test and design different types and shapes of light diffusing sunshades.

6. MEP Coordination and Consultants Coordination

Science equipment required in labs is becoming more sophisticated and complex. Some equipment is extremely costly. From the very beginning, the design...
team needs collaboration from various consultant groups. Particularly, BGC accommodated many lab fume hoods and biosafety cabinets. These needed to be connected to special exhaust systems designed to sufficiently dilute the fumes and to carry them out of the building and into the atmosphere.

In terms of supply and exhaust systems, a typical classroom construction may require 6-10 air changes per hour. At WHOI, 12-15 air changes per hour was required to meet the density of the hoods.

Along with the cooling and heating systems, lab buildings are typically loaded with MEP systems. About 40 percent of the construction budget is spent on the MEP requirements of the building.

Hence, a coordination effort between structural, architectural, and HVAC is critical. The section in Fig. 8. illustrates the result of such a coordination effort.

At MRF, a more challenging coordination effort was required. The Necropsy Lab at the lower floor was the core of the marine research group.

This lab accommodated a whale as its primary research specimen. Ceiling mounted monorails therefore needed to extend from the outside through to the instrument room and the freezer. Thermal breaks had to be coordinated. In addition, concentrated loads of whales had to be coordinated. (Fig. 9.)

Other interesting consultant coordination was driven by CCC. CCC regulated the amount of light pollution during the evening. Lam partners worked closely to coordinate the lighting strategies.

Considerable coordination with the code consultant is pertinent to lab buildings, particularly with respect to the amount of chemical storages, the hoods of the exhaust system, and biowaste treatment.

In addition, interdisciplinary buildings typically require Chemical fume exhaust stacks. Air Quality consultants informed us in order to meet the dilution levels of chemicals, the height of a building needed to be twice its size. The design team devised a secondary penthouse above the mechanical penthouse to conceal the grotesque appearance of the two stacks.

The field of science is expanding its realm of knowledge, using computer generated multi-million dollar equipment. Conventionally, NMR labs for scientific labs and pharmaceutical labs demanded high-level of radioactive frequency coordination. Today, nanotechnology is leading more sophisticated structural and HVAC coordination.

7. Interior Design

The interior was divided into four groups. The first group is the lab area, the second is the office area, and the third group is the seminar rooms and public corridor. The lab area is predominantly affected by
specific bench casework; hence it will be covered later in this paper.

The public corridor provides the circulation that links the offices and seminar rooms. The design team used glass at the two book-ends of the corridor and many transoms were used to bring in as much daylight into the building as possible.

Lastly, the design team also used metal baffles and wood panels to brighten the ceiling. For seminar rooms, exterior cladding system was used for interior wall finish.

8. Bench Casework Design

Research is becoming more specialized with a high level of flexibility and adaptability. Therefore, research working spaces have become more customized. Working closely with Fisher Hamilton (Casework Vendor), Ellenzweig developed a sophisticated bench system.

The structure of this casework comprises metal channels. The utility chase feeds compressed air, gas, and water lines. The whole system is integrated with an exterior curtainwall system and column enclosure.

As labs are becoming increasingly more communicative and flexible, movable benches and demountable surfaces are preferred over permanent furnishings. (Fig.12.)

De-ionized water and eyewash are also implemented as part of an integrated casework. Tel/Data outlets for internet access are now incorporated as part of plugmold chase for equipments.

A central natural gas and vacuum system is also integral to the bench system. Central natural gas is used for sterilization of various tools and a central vacuum is used for drying out samples and filtration of chemicals.

9. Conclusion

In campus planning, the design of interdisciplinary science buildings can enhance the quality of site planning. Interdisciplinary lab planning requires efficient lab typology and grouping of labs to offices is particularly critical to minimize the extent of the exhaust HVAC system. Furthermore, cross-pollination between different fields of research is important.

In interdisciplinary buildings, casual discussions amongst researchers in public spaces are important. The spark of casual discussions leads to synergetic ideas that would otherwise not have been considered. The exterior public spaces act as points of attraction in the overall appearance of the building. Hence, a careful design study is required. The exterior cladding
of interdisciplinary science buildings should meet the code requirements of national and local jurisdiction. Biosafety levels and chemical exhaust fume levels are critical, along with a green and well-crafted strategy for the selected material.

Since equipment is getting more costly with more complex spec requirements in interdisciplinary science buildings, careful coordination with the engineers and consultants is critical. Interdisciplinary science buildings seek transparency and communication, promoting competition and cooperation. The use of interior glazing and seeking the correct level of lighting should be accommodated within comfortable alcoves. Lab casework benches should be more flexible and research friendly. The design of conventional floor mounted benches should therefore be rethought to meet the requirements of the custom made research environment.

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Notes

1) Two buildings, BGC and MRF were designed by Ellenzweig and won the 2007 Lab of High Honors Award, the 2007 AIA New England Award, and the BSA Award in the U.S.
2) Ellenzweig is a firm located in Cambridge, Massachusetts specializing in a highly complex and sophisticated laboratory design in the U.S.
3) WHOI is a private, nonprofit research and higher education facility established in 1930. It is the largest oceanographic research institution in the U.S.
4) See Bonaetta's article.
5) See Livingstone's article. I visited Icahn Laboratory in 2008. The sustainable strategy of the atrium and skylight system in individual labs was impressive. Recent academic buildings by Vinoly in the U.S. illustrate excellent public space design in college level education buildings.
6) See Moneo's book below. Moneo's discussion on Herzog Demuron's wood projects (Plywood House at Bottmingen and Apartment Building at Hebelstrasse, Basel) illustrates the design team's attitude towards wood cladding.
7) The Green Strategy for architectural envelope for WHOI was based on the modeling performed by HVAC engineers using Building Energy Code. The shading coefficient of the glass was important and needed to be under .43 and the U-Value needed to be under .29. Roof Insulation: Average thickness of 5" of extruded polystyrene which has an R-value of 5 per inch, yielding a total R of 25. Exterior Wall Insulation (including penthouse): Thickness of 1-1/2" extruded polystyrene, outboard of studs, with a total R-Value of 7.5.
8) See Neuman's below book.
9) Darlene Ketten is the highest ranked key scientist of the Necropsy Lab. She works closely with the Federal Government of the USA in the field of Marine Research. Her lab was a complex lab par excellence. She requested epoxy flooring, ducted downdraft tables, a snorkel exhaust system, a refrigerator with ceiling mounted cranes, high pressurized tables with low pressurized tables for rehydrating specimens, and a top-class scanning facility. Darlene also requested that the Necropsy Lab should open directly onto the service yard, and that the overhead crane rail should travel out some distance into the yard to facilitate the loading of specimens as well as over all three tables within the lab. Both Incoming and Outgoing Freezer Rooms open directly onto the service yard. She noted that both rooms should be served by the overhead crane rail system serving the Necropsy Lab. Darlene requested that the Incoming Freezer Room have a secure holding area for legal evidence. It could be assumed that this is one example of custom-design laboratory for a top researcher.

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