THE CCBR BUILDING

UNIVERSITY OF TORONTO
TORONTO, ONTARIO

BEHNISCH BEHNISCH + PARTNER ARCHITECTS
ARCHITECTS ALLIANCE

Ken Lum
M. Arch Candidate
University of Waterloo

UNIVERSITY OF TORONTO CCBR BUILDING

TORONTO, ONTARIO

QUICK FACTS

Building Name	University of Toronto - Centre for Cellular and Bio-molecular Research
City	Toronto, Ontario, Canada
Year of Construction	2002-2005
Architect	Behnisch, Behnisch & Partners, architects Alliance
Consultants	Yolles Partnership (structural); HHArgus (mechanical and electrical)
Program	Genetics Laboratories
Gross Area	21,000m^2
Owner/User Group	University of Toronto
Climate	Temperate, Cold-humid
Special Building Conditions	Hybrid of controlled laboratory environments and uncontrolled winter garden and circulation environments
Special Site Conditions	Close proximity to adjacent buildings
Aesthetics	State-of-the-art high-rise glass tower with double-façade construction incorporating landscaping and natural elements into the cityscape
Structural System	Concrete structure with aluminum and glass cladding system
Mechanical System	Natural ventilation in combination with a forced air mechanical spine divided into two separate levels to reduce equipment, duct sizes, and runs

Special Construction	Double-façade, fly ash concrete, winter gardens
Daylighting	Building façade is 90% glazed with narrow floor slabs and controlled reflective surfaces
Shading	Double-skin façades and ceramic fritted glass façades are regulated by operable blinds, frequency of fritting, internal partitions and orientation
Acoustics	Concrete massing stops sound transfer, however not interior reverberation
Thermal Conductivity	Exposed concrete thermal mass - regulated by orientation and exposure
Ventilation	Natural ventilation in atria, double-façade and controlled mechanical ventilation
Adaptability	Lab design to accommodate flexibility in working space
User Controls	Manually operated double-façade vents (operable windows), atrium blinds
Automated Controls	Local lighting in uncontrolled environments, Photocells and/or astronomic time clocks used for external lighting controls
Estimated LEED rating	24 points – No Status
Budget	Unavailable
Cost of Construction	85 million stage one – 105 million total cost [1]
Annual Maintenance Cost	Not yet applicable

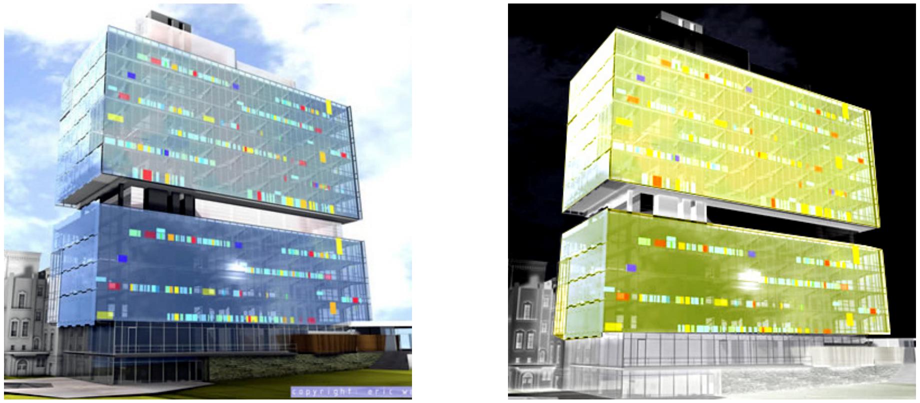
INTRODUCTION

> “The design solution proposed for CCBR provides a highly functional, flexible and technically advanced research facility in a building that creates a new University presence on College Street and also reflects the University’s status as a world leader in the field of genome research.” - *Behnisch, Behnisch and Partner, Stuttgart, Germany* [2]

The University of Toronto and its affiliated institutions established three decisive conditions that the new CCBR Building would have to fulfill when they sent out the Call for Expressions of Interests in August, 2001. First, the CCBR’s primary design criterion was to create a start-of-the-art facility capable of competing with other world leaders in the quest to link genes to disease. Not only should the building become a landmark, but the design should also attract the very best scientists and conduct the very best research. The second condition was to design a facility that would unite various research groups that are currently scattered in eleven different buildings across the St. George Campus. The CCBR must house all of the university’s molecular biologists, pharmaceutical scientists, and biomedical engineers under one roof to allow for faster and more efficient coordination and problem solving. Third, the Center must recognize and respect the surrounding historical importance of the site and its buildings on College Street. It will become the new street frontage and entrance to the university’s Academic Health Science Complex, and as such, will become iconic of the institution and the research it conducts.

Behnisch, Behnisch and Partner in collaboration with Architects Alliance responded to the proposal call with a design solution that not only addressed the conditions laid out by the University of Toronto, but also went further by introducing concepts of environmental and collaborative sustainability into the

Figure 1 (Above): A computer rendering of the south-facing entrance to the CCBR.
Figures 2 and 3 (Below): A computer model of the east facade at day and night.



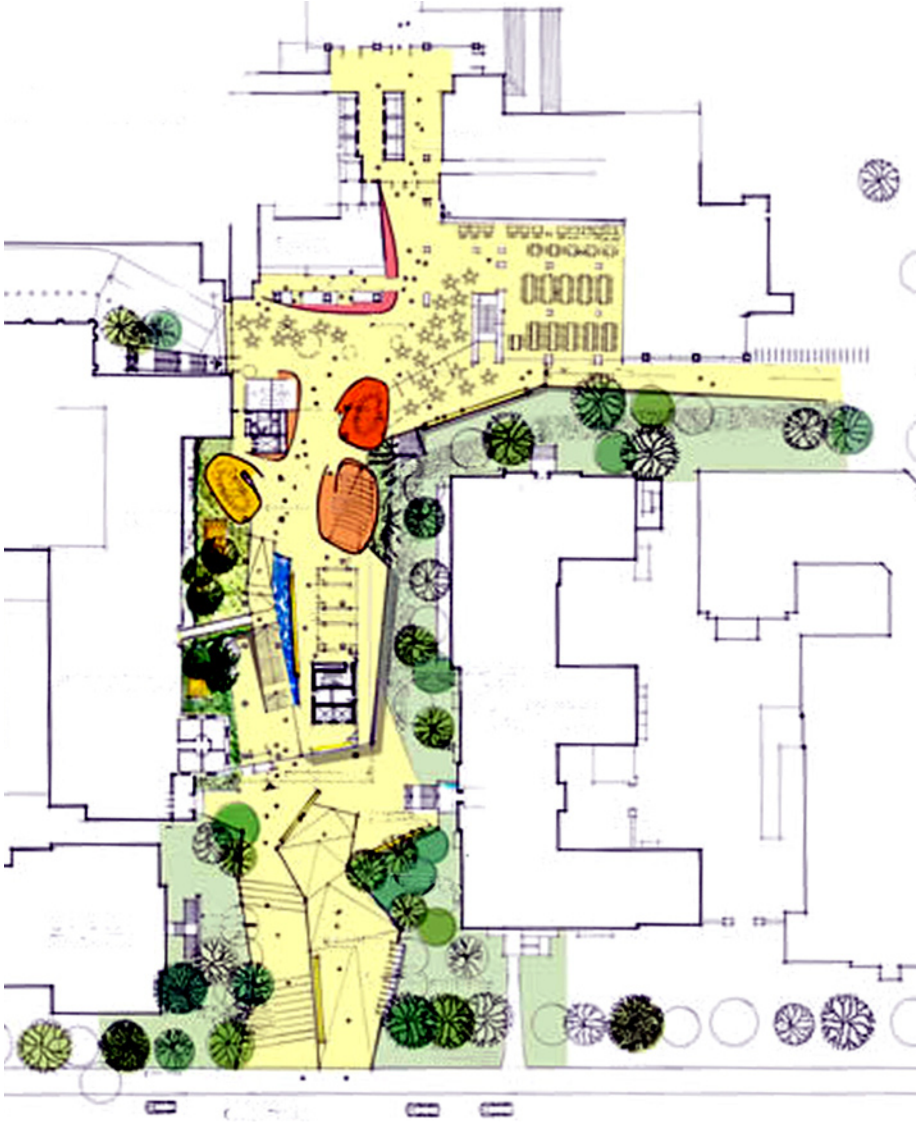


Figure 4: University of Toronto CCBR Entry level / Ground Floor Plan

project. The architects proposed a building which consisted of a state-of-the-art aluminum and glass tower composed of controlled laboratory spaces hovering over a modulated concrete ground plane consisting of public spaces. In the tower, repetitive floor-by-floor layouts with modular systems of organization responded to the functional requirements of adaptability, functionality, and expandability requested by the university. The articulation of the tower and ground floor spaces were not only determined by the need for flexibility, but also by the existing site conditions. As an infill site, the building had to weave between adjacent heritage buildings while also revitalizing existing dead zones and enhancing current programmatic elements and circulation spaces. The building also had to respond to Southern Ontario's harsh winter and hot summers while minimizing heating and cooling costs.

The design of the CCBR maintains and enhances the site and building through the use of sustainable and environmental strategies. It also holds true to the university's goal of providing its faculties and scientists with a fully adaptable, functional, and expandable facility. All of this is articulated into a building which will symbolize the dazzling potential for the post genome era for the university. The CCBR is a building that will become – both literally and symbolically – a beacon not only for the Health Sciences Faculty, but also for the University of Toronto as a world leader in genome research (Figures 1, 2 and 3).

PROGRAM

The overall design of the building consists of two programmatic elements: 1) the glass and aluminum tower which houses defined program spaces divided by floor in terms of use and controlled environmental systems, and 2) the ground level entrance and public circulation floor which contains predominantly public spaces with passively controlled environmental systems, and smaller private areas with mechanical ventilation (Figure 4).

Essentially, the CCBR is a thirteen-storey, mid-rise glass tower, situated on a rectangular site flanked by historical buildings on three sides. It has a gross floor area of 21,000m^2 consisting of the Department of Comparative Medicine on the basement level, a loading dock and mechanical services at grade, a raised ground floor level consisting of public circulation, lecture rooms, administration offices, and a cafeteria (Figure 4), and repetitive laboratory floors on levels 2 through 5 and 7 through 12 which consist of private mechanically controlled research spaces and passively ventilated circulation and winter garden areas (Figure 5). The 6th floor and penthouse serve for mechanical systems and equipment.

The building is designed to accommodate more than 400 research workers including technical staff, graduate students, and post-doctoral fellows. The facility caters to research in five interactive disciplines: Proteomics and Bioinformatics, Protein Structures, Animal Models and Mechanisms of Human Diseases, Cellular and Molecular Engineering, and Cellular and Molecular Functional Imaging. These disciplines draw upon intellectuals from four different university faculties that are currently scattered throughout the St. George campus: Medicine, Engineering and Applied Science, Arts and Science, and Pharmacology. The research conducted in the building also links to programs at affiliated teaching hospitals, thereby creating a space suitable for the greater academic and research community.

Programmatically, the building was designed to foster the interaction between these diverse faculties and research groups. Ideally, by housing their research facilities in the same building, it will encourage cross-disciplinary studies,

Figure 5: Typical Upper Floor Plan with examples of space reconfiguration along the south facade

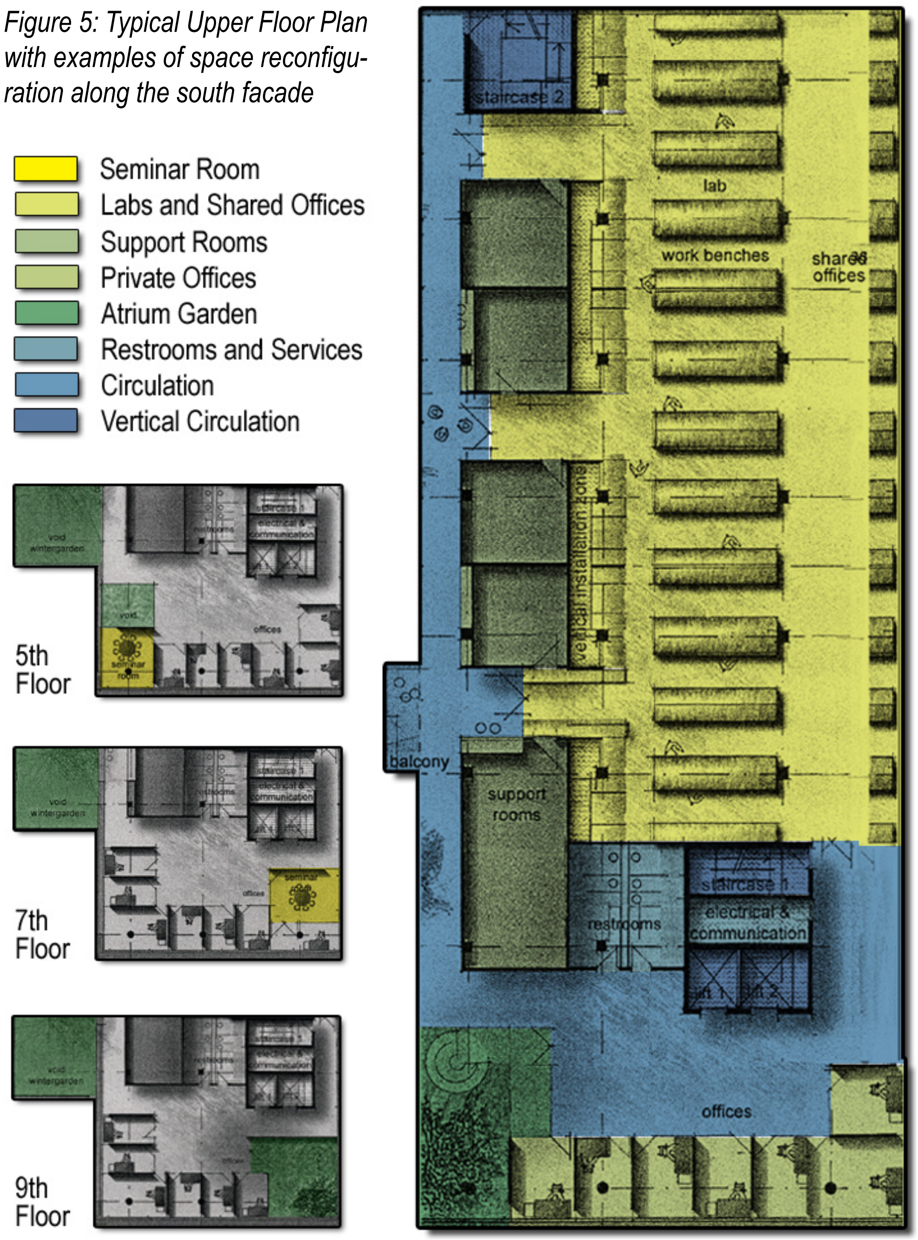


Figure 6 (Above): A sketch model view of the main entrance ramps on the south side.
Figure 7 (Below): A sketch model view of the eastern landscaped circulation strip.

approaches, and ideas in the hopes of creating a new era of biomedical research that is the result of the unconventional mixture of sciences – and scientists.

The CCBR's ground floor plan creates a link between existing site conditions, while also revitalizing and enhancing surrounding spatial programs and public interaction. These spaces consist of the main entrance stairs and ramp leading to an elevated lobby located on the south side of the building (Figure 6). By locating the "ground" floor above street level, not only is the building visually separated from its surroundings, but it is also removed from direct noise infiltration and pollution. On the western side, the building is flanked by a winter garden. On the east, it is lined with an exterior green circulation strip (Figure 7). These landscaped interventions contribute both to the aesthetics and livability of the main floor, as well as the reduction of noise and air pollutants. At the core of the ground floor is a large cafeteria and three seminar pods – or what the architects refer to as the three "pebbles." These spaces become the primary focus for the ground floor; it is an internal urban plaza which is fully functional at all times of the day and year because of its enclosed, protected nature. Natural ventilation and daylighting further enhance the ambience of the ground floor. The narrow floor plate, open design of the east and west elevations, and transparency of the upper floors allow for the natural lighting of the space. The mosaics on the lecture pods and polished concrete floors and ceilings also help refract light throughout the space.

On the upper floors, the facility is designed to house adaptable and environmentally sensitive research laboratories next to shared offices and informal meeting areas. Narrow shared offices line the east façade of the building and open onto a large, contiguous laboratory area. The main circulation space is located on the south end of the building and is interspersed with multi-storey gardens and either private offices as on the 2nd, 8th, and 11th floors, or open work areas and seminar rooms as on the other levels. Enclosed support rooms are located on the west side of each floor with a circulation corridor directly adjacent to the façade that opens onto various atria located in different positions depending on the floor. Due to the open nature of the work spaces, each morning the shared offices and laboratories are washed with diffuse natural light. The natural light levels can either be intensified or shaded with artificial lights or blinds. The concrete structure, where left exposed, acts as a heat sink by capturing direct sun light and transferring it horizontally into cooler areas of the building.

The support rooms which consist of tissue culture suites, instrument rooms, and hot or cold controlled temperature rooms are located in the central exposed concrete core of the floor plate. This core also contains all mechanical, electrical, HVAC, and service facilities like washrooms, fire stairs, janitorial, and storage spaces. This massive concrete core acts as thermal heat sink for the setting sun on the west, and an environmental divide between the mechanically serviced laboratory spaces and passively ventilated circulation areas. All major horizontal and vertical circulation spaces are located in the western zone of the building, adjacent to the core support area (Figures 8, 9 and 10).

On levels with private offices are also gardens with lounges and coffee shops. Located on the south side of the building, these spaces are flooded with intense south light. The south side of CCBR also looks onto the busy College Street below. Thus, the architects used a double-façade for the south side in order to reduce noise infiltration while still allowing for natural ventilation and shading. The double façade also helps reduce heat loss by acting as a wind screen; the outer façade thermally shields the inner building envelope by reducing its exposure to the wind tunnel effects generated by the other buildings on

Figures 8 and 9 (Above): Computer model renderings of the western facade. Figure 10 (Below): A sketch model view of the interior western atrium circulation corridor.

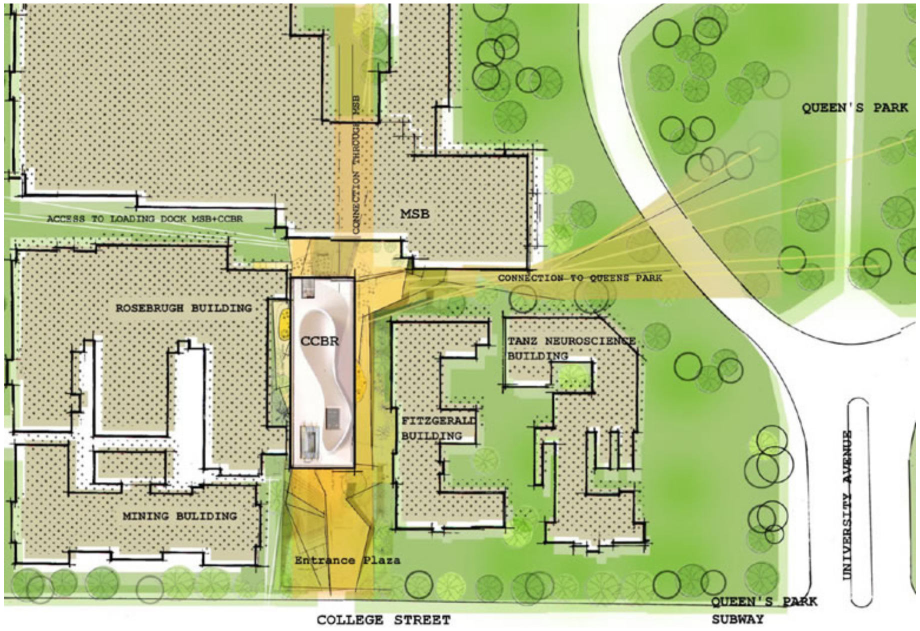


Figure 11 (Above): Architect's sketch of CCBR site plan. Figure 12 (Below): A collage elevation of the southern exposure indicating the heights of the surrounding buildings.

College Street. Although many of the winter gardens are located on the south façade, where they occur the building envelope is treated with only one façade composed of double-paned curtain wall glazing. This is due to the nature of the gardens and their need for direct sun light in order to grow.

SITE

The CCBR is situated on the north side of College Street between University Avenue on the east and King's College Road on the west (Figure 11). The facility is surrounded by historical buildings; to the north lies the Medical Science Building which stands approximately seven stories in height, to the west are the Rosebrugh and Mining Buildings standing five stories tall, and on the east is the Fitzgerald Building, also five stories in height (Figure 12).

These buildings have a very intimate history with both the University and the City of Toronto. Consequently, none of them could be removed to make way for a new building; their presence not only had to be preserved, but also respected. The proximity of the existing buildings posed a great challenge to the design team. The cramped site was already cast in shadows in the mornings and evenings, making views and daylighting a challenge for a new building while simultaneously preserving those of the old. In response to these challenges, the concept of the winter garden was introduced on the western side of the new building and a public pedestrian corridor on the east. These two elements enable light to penetrate deep into the building while maintaining the views and sightlines for the existing buildings. The ground level is also almost entirely glazed. Where glazing is not possible, the materials used bounce indirect light back into the building, creating a diffuse glow within the spaces.

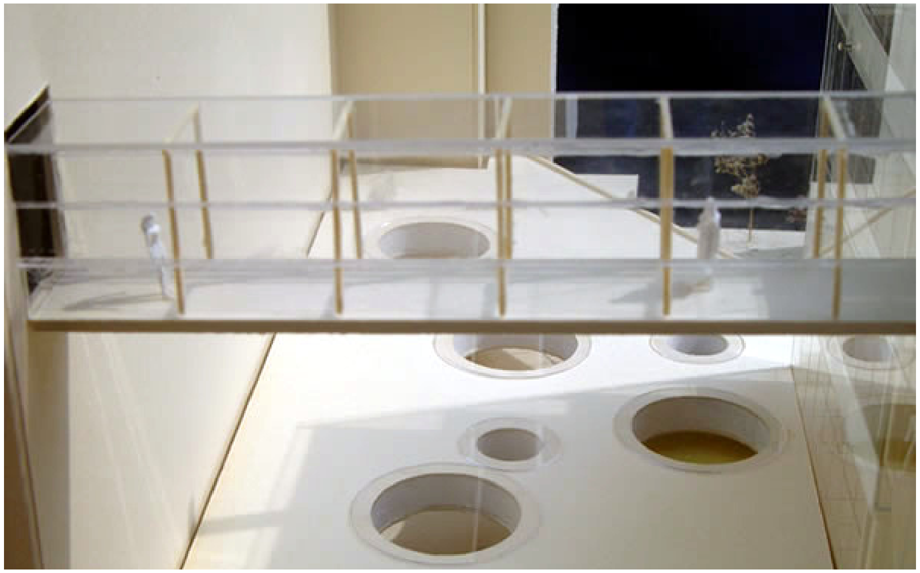
Other design criteria for the site included respecting municipal setbacks, no-build zones, and existing loading and service areas for the adjacent buildings. Additionally, the new development also had to repair, reconnect, and revitalize the surrounding buildings and landscaping. Currently, the narrow site in between the existing buildings functions as a courtyard space. The design for the new building was meant to enhance this function, and does so by creating a visually open, yet environmentally protected, urban courtyard condition on the main level with its large cafeteria and seminar pods enclosed in glass. In doing so, the CCBR is able to act as both a space of circulation and exchange between the various buildings it connects. Although the space is enclosed, it very much feels like an indoor market. This quality is aided by large, coloured skylights that allow for natural daylight to liven the space (Figures 13 and 14).

The CCBR takes full advantage of its proximity to neighbouring buildings. The north section of the loading dock is physically connected to the Medical Science Building, allowing for shared loading and service space. Two sky bridges on the north façade of the CCBR connect programmatic and circulation spaces to the south façade of the Medical Science Building (Figures 15 and 16). On the west, the CCBR forms an atrium space with the east façade of the Rosebrugh Building. Not only does the atrium serve as ground floor amenity, but it also aids in the ventilation of the new building.

Situated close to the Queen's Park Subway station, the Ontario Legislature, and the lively retail and restaurant district on College Street, the site is ideal for a landmark facility. The CCBR rises almost a full six stories above the adjacent buildings, and with its transparent façade, stands in stark contrast to its surroundings. Despite its obvious differences, the CCBR uses its prominence to bring attention to the other buildings around it. As such, it emphasizes the importance of its location, the facility, and the University of Toronto.

Figures 13 and 14: Computer renderings of the interior of the main level cafeteria.

Figure 15 (Above): Architect's collage of the western facade, demonstrating the CCBR's connection to the Medical Science Building. Figure 16 (Below): A sky bridge.



SUSTAINABLE DESIGN

In terms of environmental sustainability, the CCBR uses materials with questionable environmental impact in order to create a building that will symbolize technological progress. In essence, the building consists of a concrete service core with one way reinforced concrete slab, beams, and columns, while its cladding is a curtain wall system composed of low-emissivity glass and aluminum frames. All of the facility's principal building materials have a very high embodied energy. This means that it requires a significant amount of energy to excavate, process, and deliver the materials. Compared to easily harvested and processed materials such as lumber that has an embodied energy of 2.5MJ/kg, glass has an embodied energy of 15.9MJ/kg, structural steel has 32MJ/kg, and extruded aluminum has on average 227MJ/kg. Although concrete has a relatively low embodied energy of 1.3MJ/kg, the sealants used to give it its reflective coating have on average an embodied energy of 93.3MJ/kg.[3]

Arguably, in order to deliver the serviceable, durable, and iconic building that the university requested, these highly processed materials are the only ones suited to fulfill these requirements. Steel beams allow for large, contiguous open spans, concrete allows for multi-storey structures, and the glass and aluminum façade is less prone to long-term damage from the extreme Southern Ontario climate and the effects of pollution. Their strength and durability are also key factors in a laboratory environment. In addition, although these materials may not be sustainable in their virgin forms, they are highly reusable and recyclable. Most high embodied energy materials retain 95% of their integrity when recycled, whereas low embodied energy products are usually re-processed to form a second-generation product. A steel beam can still be a steel beam whereas a wood beam might become millwork.

The architects have also tried to incorporate the use of fly ash concrete into the building.[4] Fly ash is a fine, glass-like powder recovered from gases created by coal-fired electric power generation. Many power plants and factories produce millions of tons of fly ash annually. These by-products are usually dumped in landfills. However, fly ash can be used to replace Portland cement in concrete mixtures. When used in concrete, it can improve strength, reduce segregation, and facilitate pumping. Fly ash can also be used as an ingredient in brick, concrete block, paving materials, and structural fills.[5] With a cost competitive to concrete made with Portland cement, fly ash concrete has an advantage for both workability and durability. Because it uses less water, it is less likely to crack. As an industrial by-product fly ash has an even lower embodied energy as well. However, because the product is still relatively new to the construction industry, it will take time before it is significantly competitive to standard Portland cement concrete.

ENVIRONMENTAL CONTROLS

The environmental controls in the CCBR consist of features that enhance building shading, daylighting, natural ventilation, heating, and cooling.[6] Located on a restricted site in a climate prone to extremes, the design of the CCBR's indoor environment systems aimed to take advantage of natural humidity levels, maximize fresh air, and exploit the building's thermal mass in the winter, while encouraging natural ventilation and cooling in the summer. The designers also wished to maximize natural daylighting in the building throughout the year.

Shading and daylighting in the CCBR are achieved through a complex interplay between sunscreens, aluminum louvers, and reflective materials. Lighting systems in the building mimic its environmental systems. Direct sunlight is

Figure 17 (Above Left): North-South Section of Winter Garden. Figure 18 (Above Right): East-west section of atrium. Figure 19 (Below): North-south section of atrium.

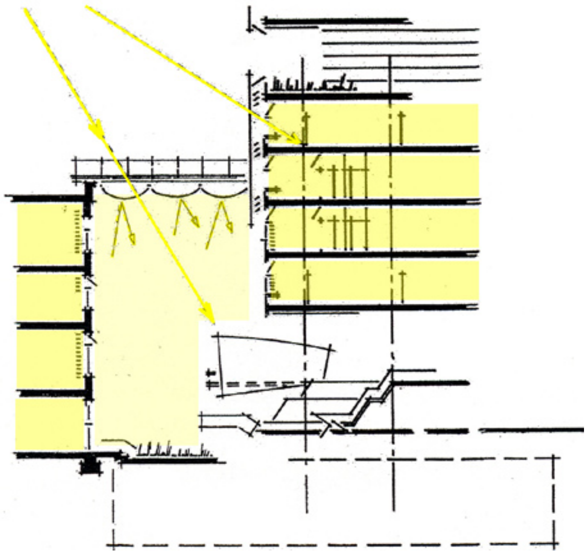
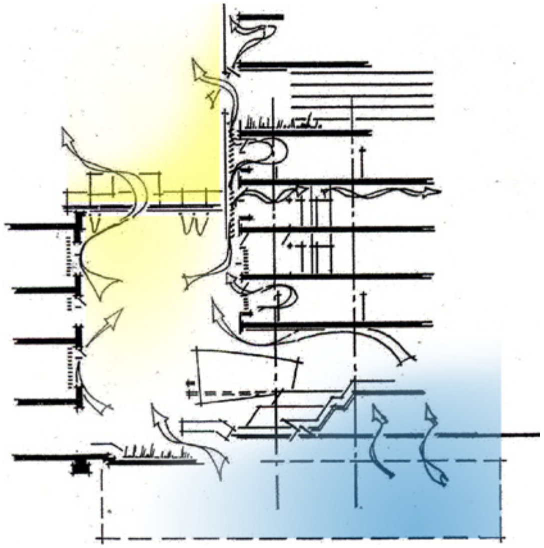


Figure 20 (Above): Winter Heating. Figure 21 (Below): Summer Night Time Cooling.



used to light circulation corridors and other public spaces which are naturally ventilated, while indirect light is used in areas with mechanically controlled environmental systems such as in the laboratories.

Daylight penetrates the building's narrow floor plate and is regulated though the use of aluminum louvers and partitions in the shared offices on the east, and a fritted glass façade along the circulation corridor on the west. Light-coloured pigments added to the concrete mixture of all exposed concrete elements redirect sunlight throughout the building. This strategy is very helpful in the late mornings and early evenings when the sun is at a steeper angle.

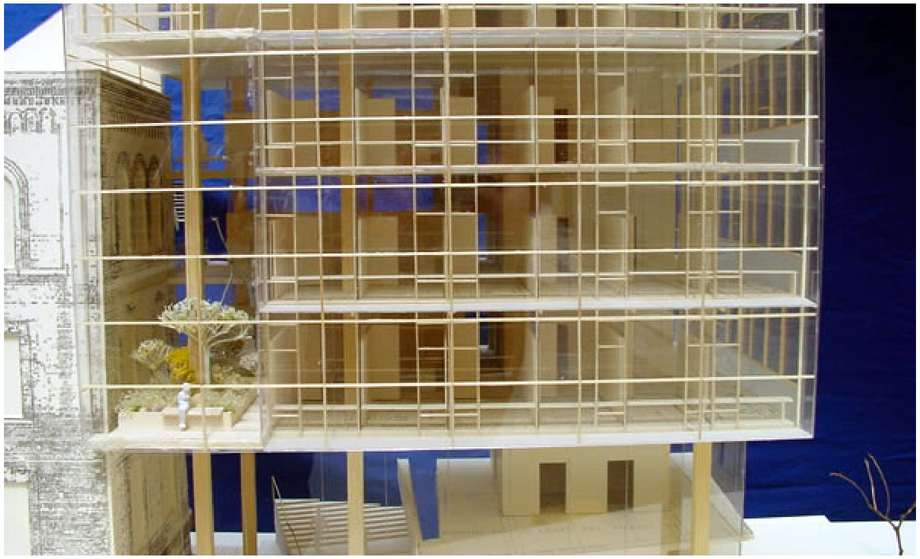
Sun shades located on the interior side of the winter garden skylights are the only shading devices used by the occupants of the lower west side of the CCBR and the east side of the Rosebrugh Building. The shades protect the interior spaces from the intense glare reflecting off the western façade during the late afternoon and summer evenings. The sun screens can also be drawn to allow natural light penetration to sustain garden vegetation, as well as allow for solar heat gain in the winter months (Figures 20 and 21). In addition to the natural daylighting strategies of the building, pendulum lights in the circulation corridors and public spaces supplement light levels on overcast days, while overhead task lighting in the laboratories and offices perform the same function.

Thermal comfort in the indoor environment is crucial in the Southern Ontario climate. In order to achieve the proper humidity, temperature, and air exchange levels, ventilation in the CCBR is controlled through both passive and mechanically driven systems. A permanent monitoring system that measures humidity and air exchange rates helps moderate indoor air quality while minimizing the use of active mechanical systems. Ventilation is controlled through a typical VAV fancoil unit system and operable windows integrated into the double-façade. Humidity is also regulated as part of the mechanical systems, but also through the vegetation in the atrium gardens.

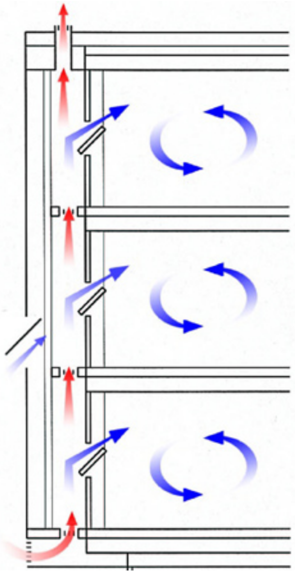
In the winter, the building uses both the garden atria and the double-façade to help moderate the interior environment (Figures 22 and 23). Because of staggered openings between the different layers, fresh air entering the building through the double-façade is preheated in the cavity between the layers (Figure 24). Air that enters into the atria before circulating throughout the rest of the building is also humidified by the plants. In the summer, the atria work to create a stack effect within the building, drawing air across the floor plate and out through vents left partially open at the top of the space. The natural ventilation helps in controlling the thermal comfort of building occupants, but also in cooling the concrete structure. The double-façade also allows for night-time cooling of the building, thereby lessening the building's summer HVAC cooling loads.

The CCBR's HVAC system is separated into two halves. An air handling unit on the 6th floor services the first five floors, and a second unit in the penthouse services the rest of the building. Although the installation of two separate air handling systems might seem like a more expensive solution, by dividing the building in half both units were made smaller and the duct work minimal. Because of the reduction in travel distance for treated air, the two-unit system also saves on energy necessary to drive the air throughout the building (Figure 14).

Although the majority of building systems are automated, occupants have some localized control over the ventilation, heating, and cooling of their spaces.[7] These include operable windows, sun shades, and thermostats to control comfort levels in private offices, meeting rooms, seminar pods, and administrative areas. In laboratory areas, however, the interior environment will be controlled



Figures 22 and 23 (Above and Below Left): Sketch model views of the south-facing double-facade. Figure 24 (Below Right): Schematic of the double-facade cavity.



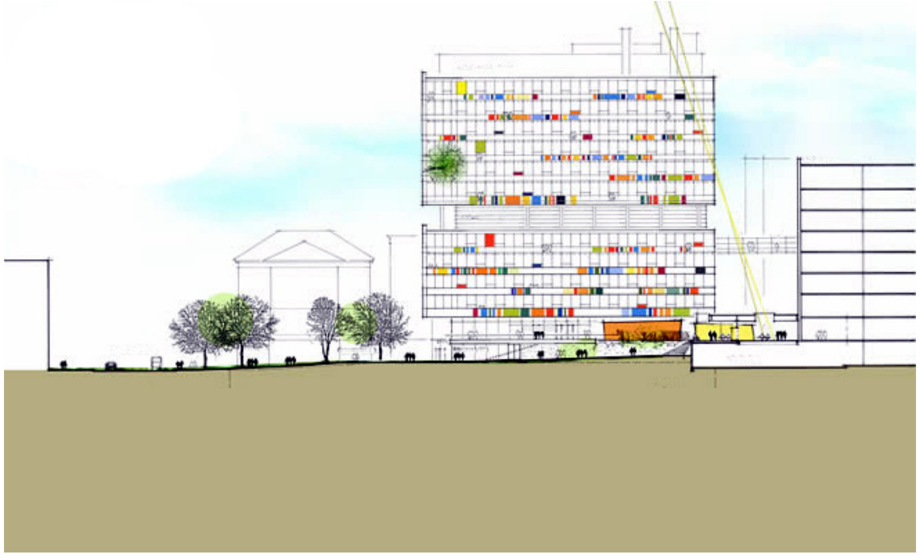
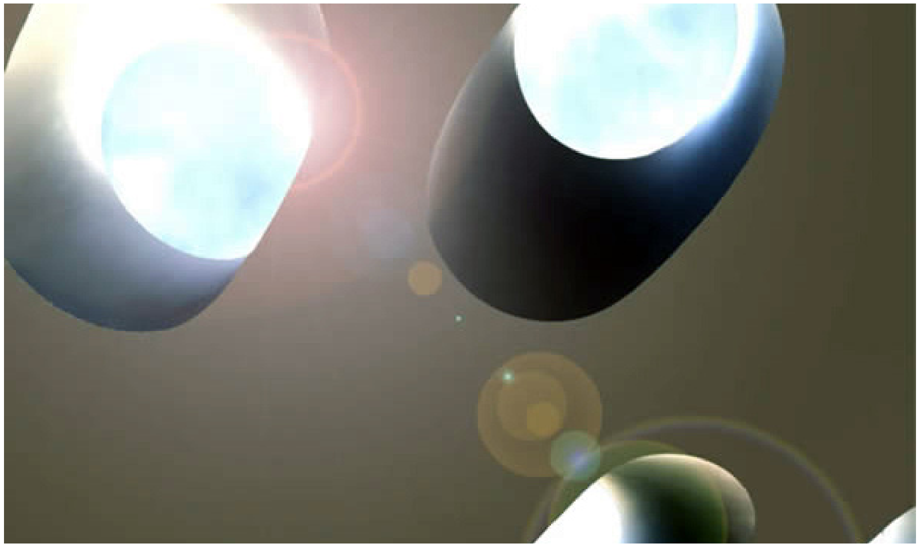


Figure 25 (Above): A section of the landscaped circulation corridor to the east shows the daylight penetration into the building. Figure 26 (Below): Skylights in the lobby.



primarily by automated systems in order to conform to university standards. In doing so, it helps eliminate possible failures for temperature sensitive research if building occupants are careless with their personal controls. Controls in each of the labs are monitored per floor, and feed back to a centralized system that oversees the entire building. Laboratory spaces are programmed to maintain an air exchange cycle of 12AC/hr with a temperature of 22^{o}C in the winter and 24^{o}C in the summer.

Along with the indoor environment, the CCBR also provides for control over the use of space. The laboratory areas are highly adaptable; services and utilities such as lights, electrical, and data cables are located within exposed ceiling raceways in order to allow for maximum flexibility. Mechanical risers pierce the support areas along the concrete core to service individual bays and work benches. This allows for the partitioning of the laboratory with dividers outfitted with clerestory windows. The partitions allow for privacy, but also natural daylight to enter all spaces. This form of adaptability allows the laboratories to accommodate a larger range of research projects while also providing the researchers with the opportunity to arrange their spaces in accordance with their needs.

CONSTRUCTION

The structure of the building consists of a slab on grade for the basement and one-way reinforced concrete slabs on concrete beams and columns for the upper floors.[8] Special framing is required, however, for the ground level entrance lobby to accommodate stairs, ramps, the winter garden, and the cafeteria connection to the Medical Sciences Building. The structure's rigidity is secured by the concrete core of the floor plate where support rooms, washrooms, and vertical circulation elements are located. This area also serves for mechanical and electrical risers, supplying the entire building through a main service shaft.

The laboratory section of the CCBR is segmented into bays running east to west. As previously discussed, this helps the spaces adapt to the needs of individual research teams. Each bay is provided with a mechanical riser in the floor slab that connects back to the centralized electrical and mechanical shaft located in the core area of each floor.

COSTING

The estimated cost for the CCBR is $105 Million Canadian. Funding for the project was gained from several sources. These included various government agencies and research groups such as the Canada Foundation for Innovation, the Ontario Innovation Trust, Ontario Superbuild Fund, the University Infrastructure Investment Fund, the Investment Income Group, L'Anson Fund, the Terrence Donally Fund, the University of Toronto McLaughlin Fund, the University of Toronto Faculty of Medicine, the Leslie Dan Faculty of Pharmacy, and the Faculty of Applied Science and Engineering.[9]

The great expense for the building is due to many factors. One such factor is the use of a little known technology in Canada – namely the double-façade. The CCBR is the first building in Ontario to use this building envelope system, although it has been used for over twenty years in Europe and the United States.[10] In order to adapt this new technology to the Canadian climate, extensive testing needed to be conducted and a manufacturer willing to take on the project needed to be found.

Figure 27: An overall view of the CCBR Building from the official architectural model.

The initial construction costs are high due to the use of materials with high embodied energy – or materials requiring more time, effort, and energy to extract, process, and deliver. Although the capital costs for the building are high, it is expected that the operational and maintenance costs will be substantially lower than those for a comparable sized building of typical construction. This will be achieved by reductions in energy consumption due to the sustainable strategies employed for lighting, heating, cooling, and ventilation.

Due to the flexibility of the spaces in the building, the CCBR also has a longer foreseeable life span than a typical institutional building. This was aided through the creation of a "shelling" versus "finished" plan for the different spaces of the building.[11] "Shelled" spaces are those without defined interior finishes – or those left open to the "shell" of the building. Forty percent of the CCBR's laboratories are "shelled" while the others are fully fitted and functional. This strategy was

LEED GREEN BUILDING RATING SYSTEM 2.1

Project Checklist	
Sustainable Sites	**6**/14 Possible Points
Water Efficiency	**0**/5 Possible Points
Energy & Atmosphere	**6**/17 Possible Points
Materials & Resources	**2**/13 Possible Points
Indoor Environment Quality	**8**/15 Possible Points
Innovation & Design Process	**2**/5 Possible Points
Project Totals	**24**/69 Possible Points
CCBR Result	**No Status**

used to reduce overall building expenditure by leaving bare spaces that do not currently need equipment. Even in the “finished” spaces, however, the CCBR reduces costs in several ways. First, because the partition walls are movable, they reduce renovation expenses and construction waste. Second, by opting for an exposed concrete structure and ducting, initial capital costs for typical interior finishes such as drywall and suspended ceiling panels were able to be redirected towards other needs. Overall, the materials chosen for both permanent and movable elements are highly recyclable, thereby reducing future environmental costs as well.

The attention given to the indoor environment quality will also have social cost savings benefits. Occupants who have access to natural daylight, ventilation, and vegetation within their working environment often take fewer sick days and are more productive. Although these costs are difficult to predict or calculate, they are serious factors that building owners to take into consideration.

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN

Although construction of the CCBR is not complete, an estimated LEED rating for the design has been calculated at 24 out of 69 possible points. For a building with as many sustainable strategies as it boasts, when evaluated according to the industry standard (LEED), the building performs poorly. The majority of the building’s points are acquired in the Indoor Environment Quality section. In these categories the building scores well for its effective ventilation strategies, low-E materials, monitoring system, and extensive natural daylighting. The design documents make it difficult to assess the building because they make no mention of other materials or strategies for reducing water consumption or energy use. With the extensive glazing used on the façades, the integration of photovoltaic panels would have been easy, and cost no more than the double-façade system. Despite the poor showing in other sections of the rating system, two points were earned in the Innovation and Design categories for the winter gardens and the use of significant night-time cooling by natural means.

CONCLUSION

The CCBR is an example of hybrid architecture that mixes passive and active mechanical strategies through the use of modern technology. The many passive and active systems for lighting, ventilating, heating, and cooling the building are well integrated with one another, creating a progressive and adaptable working environment. More importantly, however, is the building’s ability to create a sense of community by connecting disparate faculties and the buildings around it. In doing so, the CCBR is a building that will stand the test of time and become an icon for the University of Toronto not only for its academic research, but also for its community life.

BIBLIOGRAPHY

Publications

1. Architects Alliance, Behnisch, Behnisch and Partner. “Center for Cellular and Bio-molecular Research - Schematic Design Brief.” March, 2002.

Internet

1. Architects Alliance Website. Source: *www.architectsalliance.com*
2. Behnisch, Behnisch and Partner – Main Web Site. Source: *http://www.behnisch.com/current_projects/127/*
3. Canadian Architect: Measure of Embodied Energy. On-line Article: *http://www.cdnarchitect.com/asf/perspectives_sustainibility/measures_of_sustainablity/measures_of_sustainablity_embodied.htm*
4. Center for Cellular and Bio-molecular Research Home Page. Source: *http://ccbr.med.utoronto.ca/*
5. Cutting-edge research facility breaks ground on campus - Innovative, multidisciplinary facility first in Canada. Source: *http://www.newsandevents.utoronto.ca/bin3/020925b.asp*
6. Toolbase Services – Technology Inventory. Source: *http://www.toolbase.org/tertiaryT.asp?TrackID=&CategoryID=72&DocumentID=2072*
7. University of Toronto – Capital Projects. Source: *http://www.greatspaces.utoronto.ca/projects/ccbr.htm*

Personal Interviews

1. Kevin Stelzer, Architects Alliance, CCBR Architectural Team.

ACKNOWLEDGEMENTS

Thank you to Kevin Stelzer of the architects Alliance for the meetings, information, and hospitality which were essential to the completion of this document.

ENDNOTES

1. University of Toronto – Capital Projects.
2. Centre for Cellular and Bio-molecular Research – Schematic Design Brief, March 2002: page 1.
3. Canadian Architect: Measure of Embodied Energy. On-line Article.
4. Kevin Stelzer, architects Alliance, personal interview.
5. Toolbase Services Website – Path Technology Inventory.
6. Centre for Cellular and Bio-molecular Research – Schematic Design Brief, March 2002, Climate Control Studies page, and page 15, discussions with Kevin Stelzer.
7. Centre for Cellular and Bio-molecular Research – Schematic Design Brief, March 2002, Climate Control Studies page, and page 16.
8. Centre for Cellular and Bio-molecular Research – Schematic Design Brief, March 2002: page 7.
9. University of Toronto – Capital Projects.
10. The first building in Canada to use a double-façade is the Telus/Farrell Building in Vancouver. Other such buildings in North America date back to the early 1980s such as the Occidental Chemical Centre in Niagara Falls, New York.
11. Centre for Cellular and Bio-molecular Research – Schematic Design Brief, March 2002: page 2.

IMAGE CREDIT

1. Architects Alliance Website and material given to author: Figures 1, 6, 7, 8, 9, 10, 11, 13, 14, 16, 17, 18, 22, 23 and 26.
2. Behnisch, Behnisch and Partner Website: Figures 2, 3, 4, 15 and 25
3. CCBR - Schematic Design Brief, March 2002. Figures 5, 20 and 21.
4. CCBR - Research Website. Figures 12 and 27.
5. Kate Harrison: Figure 24.