McGill

McGill - Otto Maass 121, photo from Vezina Architects

Design of Research Space

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Introduction

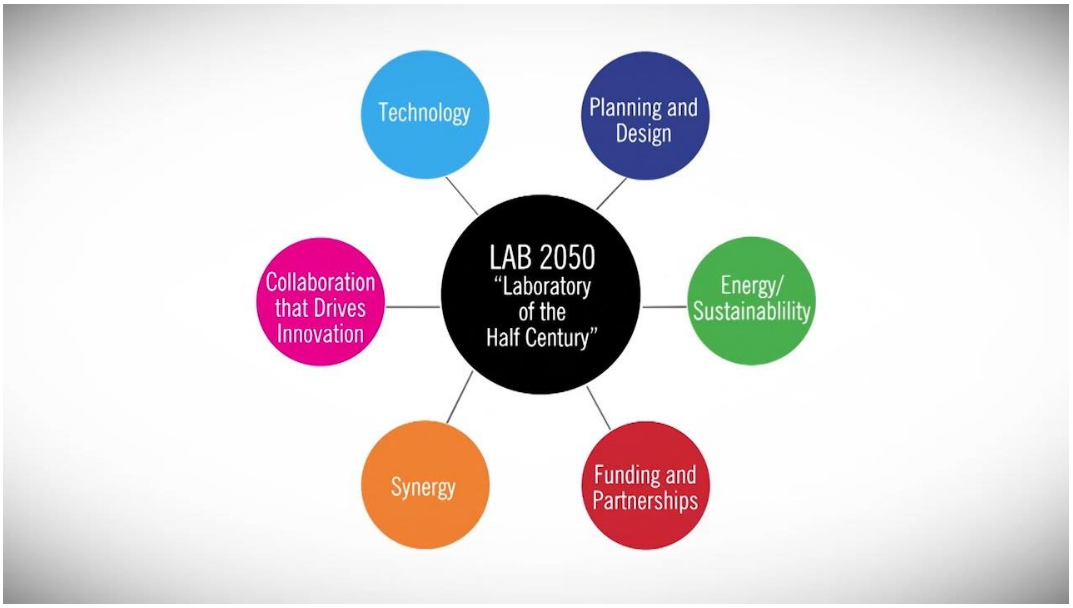
This document aims to provide guidance for the Design Process for future research spaces at McGill. It is written for lab Principal Investigators (PIs), users, Project Managers, Professionals and Operation & Maintenance people, who will execute a lab project from the Initial phase to the end of the project and who will maintain the spaces after its construction.

Photo from Flad Architects, *Beyond LEED, Sustainable Laboratory Design*

This guide is directly related to one of the five Principal Susanne Fortier's priorities, "Unleashing McGill's Full Research Potential", and which defines as following:

"Today's research landscape is global, interdisciplinary, focused on excellence, and rooted in collaboration with partners of all types (including industry, non-profits, governments, and other universities). This priority area focuses on laying the foundation for McGill to excel in this increasingly competitive and challenging environment."

Recognizing the importance of this statement and the constant evolution in every sphere of Lab Design, whether it is regarding lab organization, technology, sustainability or health & safety, Facilities Management and Ancillary Services (FMAS) wishes, by the adoption of this document, to face the future and adopt the best practices in designing future Research Spaces.



From presentation *Lab2050 : The Future and Science and Laboratory Spaces,* by SmithGroupJJR

Consultation Process

The consultations leading to the Vision, the guiding principles, the design process and the standards to design research spaces of the future took place from June 28, 2017 to December 14, 2017. In total, more than 50 professionals from various sectors participated in the seven meetings that were organized. The consultation process was spearheaded by McGill Design services, in close collaboration with the Office of Sustainability and Environment, Health and Safety.

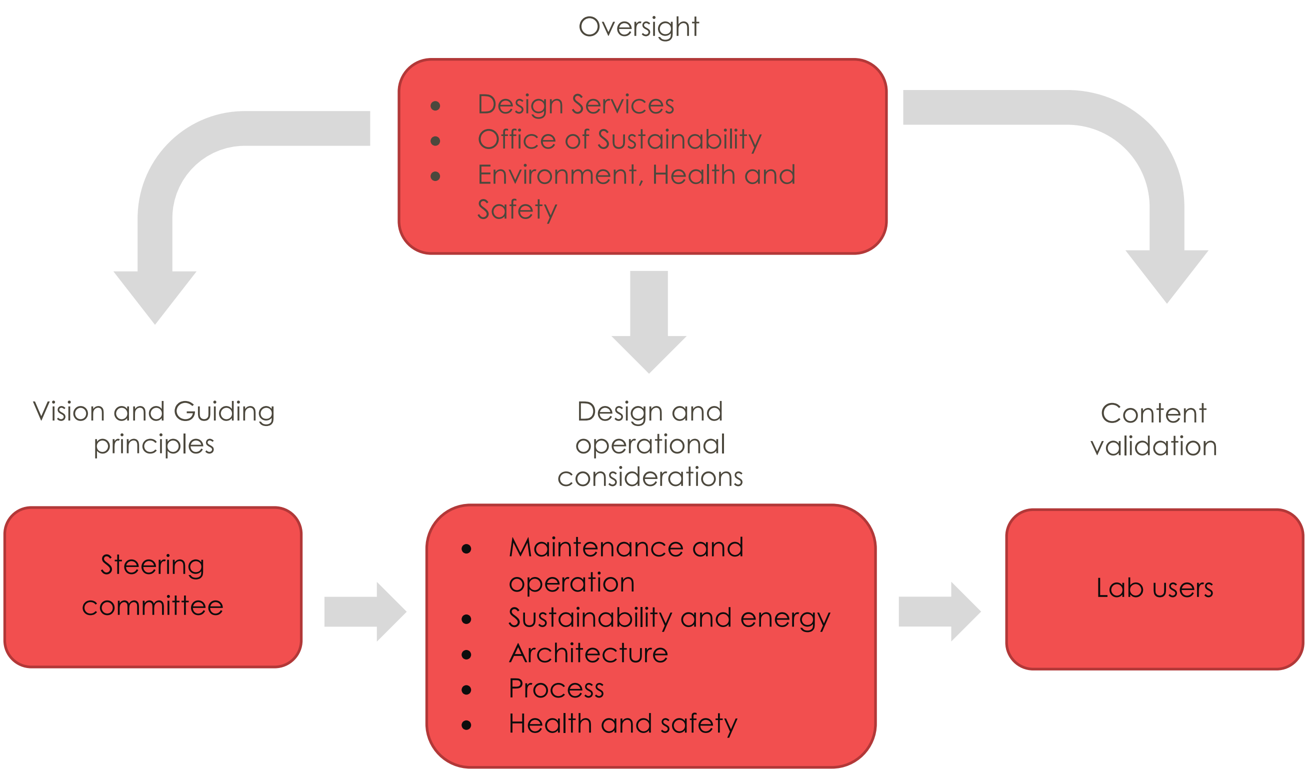
The consultation sessions were meant to address the main design and operational considerations of the labs of the future, and gather the opinions and feedbacks from professionals who are either planning, using or operating labs at McGill.

The seven meetings tackled the following topics:

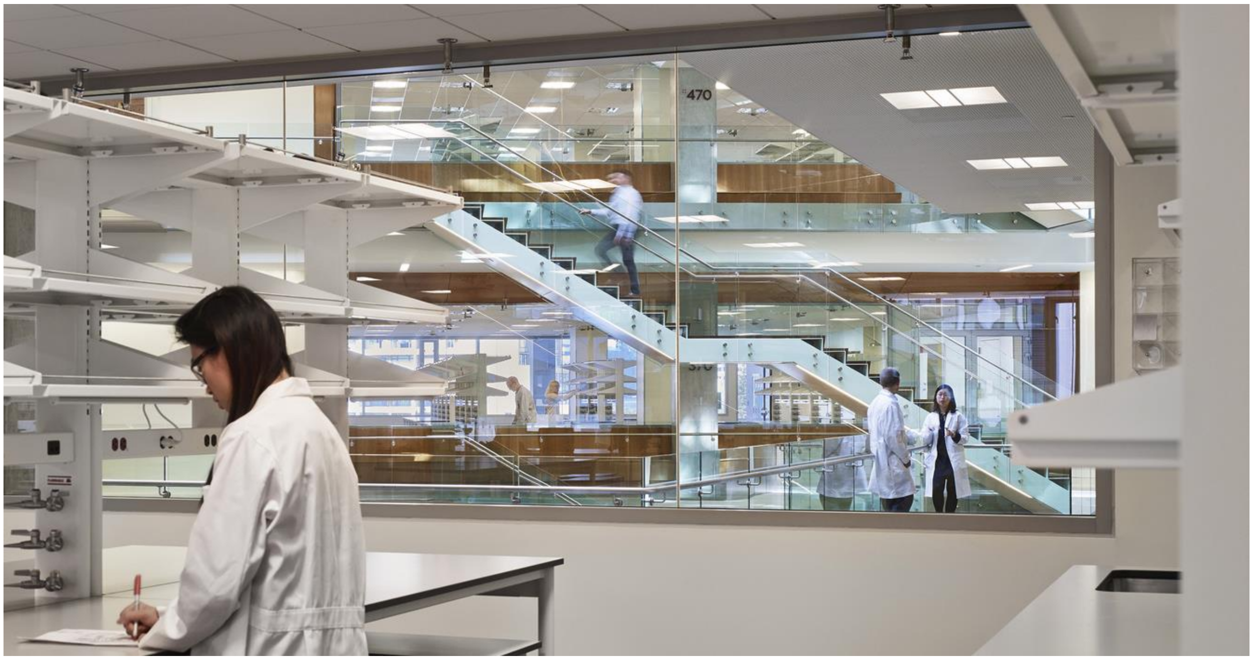
- Steering committee – Vision and Guiding principles (June 28, 2017)
- Maintenance and Operation (October 24, 2017)
- Sustainability and Energy (November 9, 2017)
- Architecture (November 15, 2017)
- Process (November 20, 2017)
- Health and Safety (December 12, 2017)
- Lab Users (December 14, 2017)

The focus groups of these topics contributed to the overall approach, and had a precious input on the principles, the process and the standards to design research spaces at McGill.

Overview of the consultation process



Vision



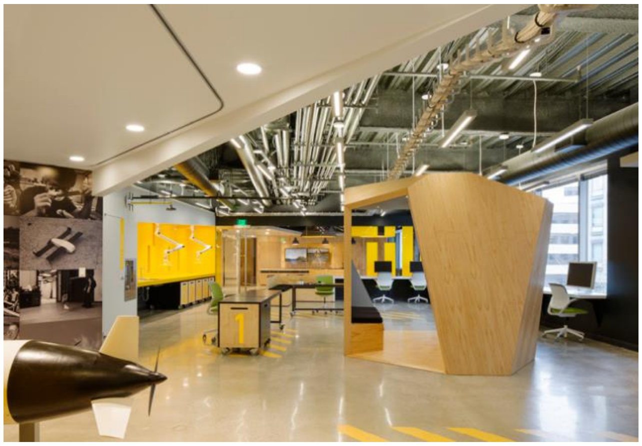
Allen Institute, Perkins+Will, photo from archdaily.com

"The University research spaces will support collaboration, innovation and foster creativity with cutting-edge design that is adaptable, safe and sustainable, thus strengthening McGill's role as a world leading institution"

Center for Science and Technology, Chapman University. photo from AC Martin

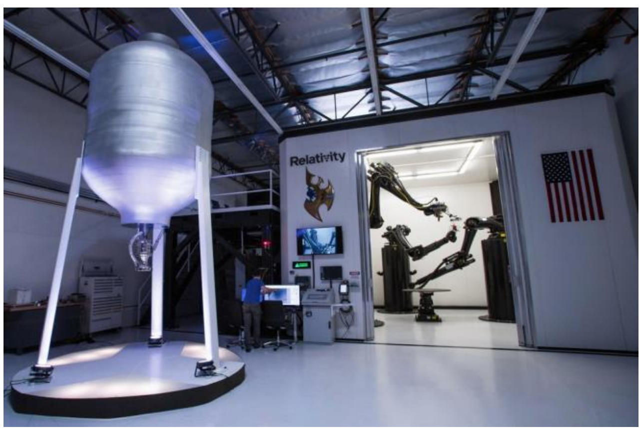
Guiding Principles

1. Creativity, Innovation & Technology

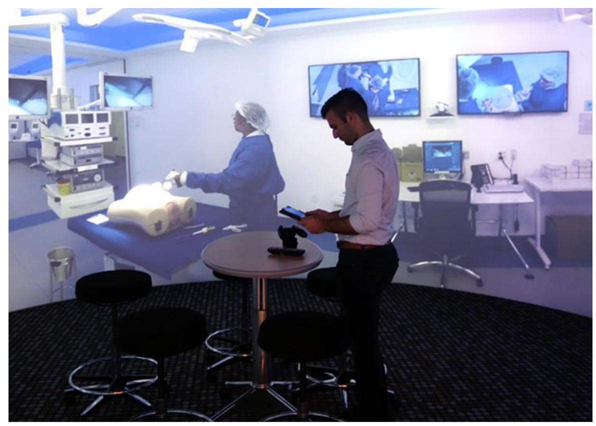


MIT Beaver Works, photo from retaildesignblog.net

The primary goal of the laboratory remains the same: Experimentation. However, the path to discovery, and the way scientists work and interact, are being revolutionized by **emergent technologies** including smaller, more powerful instruments, robotics/automation, computer analysis and advanced communication systems. In a recent Laboratory Equipment reader survey, 48 percent of respondents said instrumentation improvements will expand their research capabilities in the next 10 years. The most significant changes in technologies expected are likely to be **automation systems**, **data acquisition systems**, **detectors**, and **sensors**.

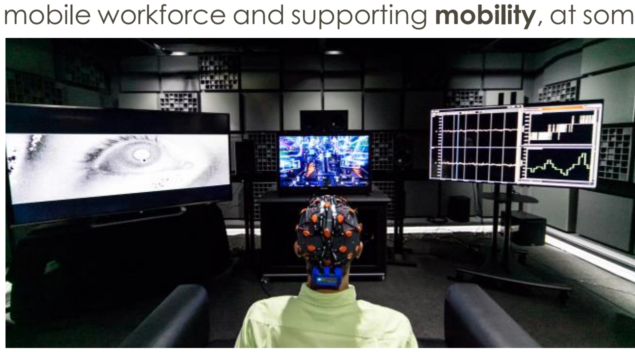


Stargate 3D printer, photo from Relativity Space



360-degree video, photo from Medtronic Applied Innovation Lab

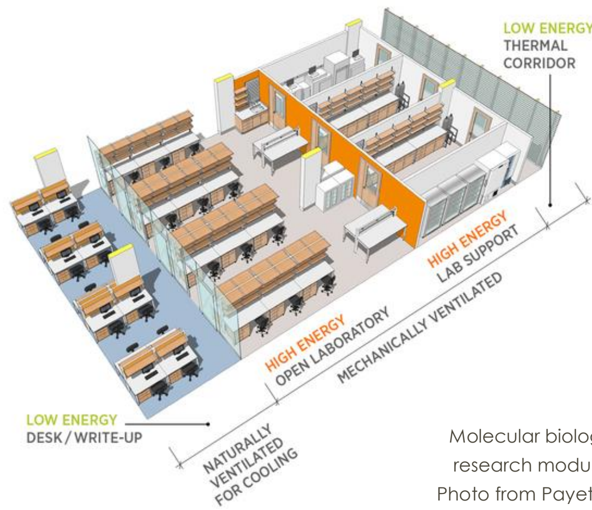
Emergent technologies will reduce the physical footprint of laboratories and free up time for scientists to engage in more collaborative and idea-based endeavours. The future laboratory will need to reflect this change, with a choice of **working environments** replacing the space that was previously dedicated to traditional laboratories. The future laboratory will also provide **flexibility** in the **physical** and **operational aspects** of the laboratory to allow for **emergent technologies**. Additionally, it will provide collaborative **hi-tech tools** such as video and virtual conferences to accommodate a more mobile workforce and supporting **mobility**, at some level, for all employees.



Sensory Immersion Lab at Dolby Laboratories, photo from Business Wire

2. Planning & Design

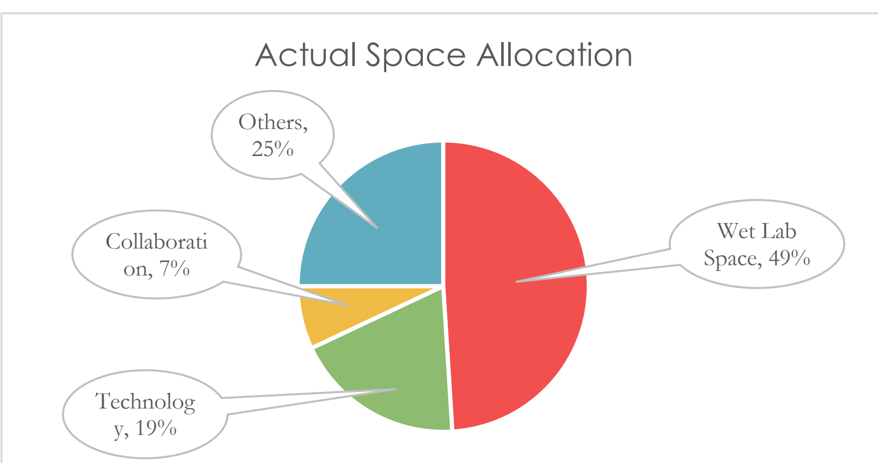
The ultimate goal of laboratory design is to foster innovation, support science and keep scientists safe. Laboratories are traditionally designed as units, compartmentalized, self-contained and not collectively. Scientists are separated from each other in formally arranged and rigid layouts, reflecting linear processes and static functionality.



Molecular biology research module, Photo from Payette

The nature of laboratory work requires **distinct** workspaces, and a defined, but permeable barrier between them. Scientists working in these spaces need an area that allows for both **focused concentration** and **easy engagement** with colleagues. Design should use acoustic technologies and visual cues to bring these different spaces as close together as possible. **Adjacencies** and **visual connections** should be created to allow for spontaneous interaction and collaboration between disciplines. Design should focus on workplaces that promote innovation, the transfer of knowledge, collaboration and effectiveness while still providing a pleasant environment which is desirable to occupy. Another consideration to take into account is the integration of **flexible laboratories** that would allow **rapid reconfiguration** for changing scientific needs.

Photo from CO architects

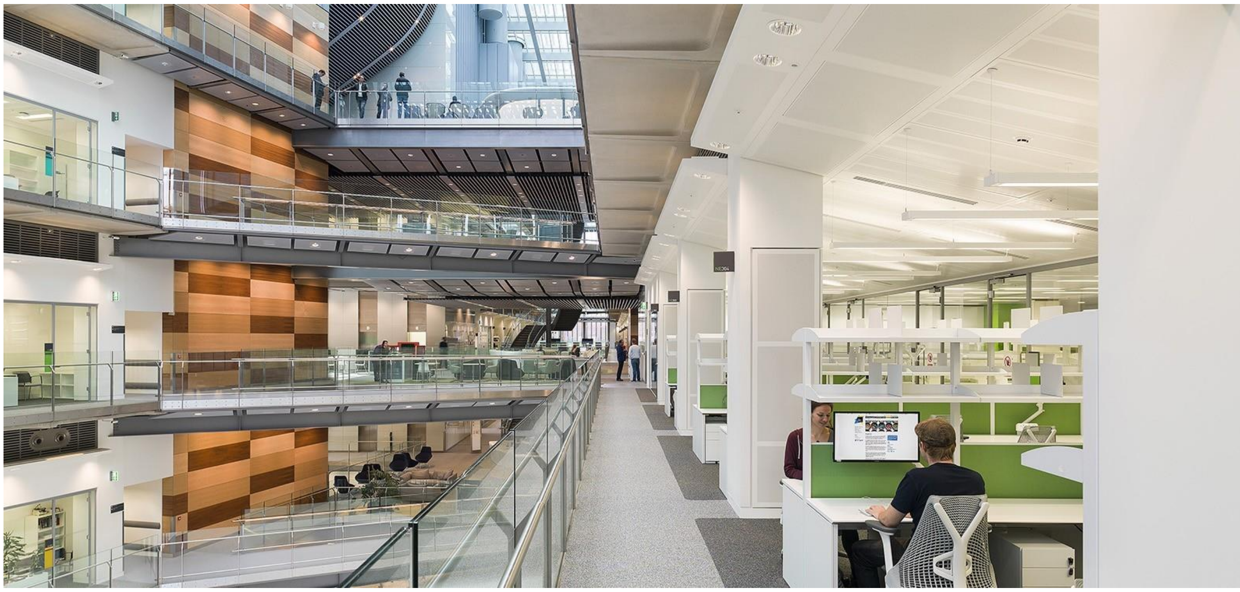


A study done in 2014 by CBRE, demonstrated that a "typical" laboratory in life science industry devotes only 7% of its square footage for collaboration with almost no dedicated space for thinking and contemplation. (Source: CBRE Life Science Practice)

3. Interaction

Challenging researchers to **collaborate across disciplines**, despite their initial reluctance, has led to the creation of new fields of study not defined 20 years ago.

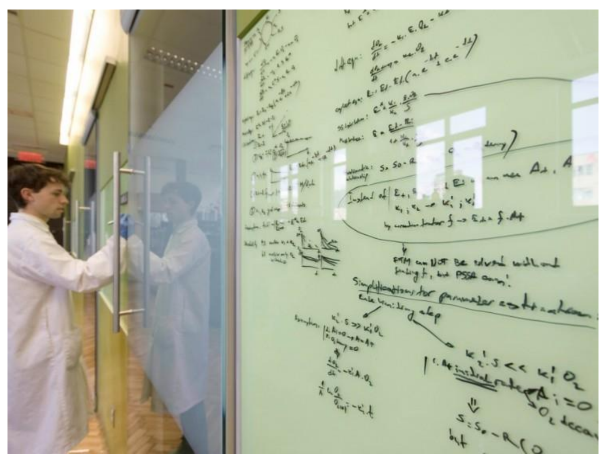
Interdisciplinary collaboration has become paramount to academic and corporate-based research. Fixed benches and utilities limit scientists to their individual workstation and hinder them from working in teams.



Francis Crick Institute, HOK architects, photo by Paul Grundy

The sharing of personnel (and equipment) may prove to be a highly effective measure to counter realities such as budget restrictions.

Collaboration spaces, venues and pathways for chance meetings are seen as critically important means to foster an innovative culture. A **variety** of meeting rooms with video conferencing, informal social/working areas with a place for laptops, whiteboards on every surface and glass walls are the norm. Design efforts will look to the creation of spaces **that promote collaboration** across more faculties and further **multidisciplinary and transdisciplinary** research. Design will also promote core facilities that create the opportunity to allow mixing of users from multiple locations based on synergies between groups around an area of study, as opposed to within a specific discipline. Other design considerations include the possibility to provide open spaces creating more **visual connections**, the use of technology to untether and connect people, and the integration of virtual communication.



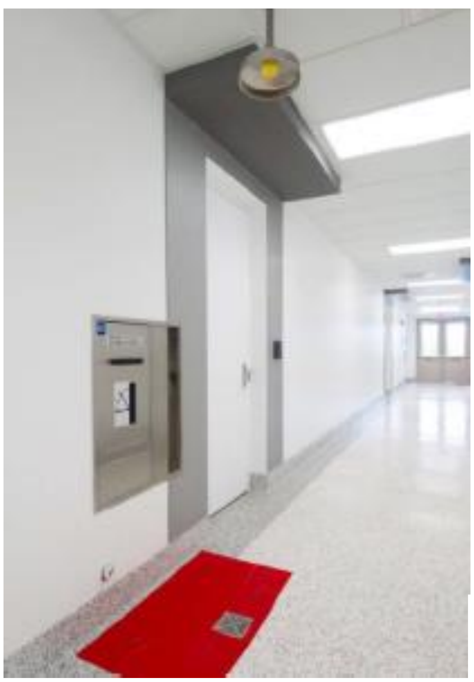
McGill - Mac Eng lab, photo from Vezina architects

Photo from Electronic Visualization Laboratory

4. Health & Safety

Health and safety means, first and foremost, **protecting** the health and safety of the university community and guests and fostering an environment that is conducive to **productive learning and research**. It also encompasses protection from material losses or events that can negatively impact on the continued operation of the institution. Compliance with health and safety legislation is a **complex challenge**, with **jurisdictions** at the municipal, provincial, national and international levels. Research granting agencies also impose health and safety conditions as a part of the research granting process. Health and safety is a moving target, with **new hazards** emerging from new research, coupled with a steady stream of new regulatory requirements.

Overhead Utility Connections, photo from presentation by James Schreyer, *From Afterthought to Forethought: Designing an Optimal Analytical lab*



Safety shower & eye wash, photo from presentation by James Schreyer, *From Afterthought to Forethought: Designing an Optimal Analytical lab*

Meeting the compliance requirements of health and safety in the research lab is commonly viewed as an obstacle to progress, however the ultimate goal is not to put up obstacles, rather it is to **effectively manage risks** and avert situations which can impede progress. The aim in the lab design process is to make sure the safety components are **"right-sized"** i.e., able to meet the demands of the present and flexible enough to also do so in the future. On one hand, an under-designed lab can result in retrofits that usually cost more than they would have if included in the original design, while on the other hand, and an over-designed lab can include expensive safety features that are never used, thereby diverting valuable financial resources that could have been used on more important items.

5. Adaptability

Flexible furniture with overhead service carriers, photo from Waldner Laboratory Systems

Science and technology change rapidly, and the facilities used for them do too. Therefore, new laboratories must be **flexible** and **adaptable**. Maximizing adaptability has always been a key concern in designing or renovating a laboratory building. Adaptability can mean several things, including the **ability to expand easily**, to **readily accommodate reconfigurations** and other changes, and to **permit a variety of uses**. Adaptable labs allow universities to meet changing needs in the future while reducing renovation costs and lab downtime. Core facilities and campus amenities are resources which enable flexibility and adaptability in general research space. They strengthen the campus community and **foster the exchange** of ideas by serving different departments, which may not have otherwise interacted. Adaptability features allow lab space to be **leaner** and **increase efficiencies** in layout.

Adaptable lab furniture, photo from New England Lab

6. Sustainability

Sustainability means meeting needs of the present without compromising the ability of future generations to meet their own needs. In addition to natural resources, we also need social and economic resources. Sustainability is not just environmentalism. Embedded in most definitions of sustainability we also find concerns for social equity and economic development. In the context of a lab, it means developing new approaches (technical, operational and behavioral) to enhance the environmental performance of a space that feels safe, inclusive and connected, with a sound economic approach.

Tufts University Science and Engineering Complex, photo by Payette

Photo from labconco.com

Laboratories are places of discovery and scientific progress, housing both the research that matters and the researchers themselves, and equipment responsible for it. All that science, though, takes **energy**, and many facilities—especially those with significant ventilation needs—utilize it in **high volumes**. To combat this issue, it is important to implement strategies in the workplace that will **minimize the environmental footprint** of our labs and make them environmentally friendly homes for the science of tomorrow.

In a lab that embodies the principle of sustainability, people collaborate across disciplines to inform and advance solutions to contemporary problems. They are aware of and responsible for the **environmental**, **economic** and **social implications** of their research.

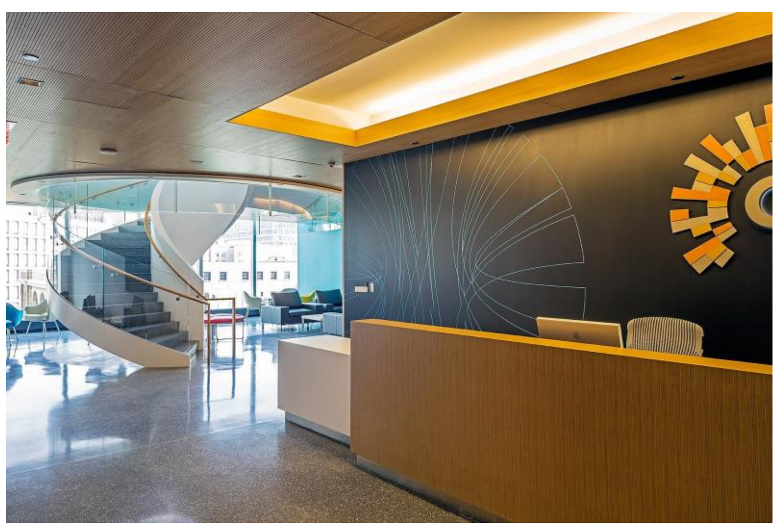
The Well Living Lab, photo from Delos Ventures and Mayo Clinic

7. Ownership & Governance

In a large institution where responsibilities are widely dispersed the question of ownership is a subject of ongoing debate. Who actually **owns a lab**? The PI, the department, the faculty, and central administration can all lay claim to ownership in some respects, but who is responsible for the space allocation, the design, construction, and choice of materials; the operation of the lab and its maintenance. What about safety surveillance, emergency preparedness, and the responsibility for reporting and correcting problems? When does a deficiency become an extra? Who pays?

OICR's Research Laboratory, Diamond Schmitt Architects, photo from architecturelab.net

Ownership of laboratories, responsibility for **maintaining** them and **accountability** for what goes on inside the laboratory should be clearly defined and well understood by all stakeholders. New laboratories do not always require new space if existing spaces are optimized. To achieve this, laboratory spaces should be allocated on the basis of the **needs of the University**, **irrespective of inter-departmental or inter-faculty** differences over ownership. This will also go a long way towards accommodating inter-disciplinary research.



OICR's Research Laboratory, Diamond Schmitt Architects, photo from architecturelab.net

Design criteria

A survey was conducted December 12th 2017 through January 10th 2018 to gather input from lab users regarding laboratory design.

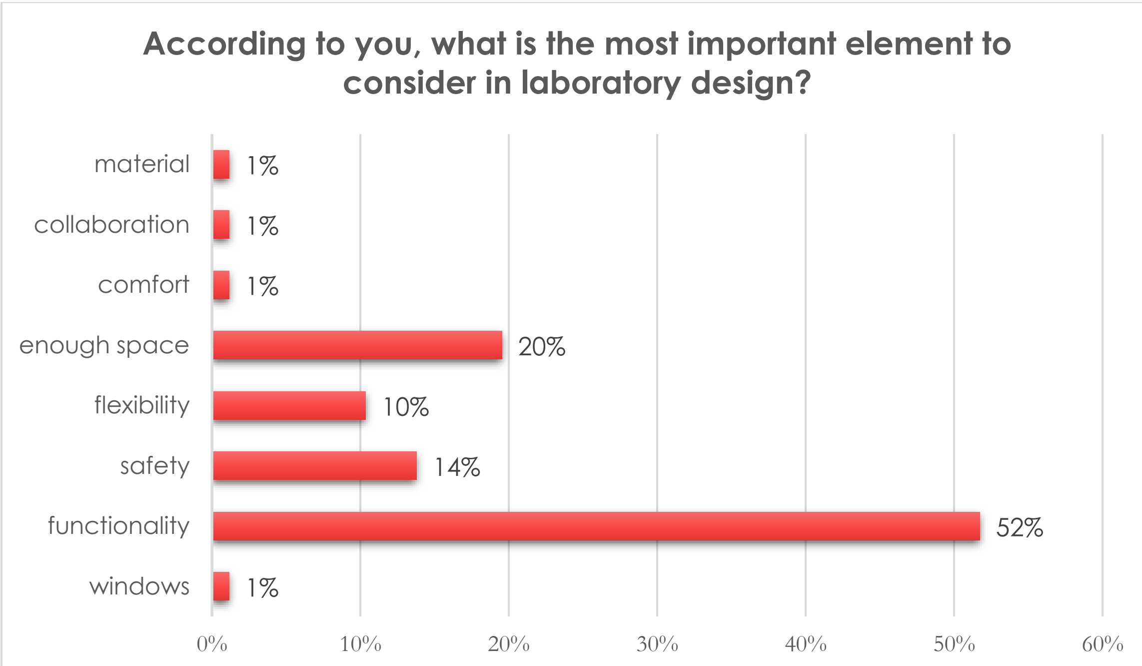
In total, 87 responses were received from users with various functions in various fields of study:

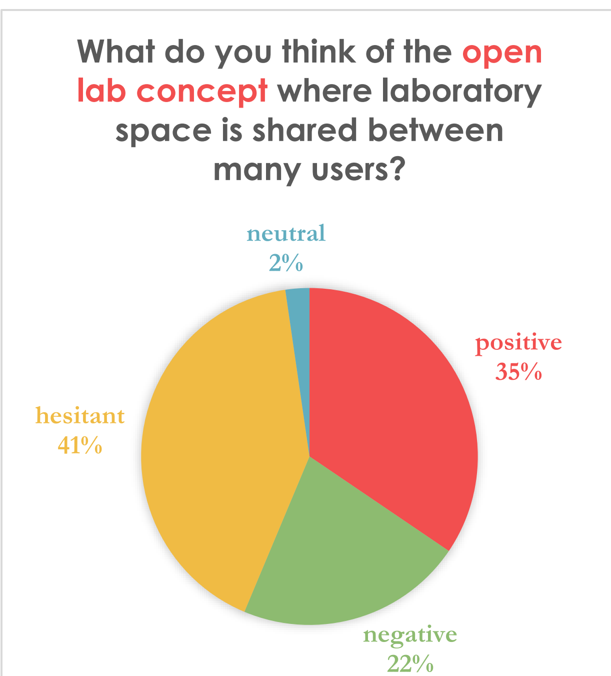
DEPARMENT	#user
Biochemistry	6
Biology	18
Cognitive Neuroscience	2
Food Science & Agricultural Chemistry	1
Building Management	1
Human Genetics	2
IPN	3
Kinesiology & Physical Education	7
Integrative Neuroscience	1
Medicine	3
Microbiology & Immunology	4
MNI	8
Natural Resource Science	1
Neurology & Neurosurgery	10
Neuro-Immunology	1
Oncology	1
Pathology	1
Pharmacology & Therapeutics	1
Physics	6
Physiology	2
Plant Science	1
Psychology	4
Redpath Museum	3

FUNCTION	#user
Academic associate	1
Academic staff	1
Assistant professor	9
Associate professor	12
Building director	1
Chair	1
Chief research technician	1
Course technician	1
Engineer	1
Grad student	6
Lab coordinator	2
Lab manager	2
Lab technician	2
Masters	4
PhD	11
Postdoc	3
Professor	10
Program manager	1
Project officer	1
Research assistant	9
Research associate	5
Researcher	1
Technical assistant	2

Questions were asked about general laboratory design, open lab concept, sharing of spaces and equipment, safety issues, collaboration, technologies, flexibility of lab layout and furniture, storage, space types, aesthetics and sustainability.

The primary criteria in laboratory design according to the users' opinion is functionality. An appropriate layout respecting the laboratory's needs can allow for a smooth work-flow dynamic between users, ensuring at the same time an efficient use of space and an adequate level of safety.

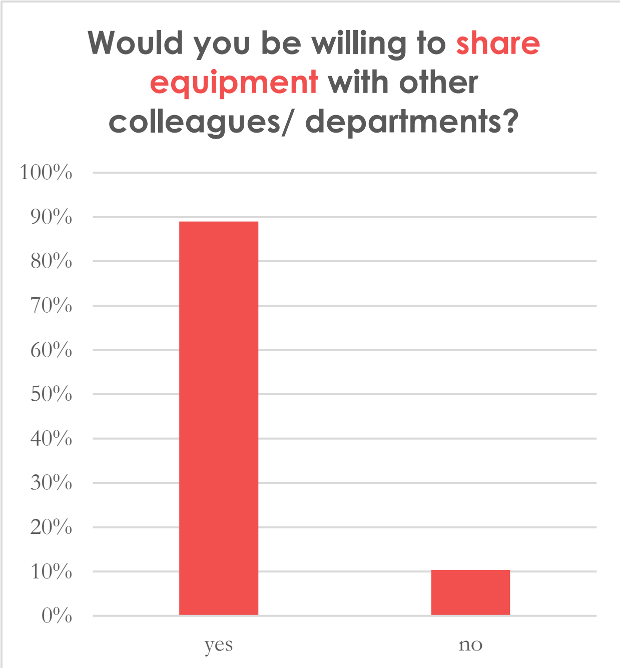




When asked about the open lab concept, 41% of the users were hesitant. They have indicated that the following requirements would have to be fulfilled in order for open lab concept to work:

- Clear rules establishing responsibilities (cleaning, schedule, access)
- Fair sharing of equipment costs, material costs, maintenance and operation costs
- Mutual trust and respect between users
- Proper layout for convenient access
- Sufficient space must remain for non-sharable specialized equipment and experiments, independent work space and personal storage

The complexity of achieving these same requirements were why 22% of the users believe that an open lab concept cannot work. In addition, they believe that open labs can hinder concentration, have inadequate acoustics, and lack confidentiality for certain labs.



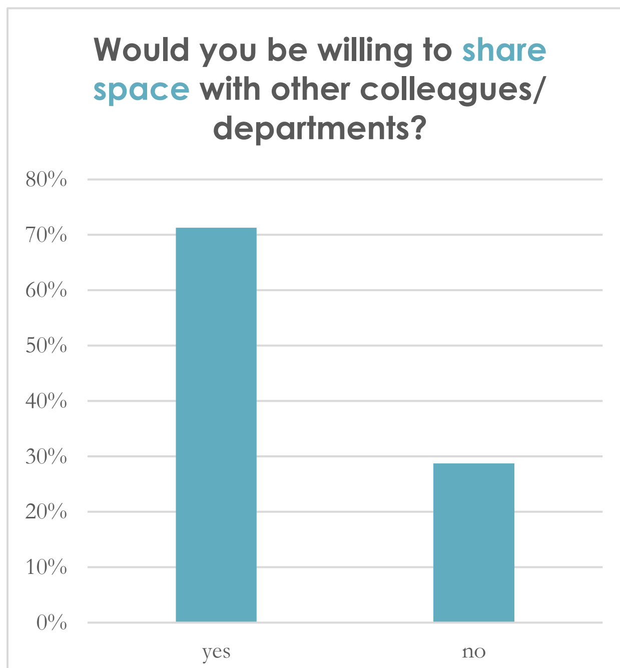
Equipment users are willing to share:

- Low-usage equipment
- Expensive equipment
- Common equipment
- Large equipment
- Core facility equipment
- Equipment not requiring personalized setup

Some sharable equipment listed by the users: centrifuge, ice machine, autoclave, shaker, balance, fume hood, biological safety cabinet, drying oven, incubator, freezer, fridge, robot, computer, microscope, flow cytometer, printer, motion caption system, imaging software, spectrophotometer, PH meter, dishwashing machine, gel imaging, etc.

Spaces users are willing to share:

- Lab space
- Bench space
- Equipment room
- Storage room
- Meeting / conference room
- Student space
- Office space
- Kitchen / lounge



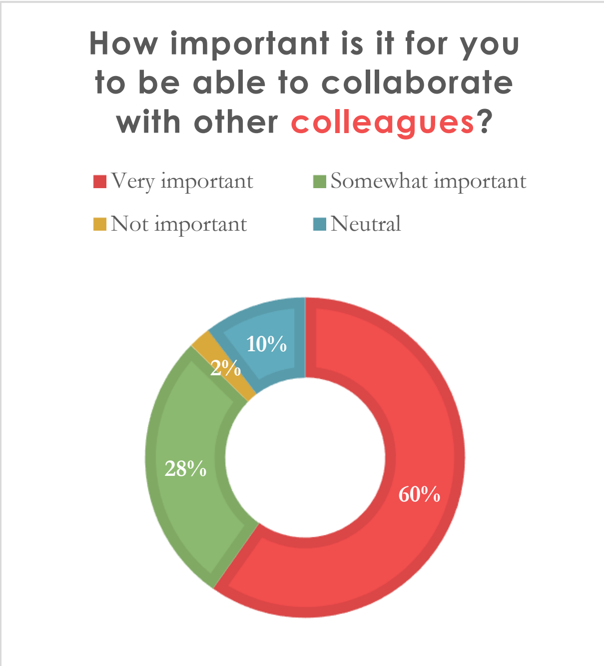
52% of the users had safety concerns regarding open labs. These concerns are mostly focused on human behavior.

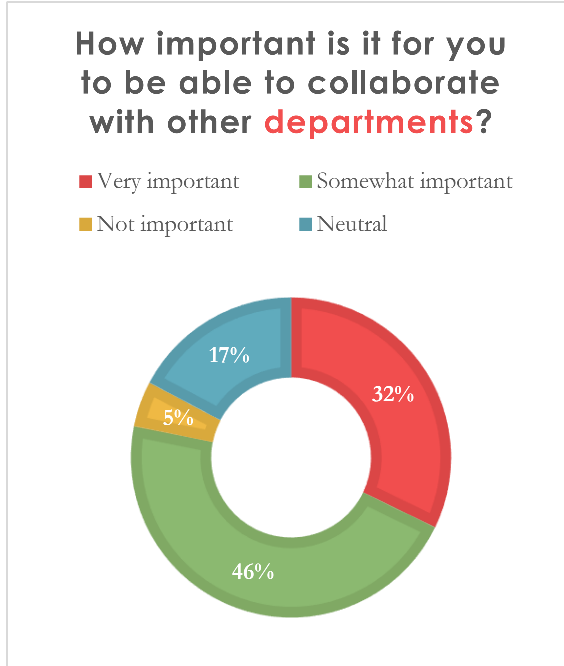
In general, the users are worried about the potential disrespect of safety guidelines, negligence, unauthorized use, the lack of communication, and the lack of accountability. Other safety issues raised related to waste management, spill containment, and possible contamination.

Proper safety training is therefore compulsory for everyone who will be using the shared spaces and the shared equipment in the open lab setting.

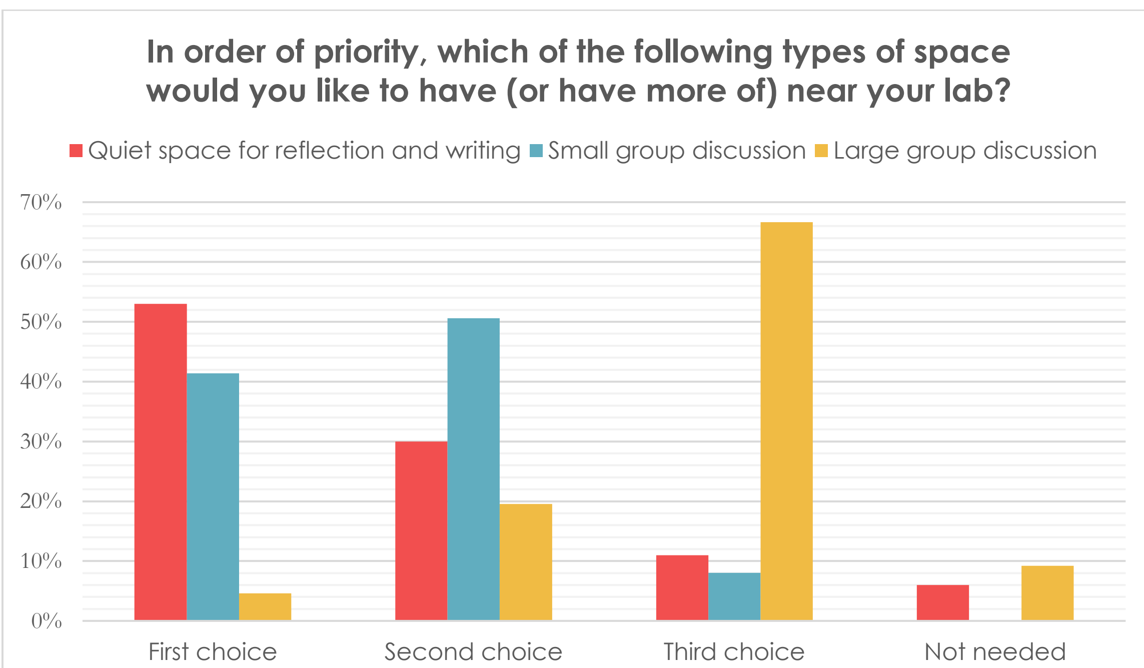
Certain equipment or experiments with high security protocols may be inadequate in an open lab setting, such as lasers, animal allergens, and radioactivity.

An effort should be made in lab design to provide collaboration spaces to allow lab users to exchange ideas and encourage interaction that can lead to innovation.



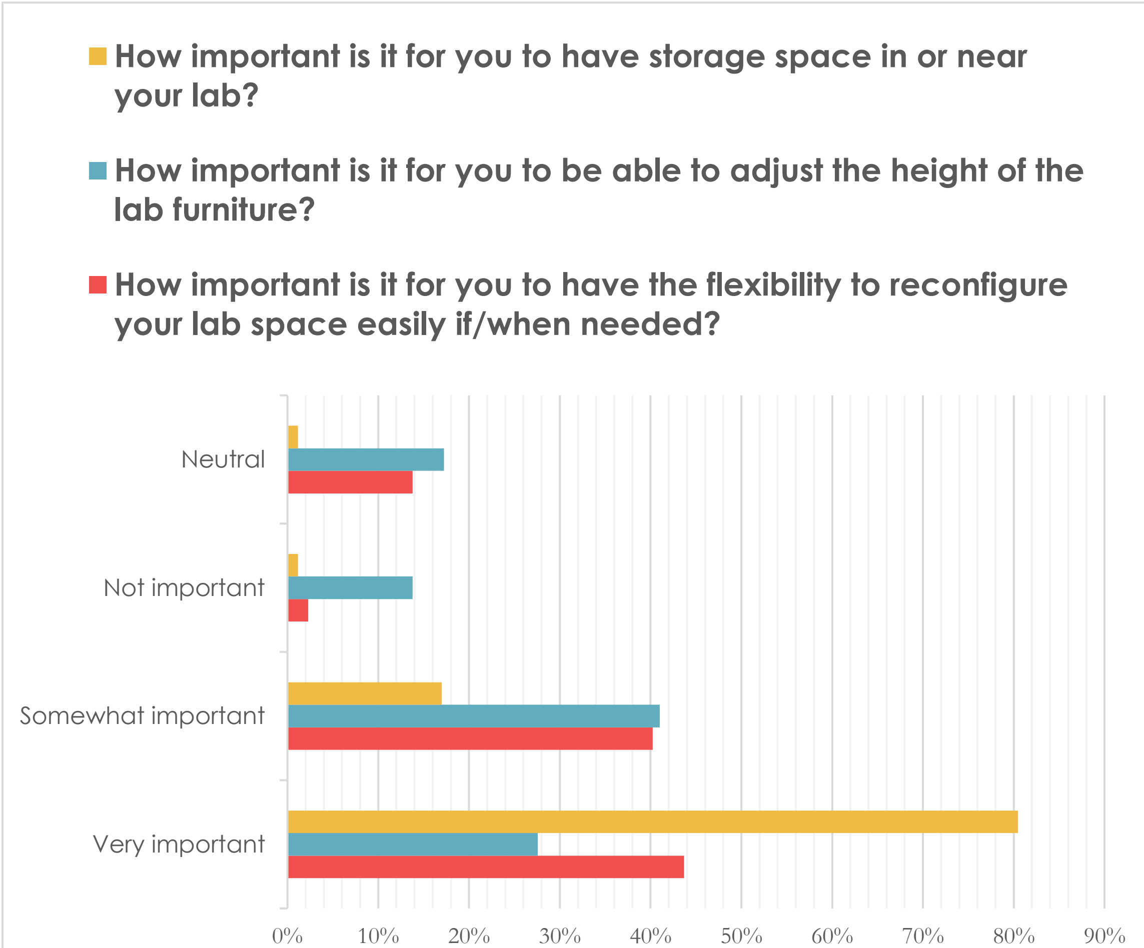


A proper balance should be provided between collaboration spaces for small and large groups, and quiet spaces for individual reflection and writing.



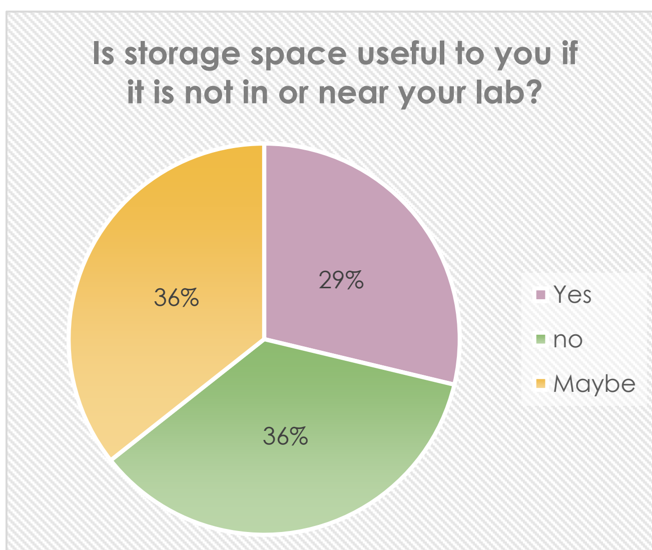
According to the survey results, there are significant needs for quiet individual workspaces and break-out spaces for small group discussions. This requirement should therefore be taken into consideration when planning research spaces.

Since laboratory furniture and storage occupy a large footprint in many laboratories, users were asked to grade the level of importance of these elements in their lab spaces.

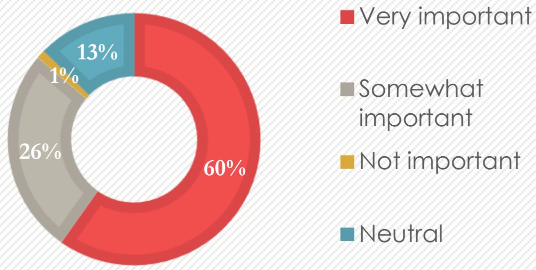


The results indicate that storage is primordial, and it would be best if storage spaces can be in proximity of the lab spaces.

Flexibility and adaptability of the laboratory furniture are also important. Being able to adjust the height and the configuration of the furniture easily and quickly according to the users' needs should be considered a basic feature of the laboratory of tomorrow.



In your opinion, how important is the capacity to integrate emergent technologies in lab space design?



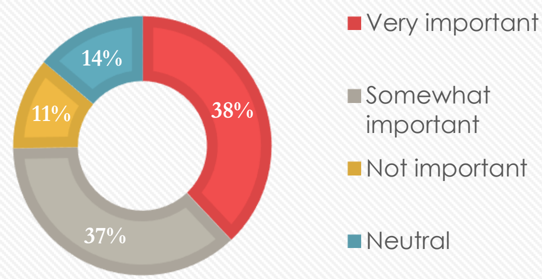
Most laboratories are heavily technology-focused. As technology advances, 86% of the users agree that laboratory design should take into consideration the capacity to adapt and integrate these emergent technologies.

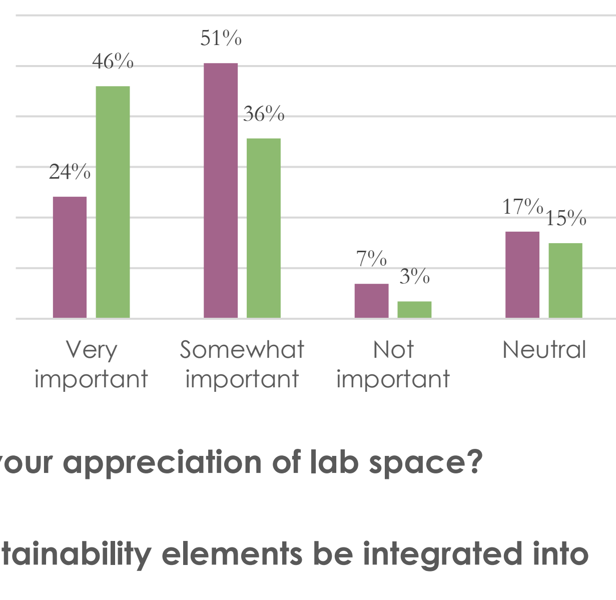
At the same time, as workforce has become increasingly more mobile, lab users do not necessarily have to be physically inside their lab spaces to perform or monitor experiments. 75% of the users responded that being able to connect to their lab remotely is somewhat important to very important.

The kind of information that users would like to access remotely are:

- Computer data
- Cloud storage for data / data saved on a lab server
- Data recording and filing
- Monitor long term experiments
- Experiment results
- Lab status (Temperature/humidity)
- Equipment status
- Remote control of equipment
- Space booking system
- Online lab tools
- Software, computer programs
- Inventory lists
- Schedules for equipment use
- Real-time monitor of who is using the equipment (log-in's)
- Communication to other lab users (Videoconferencing)

How important is it for you to be able to connect remotely to your lab?





Finally, we asked the users to elaborate, based on their previous lab renovation and construction projects, on the most important oversights to avoid:

- Lack of communication between Design team and users. Design has to be consulted with all the users, including TAs and lab coordinators
- Lack of basic supplies (vacuum, CO2, network, air conditioning)
- Not sufficient power (variety and number of electrical and data outlets)
- Interference with lab research (downtime and disturbance to adjacent spaces)
- Low ceiling height, inadequate circulation space, lack of natural lighting
- Inadequate separation of student offices from PI offices (hamper productivity)
- Inadequate acoustics for offices
- Loud and inadequate HVAC system
- Lack of space for equipment room, storage, meeting space, and lunch room
- Lack of functionality and flexibility
- Lack of appropriate equipment
- Bad quality of material

Conclusion

In conclusion, in order to have a proper laboratory design, it is important to involve key stakeholders such as the lab users throughout the design process. Since a lab has generic areas that can be common with other labs, but also function-specific areas that are unique to it, an in-depth needs analysis is required at the early stage of Design.

At this needs analysis, key questions to ask would be regarding infrastructure requirements and also space requirements in order to achieve functionality and flexibility.

Design criteria such as aesthetics, quality of material, quality of space, and access to natural light should be inherent to all design.

Other design criteria and objectives

In addition to the criteria mentioned in the survey, during the different focus group sessions, various key design elements were raised (some of which are already listed in the survey). These design elements should be taken in consideration whenever possible in the planning of new labs or in the renovation or redesign of existing labs.

- Promote the international reputation
- Place Human at the center of the project
- Ally "WELL" principles for the well-being of the users
- Use materials with a beneficial life cycle
- Plan for Universal Access
- Apply ergonomic principles

- Biofilia: Bring in nature, promote connection with nature
- Install vegetable walls (plants, natural colors, water elements)
- Plan for users and not for the equipment. Privilege the use of windows for users.
- Promote Visibility, views of outside
- Plan for low stress, safe & social spaces, noise control, privacy, art
- Plan for resource sharing. This should become interdepartmental (property management)
- Plan for management of residual materials, spaces for garbage cans, bins etc., Consider flow analysis and sorting at source
- Plan for data management: centralize servers (Burnside) or elsewhere, heat recovery (Otto Maass), redundancy, promote "virtual machines"
- Spatial planning
- General orientation: avoid closed rooms along windows, favor high occupancy rate, shared spaces. Glass wall, transparency, and light breakthroughs, light impact analysis, light wells, fiber optic applications. Traffic flow: research process to understand
- Place offices near laboratories, plan for universally accessible technical corridor, and subsidized collaborative common spaces of central offices.
- Building Dashboard
- Exhaust and ventilation
- Commissioning
- Promote sustainability : zero waste, safe
- Promote adaptability : flexible, transformative, accessibility, inclusive, evolving, mobile, design for all, modularity
- Consider human factors: living spaces, social spaces, human focused, inclusive, healthy spaces, ergonomic
- Consider community factors: interactive, interdisciplinary, innovative, build around community
- Ownership
- Potential energy saving: freezers, fridges, autoclaves, glassware washing, etc.
- Meeting places + team based labs: open spaces, visual connection, co-beneficial for students with mental health issues, meeting rooms, natural light, pleasant place, kitchen not in circulation, comfortable furniture, writing and display surface, natural light. Acoustic transparency, maintained inside the lab, shared spaces. Collaboration space. Confidentiality elements to respect. Conference rooms.
- Flexibility, modularity, mobile case-work (anti-slip floor, researchers are replaced often)
- Modulate the furniture according to the needs, flexibility in the infrastructure, equipment zone. Mixture of furniture type: Generic: fixed - sink – hood and Specialized: modular. Modular equipment room 100%. Storage space for furniture to reuse.
- Include proper lighting controls: task lighting + reduce lighting density
- Install proper lab exhaust: containment, hoods at the lowest possible flow, analysis system
- Consider the use of chilled beams : heavy infrastructure, advantage for new building
- Design all basic labs as CL2 labs

Applicability

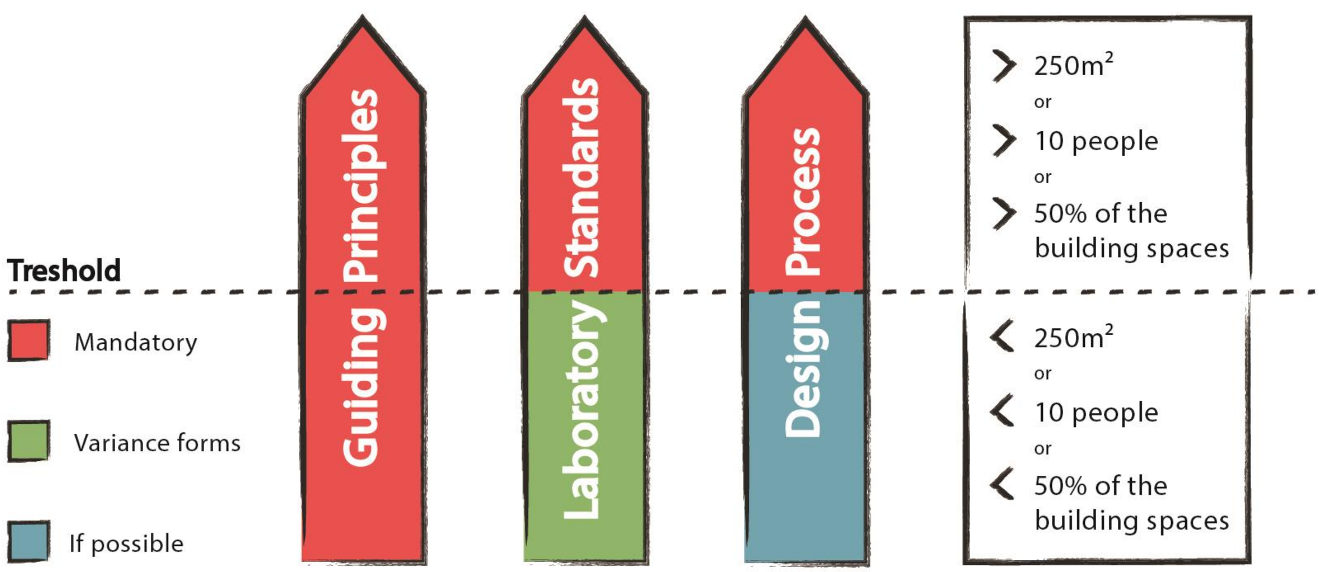
In order to assist the Design team in the vetting of future labs process goals and objectives, McGill has identified two levels of design requirements for projects based on their scope of work.

New Construction and Major Renovations

For all new building or building-wide, full-gut renovation projects (**more** than 50% of the Building spaces), or for all fit-outs and partial building interior fit-outs of **more** than 250 m² and/or 10 people and of at least one building story and multiple building systems, the Guiding Principles, the Building Design Standards for laboratories and the Design Process shall apply.

Minor Renovations and Improvements

For all minor renovation (**less** than 50% of the building spaces), or for all fit-outs and partial building interior fit-outs of **less** than 250 m² and/or 10 people, the Guiding Principles shall apply. Variances to the Building Design Standards must be approved at the Design phase according to the procedure of the "Design Standards Conformity" and the "Variance Request" forms. Whenever possible, the Design Process shall apply.



Laboratory Design Process

Research Facilities are complex and need to be built as controlled environments that ensure efficiency and a safe environment for workers and best integrate emergent technologies and equipment. The process for designing and building these facilities requires thoughtful design, takes into account the unique needs of each facility, and develops solutions that lead to the best possible space to perform the research. The construction should take into consideration the sophistication and the sensitivity of the nature of the work done inside the lab.

An Integrated Design calls for an early involvement of stakeholders and a collaborative decision-making.

Owner	Project Management Team	Primary Consultants	Specialities Consultants	Local Stakes	Equipment Vendor	External
• Investigators • Researchers • Staff & laboratory users		• Architect • Engineers (structural, mechanic, electric, plumbing)	• Vibration • Acoustics • Lighting • Building code	• Health & Safety • Operations • Energy • Sustainability • Network and Communication Services (NCS) • AAC • Campus Safety • Building & Grounds • Campus Planning & Development Office • Research & Innovation		• Permits • CCU • MCCU

References

CBRE (2016). Lab of the Future [Online].
Available: https://www.cbre.com/real-estate-services/occupier/facilities-management/lab-of-the-future

Crotty, Don (2017, September 27th). Welcome to the new age of laboratory design [Online].
Available: https://www.labdesignnews.com/article/2017/09/welcome-new-age-laboratory-design

Denmark A., Burton E. (2017, April). The laboratory in 2050 [Presentation].

Flad Architects (n.d.). Beyond LEED, Sustainable Laboratory Design [PDF].
Available: https://www.flad.com/content/epubs/beyond_LEED_whitepaper.pdf

Gantt N. L., Chriswell K. (2017, April). Renovating Flexible Laboratories for Changing Research [Presentation].

Hock, Lindsay (2014, June 6th). Trends in modern lab design [Online].
Available: https://www.labdesignnews.com/article/2014/06/trends-modern-lab-design

InterFocus (2017, October 28th). Science Labs of the Future [Online].
Available: https://www.mynewlab.com/blog/science-labs-of-the-future/

Kozminski K., Lewis S., Mathew P. (2016, August). Efficient Electric Lighting in Laboratories [PDF].
Available: http://www.i2sl.org/documents/toolkit/bp_lighting_508.pdf

Lee, Jinhee (2014, October 9th). Liquid labs : Designing for collaboration [Online].
Available: https://www.labdesignnews.com/article/2014/10/liquid-labs-designing-collaboration

Ostafi, Joseph (n.d). The Scientific Workplace of the Future [Online].
Available: http://www.hok.com/thought-leadership/the-scientific-workplace-of-the-future/

Paskanik, Mark (2017, September 13th). Innovation Science [Online].
Available: https://www.labdesignnews.com/article/2017/09/innovation-science

Schreyer, James (2016, June 1st). Designing the next generation instrument lab [Online].
Available: https://www.labdesignnews.com/article/2016/06/designing-next-generation-instrument-lab

Schreyer, James (2017, April). From Afterthought to Forethought: Designing an Optimal Analytical Lab [Presentation].

SmithGroupJJR (2016, March 23rd). Lab2050: The future and science and laboratory spaces [Presentation].

Tulsi, Bernard B. (2015, July 6th). Future Labs [Online].
Available: http://www.labmanager.com/lab-design-and-furnishings/2015/07/future-labs#.WntsYxBkw8k

Watch, Daniel (2016, August 29th). Trends in Lab Design [Online].
Available: http://www.wbdg.org/resources/trends-lab-design

Appendix

Appendix 1: Participants

Steering committee - Vision Workshop (June 28, 2017): Robert Couvrette, AVP, FMAS Jim Nicell, Dean Faculty of Engineering Jean-Marc Gauthier Carmen Lampron Annaëlle Perez Alexander Munro Amelia Brinkerhoff François Miller Wayne Wood Lorraine Mercier	**Focus Group – Maintenance & Operations (October 24, 2017):** Luc Roy, Director Fabrice Lebeau Denis Mondou Dominique Gagnon Carmen Lampron Pierre-Luc Baril Alexander Munro Kevin Wade François Miller Wayne Wood Mariette Becchara Lorraine Mercier
Focus Group – Sustainability & Energy (October 24, 2017): Robert Couvrette Fabrice Lebeau Denis Mondou Jérôme Conraud Stéphanie Leclerc Carmen Lampron Pierre-Luc Baril Alexander Munro Kevin Wade François Miller Wayne Wood Mariette Becchara Lorraine Mercier	**Focus Group – Architecture (November 15, 2017):** Robert Couvrette Michael Sullivan (NFOE) George Lazaris Annaëlle Perez Carmen Lampron Maxime Gagnon Philippe St-Jean François Miller Wayne Wood Mariette Becchara Lorraine Mercier
Focus Group – Process (November 20, 2017): Anna Bendix (CDPO) Jim Nicell Jean-Marc Gauthier Sylvain Letarte Luc Roy	 Wayne Wood Jean-Pierre Mallette Mariette Becchara Lorraine Mercier

Focus Group – Health & Safety (December 12, 2017):	**Focus Group – Lab Users (December 14, 2017):**
Fabrice Lebeau	Isabelle Gamache
Carmen Lampron	Claire Trottier
Jim Gourdon	Alvin Shrier
Jozef Zorko	Linda Pelletier
George Lazaris	Hicham Benslim
Annaëlle Perez	Bennett Smith
Carmen Lampron	Matt Kinsella
Philippe Gerald Raecke Baro	Robert Morawski
Philippe St-Jean	Carole Verdone-Smith
François Miller	Jennifer Wallace
Wayne Wood	Marie St-Laurent
Joseph Vincelli	Julie Fortier
Christian Bouchard	François Miller
Christine Jarabek	Wayne Wood
Ruth Blanchette	Jean-Pierre Mallette
Mario Badilo	Annaëlle Perez
Jean-Pierre Mallette	Mariette Becchara
Mariette Becchara	Winncie Leung
Lorraine Mercier	Lorraine Mercier

Appendix 2: Building Design Standards, Special Building areas - Laboratories

Part 1 General

1.1 Summary

.1 Unless otherwise indicated, follow the guidelines below when planning for laboratories in new or renovated spaces. These guidelines are not intended to restrict or replace professional judgment.

.2 Laboratories are defined as spaces being used for research, experimentation or teaching involving the use and storage of hazardous materials as defined by the Workplace Hazardous Materials Information System (WHMIS) or nuclear substances as defined by the Nuclear Safety and Control Act.

.3 When planning Teaching Laboratories, this document should be read with the Classrooms Standards (see Special Building Areas – Classrooms)

.4 These guidelines should be read with the specific technical sections of McGill's Building Design and Technical Standards mentioned in Part 6. – Related Technical Sections.

1.2 Scope

.1 The purpose of this section is to provide safe, efficient and healthful laboratory spaces to the McGill community while respecting the operational needs of the building in which these spaces are located.

.2 For all new building or building-wide, full-gut renovation projects (more than 50% of the building spaces), or for all fit-outs and partial building interior fit-outs of more than 250 m^2 and of at least one building story and multiple building systems, the Guiding Principles, the Building Design Standards for laboratories and the Design Process (see document titled "Design of Research Space") shall apply.

.3 For all minor renovation (less than 50% of the building spaces), or for all fit-outs and partial building interior fit-outs of less than 250 m^2, only the Guiding Principles are mandatory. Apply the Building Design Standards and Design Process whenever possible. When it is not possible, submit the variances for approval at the Design phase according to the procedure of the "Design Standards Conformity" and the "Variance Request" forms.

1.3 Strategic life cycle

.1 All McGill University laboratories shall be designed and built for a 30-year life-cycle.

1.4 Vision

.1 The University research spaces will support collaboration, innovation and foster creativity with cutting-edge design that is adaptable, safe and sustainable, thus strengthening McGill's role as a world-leading institution.

1.5 Guiding Principles

.1 Creativity, Innovation & Technology

The primary goal of the laboratory remains the same: experimentation. But the paths to discovery, and the way scientists work and interact, are being revolutionized by emergent technologies including smaller, more powerful instruments, robotics/automation, computer analysis and advanced communication systems.

.1 Design should focus on workplaces that promote innovation, the transfer of knowledge, collaboration and effectiveness

.2 Emergent technologies will reduce the physical footprint of labs and hopefully, free up some time for researchers for collaborative and ideas-based working.

.3 The future laboratory will need to reflect this change, with a choice of working environments replacing the space that was previously dedicated to traditional laboratories.

.4 The future laboratory will also provide flexibility in the physical and operational aspects of the laboratory to allow for emergent technologies.

.5 Additionally, it will provide collaborative high-technology tools such as telepresence and video conferencing to accommodate a more mobile workforce and support mobility, at some level, for all employees.

.2 Planning & Design

.1 The nature of laboratory work requires distinct workspaces, and a defined, but permeable barrier between them. Scientists working in these spaces need an area that allows for both focused concentration and easy engagement with colleagues.

.2 Design should use acoustic technologies and visual cues to bring these different spaces as close together as possible.

.3 Adjacencies and visual connections should be created to allow for spontaneous interaction and collaboration between disciplines.

.4 Provide a beautiful environment that is desirable to occupy.

.5 Another consideration to take into account is the integration of flexible laboratories that would allow rapid reconfiguration based on scientific needs.

.3 Interaction

.1 Collaboration spaces, venues and pathways for chance meetings are seen as critically important means to foster an innovative culture. A variety of meeting rooms with video conferencing, informal social/working areas with a place for laptops, whiteboards on every surface and glass walls are desirable.

.2 Design efforts will look into the creation of spaces that promote collaboration across more disciplines and further multidisciplinary and transdisciplinary research.

.3 Design will also promote core facilities that create the opportunity to allow mixing of users from multiple locations based on synergies between groups around an area of study, as opposed to within a specific discipline.

.4 Other design considerations include the possibility to provide open spaces creating more visual connections, the use of technology to untether and connect people and the integration of virtual communication.

.4 Health & Safety

.1 Health and safety means, first and foremost, protecting the health and safety of our community and guests and fostering an environment that is conducive to a productive learning environment. It also encompasses protection from material losses or events that can negatively impact the continued operation of the institution. Compliance with health and safety legislation is a complex challenge, with jurisdictions at the municipal, provincial, federal and international levels. Research granting agencies also impose health and safety conditions as a part of the research granting process. Health and safety is a moving target, with new hazards emerging from new research, coupled with a steady stream of new regulatory requirements.

.2 Effectively manage risks and avert situations which can impede progress. The aim in the lab design process is to make sure the safety components are “right-sized” i.e., able to meet the demands of the present and flexible enough to also do so in the future. On one hand, an under-designed lab can result in retrofits that usually cost more than they would have if included in the original design, while on the other hand, an over-designed lab can include expensive safety features that are never used, thereby diverting valuable financial resources that could have been used on more important items.

.5 Adaptability

.1 Adaptability can mean several things, including the ability to expand easily, to readily accommodate reconfigurations and other changes, and to permit a variety of uses. Adaptable labs allow universities to meet changing needs in the future while reducing renovation costs and lab downtime.

.2 Core facilities and campus amenities are resources which enable flexibility and adaptability in general research space. They strengthen the campus community and foster the exchange of ideas by serving different departments, which may not have otherwise interacted. Adaptability features allow lab space to be leaner and increase efficiencies in layout.

.6 Sustainability

.1 Implement strategies in the workplace that will minimize the environmental footprint of our labs and make them environmentally-friendly homes for the science of tomorrow.

.2 In the context of a lab, it means developing new approaches (technical, operational and behavioral) to enhance the environmental performance of a space that feels safe, inclusive, and connected, with a sound economic approach.

.7 Ownership and Governance

.1 New laboratories do not always require new space if existing spaces are optimized. To achieve this, laboratory spaces should be allocated on the basis of the needs of the University, irrespective of inter-departmental or inter-faculty differences over ownership. This will also go a long way towards accommodating inter-disciplinary research.

1.6 Codes and Standards

.1 The existing laws, regulations and standards govern the design of laboratories:

.1 Loi sur le bâtiment

.2 Code de construction

.3 Code de sécurité

.4 The regulation respecting occupational health and safety
.5 The Canadian Nuclear Safety and Control Act
.6 The Human Pathogens and Toxins Act and Regulations
.7 The Health of Animals Act and Regulations
.8 Canada's Plant Protection Act and Regulations

.2 For the safety of the users, McGill requires the following best practices standards be applied to its laboratories design:

.1 Gov. of Canada Canadian Biosafety Handbook, Second Edition
.2 Gov. of Canada The Canadian Biosafety Standard, 2nd Edition
.3 Gov. of Canada *Radiation Safety in Educational, Medical and Research Institutions* (G-121)
.4 Gov. of Canada Containment Standards for Facilities Handling Plant Pests
.5 Gov. of Canada Containment Standards for Facilities Handling Aquatic Animal Pathogens
.6 ANSI Z358.1: Emergency Eyewash and Shower Equipment;
.7 ANSI Z136.1: Standard for Safe Use of Lasers;
.8 ANSI Z136.5: Standard for Safe Use of Lasers in Educational Institutions;
.9 ASHRAE Z9.5: American National Standard for Laboratory Ventilation;
.10 ASHRAE 62.1: Ventilation for Acceptable Indoor Air Quality;
.11 ASHRAE 90.1: Energy Standard for Buildings except Low-Rise Residential Buildings;
.12 ASHRAE 110: Method of Testing Performance for Laboratory Fume Hoods;
.13 ASHRAE: Laboratory Design Guide: Planning and Operation of Laboratory HVAC Systems;
.14 ASME A13.1: Scheme for the Identification of Piping Systems;
.15 B64.10-11/B64.10.1-11: Selection and Installation of Backflow Preventers;
.16 CSA Z316.5 Fume Hoods and Associated Exhaust Systems;
.17 CSA 434.03: Industrial Robots and Robot Systems;
.18 NFPA 30: Flammable and Combustible Liquids;
.19 NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals;
.20 NFPA 55: Compressed Gases and Cryogenic Fluids Code;
.21 NFPA 400: Hazardous Materials Code;
.22 NFPA 5000: Building Construction and Safety Code: Chapter 34 – High Hazard Contents;
.23 NIH: Specifications 15991 and 15992 – On site testing of Fume Hoods;
.24 NSF/ANSI 49: Biosafety Cabinetry: Design, Construction, Performance and Field Certification;

.3 In the case where some of these documents are revised or updated since the date of the present document, the most recent version at the starting date of the design of the lab will be applicable.

.4 Whenever design features are governed by two or more reference documents, the most stringent one will take precedence.

.5 If a requirement cannot be met, the designer shall submit a variance form to McGill's Design Services and explain the reason why it cannot be met.

1.7 Laboratory categories

.1 Generic Laboratories (GL)

.2 Biological Laboratories (BL)

.3 Chemical laboratories (CL)

.4 Physics laboratories (PL)

.5 Animal Facilities (AF)

.6 Radioisotope laboratories (RL)

1.8 General health and safety

.1 Prior to commencing a laboratory project, the Designer must obtain from the Project Manager, McGill's Environmental Health and Safety (EHS) risk assessment report of the hazardous materials or processes to be used in the projected laboratory space.

.2 At the minimum, laboratories must be designed with Containment Level two (CL2) requirements.

1.9 Accessibility

.1 Laboratories must be designed to be accessible to physically challenged individuals, refer to McGill's Accessibility on Campuses Guidelines;

.2 Where fume hoods are required, there should be at least one fume hood for disabled individuals per laboratory.

1.10 Sustainability

.1 Whenever possible, concepts and strategies for sustainability shall be integrated in the laboratory design.

.2 Whenever possible, utility systems should be designed to allow for grey water collection and usage.

.3 Vacuum systems and water-purifying systems shall be designed to high energy and water efficiency standards.

.4 Research appliances, particularly freezers and refrigerators, shall be high energy efficiency and Energy Star rated, when applicable.

.5 Water-consuming equipment (e.g., cage-washers) shall be designed so as to reuse water and reduce water consumption.

.6 Waste management and recycling protocols – to be elaborated.

Part 2 Architecture

2.1 Planning considerations

.1 Typologies

.1 Open laboratory design

.1 When possible, create open laboratories to facilitate teamwork, to promote communication and collaboration, and to encourage researchers to share not only the space itself but also equipment, bench space, and support staff.

.2 Closed laboratory design

.1 When lab equipment or functions require closed dedicated spaces, such as tissue culture labs, special containment rooms, electron microscopes, nuclear magnetic resonance equipment (NMR), darkrooms and glassware washing rooms, design dedicated closed laboratories to house these special functions.

.3 A combination of open laboratory spaces with smaller dedicated areas for special functions is the preferred design solution to be assessed by the Design team.

.2 Design requirements

.1 Security

.1 Laboratories must be separated from adjacent spaces with non-combustible fire separations having a fire-resistance rating of minimum 1 hour;

.2 In buildings where biological materials are handled, follow the physical requirements of the Canadian Biosafety Standards, 2nd edition (CBS);

.3 In buildings where the storage and usage of radioactive materials is prevalent, follow the Canadian Nuclear Safety Commission's Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms (GD-52, Appendix C);

.4 Laboratories must be kept locked if not being occupied by authorized personnel. Therefore, doors must be equipped with keyed locks, card readers or if necessary other physical security measures as defined by the Security Service department.

Follow the Security Device Installation Protocol available at: http://www.mcgill.ca/campussafety/files/campussafety/security_device_installation_protocol_2.3_en.pdf

.2 Cleanability

.1 Laboratories must be designed and finishes selected to be easily cleaned;

.2 Bench tops should be seamless to avoid contamination;

.3 Furniture and all finishes must be impermeable to facilitate decontamination and cleanup procedures in the event of a hazardous material spill or incidental spread of contamination.

.3 Layout considerations

.1 Flexibility and adaptability

.1 Consider a standard modular design to allow the space to be reassigned easily and quickly.

.2 Locate fixed furniture, fixed casework, and other fixed elements such as exhaust hoods and sinks around the perimeter of the lab with utilities provided via overhead service carriers.

.3 Ensure maximum mobility of interior equipment and furniture by using mobile instrumentation carts, mobile benches, adjustable tables or equipment carts.

.4 When designing a laboratory in a new building, provide ready and safe access for maintenance, routine servicing, or reconfiguration of utilities by way of interstitial spaces between the floors,or by using overhead service carriers.

.2 Visibility and Interaction

.1 Design transparent separations or separations that can be reconfigurede to allow for visibility between spaces.

.3 Proper circulation flow

.1 The arrangement of aisles must be regular and provide a logical path to the exit (laboratories emergencies are often accompanied by heavy smoke and fumes complicating egress and exit locating);

.2 Major aisles between equipment and benches must be planned to provide the most possible direct access to the exit door (s);

.3 Aisles between equipment and benches must have a minimum clear wide of 1500mm (for safe passage behind persons working at benches);

.4 Avoid aisles longer than 6m;

.5 The arrangement of laboratory furniture and casework must:

.1 Provide unobstructed sight lines to exits and emergency equipment for people standing;

.2 Facilitate ease of egress and ease of travel within the laboratory;

.3 Allow for proper cleaning of floor (spills and regular) and access for maintenance (equipment and other);

.4 Make it possible for users to move around quickly to reach emergency equipment and exits. Island type benches are preferred over peninsula type benches (one end attached to a wall).

.4 Emergency Safety station

.1 Each laboratory must be equipped with at least one safety station located near or next to its primary exit, comprising:

.1 an eye-wash;

.2 an emergency shower;

.3 a floor drain (if feasible);

.4 a fire-extinguisher and;

.5 a hands-free washing sink (if not provided otherwise).

.2 Clear space at safety stations must allow for wheelchair access and safety station utilization;

.3 Safety stations must be placed in high visibility locations and identified by highly visible signs (refer to McGill's Interior Signage Standards);

.4 Safety station arrangement and location in laboratory must be as consistent as possible from laboratory to laboratory.

.5 Laboratory (Hazard) zoning

.1 The path to the exit door(s) should not require passing through a zone of higher hazard. Therefore, laboratories should be planned in zones to provide safe egress from all points;

.2 Laboratory should be segregated from non-laboratory activities but remain visually connected (e.g. students access to laboratory personnel outside scheduled experimentation time);

.3 Seated workstations (laboratory desks) where users tend to concentrate their attention on a limited field of vision, thus being potentially less aware of other activities in the laboratory (microscopy, computer, writing, etc), should be located near an exit and preferably in the path of fresh make up air;

.4 Experimental work spaces/stations should be physically segregated from other laboratory functions/activities such as:

.1 Central chemical storage;

.2 Equipment or instrument rooms;

.3 Bottled/compressed gas storage;

.4 Coat and boot and private items storage.

.6 Sharing of Laboratory Support spaces

.1 As a general rule, every effort must be made to bring together, by floor, all the resources researchers use on a daily basis while avoiding duplication of laboratory support spaces whenever efficient and possible;

.2 Food and drinks are not allowed in laboratory spaces. Unless there is a nearby cafeteria or departmental eating area, design of the laboratory, and adjacent support spaces, must incorporate a break space physically separated from the laboratory and equipped with a sink and storage for consumption of food and drinks;

.3 Multi-purpose collaboration spaces shall be provided adjacent to the laboratory. These spaces should designed in such a way that they can be reconfigured and used as breakrooms, spaces for teamwork, informal gathering spaces, write-up spaces, spaces for individual work requiring concentration or a combination of these functions as required;

.4 Locate these support spaces adjacent but segregated from the laboratory, and in such a way that they can stay visually connected and be shared with other laboratories.

.7 Sharing of Research Equipment spaces

.1 Attempts should be made to centralize the location of heat generating equipment in spaces dedicated and designed for the purpose (e.g. freezers, ultra-low temperature freezers, incubators, centrifuges, autoclaves, dishwashers, etc):

.1 Autoclave: to better control the effect of heat generating equipment in the laboratory and to maximize energy efficiency, whenever possible and practical, autoclaves should be centralized in one shared room,

.2 Freezers, refrigerators, and other heat-generating equipment shall be in freezer farms or in antechambers separated from the main laboratory area and office space so as to maximize heat recovery from these appliances and minimize cooling requirements in lab spaces.

.8 Fume hoods locations (as explained in the CSA Z136.5 standard)

.1 Should be located along the perimeter of the laboratory;

.2 Should be located away from interfering room air currents (e.g. doorways, room ventilation registers);

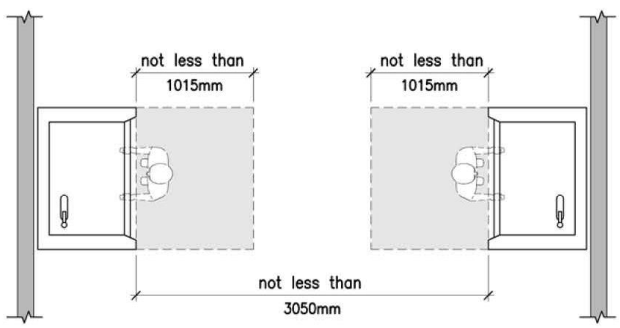
.3 Should be located out of the normal traffic pattern;

.4 Should not be located close to the primary exit (less than 3m);

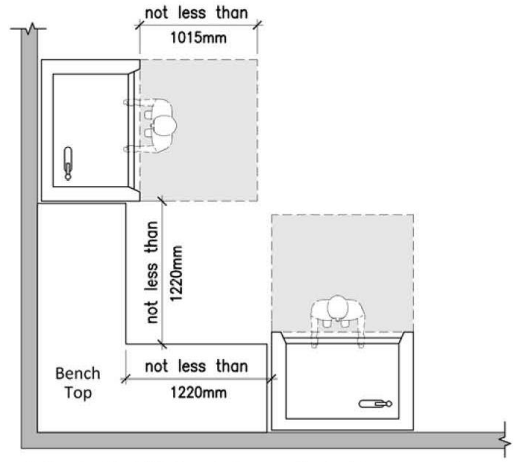
.5 Should not be located opposite workstations where personnel will spend much of their working day (e.g. desks or microscope benches);

.6 If corrosive or highly irritating or toxic substances are used in the laboratory, each fume hood shall be within 10 seconds of an emergency eye-wash/shower station;

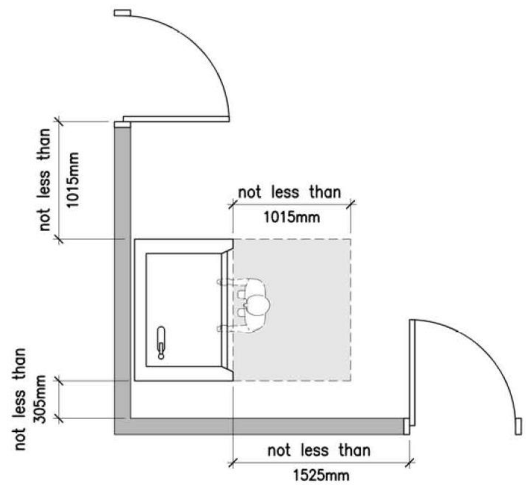
.7 Avoid face to face location. If installed opposite a Biological Safety Cabinet (BSC) or another fume hood, distance must be more than 3050mm face to face;



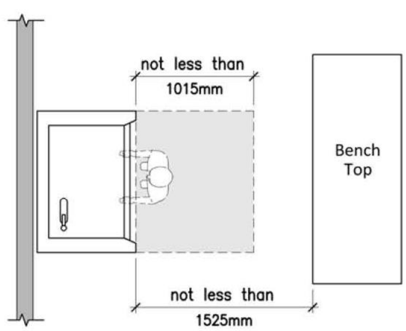
.8 Maintain 1220mm clear to the inside corner when fume hoods are placed on adjacent perpendicular walls (90º):



.9 Avoid placing fume hoods between adjacent 90º doors if possible. If unavoidable, maintain 1525mm clear to the door adjacent to the face, and 1015mm clear to doors adjacent to the side panel:



.10 Maintain 1525mm clear from the face of the fume hood to opposing bench tops with occasional traffic:



.4 Provision for storage

.1 The Design team must consult the laboratory users and Fire Prevention Office in order to determine the storage requirements.

.2 General storage

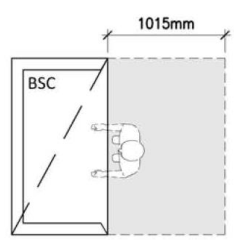
- .1 In order to avoid built-up on top of shelves, cabinets and the like, and in corridors, adequate bulk storage of dedicated laboratory supplies should be planned for laboratory spaces;
- .2 Storage space for personal items must be provided outside the area where hazardous products or process are used (shelving, laboratory coats hooks, secured coat room, lockers, etc);
- .3 Coat hooks for hanging up laboratory coats and other personal protective equipment, must be installed close to the exit of the laboratory (one per work station);
- .4 To free aisles and maintain safe circulation widths in the laboratory, enough dedicated space must be planned in the laboratory for a variety of waste collection containers (trash, hazardous waste, broken glass, sharps, recyclable, etc), preferably integrated to the laboratory casework;
- .5 Every effort must be made to avoid multiple hazardous products storage areas on one floor. Whenever possible and practical, hazardous products storage should be centralized in one shared room;
- .6 Storage spaces should be planned so there will be no vertical transport of hazardous materials other than for delivery and routine disposal.

.3 Chemical/hazardous products storage Cabinets locations

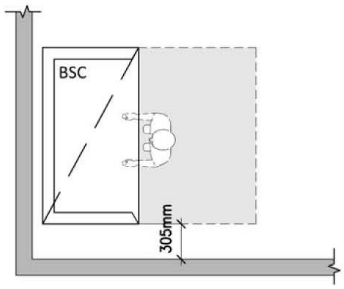
- .1 Preferred location of vented acids and flammable cabinets is below fume hoods;
- .2 Cabinets must not be stored in or adjacent to exits and travel path of egress.

.4 Biological Safety Cabinets (BSC) locations

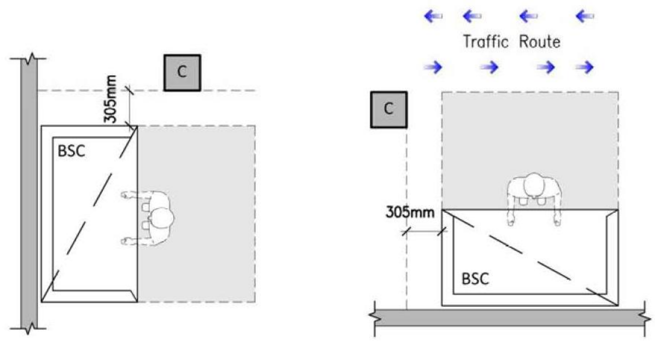
- .1 Biological Safety Cabinets should be located away from turbulence e.g. proximity to an air supply, pedestrian traffic, fume hoods, or other cabinets;
- .2 Maintain an undisturbed space of 1015 mm behind the BSC:



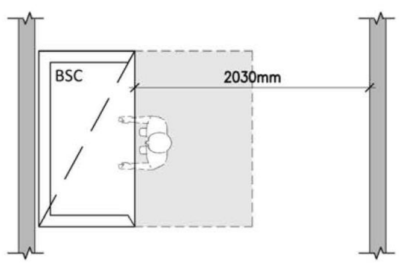
- .3 Maintain a distance of 305mm to adjacent walls:



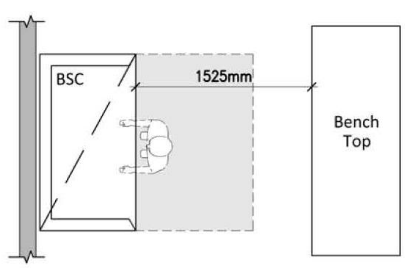
.4 Maintain a distance of 305mm to columns to avoid disturbance to BSC airflow. Columns at a distance of 305mm can aid in defining traffic routes:



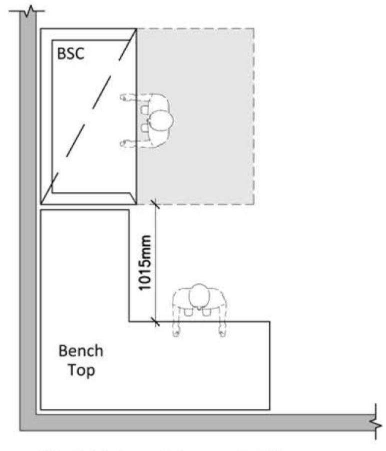
.5 Place the BSC at least 2030mm from opposing walls:



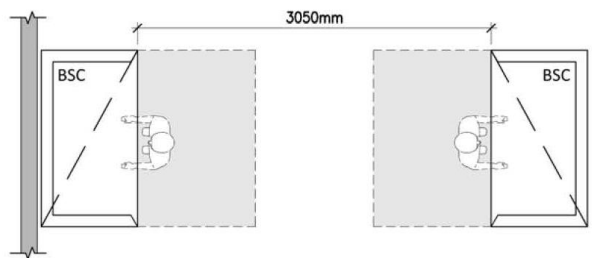
.6 Place the BSC at least 1525mm to opposing benchtops or areas with occasional traffic:



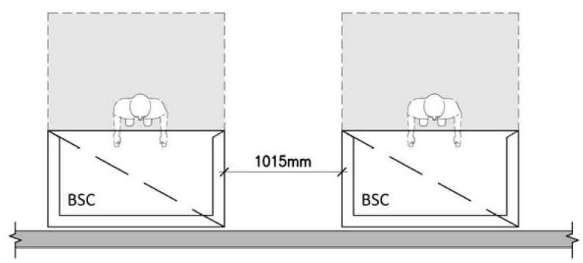
.7 Maintain a distance of 1015mm between the BSC and benchtop along perpendicular wall:



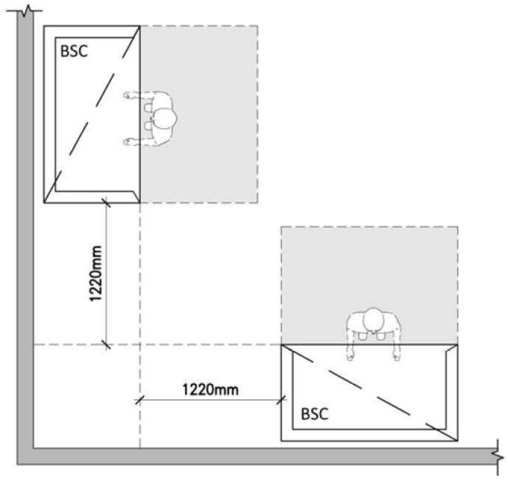
.8 Maintain a distance of 3048mm between opposing BSCs:



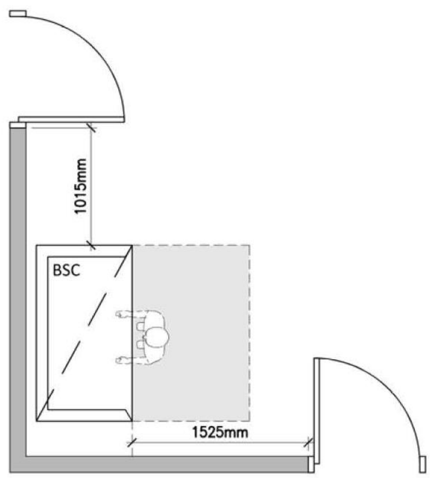
.9 Maintain a distance of 1015mm between BSCs along the same wall:



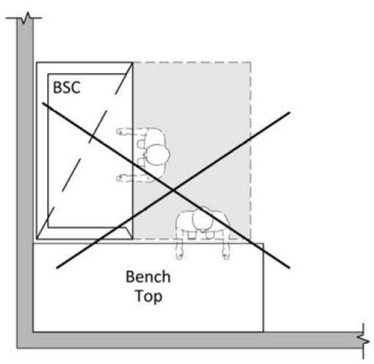
.10 Maintain a distance of 1220mm between BSCs along perpendicular walls:



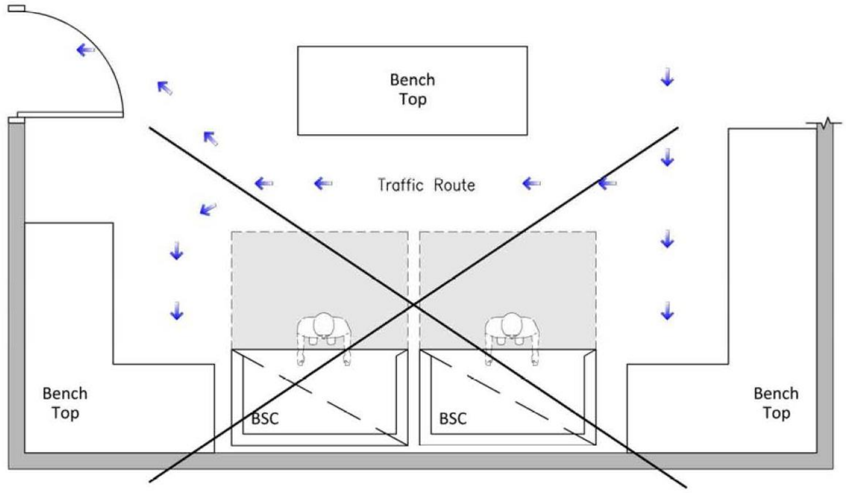
.11 Avoid placing BSCs near entryways. If unavoidable, maintain a distance of 1525mm to doorways behind workspace, and a distance of 1015mm to adjacent doorways:



.12 Avoid placing BSCs directly near benchtops. Designated workspace around BSC will be disturbed:



.13 Avoid crowding together benchtops and BSCs. Too much traffic produces dangerous disturbances to BSC airflow:



2.2 Specific requirements in architecture

.1 Building Envelope

.1 Building envelope performance and components can be adversely affected when adding negatively pressured spaces to a building. The impact of adding such space in an existing building should be carefully assessed at early design stage in order to implement remediation measures, when needed, to avoid triggering building envelope malfunctions. (e.g. humidity infiltration through walls, other areas exterior doors, and windows difficult to open, etc.).

.2 Windows

.1 To avoid adversely affecting the room pressures, there must be no opening windows in mechanically ventilated lab spaces;

.2 In spaces where fume hoods are installed, there must not be opening windows. If opening windows are present in an existing space to be renovated as a laboratory, these windows must be locked in place with temper-proof fasteners;

.3 In laboratory spaces handling biological material with no mechanical ventilation or fume hoods, opening windows must be fitted with insect screens;

.4 Direct natural light and views to the outside should be favored for laboratories and offices;

.5 If natural light and views to the outside cannot be provided, interior windows between the room and the corridor should be considered;

.6 All laboratories windows at ground floor level and basement level must be secured to prevent unauthorized access.

.3 Walls

.1 Whenever possible, specify modular demountable wall systems to allow for easy reconfiguration;

.2 Glass walls are preferable to allow visibility and transparency between spaces;

.3 Frosted films can be applied to a portion of the glass walls to signal the presence of the walls and also to provide some level of intimacy when required;

.4 Whenever possible, an easily accessible recess must be designed for housing the shower curtain of the emergency shower.

.4 Doors

.1 Whenever possible, each laboratory should have two exits;

.2 In buildings where the usage of hazardous materials is prevalent, laboratory spaces of 100 m2 and more must have at least two exit doors. (The likelihood of laboratories using high-hazard materials at some point is increased in these building);

.3 Doors from laboratory to corridor must open outward;

.4 Doors from laboratory to corridor must be self-closing (whenever possible);

.5 Provide clearance on both sides of door for moving of equipment and carts (space in front of doors must be free of obstacles and have side clearance);

.6 To allow for easy moving of equipment from/to the laboratory, doors shall be at least 1070mm wide by 2135mm high (42''x84'');

.7 Laboratory exit doors must have a glass panel or a sidelight to prevent collisions of persons entering/exiting (consider universal accessibility when planning the height of these elements);

.8 Doors and frames in laboratories must be in metal;

.9 Entrance door to laboratories shall be equipped with a door holder for laboratory information and entry caution card;

.10 See other door requirements in section Metal doors & Frames 08 11 14 of the Building Design Standards.

.5 Ceiling

.1 Ceilings should be designed to provide easy access to services.

.6 Flooring

.1 Flooring must be impervious, resistant to chemicals, washable and with 150mm high integral coving on the walls, fixed furniture or fixed equipment (liquid tight);

.2 Strippable and replaceable coating, for easier clean-up if contaminated, is preferred;

.3 Finishes in corridors from support spaces to laboratory spaces must offer leveled surfaces with no joints for safe transport of hazardous materials, glassware, etc.;

.4 Penetrations for electrical, plumbing, and other must be permanently sealed;

.5 Floor under the safety shower must be leveled and of a contrasting color to facilitate detection of shower location and placement of body under the shower head in case of an emergency (people have a tendency to walk with their head down, looking at the floor, in case of an emergency).

.7 Furniture and Casework

.1 Laboratory furniture and casework should be durable and designed and constructed in a way that provides for long-term use, reuse and relocation. Flexible furniture, casework and shelving are preferred;

.2 Seismic stabilization must be provided for furniture, casework and equipment that have the potential for falling over and for wall mounted shelving.

.1 Provide passive restraining system for shelving;

.2 Secure compressed-gas cylinders with chains or metal brackets, able to remain intact in a fire, to secure the cylinders in place (at 1/3 and 2/3 of cylinder height). Nylon cylinder straps are not acceptable;

.3 Flexible furniture and casework

.1 Mobile casework on wheels or other options to maximize flexibility and minimize costs are preferred;

.2 Whenever possible, provide mobile write-up stations of 1200mm wide and 760mm deep instead of fixed counters;

.3 Consider mobile carts equipped with levelers and castors for equipment storage. The carts should be load tested to support 2,000lbs and be designed with 25mm vertical slots to support adjustable shelving;

.4 Furniture should accommodate the use of computational technologies in mind. When necessary, provide monitor arms, server platforms, and keyboard drawer solutions.

.4 Flexible shelving

.1 Whenever possible, provide adjustable shelving instead of fixed cabinets. The bottom shelf should be 480 to 510mm above the benchtop and should stop 460mm below the ceiling;

.2 Provide shelf lips (edge guards) for seismic restraint. Lips should be 19mm above the shelf surface for bookshelves and 40mm above the shelf surface for shelves used to store breakable containers, chemicals, or other hazardous materials;

.3 Shelves for chemical should not be located above eye level when standing.

.8 Compressed gas cylinders

.1 Adequate provisions must be made for the storage of compressed gas cylinder. The cylinder must never be located:

.1 In an exit or corridor providing access to an exit;

.2 Under a fire escape, outside exit stair, passage or ramp;

.3 Within 1 meter of any exit.

.2 Gas cylinders mush be supplied with a chain to secure it to an architectural support.

.9 Acoustics

.1 General noise level in a laboratory should be kept at a maximum of 55dBA;

.2 Isolate noise sensitive areas from noise sources whenever possible;

.3 Provide noise reduction and isolation methods at source to lower the noise level;

.4 When required, walls and ceilings should be fitted with sound absorbing materials.

.10 Vibration

.1 For equipment that are vibration sensitive, provide special vibration-damping table or place them close to more vibration stable parts of the building such as at grade or near a column;

.2 Avoid placing vibration sensitive equipment near elevators and mechanical rooms.

.11 Signage

.1 All signage must be compliant to McGill's Interior Signage Standards.

.12 Interactive elements

.1 Provide opportunity for interactions between users to help drive innovation and collaboration processes, may it be informal meeting spaces or design elements that can prompt conversations.

.2 Whenever possible, provide writable surfaces and/or interactive screens to allow for informal discussions and presentations. Glass walls can be used as writing surfaces;

.3 Interactive display cases or panels, when required, should allow for easy access to promote a continuous update of the display materials.

.13 Cold Rooms

.1 Avoid placing cold rooms along the perimeter of the exterior walls or in locations which can obstruct access to natural daylight.

.2 Cold rooms must have viewing windows and three-ways light switches for internal and external control of light inside the cold room;

.3 Latch and frame must be designed to allow door functioning under all conditions (e.g. freezing). Magnetic latches are preferred.

Part 3 Plumbing

3.1 Planning considerations

.1 Design requirements

.1 Services and utilities main lines should be planned so the building's or adjacent spaces' services, and utility systems, will not be disturbed in the event of laboratory reconfiguration/repurposing;

.2 Connection points to services and utilities (valves and emergency disconnect) should be planned to facilitate future modification and adaptability to special research needs, without major changes.

3.2 Plumbing requirements

.1 Laboratory water lines

.1 As required by the latest version of CSA B64.10, the building potable water supply shall be protected against backflow resulting from back siphonage and back pressure from laboratory water lines. Where available, laboratory water lines shall be connected to existing dedicated laboratory water lines. If dedicated laboratory water lines are unavailable, connection may be made to the building water lines with appropriate backflow protection.

.2 Floor drains

- .1 Floor drains in laboratories must be limited to emergency shower's area, below the shower head, and be installed as far as possible from hazardous materials (including storage and fire cabinets) and fume hoods.
- .2 Provide trap primers in order to replenish the water seal and protect the lab from sewer gas fumes.

.3 Sinks

- .1 There should be at least one dedicated hand washing sink in each laboratory, preferably of a hands-free design. ;
- .2 Laboratory sinks must have lips to prevent overspills;
- .3 Wash-up sinks should be located in low traffic areas;
- .4 Do not install more cup sinks than required;
- .5 See section 22 42 02 for additional requirements.

.4 Faucets

- .1 Elbow, foot or electronic sensing faucet controls are recommended for laboratories handling biological agents and/or highly toxic chemicals;
- .2 See section 22 42 02 for additional requirements.

.5 Emergency equipment (safety station)

- .1 Specify barrier-free combination shower and eye/face wash safety station;
- .2 Eye/face wash head with flow control and metal pull-down valve;
- .3 Stainless steel showerhead with flow control;
- .4 Each safety station (eye-wash/shower) is to be equipped with thermostatic mixing valve;
- .5 See section 22 42 01 for additional requirements.

.6 Compressed gas

- .1 Whenever possible, line supplied gases must be used instead of gas cylinders since line supplied gases increase the potential for additional laboratories in buildings (multiple cylinders limit the quantity of gas);
- .2 Line supplied gases (natural gas, and compressed gases):
  - .1 Each point of supply must be identified with labels for each type of gases;
  - .2 Each valve at work stations must be color coded for identification of the gas it supplies, see section 22 05 00;
- .3 Each point of supply to the laboratory must have a manual shut off valve clearly identified as such. For flammable this valve must be located in a safety cabinet with a breakable transparent door (for emergencies);
- .4 See section 22 00 00 and section 22 15 00 for additional requirements.

.7 Vacuum systems

- .1 Consider the use of modular vacuum systems that can serve multiple users, operate on demand and are flexible to adapt over time;
- .2 Provide he exhaust pump with local ventilation to the outdoors
- .3 See section 22 00 00 for additional requirements.

.8 Emergency cut-off

.1 In the event of an emergency, the laboratory might be unsafe to enter. The laboratory’s gas and vacuum lines shut off valves should be located outside the laboratory, but in a close proximity to the laboratory and in a well identified location permitting easy and rapid access for cut-off.

.9 Neutralization basin

.1 When necessary, install an acid neutralization or dilution basin for liquid effluents from the laboratory;

.2 See section 22 42 01 for additional requirements.

Part 4 Heating, ventilation and air conditioning (HVAC)

4.1 Planning considerations

.1 Scope

.1 General exhaust ventilation is designed to dilute small sources of volatile contaminants such as fugitive emissions within a lab. More significant emission sources are controlled by way of local ventilation.

.2 Local exhaust ventilation, such as laboratory chemical hoods, must be used to control all point sources of emissions.

.3 Spills and other unexpected releases must be addressed by appropriate laboratory emergency planning and response procedures included in the Standard Operating Procedure.

.2 Definitions

.1 General exhaust ventilation, also called dilution ventilation, is different from local exhaust ventilation because instead of capturing emissions at their source and removing them from the air, general exhaust ventilation allows the contaminants to be emitted into the workplace air and then dilutes the concentration of the contaminants to an acceptable level (e.g., to the Permissible Exposure Level or below). (OSHA Technical Manual, III, 3).

.2 Local exhaust ventilation systems comprise fans, hoods, ducts, air cleaners, and stacks. Local exhaust ventilation is designed to capture an emitted contaminant at or near its source before the contaminant has a chance to disperse into the workplace air (OSHA Technical Manual, III, 3).

.3 Ventilation effectiveness: refers to the relative uniformity of the decay of air contaminants within the workspace.

.4 Occupied mode: where the building controls system sensors recognize that a person is physically within the room and the ventilation must increase to control the accumulation of contaminants.

.5 Unoccupied mode: where the building controls system sensors recognize that there is no one present in the room and where the ventilation is consequently allowed to decrease.

.6 Hibernation mode: in laboratories in use, hoods which are anticipated to not be used for an extended period of time (e.g. a few months) can be put in hibernation mode, i.e. locked and with their ventilation exhaust temporarily shut down. Storage of chemicals and experiments are not allowed within fume hoods in hibernation.

.7 Vacant mode: a vacant laboratory is one that isn't assigned to any occupant, and therefore, can have the general ventilation and fume hoods turned down to levels needed only for general temperature control and minimum airflow required as per ASHRAE 62.1.

.8 The owner's project requirement (OPR) is a written document that details the ideas, concepts, and criteria determined by the owner to be important to the success of the project (LEED v4).

.9 The basis of design (BOD) is the information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines (LEED v4).

.3 Basis of Design

.1 The designer shall provide a basis of design (BOD) statement for all laboratory designs that clearly defines all system criteria and assumptions made during the project design process, as per ASHRAE's Laboratory Design Guide, Second Edition. The BOD will be informed by the owner's project requirements (OPR) as well as the risk assessment prepared by McGill's Environmental Health and Safety department.

.2 The BOD shall include, but not be limited to, items such as laboratory air change rates in different modes, anticipated chemical usage, description of the air flow control system, equipment loading, anticipated occupancy, diversity factors, as well as references to codes and standards used.

.3 The BOD shall also include the following lab performance indicators: energy use intensity (in GJ/m^2.yr, use gross area for the denominator), number of fume hoods per 5,000 ft^2, anticipated population density, and overall ventilation efficiency in W/cfm or W per L/s.

.4 Airflow modelling and dispersion analysis

.1 Computational fluid dynamics (CFD) modelling shall be used to verify ventilation effectiveness on all new buildings and major renovations that include laboratory facilities with a total project cost exceeding $5.0M. On projects with total costs between $500k and $5.0M, contact McGill's Environmental Health and Safety, Building Operations, and Utilities & Energy Management departments to discuss whether modelling is required.

.2 Alternatively, tracer gas tests can be performed to assess the ventilation effectiveness of labs in lieu of CFD modelling by analyzing concentration half-lives at different ventilation rates and locations in the lab. Contact McGill's Environmental Health and Safety, Building Operations, and Utilities & Energy Management departments to discuss the acceptability and conditions of the test.

.3 A dispersion analysis shall be performed on all new buildings and major renovations that include laboratory facilities with a total project cost exceeding $5M. On projects with total costs between $500k and $5M, contact McGill's Environmental Health and Safety, Building Operations, and Utilities & Energy Management departments to discuss whether said analysis is required.

4.2 Laboratory design criteria

.1 Laboratory ventilation rates:

.1 Laboratory ventilation rates must be maintained based on Occupied or Unoccupied modes. The ventilation rates, fresh air, and temperature set points shall vary with occupation and based on applicable codes.

.2 Laboratories shall be designed to operate at the following default ventilation rates:

.1 Occupied mode: 10 air changes per hour (ACH);

.2 Unoccupied mode: 6 air changes per hour (ACH);

.3 The mechanical systems shall be adjustable and capable of operating at lower flowrates:

.1 Occupied mode: as low as 4-6 ACH;

.2 Unoccupied mode: as low as 2-3 ACH;

.3 Hibernation mode: general ventilation as needed to maintain ventilation rates as required per applicable code;

.4 Vacant mode: depending on the controllability of the air devices at their lower range.

.4 **This notwithstanding, higher ventilation rates may be required, and lesser may be acceptable, when the laboratory process is well defined.** The designer must demonstrate that the proposed ventilation rate will control room air contaminant concentrations below the current Threshold Limit Value – Time-Weighted Average (TLV-TWA) applicable.

.5 The designer must consider installation of an air-sampling system to monitor lab air quality and modulate ventilation rates based on the concentration of contaminants in the workspace. The recommendation to install this type of system shall be based on a risk assessment and a total cost of ownership (TCO) analysis. Contact McGill’s Utilities & Energy Management to get a copy of McGill’s TCO template and parameters.

.6 The designer shall include provisions for room purge in rooms where the storage of high hazard chemicals is anticipated. A highly visible push button to activate the purge must be located near each emergency exit of the lab.

.2 General exhaust ventilation

.1 Ventilation

.1 General room ventilation shall be provided to prevent the build-up of fugitive emissions in the laboratory. A general room ventilation system shall be designed to maximize the clearance of contaminants from the room while minimizing overall energy use.

.2 Variable air volume (VAV) should be used.

.3 Laboratory exhausts should be manifolded to allow heat recovery. Heat recovery systems shall be designed to prevent cross-contamination.

.4 All new and retrofitted laboratories shall be equipped with dual-technology (infrared and ultrasound) occupancy detection to control lighting and ventilation.

.5 The ventilation system that supplies make-up air to laboratories and the ventilation system(s) for other types of spaces in the building (e.g., office, conference rooms, common areas, etc.) shall be segregated (separate units, separate controls, separate exhausts, no combative situations).

.6 Connecting office and laboratory spaces should be designed to prevent laboratory emissions from entering office spaces.

.7 Pressure sensors must be installed to monitor the pressure differential between laboratory areas and adjacent spaces (e.g. between the lab and the corridor) so as to ensure proper pressurization.

.2 HVAC Terminal Elements

.1 Terminal elements shall consist of venturi valves with pressure-independent flow control, for variable-speed operation. The valves shall be complete with variable speed motor and accessories.

.2 The valves shall be provided with their own stand-alone controls, which shall be compatible with the Building Automation System (BAS).

.3 Terminal boxes are not acceptable. Any variation of concept or design of the terminal elements described here, need to be submitted to McGill's Building Operations department through a variance form.

.4 The designer must select and locate air diffusers in order to to maximize ventilation effectiveness. For instance, diffusers must be located so as to push contaminants away from lab users while maximizing thermal comfort.

.3 Local exhaust ventilation

.1 Fume hoods

.1 There should be at least one fume hood per laboratory or, when feasible and if the future use of a fume hood is anticipated, one dedicated ducted line for subsequent installation.

.2 Ductless chemical fume hoods are not acceptable.

.3 Motors for chemical hoods shall be explosion proof if the motor is located in the air stream. Metal parts are to be covered with HERESITE coating.

.4 Manifolding of hoods is only allowed for fume hoods with similar type of use and where no chemical reaction can occur. Fume hoods designed for the exhaust of perchloric acid or radioactive contaminants must have dedicated exhausts.

.5 No laboratory hood installation is allowed in rooms with return air to other spaces. All chemical use rooms shall have 100% exhaust capability.

.6 The design professional shall specify, on design drawings, the following parameters for each fume hood: full open and operating design face velocities and area. Also specify minimum flow and response time.

.7 Fume hood and ventilation system design shall be flexible enough to allow for the hibernation and de-commissioning of up to 25% of the hoods located in a space supplied by the same air make-up system. Careful consideration should be taken when sizing and selecting ducts, fans, diffusers, etc.

.8 Fume hoods must be certified to ensure safe working conditions with face velocities as low as 60 fpm using the ASHRAE-110 Method of Testing.

.9 Fume hoods shall be designed with automatic sash closure and occupancy detection at the fume hood level to modulate face velocity and the system's static set point when the fume hood is unoccupied.

.1 The control system shall reduce fume hood face velocity and airflow rates to the minimum allowed values.

.2 These values shall be determined through a risk analysis conducted by the design team in conjunction with representatives of laboratory users, McGill's Environmental Health and Safety, and Facilities, with respect to applicable standards and regulations.

.3 Among others, the risk analysis shall take into account: the amount and nature of chemicals that will be used under the fume hoods, the expected by-products of chemical reactions, the time of use of the hoods, the types of users and their level of experience, and the impact of the surroundings on the fume hood's performance.

.4 The risk analysis shall be documented, include recommendations on the face velocity and ventilation rates to be maintained in the fume hood and in the laboratory during occupied and unoccupied times, and the rationale behind the recommended values.

.10 All fume hoods controls shall be connected to DDC controls (Building Automation System).

.11 All hoods must be equipped with an audible alarm to alert users whenever a hood is not delivering the required face velocity.

.12 It is recommended that a display indicating the fume hood's status (ON/OFF) and face velocity be installed on each fume hood. The designer shall confirm with lab users whether such display is required

.2 Chemical storage cabinets

.1 All laboratories where the use of chemical products is planned or foreseen must be equipped with storage cabinets. Fume hoods shall not be used to store chemical products.

.2 Flammable and acids storage cabinets must be vented unless odour or vapour control is not a concern;

.3 If vented cabinets are used, they must be vented independently to the outdoor with ducting providing a fire protection at least equivalent to the cabinets'. Exhaust through the building general ventilation system is not acceptable;

.4 If not vented, the standard ventilation openings in the cabinets must be sealed with caps providing a fire protection at least equivalent to the cabinets'.

.4 Utilities

.1 McGill's utility distribution networks and central systems shall be preferred over independent systems.

.5 Energy recovery

.1 Heat must be recovered from the laboratory exhaust air.

.2 The designer shall provide the most efficient heat recovery system. This notwithstanding, the most appropriate system shall be identified by hazard analysis so as to limit carryover and cross contamination as per ASHRAE 62.1.

.3 In laboratory spaces with a lot of heat-generating equipment (i.e. with high cooling load), dedicated equipment to extract heat (e.g. fan coil) shall be installed in order to minimize the general ventilation requirements for those spaces. When a heat-recovery loop is available in the building, the aforementioned equipment should discharge its heat on this dedicated loop.

.6 Commissioning

.1 Fume hoods must be certified to ensure safe working conditions using the ASHRAE-110 Method of Testing.

.2 Biosafety cabinets must be certified using the ANSI 49 performance test.

.3 Verification of room pressurization shall be validated using instrument testing and visual confirmation of flow direction.

.4 Equipment balancing includes the general HVAC system and other local exhaust ventilation systems (i.e. fume hoods, biosafety cabinets, snorkels, etc.) according to ASHRAE Lab Design Guide (p. 231)

.5 Generally speaking, equipment and systems must be tested against the design parameters defined in the BOD.

Part 5 Electrical

5.1 Planning considerations

.1 Design requirements

.1 McGill's utility distribution networks and central systems shall be preferred over independent systems;

.2 Safety station

.1 No electrical apparatus, telephones, thermostats or power receptacles should be located within 1830mm of either side of the emergency shower or emergency eyewash facility. If receptacles are necessary within 1830mm, they should be equipped with ground fault interrupters (GFI).

5.2 Electrical requirements

.1 Lighting

.1 When planning for lighting, consider natural light as the primary daytime light source. Electric lighting should be designed as a supplement to daylighting or for detailed task work;

.2 Design lighting according to IESNA recommendations for research laboratories or educational facilities;

.3 Lighting fixtures arrangements should avoid casting shadows onto benchtops and other working surfaces;

.4 The selection of fixtures must take into consideration the appropriate lighting levels required for the type of spaces and the nature of work undertaken;

.5 When necessary, provide a combination of task lighting and overhead lighting;

.6 Hood lighting and other fixed electrical equipment within the hood shall be explosion-proof.

.7 Install dual-technology (infrared and ultrasound) occupancy detection to control lighting. When commissioning, ensure that the lighting zoning conforms to design requirements.

.2 Laser and X-ray machines

.1 Install illuminated X-ray laser warning signs at eye level alongside entrance doors;

.2 Laser warning signs must meet ANSI Z136.1 and Z136.5 requirements;

.3 X-ray & Lasers are to be equipped with interlock relays for emergency shut-off.

.3 Emergency exit signs

.1 Every exit door of a laboratory shall have an exit sign placed over or adjacent to it;

.2 Where the exit door is not visible from an aisle, provide an exit sign with an arrow or pointer indicating the direction of egress.

.4 Emergency power and lighting

.1 Emergency egress lighting must be provided in the area where hazardous products or process are used;

.2 Laboratory must be designed with at least one power point on emergency power;

.3 Fume hoods must be connected to an emergency power system capable of supplying at least half of the normal air-flow (in the event of power failure, back-up power will ensure that chemicals continue to be exhausted).

.5 Wires and cabling

.1 Provide wire management systems that enable quick and low-cost reconfiguration;

.2 Integrate wireless and mobile technologies as appropriate and necessary;

.6 Overhead service carriers

.1 Install overhead service carriers to provide quick and flexible access to services such as electrical, data, telephone, HVAC, local exhaust systems, lighting and plumbing services throughout the laboratory;

.2 Specify suspended or flush-mounted carriers from the ceiling;

.3 The utility services should run above the ceiling and should have quick connect and disconnect for easy hookups to the overhead service carriers.

5.3 Telecom requirements

.1 Data

.1 Servers scattered around campus put a strain on HVAC systems and the heat they generate can seldom be recovered in a cost-effective manner. McGill's IT Services manages a highly efficient and reliable Data Centre which has its own dedicated emergency power system to ensure continuous operation of the servers and the air conditioning systems to support them; heat generated by the servers is recovered and used to heat other buildings in the vicinity. All qualified computer equipment shall be installed in McGill's central Data Centre.

.2 Communication and network

.1 Interactive technology

.1 When required, provide information and communication technologies to allow for global networking with other laboratories, real-time monitoring or remote access to virtual laboratories;

.2 These equipment could include videoconferencing equipment, projectors, monitors, cameras, microphones, etc.

.2 Computational technology

.1 Access to the University computer network must be possible in each laboratory;

.2 Plan for a growing use of internet communication and ‘plug and play’ infrastructure so that users can connect their own computational devices (tablets, laptops, cellphones, etc.) when necessary.

.3 Rules and Regulations

.1 All network capable devices must connect to the McGill network and abide by the Policy on the Responsible Use of McGill Information Technology Resources, available at https://www.mcgill.ca/secretariat/files/secretariat/Responsible-Use-of-McGill-IT-Policy-on-the.pdf

.2 Network behind networks are not allowed unless an exemption is allowed by IT Services. See IT services for supported technologies;

.3 Supported network technologies can be found on the McGill IT web page.

.4 Any wireless technology must not use the frequencies that interfere with the McGill network. The specific wireless frequency ranges McGill uses (and other must avoid) are 2.40GHz – 2.5GHz (2.4 GHz Range) and 5180 MHz – 5875 MHZ, (5 GHZ range).

.3 Emergency communication

.1 Safety in the laboratory should not depend on cellular phone communication. Each laboratory must be equipped with a telephone or alternate wired emergency communication system, such as an Emergency Telephone:

.1 This wired communication equipment must be easy to reach, located in a high visibility point, preferably close to the primary entrance door or safety station, and clearly identified;

.2 It should be accessible to people using wheelchairs;

.3 Its location should be consistent from laboratory to laboratory.

.4 Emergency alarms

.1 The design and installation of emergency alarms systems and components must be coordinated with University’s Fire Prevention Office (FPO).

.5 AED’s

.1 All new facilities should have access to an Automated External Defibrillator (AED).

.2 The AED should be located in a display cabinet mounted in a visible location familiar to the majority of building users, for example beside the elevators in the main lobby of a building.

.3 AED cabinets should be wired to the Security Services Dispatcher to send a signal that someone has opened the cabinet.

Part 6 **Related Technical Sections**

The technical sections of the McGill Building Design and Technical Standards should be consulted with the current document, most notably (but not limited to) the following:

Section Number	Title of Section
Special Building Areas	Animal Facilities
01 81 13	Sustainable Design Requirements
01 86 00	Facilities Services Performance Requirements
01 91 13	General Commissioning Requirements
08 11 14	Metal Doors and Frames
08 71 10	Hardware
09 22 27	Suspended Ceiling
09 65 16	Resilient Sheet Flooring
09 91 26	Painting
11 53 13	Laboratory Fume Hoods
12 35 53	Laboratory Casework
12 35 54	Chemical Storage Cabinets
12 50 00	Furniture
22 00 00	Plomberie
22 05 00	Exigences générales concernant les résultats des travaux
22 42 01	Appareils spéciaux
22 42 02	Éviers et cuviers
23 00 00	Heating, ventilation and air conditioning
25 00 00	Automatisation Intégrée
26 50 00	Éclairage

END OF SECTION