Sustainability Project Fund Application

Project Title: SP0091 - Mercury Free Microscopy, Phase 2 – Renamed – Green Light Microscopy (GLM)
Budget Requested: $39,482
Applicant/Project Leader: Dr. Claire Brown

Contact Information:

Last Name: Brown
First Name: Claire
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Affiliation: Academic
Faculty/Unit: Medicine, Physiology, Assistant Professor

Links and media coverage:

- *Mercury Free Microscopy at McGill:* http://www.mcgill.ca/MFM
- *BioOptics World: "Fluorescence Microscopy: A program to help labs 'go green"* http://www.bioopticsworld.com/articles/print/volume-6/issue-6/departments/news-notes/fluorescence-microscopy-a-program-to-help-labs-go-green.html
- *BioOptics World: "Fluorescence Microscopy/Light Sources"* http://www.bioopticsworld.com/articles/print/volume-6/issue-6/features/fluorescence-microscopy-light-sources-light-engines-lighting-the-way-to-mercury-free-microscopy.html
- *Journal of Biomolecular Techniques: "Mercury Free Microscopy: An Opportunity for Core Facility Directors"* **Outstanding Manuscript Award – 2014** http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3970759/
- *My Green Labs:* http://www.mygreenlab.org/mercury-free-microscopy.html
- *Green Light Microscopy:* http://greenlightmicroscopy.org/index.html

Project theme(s):

academics, community, energy

Project Group:

Claire Brown (CB)	Claire.brown@mcgill.ca	Advanced BioImaging Facility (ABIF)	514-677-7493
Erika Wee (EW)	Erika.wee@mcgill.ca	Advanced BioImaging Facility (ABIF)	514-398-5248
Guillaume Lesage (GL)	Guillaume.lesage@mcgill.ca	Cell Imaging & Analysis Network (CIAN)	514-398-5414
Elke Küster-Schöck (EKS)	Elke.KusterSchock@mcgill.ca	Cell Imaging & Analysis Network (CIAN)	514-398-5414
Thomas Stroh (TS)	Thomas.Stroh@mcgill.ca	Montreal Neurological Institute (MNI)	514-398-2719
Regan Baird (RB)	regan@greenlightmicroscopy.com	Close Focus Consulting	857-928-5099

I. Project Overview

Project summary:

In December 2012, The Advanced BioImaging Facility (ABIF, Physiology), the Cell Imaging and Analysis Network (CIAN, Biology) and the Montreal Neurological Institute (MNI, MUHC) microscopy core conceived the **mercury free microscopy (MFM)** program and it was funded by the McGill Office of Sustainability. The grant funding plus funding from the ABIF, CIAN, the MNI Microscopy core and Lumencor, Inc. was used to replace nine mercury based light sources with new solid state mercury free systems eliminate approximately one kilogram of mercury waste from McGill. Two PHGY396 undergraduate research projects showed that the LED technologies had increased light intensity output, increased intensity stability, reduced consumable costs and decreased power consumption. In September of 2013, the team presented the LED light source results to faculty, staff and students from across campus. Seven light source companies funded the event with sponsorships and set up information booths to present their LED based technologies (see the Event Brochure - Appendix 1). The program was highlighted by **BioOptics World** in 2014 and the research results were presented at the Canadian Cytometry and Microscopy meeting (June 2013) and at the international Association of Biomolecular Resource Facilities (ABRF) meeting (March 2014). An article on how core facilities can integrate LED based light source initiatives into their operations and also act as ambassadors on their respective campuses to promote the green initiative was published in the Journal of Biomolecular Techniques and was recently awarded the **outstanding manuscript award** for 2014. Drying phase 1 of the project we created marketing material that is on display in the three team member facilities and has been incorporated into educational materials (Poster – Appendix 2).

The program, Mercury Free Microscopy, will be renamed **Green Light Microscopy (GLM)**. GLM is a more inclusive name that will not be limited to mercury free initiatives. It includes all of the sustainable advantages of the program in

addition to the elimination of mercury such as reductions in energy consumption, health hazards, ownership costs and waste streams. This name also indicates that microscopes will perform more efficiently with an upgrade to a sustainable lighting solution. All of the MFM marketing material will be updated to reflect this new name.

The team is now looking for additional funding for **GLM-Phase 2** of the initiative. In order to be a true ambassador of GLM the ABIF has been chosen to be the first McGill Microscopy core facility to go completely mercury free. In order to do so the 5 remaining mercury based light sources in the facility will be replaced. A quote for the five replacement systems is attached. The systems will be incorporated into existing Zeiss equipment on campus and Carl Zeiss Canada is very supportive of the initiative and will maintain the equipment after it is purchased. A campus wide campaign of awareness to remove old mercury based technologies and replace them with sustainable light sources will be expanded. Educational initiatives and student projects to investigate new and emerging light source technologies will be conducted. Two or more PHGY396 projects will continue the work in partnering with companies and testing different light sources on the market for optimal performance and economic feasibility. In addition, funding for one summer student to streamline this testing is requested. A second set of PHGY396 projects and a second summer student will focus on completing an inventory of the total number of existing mercury containing light sources in the life sciences complex (LSC). The projects will also involve determining estimates of the total return on investment economically and environmentally of a complete GLM conversion beginning with the LSC. This will lay the groundwork for a full campus wide GLM initiative. The project will investigate the role external stakeholders such as Quebec, Hydro Quebec, Environment Canada, UNEP, and other institutions can play in this light source replacement initiative. The team will also develop an incentive program to encourage researchers to replace their existing mercury based light sources. Some of the incentives for researchers will include reduced consumable costs, better instrument performance, reduced energy consumption and a stake in Vision-2020.

Project eligibility:

Research laboratories are energy intensive, resource heavy, and produce significant amounts of hazardous waste. Most sustainable projects for laboratories focus on the laboratory as a structure, but not the laboratory as a research team. The GLM initiative will affect laboratory workers as tenants of sustainability. Researchers will be consciously choosing a sustainable solution for vital laboratory instruments that not only reduces energy, hazardous materials, and costs but also simultaneously improves their science. Phase 1 of the project encouraged researchers to avoid bringing new mercury based light sources on campus through our work with **Procurement Services (PS)** and the **Office of Sponsored Research (OSR)**. The Phase 1 campaign has influenced the types of light sources that light source vendors recommend with most almost exclusively quoting mercury-free solutions. Phase 2 of GLM will focus on existing microscopes containing mercury based light sources. The awareness campaign will continue and new GLM literature to educate microscope owners will be created. The work with the OSR and PS will continue so that mechanisms can be developed to flag proposals or purchases with mercury based light sources and encourage mercury free alternatives. Throughout the inventory process laboratory workers will be reminded about the contamination potential of mercury based light sources, compliant mercury bulb disposal procedures, and will be encouraged to consider the merits of mercury free alternatives. The GLM outreach program will be used as a gateway for other sustainable messaging from McGill Sustainability, EHS, or other offices to continue to encourage sustainable laboratory practices.

SPF Funding Use:

The long term goal is to work closely with the McGill Office of Sustainability to eliminate all mercury-containing microscope light sources on campus, and bring **McGill** to the forefront as a **leader in GLM** for other institutions to follow. This project was originally identified as a large multi-phasic undertaking, starting with Phase 1 of SP0091. In order to continue on this path, the education programs and events will be extended as a follow-up to our successful campaign in 2013-2014. As a second step the SPF funding will be used to eliminate all mercury based light sources in the ABIF so it can be a flagship and model for GLM at McGill and internationally. Continued testing of current and emerging light engine technologies through PHGY396 projects and summer student stipends will identify the leading technologies in the field. Partnerships will be built with several of the corporations producing green lighting solutions. The ABIF already has strong relationships with the leaders in the field so these relationships will be built upon. As with Phase 1, the results of the studies will be presented on GreenLightMicroscopy.org, in GLM workshops, webinars, on posters in the three member facilities, at external scientific conferences, and in published manuscripts. All mercury based light sources in the LSC will be catalogued and laboratory staff will be directly engaged and educated about the benefits of mercury-free light sources. Other stakeholders such as the McGill Office of Sustainability, GLM corporations with mercury free light sources, facilities, PS, OSR, Hydro Quebec and Environment Canada will also be engaged to develop a new fund for GLM replacement campus-wide. A campus-wide GLM conversion plan will be developed in Phase 3 of the project.

Performance indicators:

Determination of the amount of mercury **eliminated** from the waste stream at McGill. Almost a **quarter of a kilogram of mercury** per year was eliminated in Phase 1 of the project. Inventory of the current number of mercury containing light sources in the LSC and associated departments along with estimates of reductions in power consumption will allow for an accurate estimate of the **power savings** and the additional **kilograms of mercury** removed from the McGill waste stream. Providing summer internships and interesting scientific and ”green” PHGY396 projects will be very valuable experiences for the students involved. As with Phase 1 of the project facilities will assist in determining the power consumption of the newest generation of GLM compatible light sources and estimates of power savings will be made. The outreach activities can be evaluated by numbers of researchers impacted and through exit surveys following the events. Numbers of GLM compatibility purchases over the course of the project will provide a metric of impact. Metrics will be used to develop microscopy based items that can be incorporated into the sustainable labs check-list. Success of the identification of additional stakeholders, including light source vendors, the government of Quebec, Hydro Quebec, Environment Canada and solicitation of funding for the GLM initiatives will be indicated by the number of stake holders who buy into the GLM initiative and the amount of funding they allocate.

Sharing Outcome with the Community:

The project involves participation of investigators that are in the Faculty of Science, Faculty of Medicine and a part of the MUHC. Users from these facilities are from departments across campus ranging from Chemistry and Physics to Biomedical Engineering and Oncology. Outreach will be through the facilities informing the hundreds of users who come to the cores, both verbally during consultations and training, and with posters near the microscopes. OSR grant applications or instrument orders that go through PS will be systematically identified and flagged, and investigators will be informed about GLM with a two page flyer (Appendix 3). Outreach through information sessions, at the Montreal Light Microscopy Course in 2016 and at national (CCMA) and international (ABRF) meetings will ensure microscopy users and core facilities around the world are aware of the benefits of GLM. At least four students will be trained and educated in GLM through summer internships and PHGY396 projects. The group will work with media outlets like BioOptics World, McGill campus based media and others to disseminate the GLM initiative. The publication of additional work in journals such as the Journal of Biomolecular Techniques will benefit the program at the international level similar to our accomplishments in Phase 1 of the project. The GLM website (www.greenlightmicroscopy.org) will be central to disseminating information.

Stakeholders:

- **Advanced BioImaging Facility (ABIF), Cell Imaging and Analysis Network (CIAN), Montreal Neurological Institute (MNI) Microscopy Core:** The ABIF will benefit from GLM compatible light sources, will save on staff hours for maintenance of mercury based light sources, will reduce operating costs because of reduced costs for consumables. The three facilities will act as ambassadors for GLM at McGill. Information gained in Phase 2 will direct the purchase of new GLM compatible light sources.

- **Departments of Biology and Physiology, and the MNI:** All invest considerably in the core facilities and will benefit from the GLM with better use of staff time and better quality light sources for high end quantitative light microscopy applications. Members of the departments who own mercury based light sources will gain from the education and incentive programs developed during Phase 2.

- **Close Focus Consulting:** Has invested considerable time and effort developing the GLM program with the ABIF at McGill and other institutions internationally. They have developed GreenLightMicroscopy.org as a resource to share the GLM sustainable message, including our work, with microscope owners globally. They will provide the link to other GLM programs currently in development around the world, links to corporate partners and will provide expert advice about the development of the funding model created.

- **McGill University:** McGill will continue as a pioneer of the GLM sustainability project in Canada and internationally. To our knowledge no other such initiative exists. The university will see a reduction in energy consumption, save thousands of dollars in mercury waste removal charges and employees will not have to work with this hazardous material. Researchers who take advantages of the incentives to upgrade to GLM technologies will benefit from reduced staff time, consumable costs and power consumption for their microscopes. They will also be aware of “green” microscopy hardware and the GLM initiative on campus.

- **Carl Zeiss Canada:** Zeiss will invest in the project by providing a discount on the purchase of the new mercury free light sources and will play a role in GLM education. They will benefit from the research data generated.

Others affected by the project:

Any researchers in the LSC and affiliated departments who have a mercury based light source or are planning to purchase a new fluorescence microscope will be affected. They have not been consulted yet. A major part of the project will be to identify these researchers and educate them about GLM compatible light sources. Another major initiative is to create incentives to phase out mercury based light sources and to generate a fund to assist in the upgrade costs. Procurement and OSR will also be affected by the project. They are aware of the project and are supportive.

II. Project Implementation: See Milestones/timetable in Appendix 4.

III. Financials: Critical Date: Funding should be secured as soon as possible so summer interns can be hired.

Detailed expenses:

Five GLM compatible light sources will be purchased for the ABIF to make the facility completely mercury free. Two interns will be hired for the summer of 2015 for 16 weeks ($6,000 stipends) to work on the two project areas. Summer Intern 1 will work with corporate partners and test the most current light sources on the market, analyze the data and present it at information sessions and to existing and potential new stakeholders. The ABIF has recently signed an NDA with Excelitas and is testing a new light source that is not even on the market. Summer Intern 2 will catalog existing mercury based light sources in the life sciences complex and affiliated departments, and develop marking material and incentives for researchers to upgrade to GLM compatible light sources. Two or more PHGY396 students will work on the project areas in the fall of 2015 and/or winter 2016 and will continue the work of the summer interns. There will be **no cost** for these students as they will do the project for credit. Information sessions and conference expenses are listed but will be **offset by corporate support**. This funding is not secured but precedent for this funding has been set as the information session in 2013 was fully funded with $3,000 of corporate support. A small budget is set for graphic design and printing of educational posters for the core facilities and across campus. Consulting costs are budgeted but offset by Close Focus Consulting who will **donate their time**.

Expense Description	Cost
Five Light Engines	$30,824
Taxes (6.937%)	$ 2,138
Summer Intern 1–16 weeks	$ 6,000
Summer Intern 2–16 weeks	$ 6,000
PHGY396 Student 1	$ 0
PHGY396 Student 1	$ 0
Scientific Conferences	$ 5,000
Graphic Design and Printing	$ 2,000
Consulting Services	$10,000
Total Expenses	**$61,982**

Revenue Description	Revenue	Confirmed
Sustainability Projects Fund	$39,482	No
Close Focus Consulting	$10,000	Yes
Carl Zeiss Canada In Kind	$ 4,928 (in-kind plus tax savings)	Yes
ABIF/CIAN/MNI	$ 5,000	Yes
Corporate Support - Outreach Events	$ 5,000	No
Total Revenue	**$61,982**	

IV. Additional information:

Dr. Brown has been the director of the ABIF for 9 years and she successfully managed the oversight of Phase 1 of the project. Dr. Lesage and Dr. Stroh have been directing their respective core facilities for 9 years. The team has a combined experience of over 60 years working in microscopy. We have published in peer-reviewed journals and written book chapters on microscopy related topics. The facilities have organized more than 60 courses and workshops including the MLMC which runs every two years and reaches students, corporations and other core facility staff from around the world. Their extensive expertise and their extensive network of researchers and corporations in microscopy will make the awareness campaign highly targeted with a broad base for outreach. The group also has very close ties to the ABRF – the international association of core facilities. Appendix 5 shows how the project is aligned with almost every action point for **Vision 2020**.

McGill

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Department of Physiology
Life Sciences Complex Advanced BioImaging Facility
3649 Prom. Sir William Osler, Bellini Building
Montreal Quebec H3G 0B1

Attn: Dr. Claire Brown

Subject: Mercury Free Microscope Program

As a member in the McGill 2020 Sustainability Project and a member of the McGill Procurement Sustainability I had the pleasure to work on the first project that was approved by the Sustainability Projects Fund (SPF) directed to Dr. Brown to pursue the Mercury Free Microscope Program.

This program hit all of the "hot" buttons that were of interest to SPF committee. Not only was this a movement toward a more sustainable energy efficient program by increasing the bulb life cycle from 200 hours to a multiple of 10 times (X10) therefore reducing continuous replacement and alignment time by lab staff, and the reduction of electrical usage, but also rid McGill of the hazardous mercury component that was a potentially dangerous to lab staff and those of our hazardous waste management staff.

Based on the extensive study and experimentation of various platforms offered in the marketplace, Dr Brown was able to conclude that the LED light version was as good of not better in performance than the existing mercury bulb technology as it relates to scientific experimentation. Not only is this a tremendous result for the Life Sciences at McGill but can now be expanded to a campus wide initiative that will include all other Facilities and Departments that are part of the McGill network.

It is without saying that continued funding is required in order to push this project through its next phase and I fully encourage and will continue to support this project.

Yours Truly,

Graham R. Currie
Lead Buyer – Faculty of Medicine, McGill

Thomas Stroh, Ph.D.

Professeur adjoint
Département de neurologie et neurochirurgie

Assistant Professor
Department of Neurology and Neurosurgery

02 April, 2015

RE: Green Light Microscopy Initiative

Dear Claire,

On behalf of the MNI Microscopy Core Facility, it is my pleasure to continue our participation in and support for the Green Light Microscopy (GLM) initiative at McGill University. As you know, we already participated in the first installment of the program, then termed Mercury Free Microscopy (MFM) program. Through its support we replaced two of our mercury-based light sources with mercury-free SOLA light sources with great success. In our ongoing training sessions for microscope users and in information sessions with new and established PIs at the MNI we also educated the community on the availability and advantages of environmentally friendly light sources and are continuing to do so. Therefore, I am very pleased that the initiative is now widening its scope to include all aspects of sustainability related to light microscopes as reflected in its new name. The MNI Microscopy Core Facility will be proud to continue supporting the initiative and I will personally lend all the support to it that I can muster. I am happy to assist in student project supervision, the development of a new funding model for mercury light source replacement and to continue to educate and make people aware of sustainability initiatives in light microscopy. I am happy to play a central role in developing plans for Phase 3 of the initiative and do all I can to get the MNI 100% on board with phasing out mercury based microscope light sources. The dedication of the MNI facility to this project is evident by our $2,000 financial support of the Phase 2 initiative. I am looking forward to continuing to work with you on this very fruitful project.

Sincerely,

Thomas Stroh, Dr. rer. nat.
Director MNI Microscopy Core Facility
Montreal Neurological Institute, McGill University
3801, University Street, # 896
Montreal, Quebec
H3A 2B4
Canada

McGill | Faculty of Science | Faculté des sciences

Tuesday, April 7, 2015

Dear Claire,

The Cell Imaging and Analysis Network (CIAN) is very excited about the sustainability project to develop Green Light Microscopy (GLM) at McGill. The CIAN is happy to contribute to the GLM initiative by giving $1,000 to help survey microscope light sources at McGill. In addition, the facility is willing to include information about sustainable light sources as part of our one-on-one training programs. We will put signage throughout the facility and will be happy to participate in educational sessions throughout the year. There are many researchers in the Biology Department who use mercury based light sources in their laboratories and we will educate them on the advantages in moving to more sustainable environmentally friendly systems.

We are looking forward to working on this project with you.

Sincerely,

Guillaume Lesage, Ph.D., Administrator

Cell Imaging and Analysis Network
Department of Biology
McGill University
1205 Dr. Penfield Ave, Rm N5/25
Montreal (QC) H3A 1B1
Canada

Sustainability at McGill

McGill University is proud to be a leader in sustainability.
Our commitment is embodied in the many truly innovative projects underway across McGill as we aspire to achieve the highest possible standards of sustainability on our campuses—in our day-to-day activities, through our academic practices, in our facilities and their operations, and by our outreach to the broader community.

***Heather Munroe-Blum**, Past Principal and Vice-Chancellor*

Sustainability Projects Fund (SPF)

In the fall of 2009 McGill's three student societies — SSMU, MCSS, and PGSS — came together with McGill in a partnership to create the Sustainability Projects Fund (SPF). The proposal was passed by a student referendum in 2009, with 79% of voters – some 5,300 students - voting to adopt the fund. In 2012 students voted to continue the fund for another three years. McGill matches dollar-per-dollar student contributions to the fund.

Over 100 SPF projects funded!

Aboriginal Sustainability (SP0039), Addressing Business Travel Behaviour (SP0061), Apartment Gardens (SP0001), Bellairs Recycling Program (SP0030), Biodiesel Production (SP0070), Biodigester Feasibility (SP0082), Butterfly Garden (SP0048), Cafe Rhizae (SP0060), Campus "Big Hanna" Composter (SP0018), Campus Crops (SP0008), Campus Crops 2 (SP0035), Campus Crops 3 (SP0072), Campus Swaps (SP0046), Chemical Curriculum Development (SP0068), Childcare Access Study (SP0096), CKUT Ecolibrium Radio Residency (SP0054), Community Engagement Day (SP0069), Constructive Consumerism (SP0080), Desautels Business Conference on Sustainability (SP0028), Dew Water Harvest (SP0098), DigFab Sunscreen (SP0086), Edible Campus (SP0003), Edible Campus 2 (SP0036), Egg Grader (SP0052), Electric Low-Speed Vehicle (SP0011), EnGage (Off-Campus Residence Energy Metering) (SP0040), Farm Fresh Truck (SP0079), Farm to School, Farmers' Market (SP0012), Farmers' Market 2 (SP0037), Farmers' Market 3 (SP0076), Fluorescent Lamps Disposal (SP0024), Food & Dining GHG Audit (SP0090), Food Systems Administrator (SP0007), Food Systems Administrator 2 (SP0034), Food Waste Processor for In-Vessel Composting (SP0009), Furniture Asset and Management (SP0085), Gault Electric ATV (SP0016), Gault Electric ATV 2 (SP0075), Green Biobanking (SP0051), Greening Indoor McGill Initiative (SP0065), Greening McTavish (SP0053), Hazardous Chemical Disposal Campaign (SP0032), Hazardous Waste Minimization (SP0025), High-Density Bike Racks (SP0021), Hitting the Benchmark (SP0023), Home Energy Team (SP0059), Integrated Education Hub (SP0089), La Cave Bike Collective (SP0005), Law Plate Club (SP0033), Library multibins (SP0097), Mac Water Bottle Refill Station (SP0029), Macdonald Student-Run Ecological Garden (SP0004), Macdonald Student-Run Ecological Garden 2 (SP0042), Macdonald Student-Run Ecological Garden 3 (SP0071), Macdonald Student-Run Ecological Gardens 4 (SP0094), Materials Analysis Tool (SP0031), McGill Energy Project 2 (SP0095), McGill Feeding McGill (SP0002), McGill Feeding McGill 2 (SP0038), McGill Feeding McGill 3 (SP0074), McGill Feeding McGill 4 (SP0099), Meatless Mondays (SP0006), MEP Interns (SP0067), **Mercury Free Microscopy (SP0091)**, Mercury Thermometer Exchange (SP0062), MFDS Marine Stewardship Certification (SP0088), MFSP Intern 2 (SP0056), MFSP Local Food Plus Intern (SP0045), Montréal à Votre Service ...Écologique (SP0093), Off-Campus Residence Energy Dashboard (SP0049), Out of the Garden (SP0047), Outdoor Frosh (SP0020), Pulse Check (SP0044), Pulse Energy Dashboard (SP0026), Shut your Sash (SP0041), Solin Hall Compost Pails (SP0058), SPF Review (SP0083), SPF Support Position (SP0081), SSMU Sustainability Coordinator Research Position (SP0019), Sustainability Case Competition (SP0066), Sustainability Fair (SP0050), Sustainability Projects Budget, Sustainability Symposium (SP0017), Sustainability Symposium 2 (SP0063), Sustainability Symposium 3 (SP0092), Sustainability Videos Project (SP0078), Sustainability Website Revamper (SP0010), Sustainable Eating (SP0013), Sustainable Education@McGill (SP0087), Sustainable Thomson House (SP0027), Teva Recycling (SP0055), Thomson House Permaculture Garden (SP0043), Toolkit for Change (SP0084), Transport Survey (SP0022), Vision 2020 (SP0057), Waste to Resource Assessment (SP0077), Water Collection System (SP0015), Water Intern (SP0073), Water is Life! (SP0014), Wood Shredder (SP0064)

Mercury Free Microscopy (SP0091)

THE CHALLENGE: The Life Science Complex **Advanced BioImaging Facility (ABIF)**, the **Cell Imaging and Analysis Network (CIAN)** and the Montreal Neurological Institute (MNI) **Microscopy Core Facility** have eleven microscopes with mercury based light sources that they would like to eliminate. The facilities are migrating to newer sustainable, energy efficient, mercury free light sources. Mercury bulbs each contain about 125 mg of mercury, they only last for about 200 hours and they require staff time to install and align and the intensity of light decays over time making quantitative fluorescence microscopy experiments difficult. The facilities would like to migrate to newer sustainable, energy efficient, mercury free light sources.

NEW TECHNOLOGIES OFFER A SOLUTION: Many mercury free microscope light sources now exist including light emitting diode (LED) based sources and mixed source light engines. These mercury free sources last ~100 times longer than mercury bulbs and ten times longer than mercury containing metal halide sources. They have stable power outputs over time making them ideal for state-of-the-art quantitative fluorescence microscopy research.

SUSTAINABILITY: Each new light source will replace the equivalent of 100 mercury bulbs each of which contains about 125 mg of mercury. Replacing eleven light sources would be the equivalent of 1,100 mercury bulbs or about 140 g of mercury. This amount alone could contaminate over 5 billion liters of water.

NEXT STEPS: This project is the beginning of a new initiative for mercury free microscopy (MFM) that provides awareness, recycling, and elimination of mercury based light sources.

MFM at a Glance

- **Eliminate** mercury.
- **Eliminate** potential hazard to staff.
- **Eliminate** waste management.
- **Save $$$money$$$** - no bulbs to buy.
- **Save time** – no bulbs to replace and align.
- **Quality science** - Stable power source for quantitative microscopy.

Mercury Free Microscopy (MFM) Program

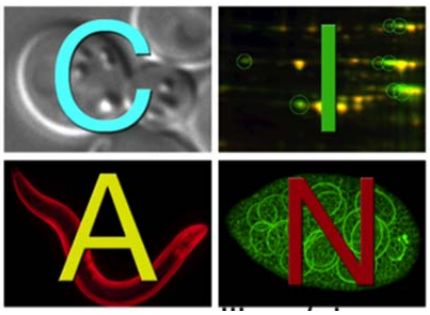
Advanced BioImaging Facility (ABIF)

The ABIF offers more than a dozen state-of-the-art light microscopy platforms. With over 35 years of combined microscopy expertise our in-depth training and expert advice will accelerate any light microscopy research project. Comprehensive consultations, sample preparation advice, ongoing support, image processing, image analysis and preparation of data for publication all contribute to using researcher's time effectively, generating high quality quantitative data and elevating research projects to the next level. The facility has expertise in many areas of cellular imaging including, but not limited to, live cell imaging, FRAP, FLIM, FRET, FCS, image correlation spectroscopy, TIRF, spectral imaging, high content screening, multi-photon imaging, laser capture micro-dissection, cellular image analysis, and custom image analysis.

http://www.mcgill.ca/lifesciencescomplex/core/imaging.

Mercury Free Microscopy (MFM) Program

Cell Imaging and Analysis Network (CIAN)



The CIAN provides services and tools to researchers from within or outside the McGill community. CIAN is composed of six scientific platforms: Cell Imaging, Proteomics, Automation/High throughput screening, Protein expression for antibody production, Data storage/analysis and Genomics. The CIAN Microscopy platform offers access to high-end light microscopy tools for fixed and live cell imaging, as well as image analysis solutions. The technologies offered include point scanning confocal, spinning disk confocal, structured illumination based super-resolution, TIRF, deconvolution, FRAP, FRET, various image analysis software packages. For more information on the CIAN microscopy platform, or the other CIAN resources, visit www.mcgill.ca/cian.

Mercury Free Microscopy (MFM) Program

Montreal Neurological Institute (MNI) Microscopy Core Facility

The facility directed by Dr. Stroh with the support of Dr. Pedraza serves 26 MNI laboratories and other labs in Montreal with ~150 current certified active users. We provide access to four state-of-the-art confocal microscope systems enabling channel-based, and multi-spectral confocal imaging and confocal microscopy in combination with electrophysiology measurements. Several widefield systems offer automated multi-channel/multi-position fluorescence, stereology imaging and analysis, live cell calcium imaging and TIRF microscopy. The facility also offers offline imaging processing and analysis software and expertise. The facility will soon have a microscope based on single-molecule localization techniques that will enable super-resolution imaging in cells and tissue. Expertise also included histology and immunocytochemistry sample preparation, as well as complex neuroanatomical and electron microscopic preparations.

Lumencor, Inc.

Lumencor, Inc. is a North American based lighting and optical design manufacturer that produces long lasting, powerful, visible spectrum, solid state light for scientific equipment, including the SOLA and SPECTRA product lines. These lighting products are a superior sustainable alternative to the mercury arc lamp industry standard by all performance metrics. Moreover, Lumencor only manufactures light engines that are mercury(Hg)-free, CE certified and both RoHS and REACH compliant.

Lumencor has developed an awareness program called Mercury Free Microscopy (MFM) in collaboration with the Cell Imaging and Analysis Network at McGill University. MFM is designed to:

- inform institutions about their Hg levels from lighting in labs and clinics,
- educate about compliant Hg disposal procedures and
- identify stakeholders to help defray the costs of converting to Hg-free lighting.

Independent studies have established the scientific merits of these state-of-the-art light engines over current Hg-based lamps. MFM has fostered studies that establish a 13-month return on investment when switching to light engines from lamps, justifying the initial investment. Furthermore, light engines dramatically lower both the lamp users' energy consumption and carbon footprint. The MFM program helps to bring together and make aware technology-conscious and clean-tech conscientious microscope users. The program significantly reduces expenses related to scientific grade lighting. It eliminates a significant laboratory and human health and safety hazard. Finally, it opens a gateway for additional sustainable discussions with respect to clean, high-performance, high-tech tools for research and clinical laboratories.

CoolLED Limited

CoolLED Limited is a design and manufacturing company specializing in high-performance LED technology for microscopy. LEDs offer many benefits to the life scientist, from instant on/off to long lifetime, stability and precise control. With a wide range of wavelengths available, including white, we can provide LED excitation matched to fluorescent stains and microscope filter sets. The new additions to the pE-Series of products means CoolLED now offers single, dual, 3 or 4 wavelength units which are perfect for Live Cell and Clinical Screening work. As many hospitals and universities are actively-seeking to eradicate mercury-based products from their facilities, the benefit of these safe and environmentally-friendly illumination sources which do not use mercury will be appreciated.

Leica Microsystems

The Contrast You Need to See Your Next Discovery. Great model organism images start with great illumination. Leica's LED illumination offering gives you the contrast you need to see your next discovery.

For example, the Leica LED5000 RL, ring light illumination system with 40 bright LED's provides homogeneous light distribution.

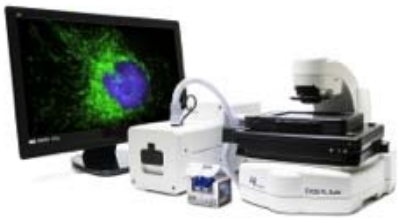
The illumination system allows true colour reproduction of the specimen at all brightness levels without the yellow hue of halogen illumination and provides up to 50,000 hours of bright daylight quality, flicker free LED illumination, which is very comfortable for the eyes. No additional white balance is necessary.

Combined with Leica LAS software, the illumination becomes part of the automated system and illumination settings can be stored together with the image for easy reproducibility and higher throughput.

Life Technologies

LifeTechnologies offers our newest EVOS® line of brightfield and fluorescent LED-based, digitally inverted microscopes. The EVOS® microscopes include the XLCore, XL, FLoid, FL and FL-AUTO, all designed to provide superior imaging capabilities and to support our industry leadingMolecular Probes® Portfolio.The EVOS® line of fluorescent microscopes including the EVOS® FL and EVOS® FL-Auto systems pictured above. EVOS® FL-AUTO is our all-in-one automated imaging system the provides:

- An LED light source can last 50,000 hours (17 years @ 8 hours/day, 7 days/week)
- Dual camera: monochrome and color
- Minimal maintenance or alignment
- Integrated camera and imaging software including timelapse, scanning, tile and stitching, Z-stack, manual and automated cell counting
- Touch Screen manipulation of fully automated x, y and z stage
- Fits on your bench-top, avoiding the need for a darkroom
- Live cell imaging capabilities on our newly launched Onstage Incubation Chamber (at right).



Lumen Dynamics Group Inc.

Lumen Dynamics is a world leader of innovative light delivery solutions and was the first to launch an HBO-replacement fluorescence lamp back in 2003 known as X-Cite® which started the revolution to reduce mercury waste. In keeping with this theme, X-Cite® launched its first mercury-free system back in 2011, the X-Cite® XLED1. The award-winning XLED1 is a rapid wavelength switching LED fluorescence illuminator ideal for live cell imaging applications with advanced triggering options for those conducting more complicated experiments. The X-Cite® XLED1 was awarded the 2012 Microscopy Today Innovation Award for its advanced triggering capabilities.

The newest addition to Lumen Dynamics' X-Cite® product family, the X-Cite®120LED, is a broad spectrum LED illuminator suitable for all common fluorescence applications without compromise. The 120LED boasts all the advantages of LED including instant ON/OFF, long life and zero-maintenance while providing excellent field uniformity, along with manual, PC, and TTL control options. Quiet, vibration-free, powerful performance will provide researchers with the ability to excite all their favorite fluorophores ranging from DAPI to Cy5.

Lumen Dynamics' has almost 30 years of light expertise and application knowledge. This combined with its award-winning customer service make X-Cite® products the trusted light sources for researchers worldwide. Please visit www.ldgi.com for additional information and see what our customers have to say about X-Cite® products via our customer testimonials.

Olympus

Olympus Canada's Scientific Equipment Group is the leader in providing innovative microscopy and image analysis solutions to the broad scientific collectivity. Olympus microscopy systems offer unsurpassed optics, innovative designs and versatility to meet the ever-changing needs of users, paving the way for future discoveries in research, medicine and engineering. We work in close partnership with third party companies to distribute mercury free fluorescence excitation light sources. These leaders in light delivery solutions include Lumen Dynamics, CoolLED and 89North. Some of the products we distribute and support:

The X-Cite® 120LED from Lumen Dynamics is the ideal choice for common Hg-free fluorescence imaging applications. The X-Cite® 120LED provides high-power, broad-spectrum fluorescence excitation from 370-700nm, catering to a wide range of popular fluorophores. Highly-engineered direct coupling optics ensures bright and uniform illumination.

The X-Cite® XLED1 from Lumen Dynamics, the PE2 from CoolLED and the Heliophor from 89 North offer superior LED illumination and advanced control for high-speed automated fluorescence imaging. They all offer a high degree of control over the individual intensities, and triggering (USB or TTL) of LED modules, to achieve ultra-fast wavelength switching. Olympus Canada invites you to discover and understand the differences between these available technologies.

Carl Zeiss

Zeiss is an innovator in the field of LED technology for fluorescence microscopy.

Since the introduction of the first commercially available LED Fluorescence illuminator, the Colibri, in 2007 Zeiss has continued to develop its product portfolio of LED enabled microscopes.

The microscopes Axio Lab A1, Axio Scope A1, and Axio Vert A1 feature integrated high intensity LED's. While the highly flexible Colibri 2 LED illuminator can be connected to any of our stands in place of a traditional HBO system. With its software connection and multiband filters the Colibri 2 allows a manual microscope to be used as an automated multichannel fluorescence imaging platform. For live cell imaging applications, Colibri 2 allows hardware triggering, fast wavelength switching, and variable intensity.

With available excitation wavelengths from 365nm through to 625nm most fluorochromes and fluorescent proteins can be used.

Furthermore, the Discovery series Stereo Microscopes can be equipped with intermediate tubes providing LED illumination.

In addition to fluorescence illumination, Zeiss also actively utilizes white light LED technology as a replacement for traditional halogen bulbs in transmitted light and stereomicroscopy applications.

For more information visit
http://zeiss-campus.magnet.fsu.edu/tutorials/colibri/.

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Mercury Free Microscopy (MFM) Program

MFM Project Partner

lumencor

AMG part of life technologies

CoolLED

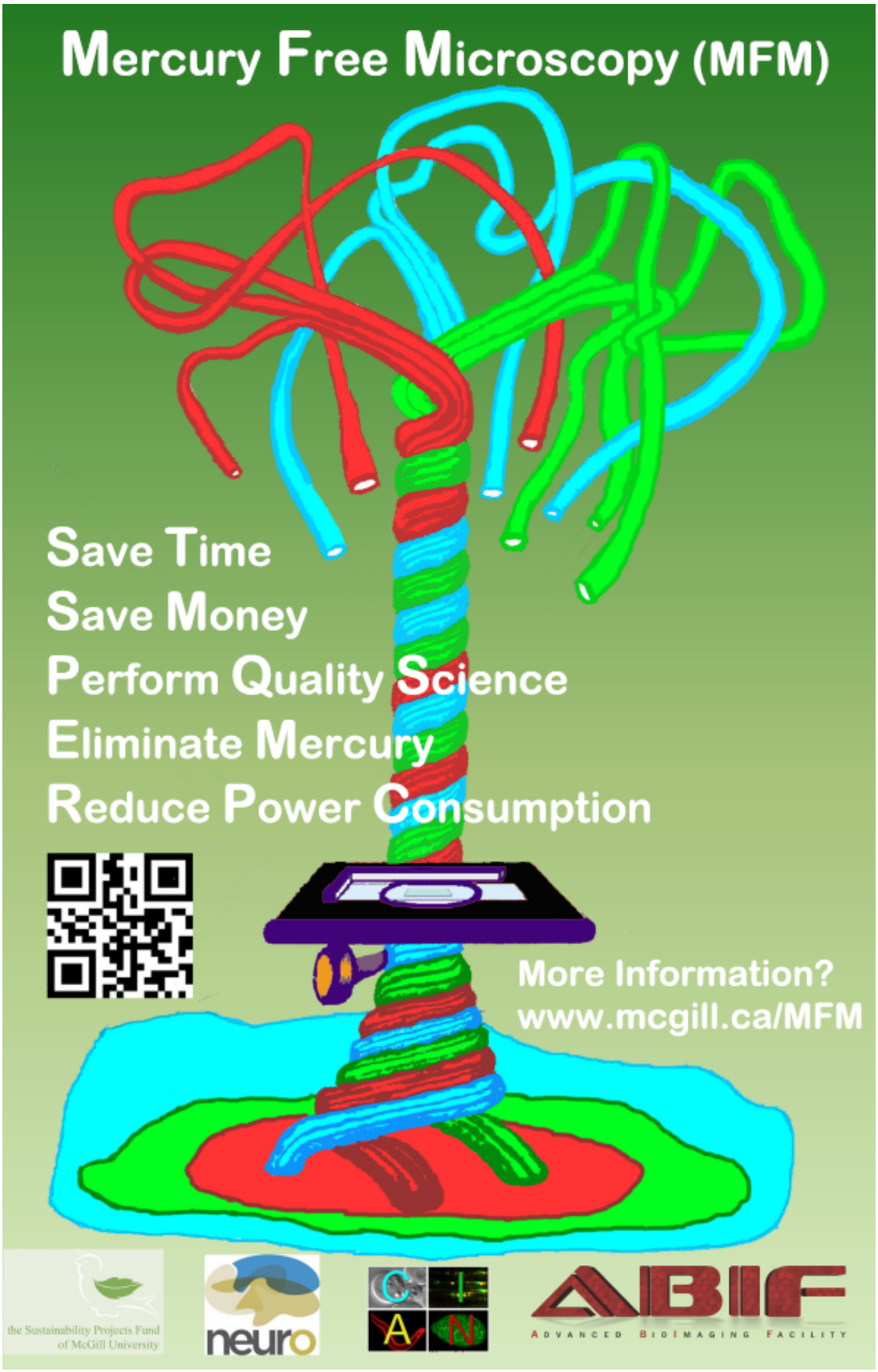
Leica MICROSYSTEMS

LUMEN DYNAMICS PUTTING YOU IN CONTROL

OLYMPUS

ZEISS

Appendix 2: Marketing Poster



Appendix 3: Procurement Information

Sustainability Project (SP0091) – Mercury Free Microscopy (MFM)

Mercury Free Microscopy Program

THE CHALLENGE: The Life Science Complex **Advanced BioImaging Facility (ABIF)**, the **Cell Imaging and Analysis Network (CIAN)** and the Montreal Neurological Institute (MNI) **Microscopy Core Facility** would like to promote the migration to newer sustainable, energy efficient, mercury free light sources for microscopy. Mercury bulbs each contain over 100 mg of mercury, they only last for about 200 hours and they require staff time to install and align. In addition, the output intensity of light decays over time making quantitative fluorescence microscopy experiments difficult.

NEW TECHNOLOGIES OFFER A SOLUTION: Many mercury free microscope light sources now exist including light emitting diode (LED) based sources and mixed solid state light source light engines. These mercury free sources **last ~100 times** longer than mercury bulbs and ~10 times longer than mercury containing metal halide sources. They have stable power outputs over time making them ideal for state-of-the-art quantitative fluorescence microscopy research.

SUSTAINABILITY: Each new light source will replace the equivalent of 100 mercury bulbs each of which contains about 100 mg of mercury. Replacing just ten light sources would be the equivalent of 1,000 mercury bulbs or about **100 g of mercury**. This amount alone could contaminate over 5 billion liters of water. Solid state light sources can be switched on and off electronically. This means they only have to be turned on when imaging fluorescently labelled samples. This will result in significant power consumption savings (upwards of 95%) as mercury and metal halide sources need to be powered on for the entire duration of experiments.

NEW PURCHASES: Every McGill researcher that is purchasing a fluorescence based microscope should be purchasing a mercury free solution. However, at this time, applications requiring UV excitation (<370 nm light) still require the use of mercury based technologies.

SUMMARY OF BENEFITS OF GOING MERCURY FREE:

- **Eliminate mercury**, potential health hazards to staff and the need for waste management.
- **Reduce power consumption** by upwards of 95% as sources can be switched on and off during experimentation.
- **Save money** over the long term in staffing costs, power costs and the cost of bulb replacement.
- **Save time** researchers will not be stuck when a bulb fails and staff will no longer need to change out old bulbs nor align replacement bulbs.
- **Perform quality science** with stable power outputs for quantitative microscopy.

SCIENTIFIC TESTING RESULTS:

The LED120 and Sola SM1 offer superior stability on all time scales tested.

Time Scale	LED120 Intensity Variability	SOLA SM1 Intensity Variability	Mercury HBO Lamp Intensity Variability
200 sec (every sec)	<.25%	<0.1%	2%
30 sec (every 100 ms)	<0.5%	<0.1%	2%
100 min (every 2 min)	0.5%	0.5%	2%
300 hours		2%	10%

Power consumption will be reduced by using electronic shuttering. If lead time on shuttering is reproducible shuttering electronically (2 seconds or 5 minutes) will be sufficient for quantitative microscopy. The ABIF is doing this testing now.

Test	LED120 Time for Stabilization	SOLA SM1 Time for Stabilization	Mercury HBO Lamp Time for Stabilization
Warm up time (90 min)	Not Needed	20 min	40 min
Shuttering the Lamp	2 sec	5 min	NA
Power Consumption	0-225W depending on intensity output	150 W @ 100% 2.5 W in Standby Mode 0.5 W - Off	135 W @ 100% Intensity

Appendix 4: Timeline/Milestones

Task	Dates	Time (Months)	Group Member(s) Involved - In Charge Member **Bolded**
Purchase and five light sources for the ABIF, install them and certify the facility as mercury free or GLM approved.	May-June 2015	12	**Brown**, Lesage, Wee
Identify corporations and test GLM based light sources for reliability, financial viability and power consumption – well developed methods for this testing are already in place at the ABIF.	May 2015-April 2016	12	Baird, **Brown**, Küster-Schöck, Wee, Stroh, Summer Intern 1, PHGY396 Student 1
Perform an inventory of mercury containing light sources in the Life Sciences Complex, Departments of Biology, Biochemistry, Physiology and Pharmacology	May-December 2015	8	Baird, **Brown**, Lesage, Summer Intern 2, PHGY396 Student 2, PS
Update and expand GLM information brochures (see attached), posters, website, and information outreach events.	May 2015-September 2015	5	Brown, **Lesage**, Küster-Schöck, Summer Intern 2,
Determine several incentives to encourage researchers to upgrade to GLM compatible light sources	September 2015 – April 2016	8	Brown, **Lesage**, Summer Intern 2, PHGY396 Student 2, PS, OSR
Calculate the energy, monetary, and mercury benefit of a campus-wide conversion.	Sept-November 2015	3	**Brown**, Küster-Schöck, Wee, Stroh
Develop a new funding model for mercury light source conversions	May-December 2015	8	Baird, **Brown**, Küster-Schöck, Wee, Lesage, Stroh
Continue the awareness campaign including posters, information sessions and integration of GLM into existing educational initiatives: Systems Biology Training Program workshop, CCMA Symposium, MLMC 2016.	May 2015-April 2016	12	Entire Project Team, **Brown**
Create and run PHGY396 independent study courses and summer internships.	May 2015-April 2016	12	**Brown**
Present results to external stakeholders for contributions for a light source conversion fund, e.g. Quebec, Hydro Quebec, Environment Canada	January-April, 2016	4	**Baird**, Brown, PHGY396 Student 1, Summer Intern 1
Develop a system to flag PS purchases or OSR submitted grants that might involve mercury based lamps.	May-December, 2015	8	Brown, **Lesage**, PS, OSR
Prepare for Phase 3 implementation of campus wide fiscal incentives. Implement the model to fund replacements to phase out mercury light sources.	January 2016- April 2016	4	Baird, **Brown**, Küster-Schöck, Wee, Lesage, Stroh

Appendix 5: Compatibility with Sustainability Vision 2020

Action 1: Defining Sustainability Research: GLM is in a unique position to help define sustainable research by encouraging sustainable alternatives for research. Student engagement will train future researchers so they will be thinking about sustainable alternatives in their training labs and the labs they work in throughout their careers.

Action 2: Collaborative Sustainability Research: GLM is a highly collaborative effort involving the faculty of science, faculty of medicine and the Montreal Neurological Institute (MUHC), as well as independent consultants, PS and the OSR. The initiative will continue to address the larger community during the microscope light source replacement phase researchers from the diverse fields that use microscopes will be engaged in the initiative. The team will also give seminars and provide posters and documentation to educate the research community. Student engagement in these presentations and document development will be key.

Action 3: Sustainable Labs: GLM is a perfect fit in the sustainable labs initiative because there are no consumable parts and it pushes the initiative by targeting sustainability in the instruments scientist use. GLM can develop a checklist for research labs to determine how they can upgrade their microscopes to make them more sustainable.

Action 4: Applied Student Research: GLM has always sought student involvement to make the measurements that confirm the sustainable messaging. This project will engage 4 students as summer interns or through 396 research projects. Past students have particularly enjoyed these initiatives because they involved training in the collection, analysis and interpretation of scientific data while also changing the status quo and understanding and promoting green technologies in microscopy.

Action 5: Faculty Fellows in Sustainability: Dr. Brown has already integrated GLM into the Montreal Light Microscopy Course (MLMC) and the PHGY560 course – Light Microscopy for the Life Sciences. GLM can act as a gateway to introduce the biomedical research faculty to the Faculty Fellows in Sustainability program.

Action 6: Campus Hubs: NA

Action 7: Sustainable McTavish: NA

Action 8: Green Building: While GLM is not a consideration for the LEED standard, it will support many of the mandates established by the standard. The Bellini Building and the Goodman Cancer are part of the life sciences complex (LSC) LEED gold building. GLM compatible light sources have been installing in the ABIF in these two buildings so they are already contributing to maintaining these buildings as leaders for the LEED standard because of reduced consumables, illumination of mercury and reduced power consumption. The addition of more GLM compatible light sources in phase 2 and the awareness and upgrade campaign will continue to create more sustainable labs in these LEED buildings and perhaps contribute to moving the LSC to a LEED platinum level.

Action 9: Sustainable Procurement: GLM will test green microscope light sources and establish strong ties with lighting vendors for microscopy. Phase 1 provided informative documents to procurement and these documents can be continually modified and kept current in a vast and rapidly changing light source market.

Action 10: Waste Management: GLM will reinforce compliant mercury waste disposal. Phase 1 and phase 2 will also eliminate a significant amount of hazardous waste from the waste stream. Information in phase 2 and buy in from researchers identified to own mercury based light sources to replace them will drive a continued reduction in mercury waste generated from light microscopes.

Action 11: Energy and Climate: GLM will be amenable part of an energy reduction and net zero carbon emission plan. Reduced energy consumption of GLM light sources and reduced mercury waste in the McGill waste stream are both in line with the Energy and Climate initiative.

Action 12: Monitoring and Reporting: GLM will be reporting several sustainability performance markers including mercury reduction and power consumption reductions.

Action 13: Socially Responsible Investment: GLM is a socially responsible investment. The project will be engaging the McGill community and the broader national and international community through the teams existing ties with the MLMC, CCMA and the ABRF. The project will also engage Quebec, Hydro Quebec and Environment Canada among other stakeholders advising them about GLM and engaging them in incentive plans. These initiatives will assist in promoting socially responsible investments such as GLM.

Action 14: Advisory Council on Sustainability: GLM can be a gateway to inform potential council members from the basic sciences and the biomedical research community.

McGill | Procurement Services | Services de l'approvisionnement

Montréal, Mai 1st, 2015

SPF Project SP0091
Mercury Free Microscopy, Phase 2 (Green Light Microscopy)

Letter of Support

Dear SPF Fund administrators,

On behalf of Procurement Services, I wish to express our full support of Dr. Claire Brown's request of funds to advance on phase II of the Mercury Free Microscopy project.

As you are aware, McGill University has been actively moving forward with its Sustainable Procurement Strategy, and identifying more sustainable goods and services is a key component of this strategy. It is often difficult to obtain detailed life cycle information for various products, including scientific equipment. The second phase of Professor Brown's particular project should contribute to provide this kind of information for our scientific community members, as they seek to choose more sustainable options. Indeed, the work conducted by her team should also help us define minimum standard requirements for the use of various microscopy technologies, including light engines, at McGill.

As active members of the Sustainable Labs working-group, we also agree that this project should contribute to establishing some of the criteria for our University's future Sustainable Labs standard and/or certification.

Professor Brown's project has already had many positive benefits for students (as they have had the chance to work on applied research), for health and security at McGill (reducing potential health hazards), as well as positive budgetary repercussions (reducing the cost of eliminating hazardous wastes, and reducing energy consumption). This project's triple bottom line (i.e. social, economic, environmental) track record is remarkable, and should be celebrated and further supported.

We trust that you will share this perspective and will contribute further to this project.

Kind regards,

Stéphanie H. Leclerc
Project Manager, Sustainable Procurement
McGill University Procurement Services