GUIDE

to Environmentally Responsible Laboratory Practices

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UNIVERSITÉ LAVAL

TABLE OF CONTENTS

Introduction 3
- Why implement sustainable laboratory practices? 3

Energy 5
- Fume hoods 5
- Freezers and refrigerators 6
- Other energy-efficient practices 7

Water 8

Procurement and Asset Management 9

Waste 11
- Reduce 11
- Reuse 11
- Recycle and repurpose 12

Travel and Mobility 13

Other Best Practices 14

Additional Resources 15

Checklist 16

References 17

INTRODUCTION

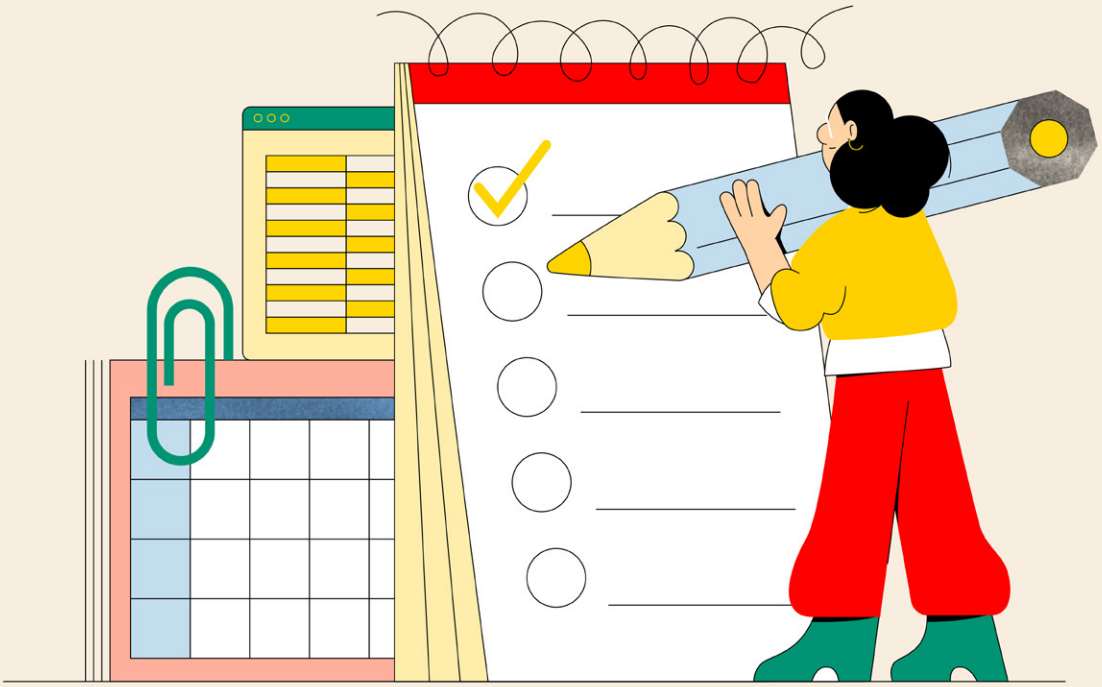
Why implement sustainable laboratory practices?

Teaching and research play a critical role in solving the medical, technological, and societal issues of our time. However, they also come with a considerable environmental footprint, especially when done in a laboratory. In fact, laboratories can account for up to 65% of a university's energy consumption and carbon emissions.[1] What's more, they generate a significant amount of waste, mainly from single-use plastics.

As such, it has become essential to implement more sustainable practices in laboratories. This guide will support users in this transition by providing tangible ways to reduce their laboratories' environmental footprint without compromising the quality or scientific rigour of their work.

Overall, this guide aims to:

- ✔ Raise awareness of the social and environmental issues that arise in laboratories
- ✔ Provide information on environmentally responsible actions that can be implemented
- ✔ Share relevant tools and resources



This guide was developed by Université Laval's Bureau de la responsabilité sociale et environnementale and revised by its Service des immeubles, Service des finances, Service de sécurité et de prévention, and Centre d'expertise en santé, sécurité et mieux-être. It reflects Université Laval's commitment to promoting a responsible and sustainable approach to research, creation, and innovation that is ethical, equitable, inclusive, and respectful of diversity. We believe that every action counts when it comes to building a future where people and the planet are respected. This is why we encourage environmentally responsible practices in laboratories that leverage interdisciplinarity, collaboration, and innovation. These practices help reduce our environmental footprint, improve our teaching and research environments, and develop solutions to major global issues.

This initiative also fits within a broader collective movement towards more sustainable science, spearheaded by a number of Québec's higher education institutions. The contributions of each and every member of that community of practice are an invaluable source of inspiration.

Caution: When dealing with controlled materials (infectious materials, regulated soils, plant pests, biohazardous materials, chemicals, radioactive materials, etc.), protecting lab users, the broader community, and the environment, as well as animal welfare, is paramount. As such, some of the practices suggested in this guide may not be applicable. Safety rules come above all else.

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ENERGY

Did you know that research laboratories consume an average of 5 to 10 times more energy than conventional office spaces?[2]

In one year, a single ultra-low-temperature (ULT) freezer can consume as much energy as a house, and each fume hood as much as up to three houses.[3]

Consider these measures to limit your laboratory's footprint.

Fume hoods

- **Keep the sash as low as possible during use and close it completely after use.**

  This reduces energy consumption by around 80% while maximizing user safety[4].

- Do not store chemicals or equipment in fume hoods. Empty hoods after each use. Piles of containers and equipment prevent air from circulating properly and make the hoods less effective.

  Products that require ventilation should be stored in ventilated cabinets, which do not require as much air.

- **Choose the appropriate containment and capture equipment for the product and activity.**

  For example, fume hoods are meant for handling flammable, corrosive, and toxic chemicals and for containing, capturing, and evacuating gases and vapours. They also protect against splashes, flames, and minor explosions. If you do not need that level of protection, consider using a capture arm instead. It captures low-hazard contaminants directly at the source, and is mainly suited to lighter-than-air fumes and vapours.

- **When purchasing new equipment, opt for high-performance hoods, which provide equal containment with around 30% less airflow.**

For a reminder of these best practices, see our best practices poster for fume hoods.

In some laboratories, the fume hood must remain on and the sash open even when not in use to allow for proper air exchange. Check with your unit's health and safety manager first.

For more information on containment and capture equipment, see Université Laval's Guide de sécurité en laboratoire (in French only).

At Université Laval, fume hood models and installation must be approved by the Service des immeubles to ensure compliance with design requirements. The department can also check whether your location is suitable for a high-performance model.

Freezers and refrigerators

- Defrost freezer doors and seals regularly. Defrost the entire freezer and clear the air intakes and filters at least once a year. Unplug unused appliances.

- **Keep an updated sample inventory and dispose of unnecessary samples.**

- Store samples as efficiently as possible, for example by using racks or high-density storage systems (13x13 freezer boxes rather than 9x9).

  When space is used efficiently, more samples can be stored per kilowatt-hour of energy use.

- Keep freezers and refrigerators as full as possible. Consider sharing with other research teams to maximize the use of space.

- Raise freezer temperatures from -80 °C to -70 °C.

  Raising the temperature saves 20-40% energy and extends the life of the freezer.[5] For more evidence that -70 °C is a safe temperature for your samples, take a look at this University of British Columbia fact sheet.

- Store samples in the appropriate place and at the appropriate temperature.

  For example, genomic DNA can be stored in a standard freezer at -20 °C for up to 24 months.[6] Standard freezers use 80% less power than ULTs

- Group freezers in a cool room, keeping them 5 inches apart and 8 inches away from the wall.

  Grouping freezers in one room also makes it easier for teams to share them!

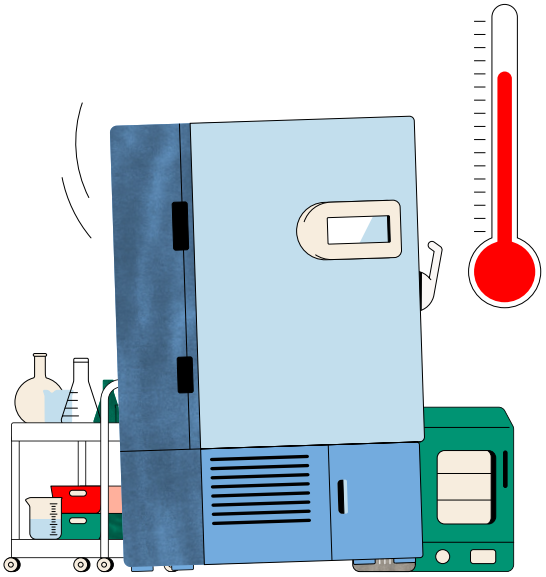
- Replace older models (>10 years old) with newer, more energy-efficient versions.

  Look for Energy Star or EPEAT labels.

Go the extra mile: Join thousands of other laboratories in the annual International Freezer Challenge.

To find out more, see our best practices poster for freezers and refrigerators.

Check the Service de sécurité et de prévention website to see the procedures for hazardous material management and collection at Université Laval.



Other energy-efficient practices

- Turn off the lights at the end of the day and whenever they are not needed.

  Use natural light when you can!

- **Turn equipment off when it is not in use, especially if it has to run at specific temperatures.**

  Colour-coded stickers are used to distinguish between devices that can and cannot be turned off.

At Université Laval, you can use the stickers developed by Mon labo écoresponsable. You just need to request them.

- Unplug switched-off devices or use a power bar that can be switched off to prevent phantom load.

  Even when devices are switched off, they consume 5–10% of their normal power.

- **Share equipment between research teams.**

- Replace energy-intensive equipment where necessary, and include energy efficiency in the selection criteria for new equipment.

  Look for Energy Star or EPEAT labels.

At Université Laval, check Hector, the tool for inventorying and promoting research equipment. It indicates whether a piece of equipment can be shared and, if so, who to contact.

WATER

Did you know that research laboratories consume four times more water than conventional office spaces?[7]

For instance, traditional autoclaves can use up to 228 L of water per cycle.[8]

Consider these measures to limit your laboratory's footprint.

- Replace water aspirators with vacuum pumps.

  Using a vacuum pump means better vacuum control and no water wastage.

- Do not use overly purified water.

  It takes 3 litres of water to produce 1 litre of deionized water. Only use deionized or ultrapure water when strictly necessary.

- Use dishwashers and autoclaves efficiently; avoid running them for only a few items.

  It is recommended to share with neighbouring laboratories and use the smallest appliance possible.

- Eliminate once-through cooling systems.

  Closed-loop cooling systems are preferred, especially ethylene glycol chillers. A simple system made from ice packs and an aquarium pump can also save thousands of litres of water with similar efficiency, while preventing the risk of flooding.

- **Install aerators on faucets and repair leaky faucets.**

  Aerators can reduce water flow from 15 litres/minute to 5 or 7 litres/minute.

> At Université Laval, leaking taps can be reported to the Service des immeubles.

- Replace water-intensive appliances with waterless ones.

  For example, bead baths can be used instead of water baths or ice buckets. Use ethylene glycol coolers or air-cooled condensers where possible rather than water-cooled condensers.

- Improve autoclave efficiency.

  Adding a water-saving device to an autoclave can reduce water consumption by 75%. When buying a new autoclave, consider a model without a steam jacket, which uses much less water than traditional models.

Go the extra mile: Find more ideas in this International Institute for Sustainable Laboratories guide.

PROCUREMENT AND ASSET MANAGEMENT

Did you know? Responsible procurement involves more than just buying "greener" products. It also involves considering a product's entire life cycle to limit its social, environmental, and economic impacts.

Consider these measures to limit your laboratory's footprint.

- **Familiarize yourself with your facility's procurement policy and/or the Act respecting contracting by public bodies and its regulations, if applicable.**

- Consider setting up an institutional call for tenders for consumables that are needed on a recurring basis. Doing so makes it easier to include sustainable development criteria in the purchase.

- **Develop a responsible procurement strategy.**

- Buy in reasonable quantities to minimize waste.

  Pay attention to product lifespan.

- Maintain an up-to-date inventory of laboratory products and supplies, and check the inventory before making any new purchases.

- Consider borrowing from another laboratory if you will only need the item a few times.

- **Buy second-hand whenever possible.**

  Some online platforms, like LabX, allow you to buy and sell new, used, and/or refurbished laboratory equipment and supplies. Some suppliers also offer refurbished equipment at reduced prices. Check with the person in charge of procurement at your facility.

- Consider the entire life cycle when choosing research equipment and laboratory supplies.

  This can mean choosing sustainable products that can be repaired, reused, or recycled.

- When purchasing, look for reliable certifications like Energy Star and check the ACT Ecolabel database for information on the environmental performance of many types of laboratory supplies and equipment.

Université Laval has a procurement and contract management policy (in French only).

Université Laval has a responsible procurement strategy and a supplier code of conduct (both in French only).

At Université Laval, visit the Entrepôt for surplus items

- Check major suppliers' websites to learn about and choose greener or more sustainable products.

  Start by checking whether there is an institutional contract for the product. If so, it must be followed.

- **Combine orders from multiple researchers where possible.**

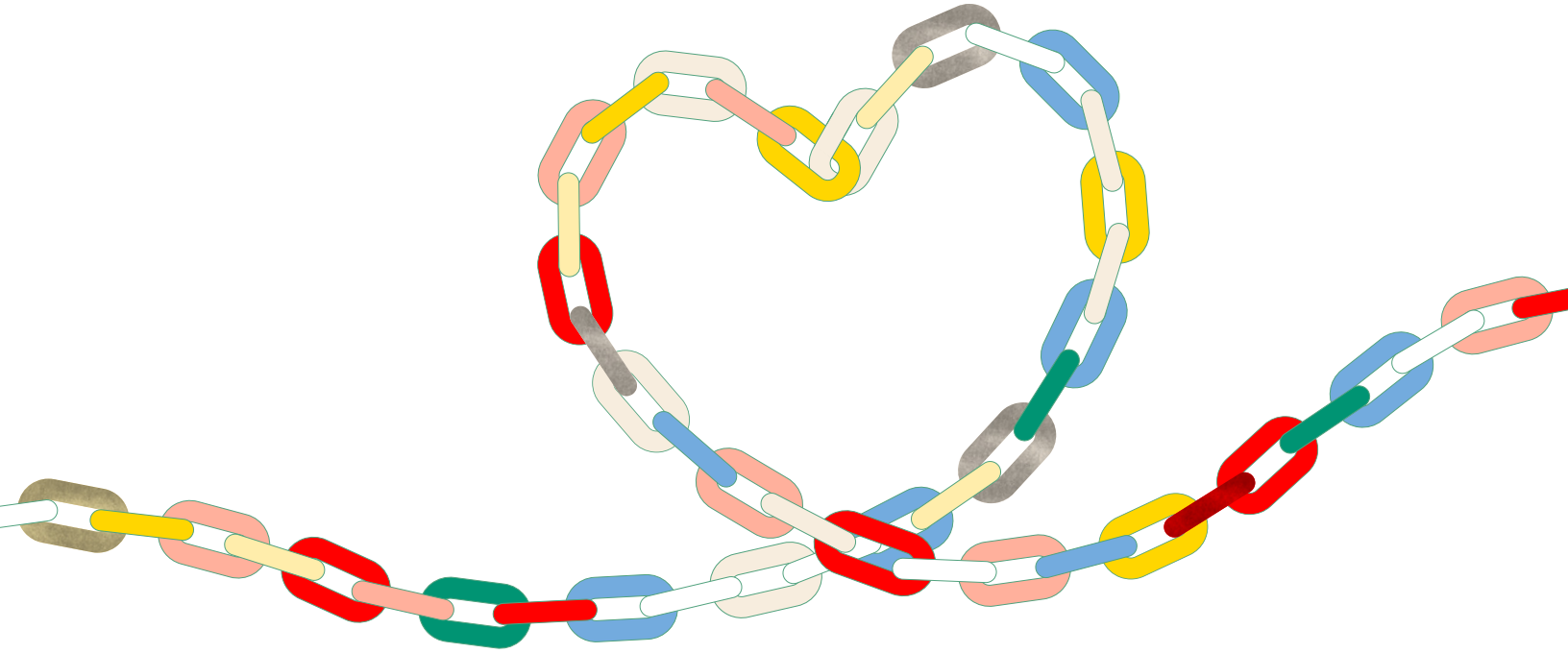
- Consider setting a minimum order value for each order and limiting orders to specific days.

- Avoid purchasing and using toxic solvents. Replace them with less harmful options.

  Read this article or this article to learn about which solvents to use and which to avoid.

At Université Laval, the IBIS Biobars store sells a wide range of laboratory supplies and chemical products in convenient sizes at advantageous prices. It offers personalized service and free delivery on campus and to affiliated centres

Go the extra mile: Take a look at this info sheet on circularity strategies.



WASTE

Did you know that life sciences research consumes around 5.5 million tonnes of plastic material per year?[9]

Consider these measures to limit your laboratory's footprint.

Reduce

- Plan your experiments carefully and/or reduce their scale whenever possible.
- Prepare your own solutions and reagents.
- Fill pipette tip boxes with bulk tips rather than buying new ones. For filtered tips, choose boxes of tips like these that can come in pre-filled racks.
- Choose products that have less plastic and/or packaging.
- **To reduce packaging, buy in bulk if you have a recurring need**.
- Consider setting up a common inventory to encourage resource sharing between laboratories.

To learn more, see our best practices poster for reducing plastic in the lab.

Do not do this for hazardous products, as buying in bulk can increase the risks. In addition, Université Laval is prohibited from purchasing 20 L or more of flammable solvents

Reuse

- Reuse items several times in a day or week before throwing them out or cleaning them for reuse.
- Wash, sterilize (if necessary), and reuse glassware and resistant plastic products whenever possible.

  Polypropylene (PP, plastic number 5) consumables, such as centrifuge tubes, are autoclavable. Specialized devices like this and this can be used to clean certain consumables, like pipette tips, for reuse.
- Replace plastic consumables, which are often single-use, with more durable options.

  For example, you can use paper, aluminum, or glass weighing boats instead of plastic ones. Serological pipettes and Petri dishes can also be replaced with glass versions.

- Reuse cardboard packaging, Styrofoam coolers, and ice packs for shipments.

- Check with suppliers to see if they can take back certain packaging or containers, such as Styrofoam coolers, boxes of pipette tips, or 4 L glass jugs

  These take-back programs already exist in some areas. If your region does not have one, we encourage you to contact your suppliers anyway. It may encourage them to start one!.

- **Repair defective equipment whenever possible and donate functional but unused equipment.**

At Université Laval, check the surplus asset management procedure (in French).

- Donate clean, unused lab coats and safety glasses to new members or to undergraduate students in science or art programs

Recycle and repurpose

- Recycle paper, cardboard boxes, aluminum foil, and many clean, uncontaminated containers (plastic and glass) through conventional channels. Check with your local waste management authority.

- **Partner with an external supplier that can recycle laboratory gloves and/or certain uncontaminated or decontaminated plastic consumables.**

  Check with your scientific suppliers, local recycling plants or sorting centres, and recycling companies.

New recovery channels for plastics and laboratory gloves are gradually being set up at Université Laval. Contact Mon labo écoresponsable for updates.

- **Set up a recycling program for batteries and electronics.**

Click here for decontamination procedures and general instructions for handling hazardous waste (in French).

- Compost brown paper and uncontaminated Kimwipes whenever possible.

Go the extra mile: Read Université Laval's bilingual sorting guide for laboratory waste.

TRAVEL AND MOBILITY

Did you know? Simply by flying for work, Canadian professors generate an average of 7.5 to 9 tons of CO_2 equivalent per year, while the average Canadian only generates 1.1 tons from air travel.[10]

Consider these measures to limit your laboratory's footprint

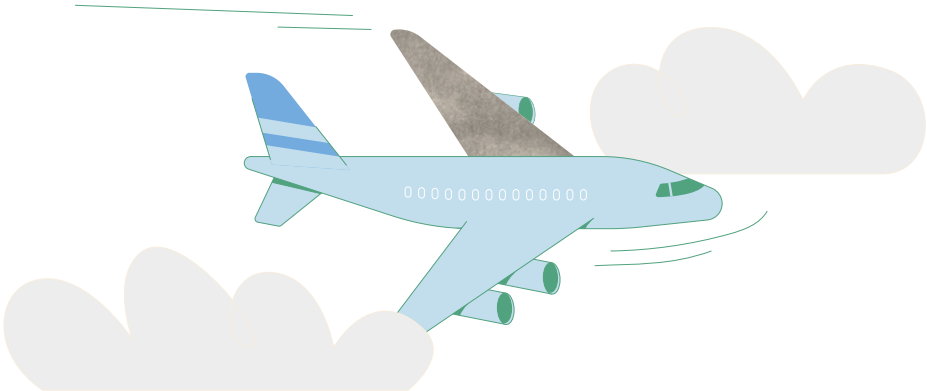
- Prioritize active transportation, public transit, and ground transportation for daily commutes and research activities.
- Choose videoconferencing when in-person attendance is not particularly beneficial.

  Virtual conferences emit 97 to 3,000 times fewer GHGs than in-person conferences.[11]
- Consider limiting the number of intercontinental trips.

  Opt for local conferences instead.
- If you do need to fly, prioritize direct flights as they are less polluting than flights with layovers. Additionally, consider combining multiple destinations into one trip if possible.
- **If travel is necessary, think about offsetting the associated GHG emissions.**

Université Laval has a voluntary offset program for GHG emissions associated with car, bus, train, and plane travel, as well as those associated with events and other activities. In addition to providing real, verifiable offsetting with social and environmental co-benefits, the Université Laval program supports innovative climate action projects. In concrete terms, for every dollar invested in the offset program, a minimum of $0.20 goes to the Climate Action Fund. A double positive impact!

To find out more about sustainable mobility at Université Laval, visit this page (in French only).



OTHER BEST PRACTICES

- **Adopt environmentally responsible digital practices in the office.**
  Many best practices can be found in this guide (in French only).

- Record experiment data in an electronic laboratory notebook.
  This cuts down on paper use and makes data more traceable.

- Follow the 12 Principles of Green Chemistry.
  They can be found in Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner.

- For in vivo studies, follow the Three Rs (replacement, reduction, and refinement) to minimize the use of animal models.

- Even if you are not working with animal models, use fewer animal-derived products in the laboratory.
  Learn more here.

- Limit or adapt computational research, which can also be very energy-intensive.
  Calculate the carbon footprint of your computational research here.

- **Consider including environmental responsibility into event planning.**

Go the extra mile:
Read the Université Laval guide to reducing your digital footprint

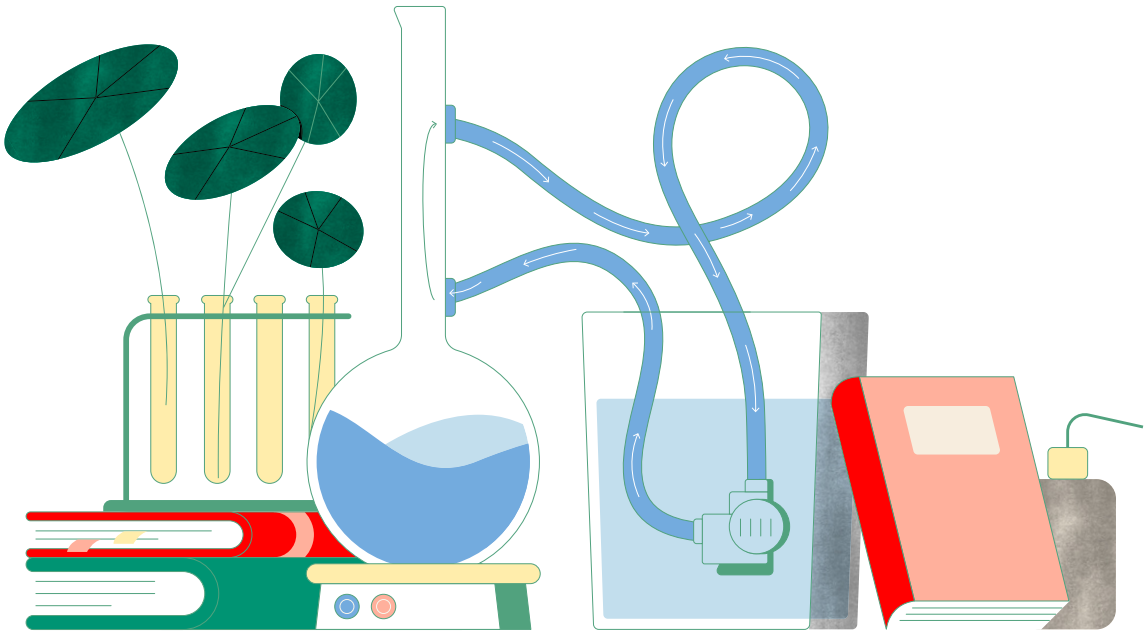
Université Laval's guide to environmentally responsible events (in French) is a good resource

ADDITIONAL RESOURCES

Mon labo écoresponsable ULaval
Mon labo écoresponsable is an initiative led by Université Laval's Bureau de la responsabilité sociale et environnementale that aims to reduce laboratories' environmental footprint by helping them implement sustainable and responsible practices. It offers users concrete tools like this guide and facilitates communities of practice to nurture collaboration, knowledge sharing, and the emergence of innovative solutions.

Guide de sécurité en laboratoire (in French)
Université Laval's Service de sécurité et de prévention is responsible for protecting people, property, and the environment. To that end, it has developed a safety guide specifically for laboratory users.

Labs en santé
The Laboratoires et groupes de recherche en santé initiative Graduate and Postdoctoral Studies promotes research team members' well-being as a key to productive—and above all, healthy—research. It addresses issues like communicating for better collaboration, taking breaks, giving and receiving recognition, taking care of mental health, recognizing and preventing work overload, and acknowledging the human element.



CHECKLIST

Energy

- ☐ Lower the fume hood sash as far as it will go.
- ☐ Turn off unused equipment.
- ☐ Turn off the lights.
- ☐ Defrost freezers regularly.
- ☐ Raise freezer temperatures from -80 °C to -70 °C.
- ☐ Encourage research teams to share equipment and appliances, including freezers.

Water

- ☐ Report major faucet leaks.
- ☐ Avoid water aspirators and once-through cooling systems.
- ☐ Only run dishwashers and autoclaves when full.

Procurement

- ☐ Centralize purchasing as much as possible.
- ☐ Keep an up-to-date inventory.
- ☐ Share reagents between research teams.
- ☐ Consider buying second-hand.
- ☐ Prioritize energy-efficient equipment and more sustainable consumables when purchasing.

Waste

- ☐ Choose glass rather than plastic consumables.
- ☐ Wash and reuse consumables whenever possible.
- ☐ Reuse cardboard boxes, glass bottles, coolers, and ice packs.
- ☐ Properly recycle everything that can be recycled.

Travel and Mobility

- ☐ Reduce and optimize travel.
- ☐ Prioritize active transportation, public transit, and travel by land rather than by air.
- ☐ Offset GHG emissions.

Other

- ☐ Follow the Principles of Green Chemistry.
- ☐ Adopt environmentally responsible digital practices in the office.
- ☐ Organize environmentally responsible events.

REFERENCES

1. Royal Society of Chemistry. Sustainable Laboratories: A Community-wide *Movement towards Sustainable Laboratory Practices*. Cambridge, 2022.
2. National Renewable Energy Laboratory. Laboratories for the *21st Century: An Introduction to Low-Energy Design*, 2008.
3. Farley, M. "How green is your science? The race to make laboratories sustainable." *Nat. Rev. Mol. Cell. Biol.*, 2022, 23(8): 517.
4. Neseliler, S. Shut your Sash! McGill University, 2013. Accessed online at: <https://www.mcgill.ca/sustainability/sp0041-shut-your-sash>.
5. PG&E, SCE, SDG&E. *Ultra-Low Temperature Freezers: Opening the Door to Energy Savings in Laboratories*, 2016.
6. Wu, J., et al. *Stability of Genomic DNA at Various Storage Conditions*, Poster Presentation, QACO3 ISBER Meeting, 2009.
7. Watch, D. and Tolat, D. *Sustainable Laboratory Design*. Whole Building Design Guide, 2016.
8. My Green Lab
9. Urbina, M. A., Watts, A. J., and Reardon, E. E. "Environment: Labs should cut plastic waste too." *Nature*, 2015, 528:479.
10. Arsenault, J., et al. "The environmental footprint of academic and student mobility in a large research-oriented university." *Environ. Res. Lett.*, 2019.
11. Jäckle, S. "Reducing the Carbon Footprint of Academic Conferences by Online Participation: The Case of the 2020 Virtual European Consortium for Political Research General Conference." PS: Political Science & Politics, 2021, 54(3): 456-461.