VANDERBILT
Division *of* Administration
Environmental Health, Safety, and Sustainability

# SUSTAINABLE LABORATORY GUIDE

## Tips for Reducing the Environmental Impact of your Lab

VANDERBILT
Sustainable Labs

**Developed by Environmental Health, Safety, and Sustainability (EHSS)** in order to assist laboratories interested in mitigating their environmental impact and becoming a more safe and sustainable lab.

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# INTRODUCTION: GREENING YOUR LABORATORY

**Sustainability** is broadly defined as meeting the needs of the present population without compromising the ability of future generations to meet their own needs. To achieve sustainability, we must examine the impact that our activities have on the environment and implement practices that reduce our consumption of resources and our generation of waste. A safe and sustainable research laboratory provides a safe environment for its members and minimizes both the resources it requires for operation and the quantity of the waste products it generates.

By its very nature, labs generate multiple waste streams. To help reach Vanderbilt's zero waste goals, these guidelines were developed to help you minimize the environmental impact of your laboratory as much as possible. More specific information about lab waste reduction strategies is discussed below.


Across the Vanderbilt community, laboratories come in all shapes and sizes, each one unique. Over 1,000 in number, they comprise a significant part of our campus operations. **Lab spaces use about five times more energy per square foot than ordinary office spaces[1].** Therefore, laboratories make up a large portion of VU's energy consumption profile and require more resources than other buildings.

[1] Mills, E., & Sartor, D. (2005). Energy use and savings potential for laboratory fume hoods. Energy, 30(10), 1859–1864. https://doi.org/10.1016/j.energy.2004.11.008

Labs present a unique challenge within the larger effort to increase sustainability; although laboratory staff may embrace the need to conserve resources and change habits, performing accurate and reproducible experiments often may be resource intensive. Furthermore, safety requirements in laboratories can be energy intensive and cannot be compromised. Thus, all suggestions in this guide acknowledge the need to protect the well-being of both lab staff and their research. **This guide focuses primarily on labs that use hazardous materials such as biomedical research, engineering, or arts and sciences labs but the general principles can be widely employed in many contexts. All types of labs can consider these ideas to pursue greener operations without compromising their research. Specific greening information for teaching labs, animal care facilities, and biorepositories, is provided in supplemental appendices.**

The **Sustainable Lab Checklist** included as an appendix to this document provides an outline for sustainable laboratory practices. It can be used as a starting point for sustainable activity in your lab and for documentation of your progress.

# TOP 10 SUSTAINABLE LAB ACTION ITEMS

Complete these 10 steps today to improve the sustainability of your lab!

| | Category | ✓ |
|---|---|---|
| | **Recycling and Waste Reduction** | |
| **1.** | Create a list of lab items that are typically recycled or thrown away. Can any be avoided, reduced, or reused? More information | |
| **2.** | Locate the closest collection points for plastic, paper, glass, cardboard and aluminum. If collection is to be done within the lab, who is responsible for getting these materials to the collection point? More information | |
| **3.** | Use manufacturer recycling programs for otherwise unrecyclable lab plastics. More information | |
| **4.** | Find less hazardous alternates for hazardous chemicals used in your lab and dispose of harmful chemicals safely. More information | |
| | **Energy Efficiency and Conservation** | |
| **5.** | Close the sash on fume hoods when not in use and keep fume hood fans on lowest setting possible for your experimental and safety requirements. More information | |
| **6.** | Keep samples well organized and create and follow a schedule to clean and check seals on refrigerators/freezers each quarter. More information | |
| **7.** | Turn off any lab equipment that is not needed for the day's activities and is not designed to be energized at all times. More information | |
| **8.** | Establish a protocol for turning off lights in lab at end of day. More information | |
| | **Green Purchasing** | |
| **9.** | Purchase the most energy-efficient equipment possible (ENERGYSTAR good indicator of efficient models) and pay particular attention to purchasing energy efficient fume hoods and ULT freezers. More information | |
| **10.** | Choose companies that implement more environmentally responsible shipping practices. More information | |

# RECYCLING AND WASTE REDUCTION

## ZERO WASTE HIERARCHY

Vanderbilt's 30-year history of recycling has expanded in recent years to include food and material waste reduction. The Zero Waste Master Plan continues this forward progress to attain a higher standard of waste prevention, reduction, reuse and diversion. Zero waste is defined by the U.S. Green Building Council (USGBC) as at least 90 percent diversion from the landfill, but it is much more than that. The zero-waste hierarchy as discussed in Figure 1 includes:

**RETHINK** - avoid purchasing products/materials or redesign processes or spaces to reduce material use and provide use flexibility.

**REDUCE** - make conscious efforts to lessen your consumption of resources and products on a day-to-day basis.

**REUSE** - find new ways to reuse or upcycle materials instead of recycling or disposing of them. Try to source products that you can easily reuse.


*Figure 1: Zero Waste Hierarchy*

**RECYCLE (DIVERT) -** To close the waste loop, **recycle** any products that cannot be reused. There are many recycling opportunities for laboratories at Vanderbilt; these are discussed in a later section of this guide.

**LANDFILL** - landfill remaining waste as the last option.

## WASTE STREAMS

### Traditional Recycling

Vanderbilt University recycles plastic (all clean plastic containers: #1 - #7), paper, glass, cardboard and aluminum. Within VU buildings, recycling containers are generally located in lobbies, hallways, break rooms, classrooms, copier rooms, and various departmental areas. Additional information about the campus recycling program can be found on the FutureVU Sustainability campus recycling page. For information on the exact location of bins in your building, submit a ReADY request with the Waste and Recycling tile.

## Lab Plastics

### PIPETTE TIP BOXES

When sourcing pipette tip systems, try to reduce the amount of new material consumed. Many manufacturers have pipette tip systems where parts of system can be reused and requires only the tip decks to be changed out. You can also purchase non-disposable pipette basins to use in your lab area.

Some manufacturers (including Thermo Fisher) have pipette tip recycling boxes that can be placed in your lab and shipped back through FedEx when full for recycling.

You can also consider repurposing pipette tip boxes as storage containers for Eppendorf tubes or other small non-glass or non-sharp items within your lab or home. Consider donating properly cleaned pipette tip boxes to local reuse programs like Turnip Green Creative Reuse. Tip boxes used in BSL-1 and BSL-2 labs must be thoroughly cleaned and disinfected with a product that is EPA-registered for destruction of HIV and HBV before being repurposed or recycled.

### OTHER LAB PLASTICS

Consider reducing your use of conical tubes by using alternate containers. Evaluate if conical tubes that were used for liquids like water or buffer can be reused.

### LAB PLASTIC RECYCLING PROGRAMS

For lab plastics that are not recyclable through the campus recycling program, look for manufacturers that provide options for recycling programs for their products. Many manufacturers will take back their products to recycle, free of charge if unused or decontaminated in accordance with VU and/or the vendor's policy.

## Used Computers and Electronics

Used computers and electronics must be disposed of by the Vanderbilt Electronics Recycling Program. U.S. regulations forbid electronics or computers from being sent to the landfill because these items contain chemicals and heavy metals that are harmful to people and to the environment. Directions on how to recycle your electronics can be found on the FutureVU Sustainability campus recycling page.

## Paper Reduction

Paper is the largest component by weight of the solid waste stream in the United States, comprising about 23% of total waste or 67 million tons a year. Paper also represents a significant portion of most departments' budgets. You can reduce the amount of paper you use in your lab by communicating electronically and printing only when necessary, printing double-sided, reusing where appropriate, buying recycled-content paper, and recycling. [2]

**Electronic notebooks and documentation** are superior to paper equivalents, as they are searchable, and can quickly be duplicated at a low cost. "First-to-file" patent laws reduce intellectual barriers to switching to electronic notebooks.

**Develop an electronic file saving system.** Edit documents on screen using the "track changes" function, use online group editing software and save files electronically. **Store articles online instead of printing.** Not only is this environmentally friendly, but it allows you to electronically search articles for keywords or phrases and easily share the document.

When printing is necessary, set the printers to a double-sided setting in order to use both sides of the paper. Moreover, set page margins on printed documents to 1" or less whenever possible.

## Ink & Toner Cartridges

Vanderbilt and Guy Brown offer recycling for copier, fax, laser and ink jet toner cartridges at Vanderbilt University. Drop-off locations have been established at the following locations:

- Main Desks at Commons Center, Kissam Center, and Sarratt Student Center
- Lobbies at Baker Building and 3rd floor of Medical Research Building III (MRBIII)

## Used Batteries

Small used batteries from work-related activities should be recycled through the battery recycling program. Battery recycling locations can be found throughout campus. More information and drop-off locations can be found on the FutureVU Sustainability campus recycling page.

If your lab has a large battery that needs to be recycled ('large' being the size of a car battery, or bigger), please contact VU EHS and submit a pick-up request.

[2] United States Environmental Protection Agency. (2017, September 7). Paper and Paperboard: Material-Specific Data | US EPA. US EPA. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/paper-and-paperboard-material-specific-data

## CHEMICAL USE MINIMIZATION

Hazardous waste from labs is potentially dangerous to the environment and harmful to human health. If hazardous waste cannot be avoided, it is imperative that such waste is disposed of properly through Environmental Health and Safety. Reducing the production of hazardous chemical waste wherever possible is a major step in reducing the environmental and health impact of your lab!

When it comes to hazardous chemicals, the goals of safety protocols and sustainability principles may seem different, but the processes are often the same. Safety protocols aim to reduce health risks, while sustainability guidelines aim to reduce environmental impacts. Both can be accomplished if you:

- **Substitute** nonhazardous for hazardous chemicals
- **Reduce** the use of hazardous chemicals. Reduce sample size or scale down your experiments to reduce material and energy consumption and waste production
- **Dispose** of harmful chemicals safely

**Don't purchase chemicals in bulk!** Purchase only the chemicals you need and in the quantity needed. You can always order more! **Inventory your chemicals** periodically to be sure you know what you have and are using what is in stock. Excess and unwanted chemicals make up a large volume of the chemical waste generated by Vanderbilt, and some chemicals become very dangerous when stored for long periods of time. Use the Chemical Redistribution Program to **redistribute unwanted, useable chemicals** from one laboratory to another instead of disposing of them as hazardous waste. Email ehs@vanderbilt.edu to learn more about what surplus chemicals are available to be redistributed.

Other specific suggestions for minimizing unnecessary chemical use include:

- Compare expiration periods of chemicals to lab usage rates when ordering to minimize expired chemicals
- Observe manufacturer's recommended storage guidelines for chemicals to minimize deterioration
- Segregate stored chemicals to avoid hazardous situations and premature deterioration due to chemical reactions

When at all possible, attempt to **use biodegradable** or less harmful chemicals in laboratory processes, such as biodegradable scintillation fluid instead of solvent-based fluid.

There are many **green alternatives** to traditional hazardous chemicals. You can look for the ACT Environmental Impact Factor Label on products, which was designed to address the need for clear, third-party verified information about the environmental impact of laboratory products. By emphasizing Accountability, Consistency, and Transparency (ACT) around manufacturing, energy and water use, packaging, and end-of-life, ACT makes it easy to choose more sustainable products.

For example:

- Ethidium Bromide is an intercalating agent and known mutagen. Look into alternatives such as SYBR, DAPI, GelRed or GelGreen or Methylene Blue. For more resources on EtBr alternatives, see:
  - Case study from MIT on the use of SYBR Safe
  - White Paper on safety study on GelRed and GelGreen.
  - Paper comparing the efficacy and safety of alternative stains.
- Instead of traditional Coomassie stains, try Bio-Safe Coomassie by Bio-Rad.
- MIT has developed a Green Chemical Alternatives Purchasing Wizard. It can help you identify greener alternatives to chemicals that are commonly used in your laboratory.

Thermo Fisher has a sustainable product alternative page that allows customers to shop for products that are less hazardous.

When researching methods and procedures, be mindful of the waste generated by each process.

- The Environmental Protection Agency (EPA) has created a list of 31 Priority Chemicals for waste reduction. Try to avoid use of these compounds in your lab.
- Avoid chemicals with National Fire Protection Association (NFPA) hazard ratings of 3 or higher.

**Reuse non-hazardous chemical bottles**. When empty, chemical bottles are perfect for collecting waste.

Store chemicals properly and use secondary containment to avoid hazardous spills or leaks. For more information on how to properly store your chemical and chemical waste, see the Chemical Safety and Hazardous Waste website.

# ENERGY EFFICIENCY AND CONSERVATION

## FUME HOODS

Fume Hoods are an important part of keeping lab staff safe. They provide a necessary safe and contained environment in which researchers can perform experiments and handle hazardous materials. Changing the way you use your fume hoods can lead to significant energy savings, but safety considerations must always be kept foremost in mind!

**Most fume hoods consume 3.5 times more energy than the average US house [3]!**

Fume hoods consume energy primarily in two ways:

1. Directly, by using a high-powered fan to pull air through the hood; and
2. Indirectly, by drawing heated or cooled air out of the lab space and expelling it outside the building. Thus, more air must be heated or cooled in a lab than in an office or classroom setting in order to maintain a desired temperature.

[3] Wesolowski, D., Olivetti, E., Graham, A., Lanou, S., Cooper, P., Doughty, J., Wilk, R., & Glicksman, L. (2010). The use of feedback in lab energy conservation: fume hoods at MIT. International Journal of Sustainability in Higher Education, 11(3), 217–235. https://doi.org/10.1108/14676371011058523

**Closing the sash on the fume hood when it is not in use is the best way to save energy in your lab!** A Massachusetts Institute of Technology (MIT) study found that lowering the sashes on fume hoods by 26% reduced the amount of air drawn through each hood by approximately 23 $ft^3$/min or over 5%, saving $41,500 per year. Make sure that your staff and students know to close the sashes when they are not using the hoods[3].

If your fume hood has an adjustable fan, keep it on the lowest settings possible for your experimental and safety requirements. This minimizes the amount of air that the hood withdraws from the lab space and the amount of energy needed to power the fan. Recommended settings are: [4]

- 60-75 feet per minute (fpm) for combustibles and irritants;
- 75-100 fpm for common chemicals, toxic vapors, flammables and radioisotopes;
- 100-150 fpm for OSHA specific standards, chemical requirements; and
- 125-150 fpm for perchloric acid.

If you are operating or purchasing an energy-efficient, high-performance fume hood, see this white paper on operational and safety considerations.

If you rarely use a fume hood, consider turning it off and/or sharing with another lab on your floor or in your department when necessary for your work. Before changing settings on your fume hood, consult with VU Plant Operations or VUMC Facilities Management.

## REFRIGERATORS AND FREEZERS

One ultra-low temperature (ULT) freezer uses more energy annually than a large house. Increasing freezer temperature to -70◦C from -80◦C can result in huge energy savings with no effect on sample storage. Some samples, such as DNA, can safely be stored in a -20◦C freezer which requires 75% less energy than an ultra-low temperature freezer.[5]

[4] Laboratory Safety Manual. (2021). Publications.ehs.iastate.edu. https://publications.ehs.iastate.edu/labsm/

[5] International Laboratory Freezer Challenge. (n.d.). International Laboratory Freezer Challenge. https://www.freezerchallenge.org/

Refrigerators and freezers use large amounts of energy. There are 8 simple steps which can be taken to reduce the environmental impact of your lab's refrigerators and freezers:

1. Maintain organization of your samples.
2. Use refrigerator/freezer space efficiently.
3. Set ULT freezers to -70˚C instead of -80˚C (if appropriate for materials in storage).
4. Separate equipment designed to run at high temperatures from refrigerators and freezers.
5. Clean your chilling equipment regularly. This includes defrosting, cleaning coils and disposing of unwanted samples.
6. Regularly check seals on refrigerators and freezer doors and replace when needed.
7. Consider converting samples to room-temperature storage (if feasible).
8. Replace old freezers with efficient new models.

One of the best ways to reduce energy use is to **maintain organization**. Knowing the specific location of samples not only reduces the amount of time spent with the freezer door open, it also helps with disposal of old and unwanted samples. You can even **make a diagram** showing where everything is located to put on the outside of your refrigerator/freezer so you can locate what you need before you even open the door. This conserves space and eliminates the need for additional freezers. Consider consolidating and sharing freezer space with another lab.

Refrigerators and freezers are most efficient when they cool as little air as possible, so make sure that you are **using the space within them efficiently**. If you consistently have unnecessary empty space, consider using a smaller unit. This will also free up more floor space in your lab, providing more room for research and equipment. If you need to store redundant samples, you may be able to store them in a freezer with other labs' redundant samples rather than having your own dedicated freezer.

Ultra-low temperature (ULT) freezers, particularly older models, can consume about 25-30 kWh of energy per day, which is as much energy an American home uses in a day. Setting ULT freezers, particularly those that are 10-15 years old, to **-70°C instead of -80°C** will save 30% of this energy[6].

**Separate equipment** that runs at high temperatures from equipment that runs at low temperatures. When a piece of equipment designed to run at low temperatures is exposed to excess heat, it must consume more energy to maintain its low temperature. The converse is true for equipment designed to run at high temperatures. For further improvements in freezer efficiency, make sure that there is at least one inch of unobstructed space between the back of the freezer and the wall or next closest appliance to allow for proper air flow to the condenser coils. Don't put your freezer or refrigerator in a location where it could receive direct sunlight from a window or door as this will necessitate higher energy usage to maintain the same low temperatures.

**Clean your refrigerators and freezers** at least once a year. This includes **defrosting your freezers,** if they are not frost-free models. Just ¼ inch of ice buildup will decrease energy efficiency; buildup like this also gives you less storage space within your freezer. To defrost, transfer all the contents from the freezer to temporary cold storage devices such as a backup freezer or coolers. Then unplug the freezer, place towels around the base

and let the freezer come to room temperature. Run a hot rag along the door seals to clean them and make sure they work as efficiently as possible. Take an inventory of the freezer's contents and dispose of any items which are no longer needed.

While defrosting, **clean your freezers' and refrigerators' coils and motors**. The refrigerator performs its heat exchange through these coils and this process occurs most efficiently when there is no dirt or dust between the coils and the ambient air. In addition to improving energy efficiency, maintaining freezers at optimum running conditions helps to prolong freezer life and reduces the risk of a malfunction, keeping your samples safer. Simply locate the condenser coils and wipe them with a rag or vacuum to remove excess dust.

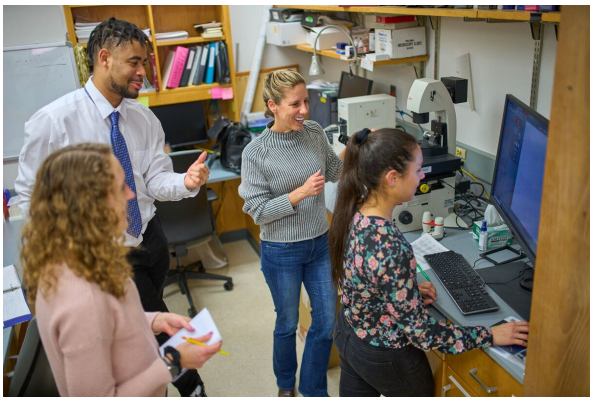
**Check your refrigerator, freezer and cold and warm room doors for seal leaks** and repair these as quickly as possible. An easy way to test the seal is by laying a piece of paper on the seal and closing the door. If you can easily pull the paper out, the seal is too loose. If this is the case, purchase and install a new seal. You can perform this test on cold and warm rooms also. Whenever closing the door of a refrigerator, cold room or warm room, ensure that it is sealed properly before walking away.

**Consider room temperature storage** for biological samples when appropriate. Researchers at Stanford University and the University of California, Davis have implemented these methods and have shown that replacing ultra-low temperature frozen storage with room temperature storage significantly reduces energy consumption and optimizes space utilization and sample management. Read more here.

If an Ultra-Low Temperature (ULT) Freezer is essential for the laboratory, look for the most energy-efficient options. See the Green Purchasing section for more information on selecting an energy efficient ULT freezer.

## COMPUTERS AND RELATED EQUIPMENT

Beyond purchasing energy-efficient equipment, take steps to reduce the energy consumption of equipment already in your lab. A good first step is to **turn off computers and other equipment** when not in use. Use a power strip that is turned off at the end of the day or unplug equipment. This will prevent your equipment and electronics from draining extra power even when not in use. Additionally, consider using wall timers that are set to turn on and off at specific times if equipment is needed daily at the same time. If a piece of equipment must remain on, consider sharing it between labs to reduce energy consumption.



Computers and Related Equipment often have **sleep settings** that are relatively easy to activate. Make sure to activate this setting if the option is available.

**Don't forget!** Some of your lab equipment may have associated computers and computer monitors, too. Check to see that these computers are set to activate sleep settings and remember to unplug computers or turn off surge protectors at the end of the day.

Computers that meet Energy Star standards power down to a sleep mode that consumes 15 Watts less power–that is approximately 70% less electricity than a computer without power management.[6]

## EQUIPMENT USE & MAINTENANCE

**Maintain all equipment in good condition**. Repair or replace broken parts and keep each part as clean as possible. Electronics, appliances and supplies will be most effective when functioning at their highest capacity, which is important to energy and resource efficiency. Taking care of equipment also increases its lifespan, which means that pieces will need to be replaced less often, saving both money and resources.

**Share lab equipment** on your floor or within your department when possible. Some lab groups use shared equipment rooms monitored by a lab manager while others have created documents listing equipment that each individual lab is willing to check out to others. A good way to ensure that shared equipment will be properly handled and cared for is to develop a check-in and check-out protocol used by all of the labs within the sharing group.

**Turn off any equipment** when it is not in use. Set autoclaves to standby mode when not in use and only run when full. Talk to your staff and students about which pieces of equipment can be turned off regularly and establish protocols for shutting them down when the last person leaves each day.

## LIGHTING

Lighting accounts for up to 25% of the energy use in US laboratories. Good lighting is often essential to lab work and thus the lighting in laboratories can be up to twice as intense as that of typical office spaces.[7]

**Establish a protocol for turning the lights in your lab space on and off each day**. If everyone knows that there is a set procedure, they will feel more comfortable flipping the switch. This could be as simple as making sure that everyone knows to turn the lights off when leaving an empty lab or assigning one person or the last person out to turn off all the lights. Putting small reminders underneath the light switches can help prompt people to turn them off!

Where possible, **reduce the number of lights turned on** in labs and in office spaces. This can be done by keeping the lights off where natural lighting is sufficient, turning on only the lights over the benches that are currently in use, turning on only a portion of the lab lights that is necessary to do work (if your lab has two or more sets of switches controlling overhead lighting) or even asking Vanderbilt

[6] ENERGY STAR. (n.d.). Www.energystar.gov. Retrieved February 9, 2023, from https://www.energystar.gov/?s=mega

[7] Kozminski, K., Lewis, S., & Mathew, P. (2006). Laboratories for the 21st Century: Best Practice Guide: EFFICIENT ELECTRIC LIGHTING IN LABORATORIES. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://labs21.lbl.gov/docs/Lighting_reduced_R11.pdf

University Maintenance and Operations (VUMO) if your lab is on main campus or VUMC Facilities Management if your lab is in a VUMC building to remove bulbs in additional lights that are unnecessary.

In offices, try to maximize your ability to use natural lighting by positioning furniture and computers in areas with the most window lighting.

Employ **motion sensors** to the lights in your lab space to ensure that lights are kept on only when someone is working in a particular area. Labs on main campus that are interested in installing motion sensors to control their lighting should contact VUMO and labs in VUMC buildings can contact VUMC Facilities Management.

## TEMPERATURE CONTROL

> Heating, ventilation, and air conditioning systems in lab buildings can use five to ten times more energy than a normal office building.[8]

Heating, cooling and filtering the air in labs is very energy-intensive because lab spaces require 100% outside air. This means that air is pulled into the building, heated or cooled, delivered to the lab space and then vented out of the building with no recirculation. Large quantities of outside air must be heated or cooled to achieve comfortable lab ventilation and temperatures. Additionally, lab spaces often contain large equipment that generate high amounts of heat, so air treatment must make up for this.

Many lab rooms have thermostats that can be controlled by staff in the lab. Set thermostats to **75° – 77° F in summer** and for **68° – 70° F in winter**. In order to maximize efficiency of the Heating, Ventilation and Air Conditioning (HVAC) system, make sure that you:

- **Keep the doors to the hall and other rooms closed whenever possible**. This will prevent conditioned air from escaping from the lab space. There may be regulations on which rooms can have the doors closed based on experimental, fire and safety concerns related to your lab, so make sure you check these first.
- **Keep fume hood sashes closed and air flow running at the lowest setting whenever possible**. This also will prevent treated air from escaping as rapidly.
- **Close the blinds** on all windows whenever you are cooling air in the summer, as windows can be a major heat source. You can also open the blinds in the winter to help warm the lab without kicking up the heat.

Another great way to save energy on heating and cooling is to **set the lab temperature differently during unoccupied times,** such as at night, on weekends, and during extended breaks. For example, during the winter, if the lab is closed for holiday break, set the thermostat to a cooler temperature than you normally would **(68° or below)**. If you can control your thermostat, adjust it more radically when everyone leaves for the day. An easy way to do this is to assign the duty of adjusting the thermostat to the last person who usually leaves the lab each day or have a programmable thermostat installed. If you are interested in having this automatically done, VUMO or Facilities Management will be happy to talk to you about the options available for your lab.

[8] Johnson, G. (2008). HVAC design for sustainable lab. *ASHRAE Journal, September*, 25-26.

If you have lab equipment or experimental procedures that require a specific temperature or humidity regime to run, limit this equipment and these processes to the smallest space possible so that it is easier to maintain the correct environmental conditions. This will also make lab operations easier to regulate.

**Dress for the season**, particularly in layers that can help moderate personal temperature. Then the lab can be adjusted to more seasonal indoor temperature settings.

If your lab is on the main campus, contact VUMO about comfortable temperatures in the lab. If your lab staff can tolerate warmer temperatures in the summer and cooler temperatures in the winter, this can save large amounts of energy.

# GREEN PURCHASING

## LABORATORY EQUIPMENT

When buying a new piece of laboratory equipment, first consider if it is truly necessary. No matter how energy-efficient a piece of equipment may be, the production of the equipment requires energy and other resources as well. Consider sharing equipment between labs if possible. Start a cataloging system with your floor, department or building to avoid unnecessary equipment purchases.

When buying equipment, look for the bright **yellow Energy Guide label** for information which details the **energy performance** of the equipment. You can use this information to compare different models and brands. Many large appliances, such as standard refrigerators and freezers, are required to have this label.

Purchasing equipment with the **ENERGY STAR label** ensures that these appliances meet the minimum Federal requirements on **energy efficiency**. The ENERGY STAR Product Finder allows you to compare different models and view important information like energy efficiency to help you choose the best product for you.

**Ultra-low temperature freezers** are extremely energy-intensive, making purchasing decisions particularly impactful for sustainable labs. Some models use 70-75% less energy and generate 70-75% less heat than standard compressor-based ULT freezers. For the most energy efficiency, look for a freezer that uses ~8kWh/day or less. You can also compare different ULT models and view energy efficiency ratings through the ENERGYSTAR website. Some energy efficient models of ULT freezers include:

- PHCbi brand VIP ECO SMART ULT
- Sterling Ultracold
- PHCbi brand VIP ECO Natural Refrigerant Upright Freezer

If you are purchasing an energy-efficient, high-performance **fume hood**, see this white paper on operational and safety considerations.

Look for TVs and monitors with light-emitting diode **(LED) screens**, as they use less energy. Seek televisions with a standby or sleep mode consumption of under one watt, an ambient light sensor which adjusts

backlighting to the needs of a given room and that are made and packaged with recycled material.

When ordering products online from Thermo Fisher Scientific, Vanderbilt's primary approved supplier, you can search for **the most energy-efficient** versions of whatever equipment you are buying by selecting the "ENERGYSTAR" option under the 'Certifications/Compliance' heading in the left-hand column. For information on Fisher products, please contact your Fisher sales representative at (615) 361-7011.

Check out the Vanderbilt ReUse Surplus Program (VU) or the Vanderbilt Surplus Equipment Store (VUMC) before making office furniture or equipment purchases to find **used or pre-owned items** that can be a cost-effective and eco-friendly addition to your lab.

## PAPER & PRINTING SUPPLIES

When purchasing paper or paper products, try to find paper with the following characteristics:

- High recycled content
- FSC Certified paper
- Chlorine-free paper
- Paper made with renewable energy
- Printed with environmentally-friendly inks

Don't forget about paper products found in the kitchen or elsewhere! Try to use non-disposable dishes and paper towels made from recycled material.

Purchase **recycled or remanufactured laser toner and ink jet cartridges** from Guy Brown through Vanderbilt's purchasing system.

## OTHER LABORATORY SUPPLIES

It is important to keep sustainability in mind even with regards to processes that require sterile technique or biohazard disposal. **Buy products made of recycled material or with reduced packaging or packaging made of recycled material**. Often, companies will list whether or not their products contain recycled content in the product description. Examples of commonly used items which can be manufactured or packaged using recycled material include the following:

- Pipette Tips
- Conical Centrifuge Tubes
- PCR Tubes
- Gloves
- Kim Wipes (try Friendly Green Wipes)
- Petri Dishes

When purchasing items with greater longevity, consider companies who will assist with end-of-life recycling or accept trade-ins. Examples include:

- Mettler-Toledo
- Beckman Coulter

Thermo Fisher Scientific has a line of green pH meter equipment. They have lead-free electrodes that meet ORP standards and do not contain hazardous chemicals. Also, look for equipment that is mercury-free. Even minute quantities of mercury can have harmful effects on humans and wildlife.[9] Eliminating its use in lab products removes any possibility of its release into the environment.

Thermo Fisher has a sustainable product alternative page that allows customers to shop for products that are less hazardous, are energy efficient, have less waste or use fewer resources, are responsibly packaged, or have recycling or take back programs at the end of life.

## SHIPPING AND PACKAGING

Shipping and packaging of laboratory supplies often generates large amounts of packaging and Styrofoam waste. Look for companies that implement more environmentally-responsible shipping practices. When ordering multiple items from one vendor, you can ask them to hold for a single shipment if not needed immediately.

Look for products that ship at ambient temperature instead of needing cold shipping.

Buy products with minimal packaging. If you know that you are going to be purchasing large amounts of one particular kind of equipment, check out the supplier's options for minimizing packaging materials.

If your laboratory ships items, look in the hallways for discarded Styrofoam and cardboard boxes. If boxes are in good condition (free of visible contamination, crushed corners, punctures, etc.), these can be reused by your lab to minimize costs and waste. However, all markings from the previous shipment must be completely defaced.

Thermo Fisher has a sustainable product alternative page that allows customers to shop for products that are responsibly packaged. For more information on green and energy efficient products, please contact your Research Purchasing Agent from Purchasing and Payment Services.

[9] Basic Information about Mercury. (n.d.). United States Environmental Protection Agency. https://www.epa.gov/mercury/basic-information-about-mercury

# TRANSPORTATION

Taking advantage of sustainable transportation is a great way to care for the environment. Further, it can improve health through exercise, reduce air pollution, and save significant amounts of money. See the MoveVU website for environmentally friendly transportation options and information on local transportation resources.

If you must use facilities at remote locations outside Vanderbilt, check to see if you can **operate them remotely**. Some VU researchers mail samples to research labs with specialized facilities not available at Vanderbilt; they then use remote control software to conduct their experiments. By reducing air travel, researchers **save money and greatly decrease their environmental footprint**. You can also reduce trips to campus by using software tools such as Windows Remote Desktop Connection to **monitor on-campus experiments from home**.

Sometimes, meeting in person is essential for effective research collaboration. Whenever possible, take advantage of remote work software such as multi-site video conferencing, web conferencing, peer-to-peer networking and file sharing.

# WATER CONSERVATION

**Eliminate water vacuum aspirators** from your lab space and replace them with **energy-efficient vacuum pumps**. If water distillers or Reverse Osmosis (RO) units are used, consider shutting them down during non-working hours if possible.

**Wash full, rather than partial, loads of glassware and dishes**. If you need to autoclave your lab ware, **fill the autoclave completely** before running it.

Consider using a **batch rinsing system when washing items by hand** so that the water used in a final rinse of one batch of lab ware is reused in an earlier rinse for the next.

**Reuse water when you can**. For instance, if your water baths do not require sterile water, you can recycle water from other processes.

If you have a piece of lab equipment (such as a cooling system) that requires continuously running water, there are a number of ways to prevent that water from simply going down the drain:

- Small package chillers are a good alternative to single pass cooling, and they can maintain a constant temperature; or
- It is possible to make your own closed-loop system using a simple pump and piping such as you can find in the gardening section of most home improvement stores.

**Report and repair water leaks, broken pipes and dripping faucets**. Contact VUMO or VUMC Facilities Management.

# RECOMMENDATIONS FOR ANIMAL CARE FACILITIES

The VUMC Division of Animal Care (DAC) strives to implement responsible environmental management practices throughout the animal facilities under its care. When entering and working in an animal facility, you can help by incorporating specific practices that can reduce the environmental impact of your work. Some of these practices and the initiatives taken by DAC are outlined below.

According to animal welfare regulations, housing areas for research animals must be kept on regular lighting schedules and maintained within an acceptable range of temperature and humidity for the species. These parameters are maintained by DAC and this means that electricity consumption from lighting, heating, cooling and humidification may be higher in these areas. However, you can help minimize unnecessary energy expenditure **by closing doors, turning off equipment** when not needed (such as biological safety cabinets) and **turning off the lights where acceptable to do so** (such as bathrooms and other support rooms - check with the DAC facility manager first).

Bedding often requires a lot of materials. For most studies, the VUMC Division of Animal Care uses environmentally-friendly corncob bedding from a company that uses the grain for animal feed and ethanol production. Corncob material is completely biodegradable and requires less cage changing, and therefore reduces overall amount of waste generated. If your studies still use shredded paper bedding, **consider whether corncob bedding is an option** for part or all of your study.

Most of the animal housing areas at Vanderbilt have caging connected to **automatic watering systems.** Using these systems wherever possible eliminates the need to dispose of deteriorating or broken bottles and conserves water. If your studies will allow, use this type of caging rather than the kind that requires a separate water bottle.

If you provide your own feed to the animals, keep in mind the environmental impact of the feed you use. Since it often expires 6 months from the mill date, **order only what can be consumed** during that time.

The VUMC Division of Animal Care can provide you with **autoclaved, reusable transport crates** that come from animal research vendors. Consider whether these could be used for your internal animal transport needs.

Some studies require the use of research chemicals, detergents, disinfectants that differ from what is supplied in the animal facilities. **Minimize the amount of chemical used** and make sure appropriate disposable methods are used. Investigate detergents and disinfectants that are more eco-friendly, as the Division of Animal Care is currently doing for its processes. Many vendors now offer products that are more environmentally friendly that can achieve the same results.

When purchasing new equipment, consider the greener options first. Techniplast offers a variety of caging products, biosafety cabinets, and other items that are designed for animal research and are manufactured in a facility that is ISO certified for its environmental management practices.

# RECOMMENDATIONS FOR TEACHING LABORATORIES

Because experiments are often repeated many times in teaching labs, efforts to reduce and recycle can produce significant environmental effects. **Minimize chemical use** by performing microscale experiments or computer simulations, **reusing leftover materials** from a given procedure, or by **disposing of them in an environmentally conscious way**.

Ensure **fume hood sashes are closed** at the end of the lab session.

Instead of water aspirators, **use the vacuum attachment in the wall of the fume hood**. Eliminating a water aspirator can save up to 120 gallons of water an hour.

Avoid using chemicals that are difficult to dispose of or hazardous. Consider **regenerating and reusing chemicals** between class sections. Consider installing a solvent recycler in your lab if appropriate.

While it may be easier to simply leave equipment running all day, unplugging **energy-consuming equipment between class sections** can result in huge energy savings and decreases in carbon emissions.

# RECOMMENDATIONS FOR BIOREPOSITORIES

A **Biorepository** is a biological specimen repository that collects, processes, stores and distributes biospecimens to support future scientific investigation. Biorepositories can contain or manage specimens from animals, including humans and many other living organisms. The Biorepository assures the quality and manages the accessibility and distribution/disposition of the biospecimens in its collection.[10]

Biorepositories need to keep samples at low temperatures in order to maintain the integrity of the samples, so energy conservation and efficiency efforts can produce significant effects.

Opportunities to conserve resources include:

- **recycling and reusing all supplies possible**, such as boxes and ice packs for shipments
- **utilizing electronic media for communication** with pathologists
- **maintaining inventory of all supplies** to avoid waste through expired products
- **maintaining detailed maps of freezers** to reduce time in and out while pulling specimens
- **invoicing electronically** to reduce paper/envelope usage.

Some specimens, such as DNA or RNA, can be stored at room temperature with negligible degradation over time. Check to see if this is a possibility in your biorepository to conserve energy and freezer space. See more information on freezer and refrigerator management.

[10] Biorepositories and Biospecimen Research Branch (BBRB). (n.d.). Biospecimens.cancer.gov. http://biospecimens.cancer.gov/default.asp

# SUSTAINABLE LAB CHECKLIST

This checklist can be used to improve the sustainability of your laboratory. Use any or all applicable strategies.

| Category | | ✓ |
|---|---|---|
| **Recycling and Waste Reduction** | | |
| **Zero Waste Hierarchy** | Create a list of lab items that are typically recycled or thrown away. Can any be avoided, reduced, or reused? | |
| **Traditional Recycling** | Locate the closest collection points for plastic, paper, glass, cardboard and aluminum. If collection is to be done within the lab, who is responsible for getting these materials to the collection point? | |
| **Lab Plastics** | Source pipette tip systems with reusable and recyclable pieces | |
| | Use manufacturer recycling programs for otherwise unrecyclable lab plastics | |
| | Reuse or donate pipette tip boxes | |
| **Used Computers and Electronics** | Use VU Electronics Recycling Program for all used electronics | |
| **Paper Reduction** | Use electronic document generation, sharing, and saving systems | |
| | When printing is necessary, use 2-sided and narrow margin settings | |
| **Ink/Toner Cartridges** | Recycle ink/toner cartridges | |
| **Small Used Batteries** | Recycle small batteries | |
| **Chemical Use Minimization** | Find less hazardous alternates for hazardous chemicals used in your lab. | |
| | Make a list of chemicals in your lab that do not have an ACT label and find alternatives. | |
| | Avoid the use of the EPA 31 Priority Chemicals in your lab | |
| | Reduce the quantity of hazardous chemicals used (scale down experiment) | |
| | Dispose of harmful chemicals safely | |
| | Only purchase the chemicals you need in the quantity needed | |
| | Utilize the Chemical Redistribution Program for unwanted chemicals in your lab | |
| | Follow manufacturer's recommended storage guidelines for chemicals to reduce deterioration | |
| | Segregate stored chemicals to avoid premature deterioration due to chemical reactions | |
| **Energy Efficiency and Conservation** | | |
| **Fume Hoods** | Close the sash on fume hoods when not in use | |
| | Keep fume hood fans on lowest setting possible for your experimental and safety requirements | |
| | Consider sharing fume hoods with another lab | |
| **Refrigerators and Freezers** | Make a schematic to organize your cold samples | |
| | Use refrigerator/freezer space efficiently | |
| | Separate equipment designed to run at high temperatures from refrigerators/freezers | |
| | Create a cleaning schedule and clean refrigerators/freezers regularly | |
| | Create a seal check schedule and check seals on refrigerator/freezer doors regularly | |
| | Change -80° freezer temperature to -70° | |
| | Consider converting samples to room-temp storage: Resource 1 & resource 2 | |
| | Replace old freezers with energy efficient new models | |
| **Computers and Related Equipment** | Turn on sleep settings for equipment to save energy | |

| | | |
|---|---|---|
| **Equipment Use and Maintenance** | Make a schedule and do routine maintenance on all equipment | |
| | Share lab equipment | |
| | Turn off all equipment when not in use | |
| **Lighting** | Establish a protocol for turning off lights in lab at end of day | |
| | Perform an inventory of laboratory lights and determine a plan to reduce the number of lights turned on inside lab | |
| | Employ motion sensors in lab space | |
| **Temperature Control** | Set thermostat appropriately for season - ~75° for summer and ~68° in winter | |
| | Keep doors closed whenever possible | |
| | Close blinds in summer when cooling, open blinds in winter for additional solar heat gain | |
| | Set thermostat to more efficient temperatures when space is unoccupied | |
| **Green Purchasing** | | |
| **Laboratory Equipment** | Only purchase equipment that is necessary | |
| | Purchase the most energy-efficient equipment possible (ENERGYSTAR good indicator of efficient models). Pay particular attention to fume hoods and ULT freezers for more energy efficient models. | |
| | Consider used equipment | |
| **Paper & Printing Supplies** | Choose paper with one or more of the following characteristics: | |
| | • High recycled content | |
| | • FSC certification | |
| | • Chlorine free | |
| | • Made with renewable energy | |
| | • Printed with environmentally-friendly inks | |
| | Purchase remanufactured ink/toner cartridges | |
| **Other Laboratory Supplies** | Choose products with the following features: | |
| | • Recycled content | |
| | • Reduced packaging | |
| | • Packaging made of recycled material | |
| | Choose manufactures with end-of-life recycling programs | |
| | Choose lead-free or mercury-free equipment | |
| **Shipping and Packaging** | Choose companies that implement more environmentally responsible shipping practices such as: | |
| | • Minimal packaging | |
| | • Packaging with recycled content | |
| **Transportation** | | |
| **Transportation** | Choose sustainable transportation options for your commute | |
| | Reduce lab visits with remote monitoring programs | |
| | Choose virtual meeting options instead of traveling to conferences/meetings/etc. | |
| **Water Conservation** | | |
| **Water Conservation** | Eliminate water vacuum aspirators and replace them with energy efficient vacuum pumps | |
| | Only wash full loads of glassware and dishes | |
| | Only run full autoclave loads | |
| | Reuse water when you can | |
| | Report and repair water leaks, broken pipes, and dripping faucets | |

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