



Caltech

Green Labs Guide

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NEUROSCIENCE RESEARCH BUILDING

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1. Why Green Labs?

It is a truth universally acknowledged that science has a [garbage problem](#). Further, California is currently facing an extreme drought and energy shortages compounded by a [changing climate](#). We could expound on these and other issues until all the world's plastic fully decomposes. However, this kind of conversation is not conducive to getting people on board with changing lab culture to *actually* make a difference. The statistics we found when forming this guide are staggering (for example: did you know that average bench scientist typically produces over [2200 pounds](#) of plastic waste each year, as compared to the average American who produces about [200 pounds](#) of plastic waste every year? It's true!) and are, frankly, a result of scientists being overwhelmed and maintaining old habits and superstitions. So, instead of expounding on the sustainability issues facing scientists and citizens alike worldwide, Green Labs has decided instead to look at the [positives](#) of operating a sustainable lab. That's what this Guide is about!

Operating a sustainable lab is beneficial not only to the environment, but also to a lab's bottom line! Often, simple, cheap (or free!) solutions make all the difference in a laboratory setting. It is in everyone's best interests to place sustainability first when running a lab.

However, we know that running a lab is complex and busy, and not all solutions will work for every lab. Here, we have outlined a few main areas of interest that have worked for our pilot labs, in the hope that these adjustments will work or will inspire other sustainable changes in your lab! The most important part is getting your whole lab engaged and excited about increasing efficiency, reducing costs, increasing safety in the lab, allowing for innovation, all without compromising research objectives.

The benefits of voluntary participation are:

- ❖ Reduce overhead costs ❖
- ❖ Increase research efficiency ❖
- ❖ Reduce carbon footprint and pollution ❖
- ❖ Recognition for sustainability efforts on grants ❖
- ❖ Strengthen team building and community ❖
- ❖ Prolong equipment life ❖
- ❖ Greater access to sustainability resources and funding ❖
- ❖ Recognition as lab sustainability champion ❖
- ❖ Increase scientific innovation ❖
- ❖ Enhance lab visibility and attractiveness to students ❖

2. Green Labs Certification

The easiest way your lab can participate is by completing and submitting a [quick assessment](#) that will provide greater understanding of how your lab works, evaluate where your lab is already achieving sustainability goals, and assess areas where your lab has the potential to become more efficient and sustainable. After completing the assessment, please feel free to submit this to Max Christman (Caltech's Sustainability Manager) at sustainability@caltech.edu. This begins your journey to become Green Labs Certified! Once your lab has made adjustments, you can submit another assessment and get scored again. This final assessment informs your final Green Labs Certification Score, and your lab will be rewarded with a plaque advertising just how far you have come.

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Green Lab Certification Dashboard

Current Level	Gold
Total Points	25
Points Needed to Achieve Next Level	5

Leaf Level	Points Required
Bronze	5
Silver	15
Gold	25
Platinum	30



What categories are you strongest/weakest in?

Category	Total Points Achieved	Total Points Available	Progress
Commitment	2	2	100%
Administrative	2	2	100%
Education	2	2	100%
Energy/Refrigeration	6	13	46%
Materials	6	7	86%
Purchasing	4	6	67%
Water	3	4	75%
TOTAL	25	36	69%



3. Energy Efficiency

In 2020, Caltech spent over \$12 million on energy costs on campus. Since 2015, Caltech has added [fuel cells](#) and solar energy generation, and improved many [buildings](#) including making lighting systems, HVAC, air distribution, data center upgrades, and programs to incentivize purchasing energy efficient freezers. However, individual labs can also contribute towards making Caltech even more sustainable!



3.1 Turn off Equipment

This is by far the easiest way to save energy in the lab. Simply turn off any unused equipment, especially equipment that maintains temperature, as those draw the most power. One way to do this is to use [outlet timers](#), which ensure equipment is ready to use when needed, but is turned off during quiet hours. Outlet timers can save 10% of energy annually. If you'd like more information on how to make general lab equipment more efficient, Science recently published this [article](#).

Green Labs is developing colour coded stickers that can be added to equipment to communicate to lab members what the various energy needs are for each piece of equipment:

Green sticker: for equipment that can be turned off immediately after use

Yellow sticker: for equipment that can be turned off at the end of the day

Red sticker: for equipment that can never be turned off

Consider adding the condition that the last person to leave at the end of the day takes a look at the equipment and ensures all equipment that can be turned off is turned off before they leave!

You can also ask your lab members to [turn off computers](#), computer monitors, printers, and other office equipment at the end of the day. These pieces of equipment can also be run using power-save modes where, equipment that has not been in use for a while switch to lower-energy “sleep modes” and can quickly be “woken up” again. Also, turning off screen savers saves a lot of energy! Further, printers can be defaulted to [only print in black and white](#), and [only print double-sided](#) to save both energy, and office supply costs!

Computers dedicated to laboratory equipment may also have “hibernate” interfaces, but it may be necessary to talk to a specialist to confirm these settings are safe and will not interfere with normal functioning of the equipment.

Lastly, your lab can work towards sending fewer emails. Each email emits about [4 g of CO₂](#) (and if there is an attachment it emits more than 50 grams of CO₂!). So, unsubscribing from all those unwanted mailing lists could save a lot of carbon a year! Further, if you are sending large attachments, you can select “upload to OneDrive” which minimizes the emissions from your email.

3.2 Shut the Sash Initiative

We know many (or most!) fume hoods on campus have a sticker indicating where the fume hood is safe to operate at, and that the sash should be closed after use to keep everyone safe. If your fume hood does not have this feature, please contact your building manager or facilities to have one installed. Many labs have been outfitted with sensors that will automatically close after the user walks away. However, in those labs that do not have this feature, it is imperative that fume hoods are [closed](#), not only to keep working conditions safe, but also to save energy. If [possible](#), unused fume hoods may be able to be turned off, and/or work can be consolidated into a smaller number of fume hoods when [possible](#).

3.3 Equipment Share Program

If your lab is considering purchasing new equipment, first see if labs nearby have those pieces of equipment that they may be able and willing to share with your lab. This is especially important for large freezers, cold rooms, and autoclaves. Further, if nearby labs can coordinate to only run autoclaves when they are full, this saves not only on energy consumption, but also water usage and costs for labs! Green Labs also hopes to work with facilities and building managers to develop an equipment and chemical repository or email share list.

3.4 -70°C is the new -80°C!

We know, we know! Changing the temperature on your ultra-low temperature (ULTs) freezers seems like the scariest possible thing to do in your lab! However, keeping freezers at -70°C rather than -80°C saves up to 30% of energy needed to run your freezer, which in turn will make it last longer. ULTs can consume as much energy as a typical [house](#)! You will also need to defrost your freezer less often, which, let's be honest, is a HUGE plus. While we know keeping the temperature lower also increases the amount of time your lab has to respond during an emergency, but consider this [study](#) that suggests that extra -10°C only adds an [additional 35 minutes](#) before freezers get below where they are effective. Further, many things kept at -80°C temperatures only [actually](#) require temperatures between -20 °C and -60 °C, due to how [water crystallizes](#). It is also a good idea to keep an active inventory of stocks stored in the ULT, and keep the freezer free of frost, the cooling coils free of dust, and have your samples spaced out.

If your lab is unconvinced about switching the temperature permanently, you can also participate in the international [Freezer Challenge](#), which Caltech Green Labs will participate in.

Lastly, if your -80 °C freezers are very old, consider replacing them with [energy efficient models](#) that consume less electricity. Sustainability has some [financial incentives](#) for anyone considering upgrading their ultra-low temperature freezers. Further, when disposing of your old -80 °C freezer, ensure it is [disposed of correctly](#) as they contain many materials that are hazardous, and even more that can be safely recycled! Some companies even have buy-back or trade-in programs that are worth investigating, especially for your new -80 °C.

3.5 Complete the Energy Efficiency Assessment

Green Labs members are developing a simple but useful energy efficiency assessment tool (coming soon!) that will help you analyze your lab and see where much of your energy use is coming from. While this tool is not all-encompassing, as it does not account for energy costs outside of the lab (for example: the blowers on the roofs of buildings), it will inform how your lab is "spending" energy.



4. Water Conservation

California is in a drought, so water conservation is at the forefront of our minds. The cost of water continues to rise (increasing at [6x the inflation rate](#)) as Californians are forced to seek sources of water that are farther away, using aging and inefficient infrastructure. We are also more at risk for wildfires than ever. Caltech is actively [upgrading landscaping](#), including opting for climate-adapted vegetation that requires less water, and removing turf where possible, while ensuring local flora is more beneficial to local wildlife, such as [butterflies](#) which use [Caltech](#) as a stopping station on their annual migration! Caltech is also maintaining the [tree canopy](#), which reduces irrigation burden and increases shade and habitat for local wildlife.

[4.1 Report Leaks!](#)

Leaks can go unaddressed for several weeks before they are reported, especially in public areas such as kitchens or washrooms. Even a small leak can waste [a bathtub's worth](#) of water a day! You can report leaks through the [Facilities Service Requests Service Center](#).

[4.2 Turn off Taps](#)

We know this seems obvious, but you'd be surprised to know how much water gets wasted this way! Taps run at 4 gallons per minute, but aerators reduce flow to <1/5 gallons per minute (saving a whopping [300,000 – 900,000](#) gallons of water a year!). Consider installing water [aerators](#) that [reduce the flow](#) from your faucets. Further, foot pedals can be added to taps which make water usage more efficient, and more sanitary!

[4.3 Use Appropriate Water Purity for Each Experiment](#)

Water comes in many shapes and sizes in the lab, ranging from tap water to ultra-pure water. However, [did you know](#) it takes 3 gallons of water to make just 1 gallon of deionized (DI) water? You can help conserve water by using the [appropriate grade](#) of [purity](#) required for your work. Manufacture of higher purity water requires high pressure pumps and filters, all of which increase the energy consumption, consumables, and wastewater production. These adjustments will also help reduce financial and energy costs for your lab, and you won't have to replace those pesky water filters as often!

[4.4 Share Autoclaves](#)

Autoclaves use as much as [60-90 gallons](#) of water per cycle, equivalent to running your shower for 45 minutes. By running autoclaves only when full, you not only reduce water waste but also save a huge amount of energy! Consider arranging a schedule for autoclaving with your lab, and/or sharing loads with other nearby labs to reduce the need to run loads that are not full. Further, talk with your building manager about replacing older models, or installing [water-saving devices](#) on autoclaves. You can learn more about autoclaves [here](#), and how to make their use more efficient (for example: many can be turned off or put into standby mode when not in use).

4.5 Replace Water-Intensive Machines

Many pieces of laboratory equipment are [water-intensive](#), for example: water baths or single-pass cooling systems. [Single-pass cooling systems](#) use more than 13,000 gallons per year per lab! Consider replacing these machines with more sustainable models (for example: water baths can be replaced with [bead baths](#) or [heat blocks](#) (including [those](#) that can heat up to 98 °C in under 20 minutes!), which are less water- and energy-intensive!). A lab may even adopt simple alternatives for single pass cooling solutions for distillations or other procedures, such as high-efficiency air condensers, aquarium pumps placed in a bucket of ice water, or [recirculating water cooling systems](#).



5. Waste Reduction

As we all know, science has a **garbage problem!** Not only in plastics production, but also in hazardous waste production. Labs produce over 2% of the world's plastic waste annually. Caltech alone spent **\$1.5 million disposing** of over 1500 tons of waste in 2019! Waste reduction is definitely an area of sustainability that Caltech can improve upon.

5.1 Reduce, Reuse, and Recycle, folks!

Reduce: Managing purchases is the best way to eliminate waste. Consider asking other labs on campus if they have an excess of what you might need. Green Labs plans on setting up an equipment and chemical share program dedicated to sharing lab supplies (coming soon!). Furthermore, labs can order only what is needed for the current experiments when possible, rather than ordering in bulk. What's more, you can reduce plastic waste by removing it entirely from your workflow (for example: you can opt to use glassware instead of plastic test tubes).

Reuse: Using plastics more than once, where possible and safe, is a good way to reduce plastic waste and reduce costs for your lab. For example: when loading a gel, tips can be reused for multiple wells by "washing" the tips between each sample in the gel buffer. Other items, such as test tubes and syringe plungers can also be saved and reused multiple times. Further, items that have only held water can be reused to hold other solutions in the future before discarding or can be turned into waste disposal vessels (if this is the case, thoroughly rinse the item and cross out the original label so others can safely handle the containers).

Many companies have buy back programs. For those that do not, don't minimize your buying power! By asking companies you routinely purchase from to invest in buy back programs, you can use your leverage as a purchaser and sustainable champion to influence companies.

Soon, Green Labs is also establishing drop-off points where pipette tip boxes, Styrofoam, and ice packs can be recycled, so that labs in need can use your discarded items. We are working with building managers and Facilities to investigate the best places on campus to put these drop-off points and will update the community as soon as locations are chosen.

Recycle: Most hard plastic can be recycled at Caltech! If you cannot reduce or reuse these items, please recycle them! For example: did you know that clean petri dishes can be recycled in regular recycling bins? Green Labs is developing new lab-specific signage for all your lab recycling needs, which will increase ease of recycling and transparency, and increase efficiency for custodians. Please ensure that all plastic that is recycled is non-hazardous and thoroughly rinsed/decontaminated before recycling. If recycling hard plastic bottles, please rinse and cross out the label, so custodians are assured they are not handling hazardous chemicals.

Generally, the best practice is trying to replace single-use plastics with reusable glassware that can be washed and reused for many years. This saves both the environment and lab finances!

5.2 Gloves

Gloves should be worn only where needed, and can be reused where safe and possible. Your lab can also consider alternatives to plastic gloves, including [Genesee's biodegradable gloves](#), which not only are biodegradable, they are cheaper than traditional gloves (ask our rep for the Green Lab's discount!), and they come in larger box sizes (200 per box) which reduces waste! Green Labs is also looking into glove recycling programs, so stay tuned!

5.3 Hazardous Waste Disposal

Caltech removes, processes, and disposes of all hazardous waste on campus. Please contact the Biosafety Office for more information on what is, indeed, hazardous waste, and how to properly and safely dispose of this waste. EHS can provide advice and help your lab assess hazardous waste streams to optimize your workflow and waste disposal. For example: did you know that putting kimwipes or paper towel into the sharps hazardous waste disposal is an inefficient and costly method to dispose of these items? Instead, consider having a hazardous dry waste disposal area (for example: in a fume hood) where paper towel, Kimwipes, tips etc that have come in contact with hazardous chemicals can be safely disposed of.



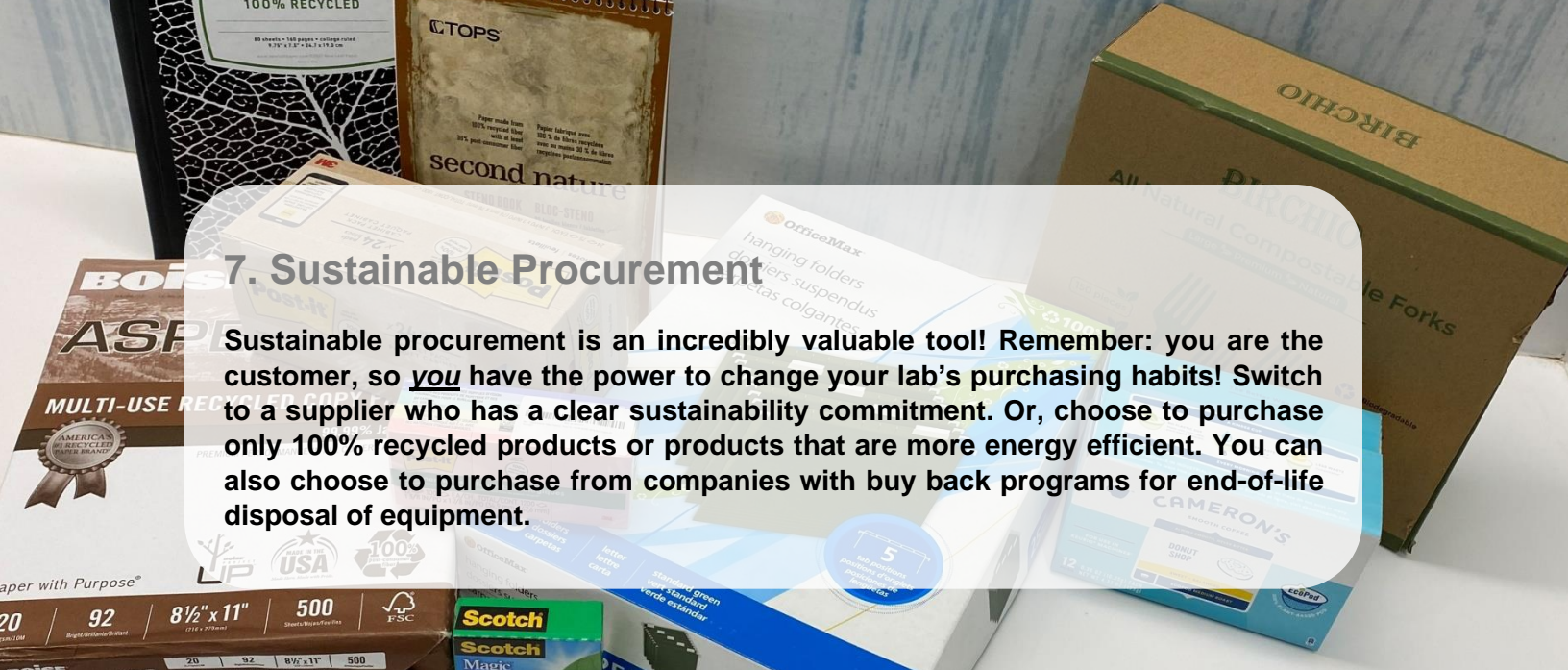
6. Green Chemistry

We know, we know! This is the scariest and most unfamiliar area discussed here. However, green chemistry is not reserved for chemists alone! Incorporating green chemistry can improve lab safety, improve lab culture, and create more proactive and innovative solutions to common problems, including the needless usage of hazardous reagents. Green chemistry basically boils down (see what we did there?!) to quantitatively assessing and substituting hazardous chemicals for green solvents, all while protecting research integrity. Some labs have reported that substituting in favour of green solvents has improved resulting data. Caltech has taken an active investment in green chemistry, as these substitutions will reduce overhead costs of hazardous waste disposal for the institute, and will increase researcher and EHS worker safety.

6.1 Adoption of Green Chemistry

Now, we realize how hard it is to convince your lab to adopt a new protocol. We hear you! However, if your lab is willing, there are often simple solutions to improve the safety of researchers. For example: did you know that when doing *in situ* hybridization, chemicals that contain the toxic chemical formamide can be switched out for [ethylene carbonate](#) without any modification to a traditional protocol (references [here](#), [here](#), and [here](#))! Researchers have even reported improved results after adopting this greener solution. Some great resources include [My Green Lab](#) and [Beyond Benign](#), which have a ton of information on green substitutions and green chemistry, and have great resources for teaching labs to incorporate green chemistry into lesson plans!

When developing new protocols or teaching modules, green chemistry can be utilized to great advantage to reduce toxic solvents and reagents. There are [12 Principles of Green Chemistry](#) that allow a researcher to compare greener alternatives systematically. There are also several green chemistry tools available, including those from [Millipore Sigma](#), or the [US EPA Chemical Substances Inventory](#).



7. Sustainable Procurement

Sustainable procurement is an incredibly valuable tool! Remember: you are the customer, so you have the power to change your lab's purchasing habits! Switch to a supplier who has a clear sustainability commitment. Or, choose to purchase only 100% recycled products or products that are more energy efficient. You can also choose to purchase from companies with buy back programs for end-of-life disposal of equipment.

7.1 Keep an Inventory of Chemicals and Equipment

Keeping an inventory of chemicals and equipment is not only a way to prevent over-purchasing these items, it also allows equitable access for your entire lab, and encourages potential collaboration with neighbouring labs. Buying wisely and in the minimum amount required for research questions ensure that chemicals are not forgotten or become unsafe with time.

7.2 Sustainable Procurement / Purchasing

Careful consideration while procuring items incorporates environmental concerns, social equity, and human health. Caltech partners with many vendors to help purchasers choose eco-friendly products, and TechMart incorporates an option to find only eco-friendly products in searches. Before purchase of a new chemical or piece of equipment, consider checking the lab equipment and chemical sharing tool Green Labs hopes to establish this year, to see if anyone has the item your lab needs. If not, consider ordering only the volumes needed for the experiment, rather than ordering in bulk, as this will reduce costs to purchase and dispose of unused items. When resupplying commonly used products, a purchaser can also change vendors to suppliers that have definite and clear commitments to sustainability, or those who have environmental criteria incorporated into their business practices.

Further, a purchaser can ask vendors if they use recyclable or reusable packaging, if they have buy back or take back programs for packaging, or if there are discounts or perks for customers who utilize these programs. A purchaser can also enquire if there are more eco-friendly options available for equipment, or if the product can be configured to be more eco-friendly (for example: is "sleep mode" configurable to reduce energy consumption). Lastly, also take into consideration that eco-friendly equipment that has a higher up-front cost may have cost-savings later on, including less expensive consumables (like bulbs or plastics), having a longer lifetime, less maintenance requirements, or fewer hazardous wastes needing disposal. A cheaper product may also be unethically produced, so a purchaser can investigate where the products were created to see if those countries of origin have fewer labour laws or environmental protections. Eco-friendly products also usually mean high-efficiency, which may be a starting point for subsidization! All of these factors contribute to a reduction of the cost of ownership and should all be considered when making an informed purchasing decision.

7.3 ACT Labels

My Green Lab has developed an [ACT Label](#) that many suppliers have adopted. This label gives the environmental impact factor incorporating manufacturing of the product and packaging, energy and water consumption, and product's end-of-life status. This tool allows you to compare different products' environmental impact, with the lowest score being the most eco-friendly.

Other great resources for sustainable procurement include [Lab Conscious](#) and [i2sl](#).

7.4 Other Sustainable Procurement Tips and Tricks

Some labs have begun swapping out traditional office supplies for 100% recycled products, to great benefit, with few lab members even noticing the change! It is estimated that the average office worker uses roughly 10,000 sheets of copy paper a year, but [around 30% are never even picked up!](#) Some recycled products include 100% recycled [copy paper](#), [post-it notes](#), [writing pads](#), or [reusable notebooks](#). More information on this trend can be found [here](#) and [here](#).

There are a lot of other eco-friendly office supplies including [tape](#), [file folders](#), [dish soap](#), [sponges](#), [scrubbers](#), [napkins](#), [beeswax wrap](#) or [bags](#) for leftovers, and [disposable plates](#). And, of course, we can't forget the most necessary of all products: coffee! A few good eco-friendly options for this ever-necessary, and life-giving substance include coffee [stir sticks](#), [compostable K cups](#) and other [reusable capsules](#) or [reusable k-cup](#) coffee pods with [disposable filters](#). Lastly, but certainly not least, eco-conscious and/or ethically-sourced [coffee coffee coffee coffee](#).