

Sustainable-Lab Consumables Guide

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A laboratory consumable is any item that is routinely purchased or replaced e.g. pipette tips. Science has become reliant on disposable and sterile equipment over recent decades. This has resulted in increased waste most notably of laboratory plastics, much of which must be incinerated.

Simple changes can be made to reduce the waste produced by research facilities, including improved planning and conscious purchasing. This is not only good for the planet, but also reduces costs to the lab. This guide is intended to provide simple advice for users on what to consider when using common laboratory consumables. There is a hierarchy of action types underpinning sustainable waste management, known as the 5 R's:

Refuse, Reduce, Reuse (or Repair), Repurpose, Recycle

Only when the earlier 4 R's have been considered is recycling an appropriate action, though any form of hazardous waste should be excluded from this.

Joining your local "Green Lab Group" or becoming a Sustainability Champion via the [LEAF](#) programme is a fantastic way to learn or share further good practice. For a poster on how you can generally reduce plasticware in the lab, click [here](#).

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General Advice

Experimental Design and Research Quality

Plan and carry out experiments in ways that avoid unnecessary repetitions and maximise data generated, saving materials and costs.

Experiment Planning

- Before beginning an experiment consider the volume of consumables required: Balance ordering sufficient amounts for contingency with avoiding excess. Use resources that are already available or that will go unused by other laboratories. Having some contingency is important as being without may interrupt and delay your work, and ordering multiple times (rather than bulk ordering) can result in increased packaging waste.
- Consider *how* your consumables are to be used – are there ways to increase the usage of consumables normally used? For example is it possible to fit more samples in less space, such as planting more seeds on a single dish?
- Scaling the size of plastic vessels is an excellent way to reduce plastic waste. E.g. avoid 50 mL falcon tubes for transporting materials wherein 2 mL tubes would be sufficient.
 - If there are a few samples that require a smaller vessel then consider using PCR strips or a smaller multi-well plate rather than leaving empty wells on larger plates.
- Where you may use a core facility, technical platform, or private company to process a batch of samples you should. Use of such facilities typically will save on time, improve comparability of results, and be cost-efficient.
- Consider the appropriate n-value, or sample size, necessary for your sought experimental rigour. Avoid going above this.

Experiment Execution

- Ensure any equipment used for measurements has been appropriately calibrated to avoid errors which may lead to results being less comparable. This includes pipettes, scales, etc.
- When pipetting, master mixes are an excellent way to reduce the number of pipette tips used. Additionally, using master mixes reduces the likelihood of pipetting errors.
- Consider the order you pipette to minimise excess tip use. For example, when using a master mix you should pipette this first before the unique samples, in order to reduce contamination and plastic waste.
- Consider using watch glass or metal weigh boats rather than plastic alternatives. If this is not possible, potentially due to concerns over the reactivity of a substance or contamination, consider paper weight boats (supplied by VWR) over plastic.

Experiment Conclusion



- Once your experiment is complete, discard all samples and materials associated which no longer have any application. Any unused consumables or sample-sets should be offered to fellow staff and students before disposal. Consider writing to wider email groups to offer materials. Alternatively, you could send out notifications or upload the materials via a laboratory management system (e.g. LabCup, or Quartzy).
- All data produced from the experiment ideally should be shared with the scientific community, even if results are considered 'negative' and don't fit the original hypothesis. In the absence of 'negative-results journals, it is recommended that each scientific talk contains a mandated portion on what didn't work (e.g. 2 minutes at the end of every talk on what went wrong).

Packaging

Packaging for consumables can be a significant source of lab waste. Avoid putting clean packaging in clinical waste.

Procurement

- Reductions can be achieved by bulk ordering regularly used consumables. Consider combining orders with more groups/departments to reduce deliveries, packaging and costs. Only bulk order though if you are certain you will use all the materials ordered.
- Engage with and purchase from manufacturers that make an effort to reduce packaging waste. Include in tenders that you are seeking minimal packaging. Request that suppliers reuse packaging. For example, purchase falcon tubes without the polystyrene holders and restack loose pipette tips.
 - New England Biolabs (NEB) and BioEcho both purposely use minimal packaging materials for many of their products, like DNA and RNA kits (e.g. NEB's Monarch kits)
- Choose alternatives that can be shipped at ambient temperatures where available to reduce ice packs, polystyrene, and dry ice.
 - ThermoFisher Scientific have begun to develop and ship room temperature Taq Polymerase and custom primers for DNA assays. They have estimated this has reduced the CO₂ associated with the manufacturing and transport of polystyrene by 38 tons each year.
 - NEB ship thermostable polymerases, DNA ladders and protein standards at ambient temperatures.

Use

- Consider if there are alternative uses for packaging, as some may be difficult or even impossible to recycle. For example:
 - Polystyrene boxes can be used as ice boxes or to fill empty spaces in cold storage.
 - Packaging can be used to send reagents or samples to other laboratories.
 - Polystyrene can be used to store glass items safely.



- Consider donating ice-packs may to a business which can find an alternative use, for e.g. veterinarians or delivery companies. Ensure this is in accordance with risk assessments.

Disposal

- All packaging should be recycled in the appropriate waste streams if it's non-hazardous.
- Do not put dry-ice down sinks, and ideally store it in a freezer for later use.
- Cold shipping:
 - Ice packs and gel packs can be reused, but often build up. Try to re-home them before disposing. Often stores or technical staff will use cold storage packs for shipping or for keeping items cool whilst they are waiting to be collected.
 - Check what type of plastic makes up the ice/gel pack. If it is an ice pack, wait for it to defrost then pour out the water.
 - For gel packs, check what the contents are. NEB use water-based gel packs which can be put onto plants as irrigation and are broken down by sunlight. The plastic from the pack may then be recycled separately.
 - Push suppliers to develop solutions for the reuse of cold shipping!

Take-Back Schemes

Take back schemes for packaging are where the supplier accepts back boxes that they have supplied and reuses or recycles them. If the scheme recycles the boxes (like Promega), use this only if your institution is unable to recycle polystyrene on-site. Take-back schemes currently do not accept ice-packs. Always check with your local stores/post-room team to ensure they are in agreement and understand the system. Contact your local sustainability team for advice.

Known Schemes

- Promega Package Return: "All boxes have a pre-paid address label that can be used to post the polystyrene boxes back to Promega for recycling."
- [NEB Package Return](#): (Each box comes with a FreePost label to send it back).
- [Thermofisher Mauser and Winchester return scheme](#): "Operates a collection and recycling service for used Fisher Chemical 2.5L glass (Winchesters) and plastic coated glass bottles",
- [Starlab Tip Box Scheme](#): (returned tip boxes are mostly recycled, but some are reused)

Glass, Plastics, and Decontamination

Determining the most sustainable solution for some lab waste can be challenging, particularly when we consider the carbon and financial cost of new materials, treatment of waste, and washing materials to a satisfactory level for reuse. In the UK DEFRA lists the carbon associated with the major waste streams (hazardous/clinical, general waste, recycling, and offensive/burnt for energy

recover) as equal (21.80 kg / tonne of carbon). In this section, we aim to provide you with some carbon costs and considerations for deciding how to treat your lab waste. Clinical waste is incinerated, and typically will cost 4-6 times more financially than recycling or landfill.

Material	CO ₂ e from primary production	Method of waste disposal		
		Recycling (CO ₂ e)	Incineration (CO ₂ e)	Landfill (CO ₂ e)
Glass (1 tonne)	895 kg	21.8 kg	21.8 kg	26 kg
Plastic (1 tonne) of plastic	3328.4 kg	21.8 kg	21.8 kg	9.3 kg

Useful factors when considering the carbon impact of waste streams:

- On-site or district heat and steam: 0.17606 kg CO₂e / kWh
- Water Supply: 0.344 kg CO₂e / m³
- Water Treatment: 0.708 kg CO₂e / m³
- No available data on CO₂e of chemical decontaminants.

From the available data, it appears that reusing glass will result in fewer carbon emissions than single-use plastics. A 2020 study supports this position, showing that reusable steel clinical tools when washed would produce a 75% reduction in greenhouse-gas emissions when compared to single-use plastic versions (L.M.Donahue, Obstet Gynecol. 2020). Please follow the appropriate risk assessments when cleaning materials, and dispose of broken or chipped glass. Also note that if you use chemical decontamination procedures instead of autoclaving, the decontaminant chemical waste should be disposed of according to risk assessments.

Decontamination Procedures

Some materials such as plastics may be decontaminated to enable reuse. This includes petri dishes, cuvettes, falcon tubes. Consider the balance as to whether you think uncertainty due to decontamination will result in repeated experiments or not.

- Decontamination for re-use steps:
 - Remove the contents and dispose of contents appropriately
 - Remove lids
 - Fully submerge the items in 10% Distel for at least 18 hours. This protocol may vary depending on what must be inactivated (e.g. 5% may be appropriate in some cases, or disinfectants as opposed to Distel). Consult risk assessments if uncertain.
 - Rinse with tap water
 - If the items have not been in contact with any biological agents or only require a low level of sterility, then this is the end of the process and you should drip-dry the item before storing it away for re-use.
 - Wash the item in a glass washer/dishwasher
 - Autoclave in paper autoclave bags



- Return to the lab in the paper autoclave bags

Pipette Tips and Boxes

Scientists can use hundreds of pipette tips a day, generating a huge quantity of waste. Whilst these tips are generally necessary, there are some ways to reduce their environmental impact.

Procurement

- Reusable tip-boxes should be prioritised over tip-box recycling schemes, which typically recycle tip-boxes exactly as your normal recycling stream would. Consider reloadable tip options – filter tips are reloaded with some suppliers.
 - Tips can be re-racked for quick use. This is particularly good when sterility is less of a concern, for example, when loading gels or in teaching labs.
 - Boxes of autoclaved re-racked tips can also be used. This is a sustainable option when used in conjunction with best autoclave practice e.g. using appropriate sized autoclaves.

Use

- When reloading tip-boxes, be especially careful, as some methods may be tricky and result in tips falling out.
- Follow the guidelines for experimental design given [above](#).
- Only use pre-boxed or filter tips when absolutely necessary. This will also save money.
- Pay attention when pipetting – loss of concentration can result in mistakes which cause experiments to be repeated.

Disposal

- Used tips are often stored in pre-bought plastic containers before disposal, as they are considered sharps. These are destined for incineration as they are classed as clinical or offensive waste. Repurpose old chemical containers to hold used tips instead, allowing the items to have a second life. This is particularly beneficial if the container is not able to be recycled and is considered clinical waste already.

Personal Protective Equipment (PPE)

Gloves

Nitrile gloves are synonymous with the sterile modern laboratory environment. At times they are necessary to ensure sterility or as health & safety measure, but there are ways to reduce their use.

Procurement

- Consider glove thickness:



- Use thin gloves where you need to change gloves more regularly for example, in environmental DNA or other areas where contamination concern is high. This is because there is less plastic used in thin gloves.
- Use thicker gloves where you can wear them for multiple uses. If gloves are too thin then they will be more likely to break and harder to put back on.
- Target suppliers which have recyclable boxes for gloves, such as the ecoSHIELD™ gloves.

Use

- In decades past, much research was successfully completed without gloves. Whilst this may no longer be possible today, reducing the number of gloves may still be feasible. This can be achieved through planning and reusing the same pair of gloves, but relies on users remaining considerate of contamination and health & safety. Gloves must not be reused if they have come into contact with a pathogen or hazardous substance, nor for sterile work.

Disposal

- Often gloves cannot be recycled as they must go in the offensive or chemical waste. However, the packaging can be recycled as it is often cardboard. Look for packaging with as little ink as possible as the de-inking stage of recycling can both produce and requires a large quantity of chemicals.
- Glove Recycling Schemes - Some suppliers will offer 'glove recycling' schemes. Before implementing, consider the following:
 - Recycling providers typically ask you to use only one company's brand of gloves
 - They generally only accept non-hazardous gloves, which could potentially work in a teaching lab but is unlikely to be suitable for research spaces
 - Suppliers may charge for picking-up the gloves. These costs may be off-set by waste savings, as gloves are typically thrown into expensive clinical waste streams.
 - Recycled gloves are likely down-cycled into products and aren't sent to produce more gloves. It is likely this may represent an overall carbon saving when compared to incineration, but clear data is lacking.
 - Ensure someone is responsible for organising pick-ups of recyclable gloves.

Other PPE

A simple way to avoid waste in the laboratory is to invest in reusable PPE, though dependent on possessing cleaning facilities. This can include foot covers, hair nets, disposable gowns or face masks. If uncertain, for most PPE you can find studies on efficacy and necessity for your work.

Cell Culturing Consumables

Cell culture consumables include cell culture flasks or dishes, cell counters and serological pipettes.



Procurement

- Consider petri dish sizes and whether they could be smaller, or if there are ways to maximise the area of the plates that is used thereby reducing the number required. If this isn't possible for an entire study, it may be applicable for preliminary experiments or undergraduate projects which are unlikely to be published. Combining orders with other labs can reduce packaging.
- Reusable glass cell counters are available and should be considered over disposable plastic options, particularly as cells contained are typically disposed and thus present no risk of contamination.
- Glass serological pipettes should be considered for pipetting non-biological solvents which do not require sterile environments. These should be reused and cleaned, not disposed of. In order to clean these pipettes a glass washer attachment or pipette washer and siphon is needed.
- Consider the scale of your culture.
 - If you are cultivating multiple cell lines, consider using smaller bottles.
 - If you are cultivating one cell line, but you need a large quantity of cells, consider using one larger container or a multi-layered flask.

Use

- Careful planning and consideration of pipetting order can reduce the amount of wasted materials.
 - Keep a sterile environment, using 70% ethanol to wipe your work surface and the outside of all bottles before use.
- Making your own media can reduce the amount of plastic waste. Ensure though that it conforms to experimental requirements.
- Plastic petri dishes and cuvettes may be decontaminated and re-used, though if they become damaged please dispose of them (see [decontamination procedure](#) listed in General Advice).
- Replacing plastic petri dishes with glass (that can be autoclaved and reused) is an excellent strategy where possible. Again, refer to [decontamination procedures](#) for advice.
 - Should you use glass petri dishes, purchase a special rack for your glass washer so you can wash them along with your other glassware.
- Use containers such as media bottles that are already contaminated for waste liquid or tip-collection. This will reduce the cost and plastic associated with purchasing plastic leftover tip-receptacles.
- Use traditional metal inoculation loops instead of plastic reusable ones, as they are a low cost and very efficient alternative. You must ensure the wire is cool enough before touching any bacteria – liquid or on a plate – otherwise you will kill the bacteria.
- Instead of single-use cell/plate spreaders, consider using glass beads or metal reusable versions which may be autoclaved between uses.
- It is feasible to re-use flasks or multi-well plates, but only if experimental implications have considered. E.g. flasks may be reused when simply growing up common cell lines. Use the [decontamination procedures](#) outlined in General Advice to clean for reuse.
- Use all wells in multi-well plates, and avoid using excessively sized flasks/plates, etc.



- Screening cell culture clones by growing a mini-culture (100µL) in a PCR tube reduces plastic waste from a 10mL culture tube to a 200µL PCR tube per clone. After identifying a positive clone, you can grow this in a regular 5mL culture to extract the plasmid. This method saves a lot of lysogeny broth by reducing the culture volume significantly.

Disposal

- Unfortunately most cell culture consumables cannot be recycled. If you are already autoclaving your waste in the lab, then most waste can be disposed of via offensive waste rather than clinical waste (after it has been autoclaved). This reduces costs and minimises energy use for incineration.
- If implementing a recycling scheme for some materials, ensure the following:
 - The materials targeted are actually recyclable
 - Potentially a means of cleaning the materials has been identified
 - Training for all staff and students have been updated
 - Current staff and students received appropriate training
 - A means of disposal has been agreed for the removal of the recycling waste
 - Local H&S officer has agreed to the process

Microcentrifuge/Conical centrifuge tubes

Procurement

- Bulk ordering tubes and consolidating orders with other groups can reduce deliveries and packaging.
- Purchase loose falcon tubes and rack them, without polystyrene holders for the tubes.
- We have found that the following tubes can be autoclaved allowing reuse and reducing costs:
 - [15 ml](#)
 - [50 ml round bottom](#)
 - [50 ml with skirt](#)

Use

- Plan your experiments to use as few tubes and samples as possible.
- Use smaller tubes where possible, and also consider moving towards smaller boxes. This will improve the usage of space within freezers and cold storage. Remember each ultra-low temperature freezer can consume as much energy as an average house.
- Clearly label all tubes with the correct contents and the date to ensure that the tubes are not lost or wasted. Ensure labels can withstand alcohol or if necessary, long-term cold storage.
- Falcon tubes may be decontaminated for reuse (see [decontamination procedure](#) listed in General Advice). Universals cannot be autoclaved so it is best to use an alternative plastic tube which can – changing to a 50ml falcon is the recommended option.

Disposal

- If you can't reuse tubes, consider what waste stream is appropriate. Please read the disposal advice for Cell Culturing Consumables [above](#).

Winchesters and other bottles

Procurement

- When purchasing chemicals held in plastic containers ensure that both the lid and bottle are made of recyclable plastic, as they will need to be separated to recycle. This information should be included in the product description. Alternatively the plastic should have a recycling code (a triangular arrow with a number inside).
 - Containers for non-toxic chemicals and laboratory reagents, typically powders, tend to be High Density Polyethylene (HDPE).

Use

- Reuse thoroughly cleaned empty bottles where possible, e.g. glass Winchesters may be used to store chemical waste prior to pick-up.
- Plastic bottles which are not recyclable, these can be used to hold used pipette tips and used microcentrifuge tubes rather than a bio-bin or new container. Ensure containers are thick enough to withstand autoclaving and not melt/collapse.

Disposal

- Your building may have a Winchester recycling scheme. Please make use of this scheme if possible, though pay attention to which brand of bottles is being recycled as companies will typically only collect their own bottles. Also ensure they are completely empty and clean.
- In the absence of a recycling scheme, clean all chemical bottles appropriately and deface or remove the label so that it is clear the item is not dangerous. Then recycle glass and plastic bottles through normal waste streams.

Reagents, Water, and Kits

Procurement

- Making gels, media, or kits on-site can reduce packaging waste. For example, pouring electrophoresis gels or creating cell culture media. Factor this in when organising your reagents and consumables. Most pre-made materials will cost significantly more.
- If you order your own kits, target suppliers that allow flexible kits so that you avoid excess buffers and reagents building up and getting wasted at the end of use.
 - E.g. NEB's Monarch kits are all flexible and all reagents can be purchased individually.
 - E.g. you can order extra mini-elution tubes which aren't wrapped in plastic for DNA extraction



Use

- You can reduce waste and energy consumption by considering the water quality and purity you need. Post signs for appropriate water purity applications in common lab protocols. E.g. avoid using Milli-Q water unless necessary. Using DI (deionised) water instead reduces the number of filters your lab will go through annually.
- Pay close attention to the kit protocol or your specific protocol. Mistakes can result in wasted consumables and reagents, or worse, require the use of a new kit.

Disposal

- Please consult your local effluent waste guidance, and ensure no hazardous substances are introduced to water treatment facilities. Non-toxic reagent containers can be cleaned and repurposed. This is particularly useful when purchasing bulk reagent kits and are aliquoting them before use. Alternatively, these bottles can be used either to store used pipette tips or be sent for recycling.

Columns, Solvents, Syringes, and Glassware

Procurement

- Solvents are frequently used in larger volumes – consider your requirements and bulk order where feasible. Favour solvent suppliers which offer reuse or recycling schemes for solvent bottles.
- Consider purchasing reusable syringes, preferably made from glass. These can be purchased with a range of nozzles and attachments. Ensure that any reusable glass syringe is autoclavable or that the department has the facilities to clean the syringes sufficiently.

Use

- Glassware is still favoured in the majority of chemistry labs. Glass should be reused as much as possible. Should glassware show any cracks or chips, immediately send this for repair (if feasible) to avoid cuts or full breaks of the glassware.
- Solvent Recycling is feasible for commonly ordered solvents like acetone, but requires distillation facilities. Solvents must be collected and sent for distillation, and potentially to check final purity. Learn more about how the universities of [Boulder Colorado](#) and [Columbia](#) set-up programmes.
- Where feasible, use dry column vacuum chromatography over flash chromatography, as the former will require less solvent and silica, is faster, and has better resolution.

Disposal

- Dispose of clean glassware through the appropriate waste streams (some labs have a specific glass waste stream, whilst in some it's through mixed recycling). Please keep in mind that not



all glass is the same, for example Pyrex ® glass is more heat resistant so should be recycled separately to general glass recycling.

- Do not pour large quantities of solvents down the sink. It is acceptable for solutions of small volumes (<500ml) of non-toxic water-soluble chemicals to be carefully washed down the sink with plenty of running water. Large quantities or hazardous chemicals should be disposed of through the institutions chemical waste disposal procedures. If you are unsure of these contact your waste manager. www.ucl.ac.uk/estates/sites/estates/files/chemical-waste-procedure.pdf
- When you finish using a gas cylinder or if you have old or broken gas cylinders, you can return them via a return scheme. Consider consolidating collections with other lab groups or organise in advanced for manufacturers to take them when they deliver new cylinders to reduce the energy associated with collection.