Ollscoil Teicneolaíochta an Oirdheiscirt

South East Technological University

PMBrc

Pharmaceutical & Molecular Biotechnology Research Centre

GREENER LAB GUIDE

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VISION & MISSION

Our Vision

This guide highlights how researchers in the PMBRC at SETU are working to improve sustainability in our laboratories. It has been developed to inspire and support teams, researchers and technical staff within SETU and at other research institutions to adopt more sustainable practices within their lab settings. The information in this document may be adapted to support your institution / organisation in its sustainability journey.

Our Mission

- To embed sustainability practices within the PMBRC.
- To communicate and encourage more sustainable practices across all laboratories in SETU. Sustainability will play an important role in all areas of our University and is a key part in our new Strategic Plan.
- To contribute to Ireland's climate target to reduce emissions by 30% by 2030.
- To respond to our **Climate Action Mandate**, as members of the Public Sector, to act in the area of sustainability, and implement **National Strategy on Education for Sustainable Development ESD-2030** in our research and teaching.

MY GREEN LAB CERTIFICATION:

A WORD FROM THE TEAM

This booklet has been developed by the PMBRC Green Lab multi-disciplinary implementation team, a collaboration of academics, technical officers, postdoctoral researchers and postgraduate students, and presents our learnings in implementing the My Green Lab Certification programme at SETU in Waterford. The Green Lab team were also supported by Estates and the Working Energy Advisory Group (WEAG) during the certification programme. This booklet is a guide for researchers at SETU highlighting practices to implement in their laboratories.

We are all aware of the change in our climate, the **increase of 1.1°C** in global temperature since 1850 and the effect that this has on the environment. If this temperature increases further there is potential irreversible damage to our ecosystems. The 2021 **National Climate Action and Low Carbon Development (Amendment) Bill** has definite targets and emission reductions to achieve by 2030 and 2050. This requires us to change the way we work in both academia and industry. We wanted to do our part in our working environment and joined The My Green Lab Certification process to help us drive and implement change in our practices.

The My Green Lab Certification process is recognised by the United Nations Race to Zero campaign as a key measure of progress towards a **zero-carbon future**. This certification process is a proven, scalable programme that helps organisations achieve their sustainability goals. The process offers support and methods rooted in science to dramatically reduce the environmental impact of laboratories without disrupting the critical work underway.

my green lab certification.

MY GREEN LAB CERTIFICATION:

A WORD FROM THE TEAM

During the implementation phase the Green Lab team met monthly to present findings and identify new ways to target each certification section. The team worked together across different functions, to drive change in our B32, B33 and B36 laboratories. Each team member brought different perspectives from areas such as chemistry, biology, and facilities which helped us to think of new ways to reduce our environmental impact, from the consumables we purchase to the equipment we use. We wanted to rethink how things have always been done in the laboratory and daily lives, to change mindsets and embed a culture of sustainability in our Centre. This will be an ongoing and evolving project, with work done and changes in place but more to do going forward.

We encourage all researchers in the Centre and Department of Laboratory and Land Sciences to consider becoming My Green Lab ambassadors **here** and implement the necessary changes in their laboratory spaces and practices. We also encourage further laboratories to complete the My Green Lab certification process. Our guide offers simple ways of making significant change across the key areas within the laboratory for energy, waste, water, procurement, Green Chemistry and Green Biology.

PMBRC
Green Lab Team

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ENERGY

Overview

SETU in Waterford achieved & surpassed our obligated energy efficiency targets to 2020, the challenge now is to surpass our 2030 targets. All Public bodies are obliged to reduce their carbon emissions by an absolute target of **51% by 2030** from a baseline year of 2016 to 2018 and further improve our energy efficiency target to 50% from our baseline year of 2001-2005. In 2021 the electrical emissions for SETU Waterford were 1,766,028 $kgCO_2$ and thermal were 853,628 $kgCO_2$. It is expected that the national grid will decarbonise substantially by 2030 and is forecast to reduce our electrical Gap To Target (GTT) based on 2021 emissions to 142,128 $kgCO_2$. With the national grid forecasted to decarbonise the biggest challenge in reaching our 2030 targets will be to decarbonise our thermal emissions. Laboratories consume significant energy, **5-10 times** that of office buildings – but this also means our laboratories present a fantastic opportunity for being more energy efficient. You can have significant impact by making a few changes as outlined below. The SEAI Energy Academy provide useful e-learning supports in the area of energy that can be found here.

Plug Load

Equipment plugged into outlets can account for up to **25% of the energy** used in a lab. We encourage you to think about whether all equipment needs to be on and plugged in 100% of the time, and to develop strategies for handling equipment differently. Non-essential lab equipment can be **unplugged** overnight, at weekends and during holidays; mark which items can be unplugged during this time using the traffic light system shown below. Electric timer switches can also be used to turn off and on equipment as required. We installed a fluke meter to assess baseline energy use before implementing energy saving measures. This provided us with useful data to monitor our progress and drive us towards continuous improvements.

Red - Machines / equipment should not be turned off.

Orange - Please get permission before switching off.

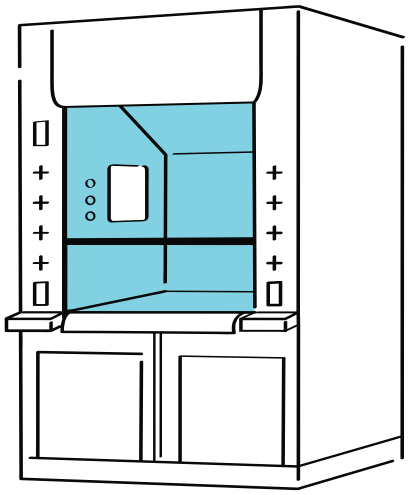
Green - Machines / equipment can be turned off immediately after use.

Use **timers** on equipment that do not need to be left on overnight, these can be set to come on early in the morning to be ready for users. Implement a system for the "last person" to check equipment or processes that can be turned off at the end of the day.

A useful link to estimate appliance and home energy use can be found here.

ENERGY

Shut the Sash



In addition to high equipment loads, laboratories require substantial amounts of fresh air ventilation which can account for **40-50% of their total energy** use. One of the simplest ways to reduce the energy required by operating fume hoods is to ensure that the sash is always in the lowest possible operating position. This simple action can lower the amount of energy used substantially and will, in all cases, provide the safest working environment. **"Shut - the-sash"** stickers have been implemented to promote behavioural change.

It is important to follow best practices while using the fume hood.

- Keep equipment towards the front, and elevated, if possible, to ensure that air flows safely away from the user.
- Equipment such as plate heaters, shakers or agitators should be **switched off** when not in use.
- In some instances, additional energy savings can be made by fully turning off fume hoods when not in use.

The energy saved by correctly and safely using the fume hoods at the correct height can be estimated using a tool developed by Lawrence and Berkeley National Laboratory **here**. We plan to regularly measure our energy use in the PMBRC and make change in this area.

Computers

Put computers and monitors in **sleep mode** or **shut them down** when they are not in use. Do not rely on screensavers to save energy- turn the monitor off. Some laboratory equipment interface with dedicated PCs. When possible, power down this electronic equipment. Alternatively, put into a "hibernate" mode when equipment is not in active use. Ensure any local and networked printers have their sleep modes activated and check its default setting is double-sided printing in black and white.

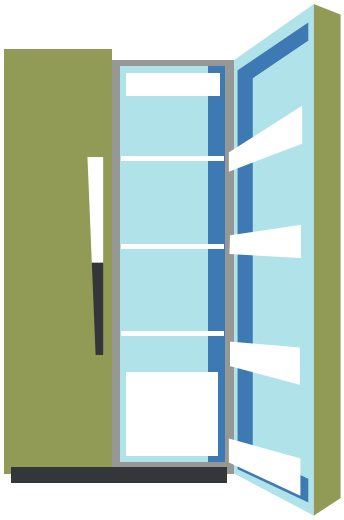
Share equipment

Sharing of large equipment such as autoclaves and ovens can reduce the lab's energy consumption, water usage, and the overall carbon emissions of laboratory work.

ENERGY

Fridges & Freezers

Ultra-low temperature freezers can use as much energy as an average household every day. Increasing the temperature from -80°C to -70°C has the potential to **reduce energy consumption by 30-40%**. In addition, it can also prolong the life of your freezer. The majority of biological samples including nucleic acids, proteins, bacteria and viruses can be safely stored at -70°C. There are **publications** to support this along with a **database** including information on samples successfully stored at -70°C.



It is important for each group to create and maintain an up-to-date fridge / freezer inventory. This helps with efficient space management. Know what you want before opening the freezer. For every minute, a fridge or freezer is open takes **more than 10 minutes** to cool back down. Clean fridge / freezer compressor coils regularly, as dust can increase power draw.

- **Defrost** freezers at least once per year, or when ice build-up reaches more than 2 cm in thickness.
- Check door seals on a regular basis to ensure that doors seal properly.
- Post a freezer map and **inventory** on the door of the freezer to keep samples organised and minimize the amount of time required to find a sample.
- Make it a lab policy that researchers are responsible for clearing out their samples and/or labelling them and giving them to other researchers when they leave.

Emails

Every email processed uses electricity. This energy is required for the computer, server, and routers. Each time an email is sent, around **4 g of CO_2 is emitted** to the atmosphere, and the addition of an attachment can emit another 50 g of CO_2. Uploading documents to **OneDrive** instead of sending large attachments can significantly minimise the carbon footprint of your email. Simple steps such as **unsubscribing from mailing lists** can also have a massive impact on our carbon footprint.

WASTE

We have all seen the publicity campaigns and heard the slogans of **"Reduce, Reuse, Recycle"** so why do we still need to focus on waste? In the EU, Ireland was found to produce the highest volume of plastic waste per person, working out on average as **61 kg per person per year**[1]. Ireland has also ranked as fourth for the worst plastic recycling rate in the EU.

As scientists we often perform daily experiments involving inexpensive and disposable plastic consumables. To ensure our research budgets are fully utilised many researchers opt for single-use plastic which is cheaper than glass alternatives. Within research, plastic can offer advantages for biological hazards and contamination, however, the environmental impacts of a single-use lab lifestyle need to be taken into consideration.

A University of Exeter study[1] found the average bench scientist generates over **1000 kg of plastic waste per year**. Recent figures have highlighted that medical, agricultural and biological research is responsible for **2% of global plastic waste**, that's around **5.5 million tonnes** of plastic lab waste per year[2].

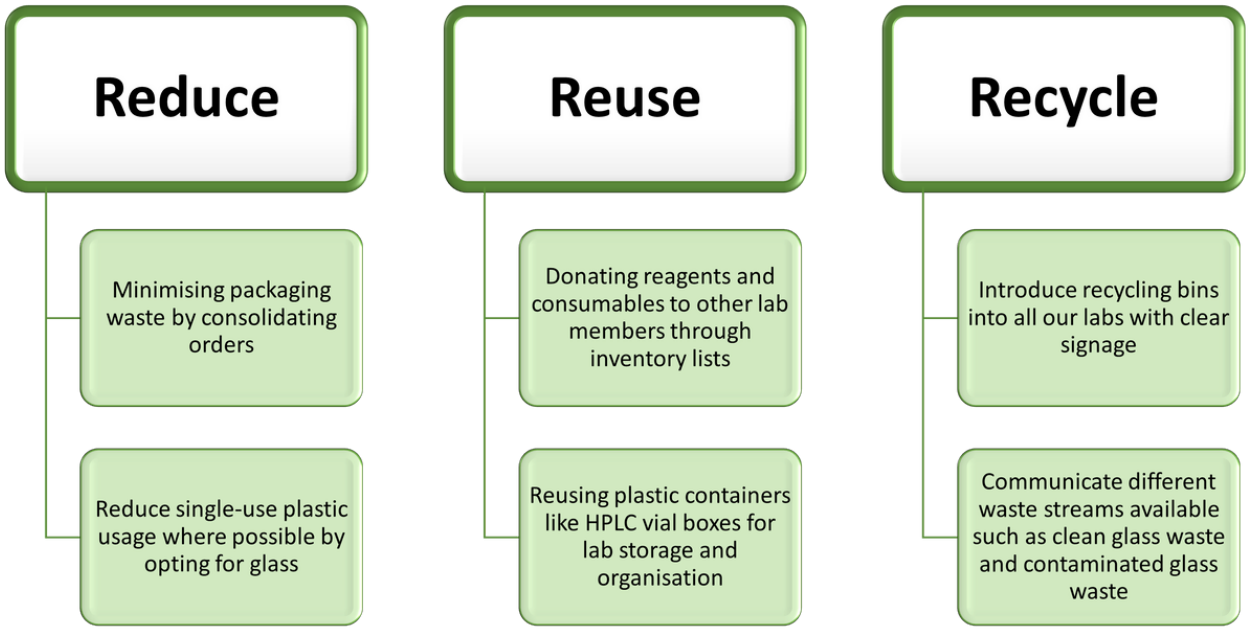
WASTE

Changes

To help aid changes to these statistics, we conducted waste audits in our labs to determine if recyclable material was being introduced into general or contaminated waste streams. We introduced **recycling bins** into each of our labs and displayed signage to communicate what was appropriate and what was not.

We attempted to reduce our waste by encouraging the following:

- Reducing our reliance on single-use plastic by switching to **glass** and **reusable plastic consumables** where possible.
- Reusing items such as using HPLC plastic vial boxes as storage containers in the lab.
- Creating a **shared resource** offering reagents, and consumables to other lab members before opting to introduce it to recycle or waste stream.
- Monitoring solvent consumption to identify opportunities for improvement by reducing the volume used through mobile phase recycling and shortening run times.
- Encouraging researchers to bring their reusable mugs for tea and coffee at meetings and seminars.



WATER

Water covers 71% of the Earths surface but only 1% is available to us as drinking water. It has been estimated that every person in Ireland uses **133 litres of water per day**. Laboratories are well recognised to be large consumers of water. This can be for washing and cleaning glassware and equipment, using water for preparing solutions, for cooling and heating applications in addition to steam and ice also for heating and cooling respectively.

As Laboratory Scientists/Lab users we can:

Recycle water purification cartridges - While not strictly impacting water consumption, it is best practice to recycle water purification cartridges according to local and specific guidelines around recycling of these cartridges.

Does it really need to be autoclaved? - Prior to autoclaving, consider what items are safe for cleaning in the dishwasher and which must be autoclaved. Turn off these items when not in use and use their “eco mode” where possible to reduce their energy and water consumption.

Reduce single pass cooling - where possible, set up two cooling stations from the same cold water supply. Consider purchasing a recirculating pump.

Communicate - Report leaking/dripping taps immediately to Maintenance/Estates office. Spread the message to all people in the lab to reduce water usage.

Consolidate and coordinate - Only run and operate dishwashers, autoclaves and other water using devices when they are full – even if that means offering to wash other people’s glassware!

Stop the flow - Consider using a basin or large container of water for rinsing glassware rather than using the running tap.

WATER

Use lower grade water when possible - Many applications in a lab may not require deionised water. The process of deionising water consumes energy and filters and can generate waste products, filters etc. so only use ultra pure water when the application absolutely requires it. Similarly, there is a very large energy input required to heat water as it has a large specific heat capacity so only use hot water when needed.

Measurement - Use a graduated cylinder to aid dispensing water and to ensure that not too much water is being collected which will end up being poured down the sink again and not used.

Update equipment - When upgrading water consuming devices in the lab such as autoclaves and dishwashers, ensure to take note of their efficiency and water usage rating. Purchase equipment with lower requirements than existing equipment. Similarly, vacuum filtration can be conducted using an oil free vacuum pump as opposed to using water vacuum aspirators on taps. Furthermore, cooling for the purposes of laboratory scale distillations and refluxes can be done with modern air condensers, or a recirculating water bath as opposed to doing single pass cooling using running water.

Measure it - Conduct a water audit (identifies uses, usage patterns, and quantify potential water-saving opportunities).

As a University we can:

- Appoint a person to complete the **Uisce Eireann Water Stewardship programme** here.
- Set ambitious but achievable institutional policies and targets for water conservation
- Launch awareness campaigns for students and staff communities, particularly those where their work involves working with water in the laboratories.
- Install **tap aerators** which can be fitted to the end of the tap to reduce the amount of water used, increase water pressure. This alone can save close to 60% of water consumption from a tap in the laboratory.

PROCUREMENT

Procurement refers to all steps involved in the process of ordering goods and services, from how it is sourced, transported, received and recorded. Before placing an order for a new chemical particularly for a trial reaction - **check**. When preparing tender specifications, ask suppliers to outline how their equipment meets sustainability goals and take their response into account during the technical evaluation.

Check:

- Is the reagent you require available within your research group/ organisation.
- There is a **chemical inventory** available for B32, B33 and B36 on the PMBRC MS Teams site. You should also check the Department of Science undergraduate chemical inventory when only small quantities are required.
- Can you purchase a rack of Starstedt tips rather than a complete box.
- Can you recycle any items as outlined above.

If completing an order then consider the **source** of materials, check if the order can wait for others to **consolidate** with you and think about product travel and packaging. Communicate with your group when you are planning to order items.

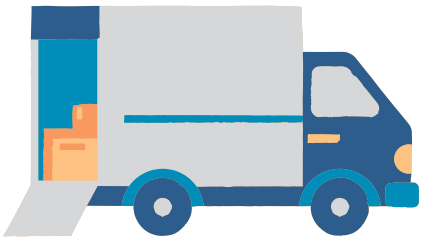
Source:

- Consider the Accountability, Consistency and Transparency **(ACT)** label developed by MyGreen Labs on products to choose more sustainable alternatives. You can view this here.
- Look to suppliers sections for more sustainable alternatives to traditional chemicals.
- Purchase paper that is chlorine-free and contains recycled content.
- Replace older equipment with more energy efficient models, recycle previous equipment as WEEE.

PROCUREMENT

Transport:

- Request suppliers to hold on delivery until all items are in stock to reduce the carbon footprint of delivery of partial orders.
- Consolidate orders within your research group where possible. Check with your colleagues and stock lists before ordering. Please follow all requirements from procurement regarding order levels and quotations.



Receipt:

- Choose suppliers with sustainable packaging.
- Reuse polystyrene boxes and ice packs which come with deliveries.
- Recycle all cardboard, paper and plastic packaging.
- Avail of and request suppliers to start take back programs (eg. Sarstedt pipette box take back program is in place within SETU).
- Update your chemical inventory with the new item and review this regularly to avoid over-ordering.

- Reach out to suppliers if you notice they are not using sustainable packaging and let them know you care. Communication with suppliers may spark change within their practices.

GREENER CHEMISTRY

Overview

The 12 principles of Green Chemistry developed by Anastas and Warner guide us in the development of products and processes that are 'benign by design'[3]. Green Chemistry itself is defined as *"the design of chemical products and processes that reduce and/or eliminate the use or generation of hazardous substances"*, the principles are summarised below.

Green chemistry was once thought of as a separate area of chemistry but now must be implemented as a guiding principle throughout all areas of the chemistry we complete.

Green and Sustainable Chemistry

Green chemistry (GC) focuses on products, processes and building blocks. It guides us to question and change our chemistry considering the health, safety and environmental impact of our work. GC greatly aids sustainability practices within our chemistry and processes. It has a key role within a fully holistic interconnected view of environmental, social and economic factors.

When making change in chemistry we need to think beyond our reactions to the life cycle of our materials and products, for example: raw materials: how were they made, are they depleting resources, what hazards were there in their production? We ask the same for process and products to evaluate the complete scope. Anastas and Zimmerman have developed an alternative metaphoric periodic table of **The Elements of Green and Sustainable Chemistry** showing the intersection needed between chemistry, engineering and technology with society, economy, policy, humanitarian aims and goals for a sustainable future[4]. You can view this here.

Prevent waste
Maximise atom economy
Less hazardous chemicals
Design less hazardous routes
Use safer solvents
Use catalysts
Design for energy efficiency
Renewable feedstocks
Reduce derivatives
Design for degradation
Real time analysis
Benign Chemistry

green chemistry.

GREENER CHEMISTRY

Implementing Green Chemistry

There are many excellent tools and guides which we can use to aid us in implementing Green Chemistry (GC) in our laboratories. It is important when you are developing or planning an experiment that you question the chemicals, in particular the reagents and solvents used and their toxicity, in addition consider the quantities and scale of reactions needed. Are there **alternative reagents/methods** that could be chosen? Could a **more sustainable** alternative be purchased? What waste will be generated? The completion of a **full life cycle analysis** of a process is difficult in an academic setting but an important part of GC is measurement of process **metrics** as a guide, for example, the waste generated (measure using the E factor, PMI), the efficiency of the reaction. Several tools have been developed to aid in answering key questions when designing new syntheses and to compare processes.

ACS Green Chemistry Institute

This global initiative seeks to develop and support green and sustainable chemistry. It is a collaborative Institute with partners from industry and academia. There are some very valuable tools on this site which have been developed to analyse solvent, reagent and waste and allows a **Green Aspiration Level iGAL 2.0** and **Green Chemistry scorecard** to be developed for your process. Metrics are key to green chemistry implementation.

DOZN™ 2.0

This simple and free tool allows you to analyse and evaluate your process to see if it adheres to the **12 principles of Green Chemistry**. It uses three major categories to compare and examine: improving resource use, more efficient use of energy, and minimizing human and environmental hazards. You can access this tool **here**.

Beyond Benign

This organisation provides excellent resources including laboratory practical guidelines for use in education in GC.

GC- SOLVENT

The choice and volume of solvent in a chemical reaction, purification or analysis is one way which you can implement GC. A **"green" solvent** can be difficult to choose and may depend on the application. Criteria such as occupational health, safety, environmental impact, chemical reaction type, LCA and cost are considered. CHEM 21 and many companies[5] have **solvent selection charts** which have ranked solvents with rationales and can allow for choices to be made. It is a good idea to print one of these simple charts for your lab and watch videos on the ACS GCI website guide in this area. In your group it is also worthwhile to track solvent use.

Changes

When purchasing solvents some drop-in **bioderived alternatives** can now be obtained. Solvents such as methanol, acetone, 1-butanol, 2-propanol and glycerol can be purchased. These could be directly substituted in your synthesis or analytical work.

The polar aprotic solvents NMP, DMF and DMAC should not be used. These have significant health concerns and there are also concerns regarding decomposition of DMF. There are some greener bio-derived alternatives which could be evaluated such as Cyrene or dimethyl isosorbide. You need to consider that these solvents have different structures and could impact the reaction and also can have high boiling points for removal.

Other solvent alternatives: cyclopentyl methyl ether (CPME) for THF and DCM (can form peroxides however), dimethyl carbonate, ethyl(-)-L-lactate, 2-methyl THF, diethyl carbonate and propylene carbonate (high boiling point). **Always complete a safety evaluation of the replacement in your reaction conditions before undertaking the reaction.**

In TLC and flash chromatography (FC), significant quantities of solvent waste are generated and alternative combinations should be considered to replace DCM eg. ethyl acetate/ethanol for DCM in FC[6]. Heptane should replace hexane in labs. You should also ask is there an alternative to a column or way to run FC more efficiently[7]. You can also ask if HPLC or higher grade solvent is necessary. When completing HPLC, consider the **volume of solutions** required and scale appropriately to avoid waste. Investigate recycling of HPLC mobile phase or use of the supercritical CO_2 system.

GREENER BIOLOGY

Overview

The latest figures from the Organisation for Economic Co-operation and Development (OECD) report that the world is producing twice as much plastic waste as two decades ago, with only 9% being successfully recycled. When it comes to laboratories, we are responsible for using up to 5.5 million tonnes of plastic annually, which accounts for 2% of global plastic production. A bench scientist produces on average **1000 kg of plastic waste** each year[2]!

We have taken numerous approaches to **lower our plastic use** in our biology laboratories and have put processes in place to recycle as much plastic as possible.

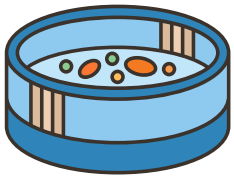
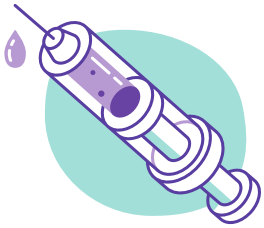
Here's how:

- Addition of recycling bins to each lab to allow recycling of paper, cardboard, soft & hard plastics.
- Replacement of plastic vials with glass vials of similar volumes to allow reuse.
- Replacement of cotton wool plugs with a reusable alternative.
- Replacement of plastic with paper weigh boats where non-hazardous solids are used.
- Replacement of plastic with glass pipettes to allow reuse. They can also be autoclaved for sterile use.
- Availability of glass petri dishes for non-sterile work, which can be cleaned and reused.
- Use of 8-well and 12-well strips for 96-well plates if small number of wells required, reducing number of plates discarded.
- Washing and reuse of plastic cuvettes for spectrophotometers.
- Reuse of ice packs contained in deliveries instead of ice, if available.
- Recycling of empty pipette boxes using Sarstedt take back program.
- Purchase of Sarstedt pipette tip stack packs instead of pipette boxes to reduce plastic coming into the labs.
- Use of timers for water baths to prevent them being left on overnight.
- Use of SybrSafe and Gel Red as safer alternatives to ethidium bromide.
- Recycling of clean broken glass, reducing the amount destined for incineration.
- Recycling of WEEE waste and batteries.

GREENER BIOLOGY

Cell culture work is the main culprit in biology laboratories for producing single-use plastic waste. However, there are many plastic components which can be salvaged and recycled.

These include:


- Needle caps
- Syringe plungers
- Falcon tube lids
- Lids of cell culture plates and flasks
- Handles of cell scrapers
- Plastic resevoirs
- All plastic wrapping on sterile consumables

It is also important to keep in mind that not all cell culture plastics (falcon tubes, syringe barrels etc.) will have come into contact with cells and may have been used just to hold media or other non-toxic solutions. In this case, they can also be recycled along with their components mentioned above.

How to recycle laboratory plastics

It is important when recycling laboratory plastics that they are clean, decontaminated, dry and loose.

1. Before recycling **empty** media or chemical containers (e.g. plastic bottles, tubs) it is important to first confirm that the contents are not harmful or toxic.
2. The containers must be **triple rinsed** to ensure removal of any residues and left to fully dry.
3. The **name** of the media/chemical must be **removed or crossed off** with black marker to help identify the container as safe and ready for recycling.

SUSTAINABILITY TIPS

Outside of the laboratory there are other ways within our University work day we can embed sustainable practices:

- Use **reusable** water bottles, keep cups, dishes and cutlery at break times.
- Utilise the many recycle bins on campus. If you are unsure if your waste is recyclable, check out **A-Z Waste Management Guide** here.
- TFI bike stations are located at 14 locations around Waterford city, two of which are located at our Cork Rd. campus. Consider whether it is an option for you to **cycle** to University using this BikeShare scheme. The other locations of TFI bike stations can be found here.
- Conferences - consider attending international conferences virtually in alternative years and how you will travel to the conference. Or if organising yearly conferences consider moving to online each alternative year. International single centre site conferences may offer regional hubs going forward.
- Join the global movement and consider signing the million advocates for sustainable science here.

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THANK YOU

The team would like to thank all those who have contributed to researching, communicating, supporting and implementing the changes outlined. During the process we have learned a lot but appreciate there is always more to do. We will continue to monitor, learn and make changes where we can and we ask that readers of this document do the same, starting with small achievable tasks and building from there. It is only through communication, shared learnings, collaboration, community and commitment that lasting change can take place.

If you have any suggestions on how to continue to make our labs greener please get in touch!

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