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SCIENTIFIC OPINION

# Charting our sustainability journey within the Division of Surgery and Interventional Science at University College London

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**Abstract**
This article describes a case study of our journey to running more sustainable labs within the Division of Surgery and Interventional Science at University College London (UCL), London, United Kingdom. Through the setting up of a self-assessment team within the division, we asked the key question, 'what does sustainability mean in science and how will we apply this to our academic Division?' Our division's sustainability team took on the challenges to tackle unsustainable practise, primarily within our laboratories. By considering and implementing simple steps within our research department, we have reduced lab waste as well as decreased our overall carbon emission. We have clarified our hallmarks of sustainability and seek to share our changed practices to provide clear and easy guidance for how to make medical research divisions sustainable based on the actions taken in our labs. This study provides guideline on how to make academic research more sustainable by describing simple steps to implement in the laboratories. These steps were described using Division of Surgery and Interventional Science at UCL as a case study. The division's sustainability team develops sustainable lab practices, which has led to reduction in lab waste and carbon emissions.

**Keywords** Sustainability · Green impact · Plastic waste · Energy · Sustainable UCL · LEAF

## Introduction

Researchers need to address sustainability challenges to tackle environmental crisis creating uncertain future. The Global assessment of the marine pollution by United Nations (UN) Environment Programme (UNEP) reported that, 85% of the marine litter is made up of plastics and the plastics pollution is expected to triple by 2040 (Programme 2021). To address this, United Kingdom (UK) set goals to achieve net-zero emissions by 2050 (UN 2021). Research labs have a significant contribution to waste production and to carbon emissions. Research labs can use 4–5 times higher energy than an average same size office or workplace (Woolliams et al. 2005) depending on the ventilation demands and specialised lab equipment and procedures. Examples include ultra-low temperature (ULT) freezers ( – 70/ – 80 °C) utilised for effective sample storage, fume cupboards for dispensation and use of hazardous chemicals, tissue culture cabinets to culture and expand cells in sterile/aseptic conditions, and specialised $CO_2$ incubators to grow cells, which are all set at 37 °C and humidified. A fume cupboard alone can consume 3 times more energy than an average UK household each year (Aldred Cheek and Wells 2020).

Many institutions have started to implement green practices to mitigate waste management and energy sources. University College London (UCL), UK aims to remove avoidable single-use plastics by 2024 and become carbon–neutral by 2030 (*Change Possible: The Strategy for a Sustainable UCL 2019–2024*, no date). Since the 1st of August 2019, UCL switched all its electricity supply to renewable electricity that is generated by solar, wind or hydro-electric power in the UK. However, there is still a long way to become carbon–neutral, because aspects like cold storage and single-use

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plastics for aseptic purposes remain a challenge. According to the Sustainable UCL Annual Report 2019–2020, 83% of carbon UCL emission comes from purchased products and 47% of this is lab equipment and consumables (*Sustainable UCL Annual Report 2019–2020*, 2020). With 52% of UCL's energy going to laboratory facilities, approximately half of our carbon emissions derive from laboratories. Researchers must play part in reducing plastic waste and carbon footprint. This article will discuss specific actions taken by the Division of Surgery and Interventional Science (DSIS) at UCL to incorporate sustainability in their research and will provide simple steps as a general guide to reduce lab waste and overall emissions.

The continuity and structure in the DSIS approach to sustainability have been provided by the established sustainability committee. This committee is composed of academics, researchers, technicians, and administrators who meet regularly to discuss a defined sustainability agenda from all divisional sites. Monthly meetings ensure continuity and inheritance of substantial sustainability actions.

UCL has developed a tool called LEAF (short for the Laboratory Efficiency Assessment Framework) that supports scientists during transition to net-zero (*Change Possible: The Strategy for a Sustainable UCL 2019—2024*, no date). LEAF sets actions to aid lab users considering how to reduce waste production, how to address single-use plastics, mitigate utilities, achieve more sustainable procurement, and improve the sustainability of laboratory operations. Based on the number of actions taken, individual labs or divisions can be awarded. The Division of Surgery maintains a gold award since 2020. All the actions that are described in this article fall within the remit of this LEAF Gold award. These actions are defined as the 'Hallmarks of Sustainability' and are discussed in subsequent sections (Fig. 1).

## Raise awareness

The Division's committee promotes awareness and accountability of sustainable practices in annual events, such as during the Division Away Days, and through social media platforms. By letting all enthusiastic members join the committee, our sustainability team maintains a growing membership and promotes our actions beyond the Division. The committee ensures sustainability matters remain relevant for the ongoing commitments. The in-house developed

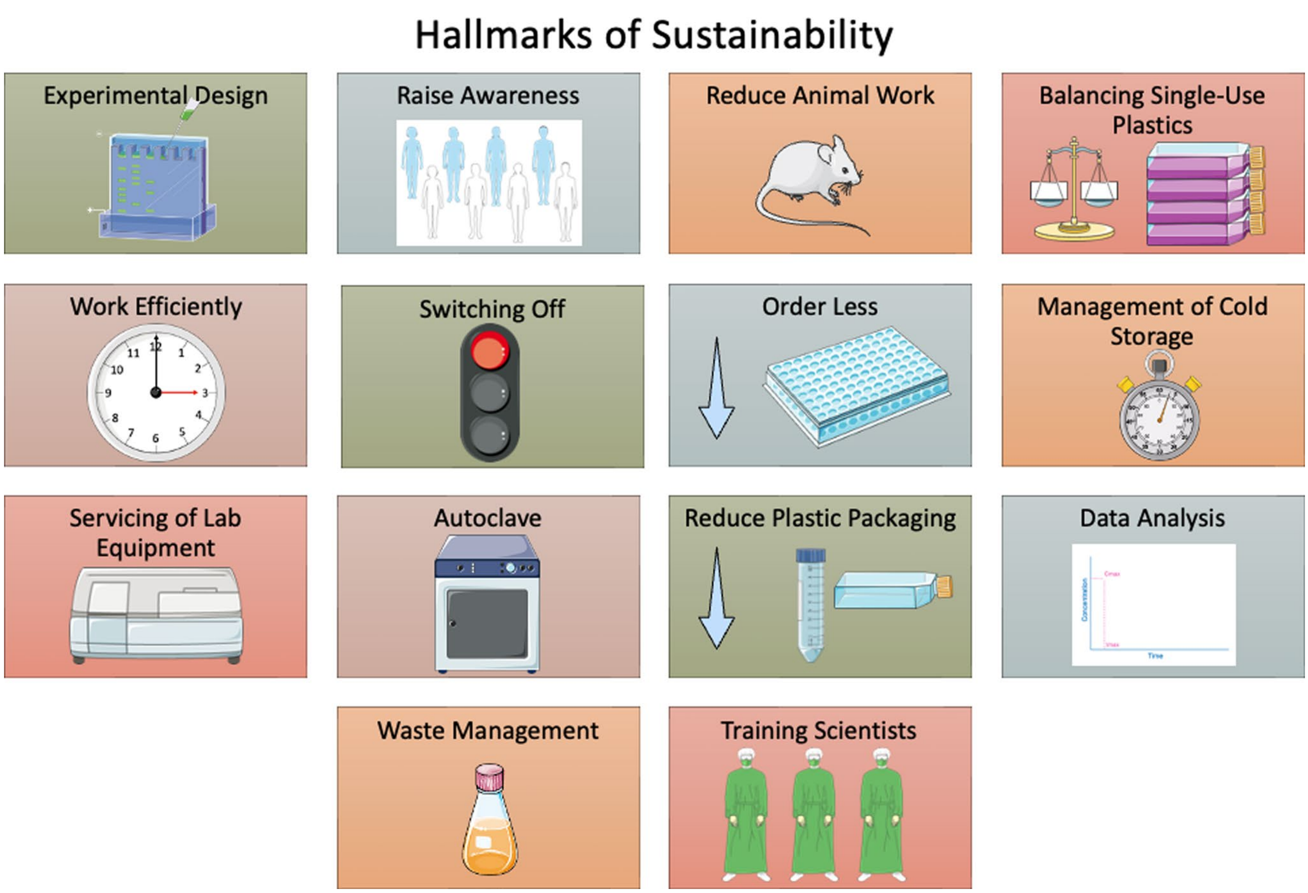


**Fig. 1** Hallmarks of Sustainability. These hallmarks are exemplars of specific actions taken to reduce energy consumption and waste production

Sustainability Induction protocol has become mandatory as of April 2022 and guides all lab users on how to make their research more sustainable.

## Rational experimental designs

Making your lab greener requires careful consideration of experimental design and planning. The first question to ask oneself is "What research is required for this research question or hypothesis?" Understanding of literature in the specific field of study is required to design novel and pertinent research questions. There are well-defined guidelines available online for researchers to help them plan their studies and determine how many repeats required for statistical significance to prove/disprove their study (Charan and Kantharia 2013). Pertinent planning minimises the use of reagents and consumables and reduces purchases and thereby shipping associated emissions and packaging. Without compromising the research integrity, experiments should be minimal to reduce lab waste. As part of the Division's sustainability efforts, new researchers must conduct literature reviews and evidence that the experiments planned are necessary for their research goals. All members are encouraged to plan experiments in advance and combine work needed for different experiments where possible to reduce the use of lab equipment. For instance, overlapping one experiment's media change with another set-up with incubations periods saves hourly use of biosafety cabinets, thereby save energy.

As part of rational experimental designs reducing animal work and using greener models are essential. In the UK, 1.44 million animals were used for experiments in 2020 (*Annual Statistics of Scientific Procedures on Living Animals, Great Britain, 2020*, 2021). For ethical and sustainability reasons, this number should be reduced. The main issue in reduction of sample size is loss of statistical power. Kramer and Font (2017) showed that the number of animals used in control groups can be reduced by half if historical control groups are included in the studies without losing power of statistical tests (Kramer and Font 2017). Animal models should be specific and physiologically relevant to the disease of interest such as using canine models for recapitulating osteosarcoma and ferret model for influenza (Maher and DeStefano 2004; Jarvis et al. 2021). However, simply using a mouse model is not always the answer. Around 92% of the drugs that have been tested in animals as the preclinical step fail to pass to the clinical stage (Hutchinson et al. 2022).

Biobanks storing and processing biospecimens allow generation of mass patient data and the specimens to be used for drug testing (Grizzle et al. 2019). Isolating cells from primary sources reduces the need to purchase cell lines and leads to generation of physiologically relevant for the research interest. In DSIS, the majority of researchers utilise UCL Biobanks, an example being isolation of monocytes from recently expired blood samples rather than ordering from companies. Biobank samples provide detailed data on demographics/survival and underlying health conditions. The data is used to map the link between basic research to clinic and makes biomedical research more clinically transferable and sustainable.

The Centre for 3D models of Health and Disease within DSIS specialised in developing alternatives to animal models such as 3D models using biodegradable materials such as collagen, and use patient-derived cells to mimic disease microenvironment (Pape et al. 2020; Stamati et al. 2020; Bakkalci et al. 2021). Better representing human physiology with 3D models decreases the number of animals needed. If animals are inevitable, relevant group members overlap experiments to maximise output from a single animal and minimise the total number of animals needed. 3D bioprinting techniques can be associated with reduction in material and transportation costs due to reduced supply chains. This method offers options such as recyclable and sustainable materials. For recycling 3D printing waste such as green recycling should be used instead of melting and high-temperature degradation (Zhu et al. 2021). Some polymers for 3D bioprinting are from petrochemical industries and have slow degradation rates, which are harmful to the ecosystem. Sustainable alternatives, like starch-derived polymers such as polylactic acid (PLA) or alginate from marine plants and bacteria, can be used in the biofabrication of hydrogels (Whenish et al. 2022).

Within the division, the core teams and centres are identified before animal experiments to increase sharing of animal resources and related reagents. We are establishing a new framework to adopt Sharing Experimental Animal Resources, Coordinating Holdings (SEARCH), which deals with leftover material from animal studies and makes these more accessible to researchers (Morrissey et al. 2017). Variations of this framework should become the standard among different universities to reduce animal use. DSIS researchers promote reduction, replacement, and refinement for animal work using different guidances such as the in vivo test guidance for strategies to refine, reduce and replace animal testing by the U.S. Food and Drug Administration Centre for Devices and Radiological Heath (FDA/CDRH) (Hampshire and Gilbert 2019).

## Balancing single-use plastics

Urbina et al. 2015 estimated that 280 lab-based scientists at Exeter University produced 267 tonnes of plastic in 2015. The worldwide estimate was calculated as 5.5 million tonnes of lab plastic assuming there are 20,500 labs (Urbina et al. 2015). Single-use plastics and consumables are unavoidable for some research practices, but their utilisation may be mitigated without jeopardising the science. Consumables should be re-used where possible including stripettes that can be re-used in a single setting including aliquoting and cell culture wash steps with reagents such as phosphate-buffered saline (PBS). Making PBS using tablets and glass bottles (autoclaved), saves many plastic bottles. Empty bottles should be utilised for other purposes such as waste buckets. Reducing plastic use typically requires critical thought, which only the scientist responsible for the research can determine.

## Saving energy

One of the most important steps to save energy is to switch off lab and office equipment when not in use, especially in holiday periods. By using LEAF's inbuilt calculators, carbon emissions and cost savings associated with turning off equipment may be estimated. The tool is accessible internationally and has helped DSIS in addressing the sustainability of the division's operations. During Christmas 2021 break, the committee developed an action plan to switch off all equipment within our Charles Bell House site laboratories. The plan included clearing and organising fridges and freezers, and switching off these and other equipment such as wax embedding stations and ice machines wherever possible. By doing this simple action plan, Charles Bell House site reduced ~ 3.7 tonnes of $CO_2$ and saved £1,230 within day 10 (Bakkalci and Olney Evangelia Smpokou, 2022). This case study was then used for other sites of the Division for the Easter Break and Bank Holiday and now the committee regularly prepares 'Switch Off' schemes for lab closures.

Reduced usage of biosafety cabinets and fume cupboards is part of these energy savings. Fume cupboards vary the exhaust rates based on the sash level and variable air volume (VAV) fans. The overall energy use by a VAV fume cupboard is dependent on the lab users. By closing the sash of the operating fume cupboards allow for reductions in energy consumption (Aldred Cheek and Wells 2020). For appropriate ventilation of lab spaces and removal of latent fumes, fans are turned back on prior to any member entering the labs.

## Efficient ordering practices and storage management

Sharing reagents and consumables have significantly reduced the division's consumable purchases and its associated shipping and packaging waste. Within the Division, there is a transparent set-up between grant holders in the same lab to enable sharing and bulk ordering of common consumables. This approach also reduces the number of expired reagents. The unwanted items are shared via UCL's Warp-it or Quartzy platforms. There is also a communal list to manage stockpiles of reagents, samples, and consumables. This list allows lab members to consult before ordering items and prevent cluttering. The companies that have recyclable packaging should be preferred. The challenge is to identify suppliers that transparently report how much plastics they have reduced. Therefore, absolute figures for plastic reduction are required.

Cold storage spaces can easily become cluttered, which causes a lack of space and eventually the purchase of more fridges and freezers. The energy use of a single ulta-low temperature (ULT) freezer can equal to a single-family home or more (~ 8–20 kWh/day) (*Thinking outside the icebox on lab sustainability*, no date). Regular checks and removal of expired or unwanted samples reduce the need for extra storage. To ensure samples are cleared regularly as part of LEAF submission, Division's sustainability committee has developed a system to ensure samples and materials of departing members are cleared regularly with regular decluttering sessions. Defrosting is another method to save energy since it has been reported to contribute 10% of ULT-related energy savings and to maximise internal space (*Thinking outside the icebox on lab sustainability*, no date).

Although – 80 °C is the standard temperature for ULT freezers, many samples can be safely stored at -70 °C without compromising sample stability. Increasing a ULT freezer temperature by only 10 °C can reduce energy consumption by 20–40% depending on the model (*-70 is the new -80*, no date; Beekhof et al. 2012). DSIS ULT freezers are switched to – 70 °C, which saves significant amounts of energy each year. For example, 6 of 80 °C freezers at the Royal Free site with 500 L are running at – 70 °C, which saves approximately £1,000 in energy costs per annum.

## Lab equipment management

Servicing of lab equipment is organised by DSIS lab technicians to prevent energy waste and increase the longevity of equipment. If any machine is broken and irreparable, energy-efficient replacements are preferred to save up to 70% of energy (*Thinking outside the icebox on lab sustainability*, no date). LEAF's Sustainable Equipment guide is used to consult on the efficiency of the equipment. The energy-intensive equipment is operated at their ideal capacity such as washers, drying cabinets, or autoclaves.

## Waste management

Each lab item is associated with an environmental and financial cost of discarding it. Biomedical labs used to only have clinical waste streams available, where all items were sent for high-temperature incineration which is associated with

5–10 times higher cost and a negative impact on the environment (Rizan et al. 2021). Recycling bins are essential both in labs and offices to segregate clinical waste from recycling to mitigate the environmental impact. DSIS mandatory sustainability induction provides all the required information related to differentiating recycle waste from other types of waste. All staff and students are being trained on how to adopt sustainable practices in their research. To reduce training associated waste, grouping trainees and organising workshops prior to lab practical are necessary. Regular trainings/workshops help reduce damage to equipment and increase the efficiency of the experiments.

In 2022, DSIS has introduced sustainability workshops before undergraduate and postgraduate project start dates. These workshops led to sustainability projects jointly conducted by the committee lead and master students. One particular case study aimed to reduce lab waste during an MSc student lab-based research project. The student created a detailed plan of a number of consumables needed for the project and reduced these numbers wherever possible under the supervision of the project manager. Reusing the same tips for media change without touching the sample and tactical combining of different conditions in plates and tubes were examples of the simple techniques to reduce this number. Over 17 days in the lab, the student reduced 1.5 kg of consumable waste. If all students followed these two simple steps, the Division would have saved £13,714 and ~ 604 kg tonnes of $CO_2$ annually (calculated by LEAF).

## DSIS and long-term sustainability

There are more things to achieve when it comes to sustainability since it is a rapidly evolving field. To keep up with the fast pace of greener technologies, more scientists should be trained in sustainability practices and conduct more impactful research with these to track updates. DSIS aims to provide sustainability guidance to all students and staff projects. The goal is to include a section on the environmental impact of research in the project students' thesis. In this section, the student can focus on the carbon footprint and plastic waste connected to the research project. The students will encourage to seek greener alternatives of materials and reagents to document in the methods section of the research projects.

The division's long-term sustainability initiatives are well adopted through the continuous growth of the Sustainability team and the training of new members for sustainability practices. The department will ensure there will always be a Sustainability Lead and the principal investigators (PIs) will be involved as much as possible within the Sustainability Team. This year, the committee signed to audit different departments to exchange ideas and share resources. The division is committed to continuing promoting and raising awareness of good, sustainable practices in laboratories. Engagement with social media content has enhanced communication with several labs worldwide and afforded opportunities to share good practise and learn from one another.

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**Data availability** The authors confirm that details of the LEAF calculation data are available.

## Declarations

**Conflict of interest** The authors declare no conflict of interest.

**Ethical approval** Ethics statement is not applicable.



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