# Urgent Action is Required to Increase Sustainability in in vitro Modelling

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Climate change and the inherent climate crisis require immediate action. Protests such as Extinction Rebellion [1], Fridays for Future [2], and events like COP26 [3] attract societies' attention and spread the news of climate change outcomes. The 1.5ºC and 2ºC benchmarks are widely recognised as limits where places will become uninhabitable if temperatures continue to rise [4] . Outcomes of climate change have been visible since 1980: decreased water availability, increased wild fire risks and damage from floods and storms arise due to rising temperatures due to greenhouse gas emissions [5]. Waste disposal is one of the areas creating pollution through burning materials that cannot be composted, recycled, or sent to landfill. Unfortunately, the healthcare sector, biomedical research, and in particular, activities like in vitro modelling, where high volumes of single use plastics are used, contribute heavily to this [6].

In 2005 – 2006 the NHS produced over 118,000 tonnes of clinical waste [7]. In 2012, bioscience research facilities worldwide produced a total of 5.5 million tonnes of plastic waste [8]. Further, the waste generated via laboratory consumables has accelerated dramatically in the past two years, due to the COVID- 19 pandemic [9]. As a result, there is an increased focus on the healthcare sector's waste production and handling, and consequently the climate change impact [7] [10]. Rightfully so since around 2% of national waste in the US was produced by biomedical institutions in 2007, this equates to 1.8 million tonnes of plastic waste [11].

Sterile materials are crucial in in- vitro research, and single use plastics are preferred for simplicity. Following use, having been in contact with potentially biohazardous waste, they are incinerated at the end-of-life cycle; this is currently the preferred safe disposal method for biohazardous waste [12].
However, incineration produces further emissions which impact on both climate and health. Firstly, these contribute to greenhouse gas emissions worsening the climate crisis. Secondly, emissions induce health impacts such as malnutrition, heat stress or worsening respiratory illnesses such as asthma. Furthermore, these emissions are toxic, resulting in further health implications for the population manifesting in symptoms such as disruption of hormone signalling, reproductive and developmental defects, immunotoxicity, liver damage, wasting syndrome and cancer [13].

Whilst CO2 emissions can be decreased in climate friendly lab practices i.e., turning off unused lab equipment, optimising freezer temperature and water usage, and using reusable packaging; current recommendations are typically limited to such steps [14]. Suppliers may offer take back schemes where appropriate and reuse packaging for other orders, however these steps are typically solely related to packaging, they do not actually reduce the plastic waste from in-vitro use. Washing and autoclaving materials for reuse should be considered where possible, whilst such procedures produce greenhouse gas emissions, the overall carbon footprint is lower and can further be reduced by sourcing green energy to power autoclaves [15].

Researchers can purchase a small range of sustainable cell culture materials, for example product from jellyfish collagen, where the production process produces less emissions compared to the more commonly used bovine serum, as the jellyfish are sourced from an area where they exist in surplus causing harm to the environment [16].

However, sustainable materials for sterile use in this field are scarce beyond this. We urge suppliers of scientific consumables to bring more products such as this to market.

In the absence of available products to replace current unsustainable single use plastics, we advocate refinement of our experimental design, as a field. For example, use of efficient technologies such as large-scale multiplexing and spatial multiomics in lieu of investigating individual targets and smaller panels [17]. Beyond this, researchers in the in-vitro modelling space should make better use of publicly available data from existing work. The combination of these two approaches can reduce overall wet laboratory experiments by refining research questions firstly based on publicly available data, then offering more efficient characterization in the wet laboratory, ultimately reducing waste.

Such measures will not only allow the lab to work more efficiently and sustainably, but additionally decrease expenses, because less material will need to be purchased, and less material will need to be incinerated, which is typically costed per kg of waste [18].

In summary, decreasing carbon emissions and plastic waste in biomedical research laboratories is urgently required, not only to reduce the negative impact that in vitro modelling has on the climate, but ultimately on the health of the population.
Actions taken can include purchasing reusable products, disposing of waste correctly, conducting sustainability audits from platforms such as LEAF, and subsequently improving practices based on optimising electricity or water usage [19], lobbying companies for the development of sustainable alternative materials, and improving research design including multiplexing and use of publicly available data.

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