Adding Sustainability to Natural Sciences

# Introduction

From the 12th of June to the 21st of July a student internship project was run at the University of Kent with the main aim of making the School of Biosciences more sustainable. This would be done as an extension of the goals put forward by the School of Biosciences Sustainability Committee and would include the implementation of many of the ideas suggested in their meetings. The purpose of this project was to take inspire change in institutions like universities on a divisional scale in light of the impending climate disaster and to further implement the United Nation’s Sustainable Development Goals across Natural Sciences.

# Aims and Approaches

Implementing Sustainability into the Biosciences Curriculum

This 6-week project’s main aim was to further implement sustainability into the Biosciences division. This was approached by taking a wholistic look at the modules within Biosciences in order to determine what modules included a sustainable aspect to them and where improvements could be made. [The United Nation’s Sustainable Development Goals](https://sdgs.un.org/goals) (SDGs) were used to advise these evaluations as well as the results from the student-led sustainable development goals curriculum audit. The audit provided the opportunity to see how sustainability was implemented into Natural Sciences by evaluating what SDGs appeared most across the modules, to what extent wider aspects of sustainability learning are included and what Education in Sustainable Development (ESD) methods were used.

Using the curriculum mapping data, it was determined that Natural Sciences were strongest in implementing SDG 3 (good health) with 16.3% of modules having some mention of it and 16.3% having significant mention of it. Natural sciences were weakest in implementing SDG 1 (zero poverty) with 0 modules having any mention of it. Out of all the wider aspects of sustainability examined in the audit, Natural Sciences was strongest at implementing critical thinking in sustainable development with 45.8% having some implementation while 26.8% having significant mention. This is comparison to the understanding sustainable development (SD) competency which was the least represented in Natural sciences with 10.6% of modules having some mention of it and only 4.2% having significant mention. Natural sciences had a somewhat well-rounded representation of implementing ESD methods with case studies having the least integration by 16.2% of modules having some mention and 19.7% having significant mention. Whereas the most represented method was problem-based learning with 26.8% of modules having some integration and 27.5% having significant integration.

Using this data it was established that Natural Sciences had potential in implementing SDGs 6, 7, 8, 11, 12, 13, and 14 due to them being relevant within Biosciences and being easier to integrate within modules without overwhelming students with too much new material. Natural sciences could also improve in implementing an understanding of SD which could be done by introducing the students to the idea of SD through the SDGs and competencies for sustainability. Students could also be introduced to the idea of challenging ‘business as usual’ by encouraging them to take a critical look and the institutions they are a part of and evaluate how sustainability could be further incorporated into these systems. There was also more focus put on implementing case studies related to ESD within the modules.

Improving Laboratory Infrastructure

One of the short-term goals was to make improvements to laboratory infrastructure, this was approached by evaluating the teaching labs and its architecture. This evaluation took note of any areas of interest and whether they contributed negatively or positively to sustainability within the labs. The recycling bins and lab manuals were recognised as the main areas of improvement within the labs and efforts were made to find ways to improve their sustainability. It was recognised that there was confusion among students in what could and couldn’t be recycled and that was exemplified through the fact that some students were putting unrecyclable latex gloves provided by the lab into the recycling bins which caused the whole recycling bin to be discarded to general waste which was very unsustainable and an urgent point for action.

Increasing Interest in Sustainability Within and Outside of Natural Sciences

Another aim was to find ways to increase student interest in sustainability within and outside of Natural Sciences, as it would be beneficial to sustainable development to continue the passion for sustainability outside of the classroom and encourage students to take individual action. One way that this was approached was to use different forms of media to communicate our aims effectively for example, using educational videos like TEDtalks or discussion posts to increase student engagement. Students would frequently be provided with additional resources for them to look at in their free time as well as links being made to employability wherever possible to pique interest. It was also important to accommodate different learning styles to ensure every student would be able to understand sustainable development and its relationship with Biosciences effectively, this also tied in to using different forms of media engagement. The natural integration of sustainability into these modules was also a priority as it would be counterproductive to overwhelm students with too much new information on modules that are already packed with information. We didn’t want to communicate the message that this is just more work for students to do dispassionately, rather a way to link their degree to relevant and important topics. Links to other divisions were also made wherever relevant as well as the discussion of individual responsibilities amongst students to help make the connection to sustainability outside of biosciences.

# Methodology

Adding Sustainability to Curriculum

To begin with, every module and topic within Biosciences was evaluated for instances of sustainability and for where sustainable development could be integrated into the module. Every module was checked against the suggestions included in the AdvanceHE and QAA [ESD Guidance (2021)](https://media.www.kent.ac.uk/se/18355/education-for-sustainable-development-guidance2021.pdf). Resources like journal articles and educational videos from reputable sources were used as support wherever sustainability was found to fit in a topic. The ESD guidance was used as reasoning whenever a link to sustainability was made within a module by using it to highlight the specific competency that the new information would target. The curriculum mapping data was also used as support by allowing the conscious inclusion of the aspects of sustainability that Natural Sciences overlooked. It was also clearly communicated which SDGs that the suggested additions would target with emphasis being put on the lesser-known goals. Suggestions were also made to academics on which methods these ideas could be effectively communicated to students by providing them with resources to support their teaching.

Changing Laboratory Infrastructure

The first change made to the teaching laboratrories was the redesigning of the bins at the end of the lab benches and near the lab exits. This was high priority as became prevalent throughout the evaluation that students were unsure as to what could and could not be recycled. It was common to see students placing non-recyclable latex gloves provided by the laboratory into the incorrect bins, so this was taken into account during the redesigning process. Another change to infrastructure was to the lab manuals provided to students at the beginning of every practical, this was identified as an opportunity to provide students with more confidence on what could and could not be recycled. The lab manual front covers were redesigned to be much clearer on whether or not hazardous materials would be used during the practical and the correct disposal methods for such materials in compliance with the [Control of Substances Hazardous to Health (COSHH)](https://www.hse.gov.uk/coshh/). This was done in hopes to make students more confident in waste management in a quick and clear manner in a fast-paced environment like the teaching labs.

# Results

### Implementing Sustainability into Biosciences modules

The following is a description of all the changes suggested to the Stage 1 and Stage 2 Biosciences modules offered during 2022-2023 with the exception of BIOS3020: Molecular and Cellular Biology and BIOS5460: Animal Form and Function. Modules BIOS3080: Skills for Bioscientists and BIOS5320: Skills for Bioscientists 2 have been excluded from the description due to the changes being the redesigning of their lab manuals as they are very practical-heavy modules.

BIOS3000 AUT/SPR: Introduction to Biochemistry (2022/2023)

**Spectroscopy and its Use in Sustainability**

Spectroscopy is the study of the interactions of electromagnetic radiation with matter and the current version of the BIOS3000 module goes over; Ultraviolet/Visible Spectroscopy (UV/Vis), Fluorescence Spectroscopy, and Infrared Spectroscopy (IR). These spectroscopy techniques have many uses in sustainability for example, the analysis and detection of pollutants in the environment using UV/Vis, as well as monitoring the chemical composition of the atmosphere using IR. ‘Several chemical compounds and contaminants accumulate in our environment and cause pollution. Identification, detection, and disposal of these pollutants require modification of the existing and/or synthesis of the novel chemical compounds through a green approach. The morphological structure of chemicals can be analysed through myriads spectroscopy techniques.’ (1)

This topic is targets SDG 6 ‘Clean Water and Sanitation’ through the uses of spectroscopy in water treatment which is specified in the UN’s target 6.3 which aims to improve water quality by reducing pollution by 2030 and eliminating dumping and minimizing release of hazardous chemicals and materials. SDG 9 ‘Industry and Innovation and Infrastructure’ is also targeted through goal 9.4 which aims to upgrade infrastructure and retrofit industries to make them sustainable by 2030, by having a greater adoption of clean and environmentally sound technologies and industrial processes. The use of spectroscopy infrastructure is an environmentally friendly way of keeping track of resources while monitoring waste products and their disposal.

This can be incorporated seamlessly into the BIOS3000 curriculum while discussing applications of spectroscopy. This could be added as a part of the PowerPoint or students could be asked to research in their own time then use vevox. Videos can be shown as an example of environmental monitoring of water. Students could be tested on their understanding of spectroscopy and would be able to identify how it could be used environmentally. This would grow their systems thinking when looking at how industrial processes have an impact on the environment and the methods used to monitor this impact as well as their problem-solving skills when looking at spectroscopy as an introduction into tackling pollution.

**Chromatography and its Effect on the Environment**

Another analytical technique explored in BIOS3000 is chromatography, this is the process by which mixtures of molecules are separated into the constituent components by means of a mobile phase passing over a stationary phase. The technique is widely used within pharmaceutical and environmental/chemical safety industries. Advancements have been made towards more sustainable chromatography due to the toxic nature of the chemicals used on an industrial scale. ‘The use of organic solvents in chromatography is one of the most toxic parts of the process. Solvents present a threat to the environment and human health. The use of them in chromatography puts those who work with the chemicals at risk of exposure. In addition, the environment is threatened by chemical leaks either by accidents or via the slow accumulation of toxins into the nearby environment’(2,3). A commonly used solvent in chromatography is the volatile organic compound acetonitrile. Journals have explored the use of a propylene carbonate–ethanol-water mixture can be used to replace this toxic solvent, while keeping the efficacy of acetonitrile. An ethyl acetate–ethanol mixture can also be used as a sustainable substitute for acetonitrile (2).

This suggestion would cover SDG 9 ‘Industry and Innovation and Infrastructure’, particularly in target 9.4 by using more sustainable methods in a technique commonly used in industry.

This can be incorporated into the BIOS3000 curriculum while summarising chromatography as a technique and would help with cementing student’s understanding of chromatography and encouraging systems thinking. Ideas like green chromatography can be explored, recommending the use of less toxic solvents whenever possible.

BIOS3010 SPR: Enzymes and Introduction to Metabolism (2022/2023)

**Fermentation in Sustainability**

Fermentation is explained in BIOS3010 as Generation of energy (ATP) without consuming oxygen or NAD+ and has the potential to be related to sustainability. Fermentation has the potential to be used in plant based alternative foods which would be more environmentally friendly than protein options from the meat industry, while also encouraging food preservation and reducing food waste. (4,5) Limitations come from scaling up fermentation with it being slow and energy consuming like with batch fermentation or hard to implement with continuous fermentation this would also be a good segway to BIOS5480 and BIOS5210.

This targets SDG 2 ‘Zero Hunger’ through the potential that man-made proteins made with fermentation could have on addressing the nutritional needs of people in developing countries. SDG 3 ‘Good Health and Well-Being’ is also covered through the known nutritional benefits that fermented foods have on human health.

This could be mentioned while talking about fermentation in BIOS3000. Students could be asked to investigate the uses of fermentation in sustainability or tasked to research further and discuss with links to outside reading sources. Looking at the real-life applications of fermentation in food production would help with student understanding and anticipatory competency, while allowing students to consider the environmental limitations of fermentation and encouraging critical thinking.

BIOS3050 AUT: Fundamental Human Biology (2022/2023)

**Green Endoscopy**

Endoscopy is a highly resource intensive procedure that generates endoscopy is held to be the third highest hazardous waste generating department in a hospital that contributes to greenhouse gas emissions. Green endoscopy is making conscious changes to mitigate some of the unsustainable parts of the endoscopy procedure like the frequent use of single-use items, the resource-heavy decontamination process and water consumption. An example of this would be minimising the amount of nitrous oxide used or substituting for lower impact substances while maintaining the maximal clinical appropriateness during the procedure. (6)

This would target SDG3 ‘Good Health and Well-Being’ through the improvements made to a hospital environment to make it more sustainable while still upholding a high standard of care. This would also be a good opportunity to challenge ‘business as usual’ by looking at the hospital environment through a more critical lens to encourage circular economy and adopt more sustainable techniques.

The endoscopy process could be mentioned in the digestion and absorption topic when discussing methods of monitoring the GI tract. This could help with employability as students would become familiar with common clinical techniques. This would also help with the problem solving skills of students by encouraging them to think of sustainable solutions to other clinical procedures.

BIOS3070 SPR: Human Physiology and Disease (2022/2023)

**The Effects of Climate Change on Lung Health**

As climate change worsens the number of pollutants found in the air has been increasing along with the number of complications rising as a result. This leads to the rise of health conditions like Chronic Obstructive Pulmonary Disease (COPD), asthma, bronchiolitis, lung cancer and cardiovascular events, (7,8)as pollutants cause obstructions in regular pulmonary function.

This links into SD3 ‘Good Health and Well-Being’ by educating students on the health impacts that climate change has on the lungs. (8)

This could be easily mentioned while discussing the lungs and pulmonary anatomy in BIOS3070. Students can expand their learning by being asked to look at how different environmental factors caused by climate change can affect lung health, this would also have the added benefit of improving their problem solving and critical thinking skills too. Videos on the topic are readily available from reputable sources and could be played for students during lectures.

**Environment and the Liver** – SDG3

Links have been found between liver disease and environmental factors like pollution, an example would be the exposure of workers to petrochemicals showing an increased prevalence in liver function disruption. Studies have shown that occupational exposure to petrol oils correlates with increased AST and ALT levels as well as cases of fatty liver amongst workers. (9,10)

This ties into SD3 ‘Good Health and Well-Being’ by keeping students aware of how different industrial structures like oil could also have negative impact on human health as well as the environment.

This can be communicated effectively to students while discussing the role of the liver in the body and allow them to deepen their understanding of its function. By putting focus on the oil industry, it allows students to take interest in how different systems contribute to the negative impact on health and the environment.

BIOS3210/BIOS3211/BIOS3220/BIOS3221 AUT/SPR: Biological Chemistry A -(2022/2023)

**Nuclear Magnetic Resonance (NMR) in sustainability**

‘NMR spectroscopy is a versatile tool for the study of structure and interactions in environmental media such as air, soil, and water as well as monitoring the metabolic responses of living organisms to an ever-changing environment.’(11) NMR us a powerful tool for environmental monitoring and plays a big role in sustainability through its potential to measure pollutants in water and soil. Soil organic matter can store more carbon than the atmosphere but knowing where this carbon ends up is difficult due to climate change, this could be problematic in sensitive ecosystems like the Artic. Soil organic matter can also bind to pollutants and metals thus its chemistry could be very interesting to environmental research. (11,12) This difficulty in monitoring difficult environmental structures is aided with NMR.

SDG 9 ‘Industry and Innovation and Infrastructure’ is also targeted by having a greater adoption of clean and environmentally sound technologies and industrial processes. The use of NMR in infrastructure is an environmentally friendly way of keeping track of resources while monitoring waste products and their disposal. This also covers SDG 13 by suggesting technologies for raising capacity for effective climate change management especially in smaller communities.

This can be incorporated into the curriculum while discussing NMR during phase 4 of BIOS3221 and could be useful in communicating the importance of NMR outside of the classroom. Students can be asked to go and research uses of NMR in sustainability. This gives students the chance to consider NMR’s role in industry while improving systems thinking and problem solving.

BIOS3230 SPR: Diversity of Living Organisms (2022/2023)

**The Uses of Bacteria in Sustainability**

There are multiple roles that bacteria play in sustainability for example, endophytic bacteria in agriculture have been proven to improve crop productivity in lieu of greenhouse gas producing fertilizers. Another example would be the role of bacteria in food production whether it be in fermentation or biofuel production. Bacteria have a broad use in sustainability and provide an interesting new perspective to sustainability development.(13,14)

This contributes to SDG9 9 ‘Industry and Innovation and Infrastructure’ by suggesting eco-friendly innovation to industries that typically use less sustainable methods of production.

The uses of bacteria in sustainability can be easily incorporated into the BIOS3230 curriculum during the bacteria and archaea topic. Students could be introduced to the functions of bacteria which would be an opportunity to link to the BIOS5480 module in stage two. Students could also improve on their critical thinking skills by being asked about the limitations of using bacteria in sustainability, like with the idea of genetically modified or antibacterial resistant bacteria being exposed to the environment. Taking these factors into consideration would help to develop their critical thinking skills and could be done using discussion posts or Vevox.

BIOS3240 AUT: Genetics and Evolution (2022/2023)

**Gene Editing in Sustainability**

Gene editing is a powerful tool in sustainability with potential in many industries. An example would be the use of gene drives in the eradication of malaria where CRISPR is used to disrupt female fertility in mosquitoes thereby supressing the population. Another example would be the genetic modification of crops. This is where crops are engineered to be more resilient to disease, famine and heat stress which would be widely beneficial in developing countries under food stress.

Gene editing falls into SDG 3 by the specific mention of eradicating diseases like malaria as stated in target 3.3 as well as SDG 2 by suggesting alternative technologies to address the issue of malnutrition especially in countries under food-stress.

Sustainability could be brought up while discussing genome evolution, especially when linking the importance of understanding a genome and its components when undergoing genetic engineering. Explaining the process of genomic editing while adding examples of sustainability would be useful to student understanding and encourage them to look further into the topic. Students could also be introduced to the cost and ethical concerns surrounding genome editing to give them a more well-rounded look and improve critical thinking skill. This could be communicated to students using videos or links to journals for them to look at in their free time.

**Sustainability and Extinction in Evolution**

Extinction is the process where a species dies out as a result of a multitude of factors. The most common causes of extinction include overharvesting, pollution, habitat destruction and introducing an invasive species to an ecosystem. This stresses the importance of sustainability in species protection. Extinction is mainly due to man-made causes and thus the prevention must be man-made, some solutions to this would be Educating people on their role in protecting the environment, legislation preventing the poaching of endangered species, international agreements, especially those tackling climate change, creating nature reserves to protect habitats.(15)

This covers SDG15 ‘Life on Land’ and 14 ‘Life Below Water’ as it would stress the importance of maintaining biodiversity and conserving vulnerable ecosystems by addressing the main causes of extinction.

Extinction as a topic could be added to this module and explored further as it links to genetics and the idea of natural selection. Educating students on the different causes of extinction would help students to understand genetics more thoroughly by giving them the space to think of ideas to mitigate this. Students could be encouraged to look at websites like [WWF](WWF%20-%20Endangered%20Species%20Conservation%20|%20World%20Wildlife%20Fund) to see what they can do on a local/personal level to help endangered species and improve their self-awareness competency.

BIOS5010 SPR: Gene Expression and Its Control (2022/2023)

**The Uses of CRISPR in Sustainability**

CRISPR gene editing has common uses in sustainability, this is where a synthetic guide RNA is used to edit the desired sequence while utilising the CRISPR-cas9 bacterial antiviral defence system. An example of this in sustainability would be the use of gene drives in the eradication of malaria where CRISPR is used to disrupt female fertility in mosquitoes thereby supressing the population. Another example would be the genetic modification of crops using CRISPR. This is where crops are engineered to be more resilient to disease, famine and heat stress which would be widely beneficial in developing countries under food stress.(16)

Gene editing falls into SDG 3 by the specific mention of eradicating diseases like malaria as stated in target 3.3 as well as SDG 2 by suggesting alternative technologies to address the issue of malnutrition especially in countries under food-stress. This would also target SDG 9 as this would be an environmentally friendly way of driving infrastructure as well as encourage innovation.

This module goes over the CRISPR system and its functions and could be a good opportunity to mention the benefits that gene editing using methods like CRISPR could have on sustainability. Being able to identify where gene editing would be useful in the form of a vevox questionnaire, or a discussion forum could be a good activity for students. This would also help with student’s critical thinking and systems thinking as it would encourage innovative thinking in students while deepening their understanding on the genome and how it works in a real-world setting.

BIOS5030 AUT: Cell Biology (2022/2023)

**The Role that Stem Cells Play in Sustainability**

Stem cells are cells that can differentiate into other body cells and have huge potential in health and sustainability. Stem cells have a wide range of use in many degenerative diseases like Parkinson's, diabetes, and multiple sclerosis. Sustainability also includes the sustenance of human health so stem cells could also play a large part in sustainability development. There are ethical concerns over the use of stem cells due to one of the sources being from embryonic cells.(17)

This would link in with SDG3 ‘Good Health and Well-Being’ as stem cells can play a big role in in the treatment and eradication of common as well as neglected tropical diseases.

Academics could make time for students to discuss the ethical implications of using stem cells in science especially in the use of sustainability and reversing environmental damaging practices like animal farming. This would be a good chance to foster student’s anticipatory competency which would be beneficial for employability, this could also encourage students to look further into stem cells which would encourage outside reading.

BIOS5050 SPR: Infection and Immunity (2022/2023)

**Climate Change and the Increase of Allergy Cases**

There have been strong links discovered between the increase in global temperatures with the prevalence of pollen allergy cases. This is due to plants being able to display enhanced photosynthesis and reproduction to produce more pollen as a result of increased atmospheric CO2 levels. An increase in Mold proliferation caused by floods and rainy storms can also be responsible for severe asthma. (18,19)

The BIOS5050 already mentions this in its slides on hypersensitivity and allergy development, but more focus could be put on discussing with student why they think this is and any problem solving they can provide to this issue which would encourage their strategic competency.

**Climate change and its Effect on the Skin**

The changing climate has caused many changes to the skin, including the rise of cutaneous diseases due to the geographical distributions of vectors changing the spread of some infectious diseases like leishmaniasis and Lyme disease. As well as more wet and humid environments encouraging the colonisation of the skin by bacteria and fungi. (20)

This could be smoothly implemented into the BIOS5050 curriculum while discussing the skin. Including this knowledge into BIOS5050 would help encourage interest in sustainability in students as well as make relevant connections to real life scenarios to increase their understanding of the skin.

**BIOS5130 AUT: Human Physiology and Disease 2 (2022/2023)**

**Environmental Factors Affecting Infertility** – SDG3 and 9

There has been a noticeable increase in infertility within industrialised countries as a result of environmental factors like pollutants and metals in our food, water and air. The worst fertility disrupters are organochlorine compounds (chlorinated pesticides, polychlorinated biphenyls, and dioxins), bisphenol A (BPA), and organophosphate pesticides. There has been strong links between the amount of pesticide exposure and infertility seen in men and women. ‘Simply consuming foods with a high pesticide level is enough to decrease fertility by a surprising amount.’(21)

This covers SDG3 ‘Good Health and Well-Being’ as it educates students on a health concern that affects individuals globally, especially those living in highly industrialised and deregulated areas. SDG 9 ‘Industry and Innovation and Infrastructure’ as it ties into infrastructure and the effect that industrialisation has on health, this could inspire thought into areas where more sustainable methods of production could be introduced into areas more greatly affected.

This could be a discussion point for students when looking at the causes of infertility in males and females during the reproduction lecture, this would be a beneficial way to expand student understanding of a sensitive topic while keeping sustainability in mind. This could encourage students to advocate for less pesticide usage in agriculture as well as the deindustrialisation of agriculture where possible. This would also be a good opportunity to suggest shopping from local markets for students which would increase their self-awareness competency.

BIOS5140 SPR: Pharmacology (2022/2023)

**The Increase of Allergies and Asthma due to Climate Change**

There have been strong links discovered between the increase in global temperatures with the prevalence of pollen allergy cases. This is due to plants being able to display enhanced photosynthesis and reproduction to produce more pollen because of increased atmospheric CO2 levels. An increase in Mold proliferation caused by floods and rainy storms is also responsible for severe asthma.(19)

This ties into SD3 ‘Good Health and Well-Being’ by keeping students aware of how different industrial structures could also have negative impact on human health as well as the environment.

This links in with the asthma and allergies topic and can be mentioned in when discussing the role of histamine in the allergic response exemplifying pollen as a potential trigger and mentioning the role of climate change in disrupting pollen patterns. It can also be mentioned how this disruption triggers an increase in asthma when talking about the role of allergens in exacerbating asthma. This would be useful in increasing student understanding of the topic by providing students with realistic examples of how sustainability affects health.

**Increasing Internal Temperatures due to Climate Change causing Hyperosmolarity in Kidneys**

There has been a dramatic increase in heatwaves worldwide, with 175 million more people being exposed to heat waves because of climate change. With this comes increased risk for people with cardiovascular and respiratory disorders. ‘Studies have reported that increasing temperatures translate into increased admissions through the emergency room of a wide range of renal disorders.’ (22) The increase in heat is unhelpful for the kidney’s function of maintaining blood volumes for patients taking Thiazide diuretics, loss of electrolytes like sodium and potassium through sweat and dehydration reduce the thiazides effect on reducing blood volume.(22,23)

This ties into SD3 ‘Good Health and Well-Being’ by keeping students aware of how different industrial structures could also have negative impact on human health as well as the environment. This also educates students on a health concern that affects individuals globally, especially those living in highly industrialised and deregulated areas.

This can be added to BIOS5140 when discussing the asthma and allergies topic. Especially when discussing the role of histamine in the allergic response and exemplifying pollen as a potential trigger while mentioning the role of climate change in disrupting pollen patterns. It can also be mentioned how this disruption triggers an increase in asthma when talking about the role of allergens in exacerbating asthma. This would be useful in increasing student understanding of the topic by providing students with realistic examples of how sustainability affects health.

BIOS5200 AUT: Metabolism and Metabolic Disease (2022/2023)

**The Role that City Design Plays in Diabetes**

Exercise has been proven to be a viable treatment in patients with type 2 diabetes through the encouragement of weight-loss and lipid metabolism. Aerobic exercise is a well-established way to reduce HbA1c, HbA1c is the number of glycated haemoglobins in the blood volume and is a good indicator of diabetes progression. (24,25)A sustainable city design is a city design that considers the social, economic, and environmental impact of urban development. A sustainable city aims to reduce air pollution and CO2 emissions, enhance air quality, and protect natural resources. A sustainable city design would include more opportunities for people to walk or cycle to their destinations instead of taking cars which would also encourage exercise and reduce CO2 emissions.

This covers SDG 11 ‘Sustainable Cities and Communities’ as this would include advocating for safe and sustainable public transport as well as environmentally friendly urbanization while linking this to the need for exercise in diabetes treatment and prevention.

Students can improve their systems thinking by discussing the role that ample exercise has on diabetes and its management and how this is factored by environment and particularly city design. This would fit into the diabetes and insulin topic when talking about type 2 diabetes and its treatment. Students could be asked about what sustainable aspects of a city help to tackle the increase in diabetes cases worldwide e.g., easy access to cycling, walking and less car dependant infrastructure. This could segway into the role of AMPK in exercise and its use in diabetes management.

**The Role of City Design Plays in Vitamin D Deficiency**

A study has shown that veterans that lived in large metropolitan areas, cities typically walkable and less dependent on cars, had the least cases of vitamin D deficiency. One reason for this could be that people are more encouraged to go outside which would allow for more UV rays to start the process of vitamin D production in the skin. (26)

This covers SDG 11 ‘Sustainable Cities and Communities’ as this would include advocating for safe and sustainable public transport as well as environmentally friendly urbanization by linking able space and opportunity to walk to preventing vitamin D deficiency.

This would be an interesting discussion point for students when discussing the sources of vitamin D and the causes of diseases like rickets while encouraging systems thinking when looking at sustainable cities and how they can benefit our health.

BIOS5210 SPR: Metabolism and Metabolic Regulation (2022/2023)

**The Role of Nitrous Oxide in Nitrogen Metabolism and how it Affects Climate Change** – SDG9 (industry innovation and infrastructure)

BIOS5210 covers the nitrogen cycle, where nitrogen atoms are cycled through living and non-living systems. At the end of the cycle denitrification occurs and is the process where nitrate (NO3) is converted to dinitrogen (N2). Nitrous Oxide is a greenhouse gas 300 times more potent than CO2 that lasts up to 114 years in the atmosphere and is produced as an intermediate during denitrification. Nitrous oxide emissions caused by nitrogen loss in soil can be caused by waterlogging or temperature changes in the soil which are much more common now due to climate change. (27) 75% of N2O emissions are caused by the agricultural industry and the use of nitrogen fertilizers in soil where denitrifying bacteria produce N2O under anaerobic conditions.(28) This can also be exasperated by nitrogen fertilizers used in soil and is dependant on the type of fertilizer used. There has been a positive relationship found between the amount of nitrogen fertilizer used in tropical and subtropical regions and N2O emissions. (29,30)

SDG 9 ‘Industry and Innovation and Infrastructure’ is also targeted by having a conversations on the adoption of clean and environmentally sound alternatives to the agricultural processes.

This can be incorporated seamlessly into the BIOS5210 curriculum as microbes play a big part in climate change and the production of greenhouse gasses through their metabolism and can be mentioned when talking about the denitrification process of the nitrogen cycle. Potential solutions can be presented to students like using less nitrogen fertilizer, nitrification inhibitors and preventing waterlogging which all address the issue of nitrogen loss in the soil.(30) Another change that students could personally make would be to shop more locally and getting produce from smaller independent farmer’s markets and community gardens which would foster their self-awareness competency. Industrial farming doesn’t have the capability to personally address every case of waterlogged soil due to the sheer magnitude of production. Individual farmers would have an easier time holding themselves accountable and have less chance of over fertilizing their soil. Could also mention any health benefits to locally grown organic produce or and the reduction of carbon emissions too.

**Biocatalysts as a Sustainable Alternative to Other Industrialised Processes of Producing Organic Materials** – SDG9 and 12 (responsible consumption and production).

Biocatalysts use a circular economy as they can utilise organic waste products to produce desired products. It is possible to use agricultural waste products, food waste and products from landfills to extract triglycerides and lignocellulosic biomass. ‘Food wastes contain a high content of lignocellulose, starch, and triglyceride which can break down into fatty acids and glycerol, sugar, lignocellulose, and GHGs.’ (31)Lignocellulosic biomass can be broken down into simple sugars like glucose and lignin which is a precursor to phenolic products that can be used in the production of aromatic compounds. ‘Phenolic compounds derived from lignin are regarded as important precursors for food, pharmaceutical, cosmetic, and chemical industries.’(31) Waste oils from food waste can be used in biocatalysts to produce triglycerides what can be further broken down into fatty acids using biocatalysts.

This links to SDG 9 ‘Industry, Innovation and Infrastructure’ as well as SDG 12 ‘Responsible Consumption and Production’ as this explores the idea of a circular economy in industries that typically generate a lot of waste. Promoting a circular economy would ensure that materials are consumed more consciously as well as reduce contributions to waste generation.

This can be mentioned in BIOS5210 when talking about biodegradation and the advantages of using biocatalysts. We can ask students why they think biocatalysts would be a sustainable/viable option compared to linear models of production (vexox or discussion forum post). Academics can approach this from a problem-solving lens e.g. ‘There’s a problem with food and agricultural waste buildup in landfills that turns into CO2 and CH4 emissions, do you have any ideas on how biocatalysts could be used to help mitigate this process?’

BIOS5250 AUT: Investigation of Disease (2022/2023)

**Increasing Temperatures and its Effect on the Kidneys** – SDG3 and 13 (climate action)

The sharp increase in the number of heatwaves worldwide due to climate change is causing an increase in the number of people admitting to hospitals with AKI and this demonstrates how the kidneys are the main site of damage in heat-related injury. Heatstroke creates major risk for kidney injury especially for those exercising or working while exposed to extreme temperatures.(22)

This ties into SD3 ‘Good Health and Well-Being’ by keeping students aware of how different industrial structures could also have negative impact on human health as well as the environment.

This would be a good opportunity to demonstrate how the kidney could lose function due to heat-stress and can be outlined as a cause of AKI or CKD in a case study using an agricultural worker in a heat exposed country as an example. This proves to be helpful in educating the students on what AKI can be caused by, using realistic examples while also keeping climate change in conversation. Students would be reminded of the bigger picture rather than just focusing on kidney physiology in a clinical setting. Students could also be asked for solutions or treatments they would recommend to the example in the case study which would home in on their problem-solving and critical thinking skills.

**Sustainability in Hospitals and the Importance of Disease Prevention**

BIOS5250 has a big focus on employability in clinical sciences as well as common diseases that would be tested in such a setting, and taking the time to discuss sustainability in hospital settings would be another opportunity to remind students of the roles they could play in sustainability in future employment. Students could be asked to discuss areas where energy consumption within hospitals could negatively and positively contribute to sustainability. Mentioning how much water and energy is consumed by hospitals daily would help them to see the bigger picture regarding climate change.

This would target SDG9 ‘Industry, Innovation and Infrastructure’ through the improvements made to a hospital environment to make it more sustainable while still upholding a high standard of care. This would also be a good opportunity to challenge ‘business as usual’ by looking at the hospital environment through a more critical lens to make any progress in sustainability.

Looking at the sustainability of hospitals as an institution would help students to further understand the importance of prevention in diseases like CKD and liver disease as well as signify the importance of screening programmes in the UK. This also would exercise student’s systems thinking competency regarding sustainability, by looking at hospitals as a whole they would be able to understand how elements within a system would influence each other and how cause and effect come into play in a hospital setting.

BIOS5470 SPR: Plant Physiology and Adaptation (2022/2023)

**Precision Farming and Circular Economy in Agriculture**

Precision farming is the practice of only using the precise amount of nutrients in farm management by using satellite position data, remote sensing devices and proximal data gathering technologies. This would drastically reduce the amount of food waste and greenhouse gas emissions caused by farm runoff due to over-fertilisation.

This concept could be easily introduced into the BIOS5470 module while taking about the process of plant growth and the new ideas that come with agriculture in sustainability. this would also improve student’s system’s thinking as they would be able to apply their knowledge to a relevant industry.

Circular economy encourages the reuse and recycling of materials, in agriculture this would include using minimal amounts of external inputs, closing nutrients loops, regenerating soils, and minimizing the impact on the environment. Examples of circular economy in agriculture would be the use of manure and food waste as fertiliser and using wastewater in irrigation. As well as mixed crop farming where crop diversity encourages soil fertility and increases yield while reducing inputs.

Encouraging students to learn about circular economy would greatly increase their systems thinking in understanding how different practices in agriculture could aggravate issues like climate change. This could be done through vevox questions or discussions posts encouraging students to research examples of circular economy in agriculture.

Both concepts are examples of SDG9 ‘Industry and Innovation and Infrastructure’, particularly in target 9.4 by using more sustainable methods in a technique commonly used in industry. This also promotes the idea of challenging ‘business as usual’ by suggesting circular economy to an otherwise unsustainable industry.

BIOS5480 SPR: The Microbial World (2022/2023)

**The Sustainable Role that Biofilms Play in Wastewater Treatment**

Biofilms play an environmentally friendly role in the process of wastewater treatment as they are energy efficient and are low cost as well as having the ability to absorb specific nutrients and organic pollutants from wastewater. ‘Biofilms-based reactors due to their economic and ecofriendly nature are used for the treatment of industrial wastewaters. Electrodes coated with electro-active biofilm (EAB) which are obtained from sewage sludge, activated sludge, or industrial and domestic effluents are getting popularity in bioremediation.’(32)

This topic is targets SDG 6 ‘Clean Water and Sanitation’ through the uses of biofilms in water treatment which is specified in the UN’s target 6.3 which aims to improve water quality by reducing pollution by 2030. SDG 9 ‘Industry and Innovation and Infrastructure’ is also targeted through goal 9.4 which aims to upgrade infrastructure and retrofit industries to make them sustainable by 2030, by having a greater adoption of clean and environmentally sound technologies and industrial processes.

This would fit in well when discussing the beneficial roles that biofilms play in systems that we use daily, it would allow students to informed on the sustainable role that bacteria can play in infrastructure and allow them to advocate for these more environmentally friendly and energy effective methods of treatment. This would also be a good opportunity to encourage critical thinking in students if they were to be asked how they think bacteria could play a beneficial role in systems like wastewater management as well as the shortcomings like the chance of spreading antibacterial resistance to the environment. Provided students can understand that bacteria can use organic material in wastewater which would link into the previous lecture on microbial culturing and growth.

BIOS5490 SPR: The Genome (2022/2023)

**The Benefits that Gene Editing Can Have on Sustainability**

CRISPR gene editing is a powerful tool in sustainability, where a synthetic guide RNA is used to edit the desired sequence while utilising the CRISPR-cas9 bacterial antiviral defence system. An example of this would be the use of gene drives in the eradication of malaria where CRISPR is used to disrupt female fertility in mosquitoes thereby supressing the population. Another example would be the genetic modification of crops using CRISPR. This is where crops are engineered to be more resilient to disease, famine and heat stress which would be widely beneficial in developing countries under food stress.(16)

Gene editing falls into SDG 3 by the specific mention of eradicating diseases like malaria as stated in target 3.3 as well as SDG 2 by suggesting alternative technologies to address the issue of malnutrition especially in countries under food-stress. This would also target SDG 9 as this would be an environmentally friendly way of driving infrastructure as well as encourage innovation.

This module goes over the CRISPR system and its functions and could be a good opportunity to mention the benefits that gene editing using methods like CRISPR could have on sustainability. Being able to identify where gene editing would be useful in the form of a vevox questionnaire, or a discussion forum could be a good activity for students. This would also help with student’s critical thinking and systems thinking as it would encourage innovative thinking in students while deepening their understanding on the genome and how it works in a real-world setting.

### Redesigning Laboratory Infrastructure

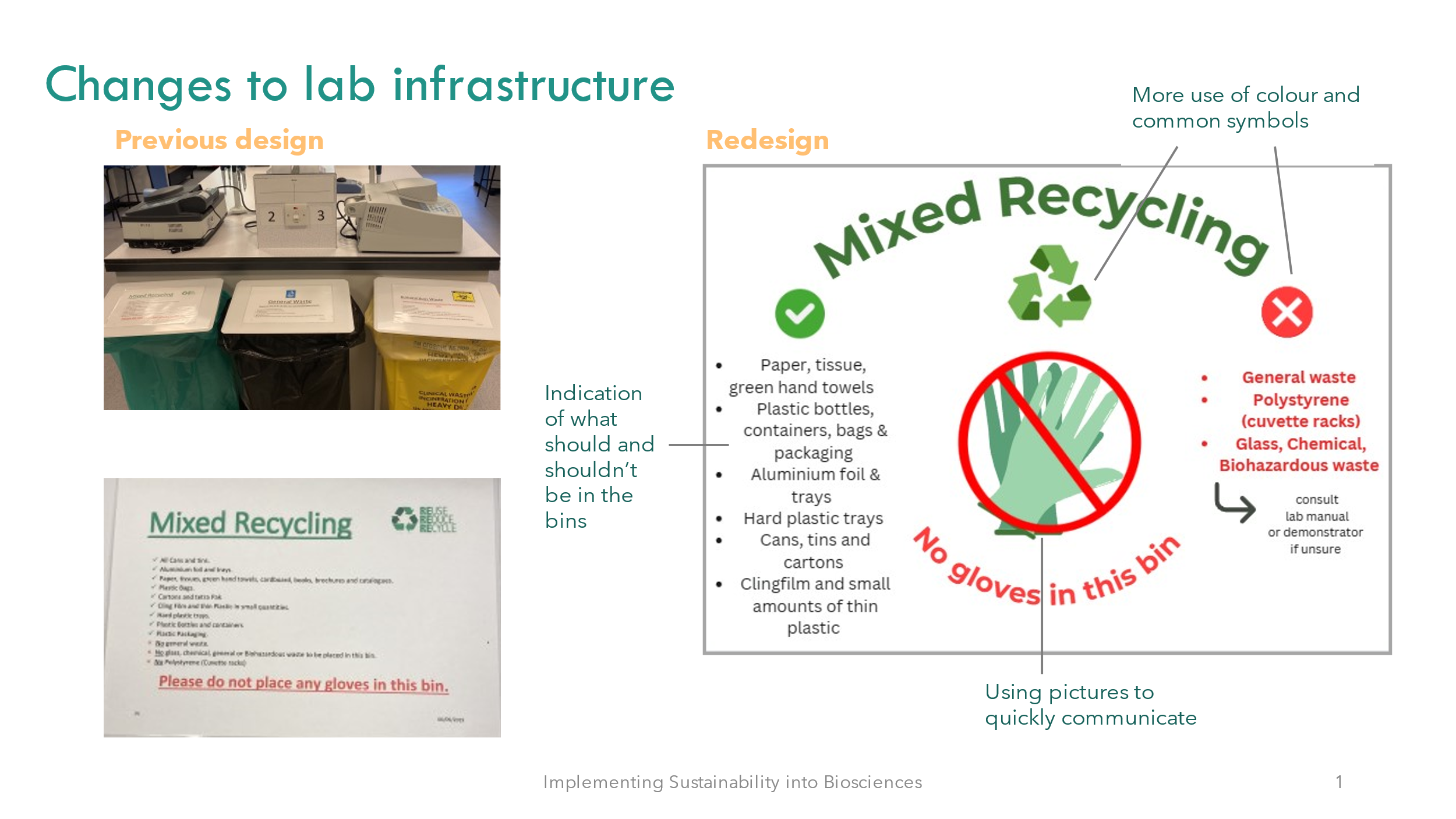
Provided is an example of a redesign to the labels on the bins in the laboratory. The previous design did well in clearly communicating the purpose of the bins as well as providing detailed information on what could and could not be placed in each bin. However, the lettering for this information could be interpreted as small or easy to miss so this was replaced with much bigger writing, easy to understand symbols and a clearer format. Another major change to the labels was the addition of images, it was suggested that images would be easily recognisable and quickly communicated in a fast-paced environment like the teaching labs. Bold colours were present in the previous design, and it was decided to bring this into the redesign as they help with quick recognition and are attention grabbing.

Figure – A diagram explaining the changes made to the lab bins, to the top left is a picture of the arrangement of the bins with their previous design. To the bottom left is a close-up picture of the label on the mixed recycling bin. To the right is an image of the redesign including reasonings for why certain changes were made.

# Conclusion

In overview of this project, it can be seen how sustainability and Natural Sciences share a close relationship and how replicable this methodology could be to other divisions. This project exemplifies how changes to the curriculum and to classroom structure could be valid methods of delivering sustainable development especially to students. Providing valuable information to students while keeping their needs and wants in mind was an important aspect of the project and it ensured that sustainability could be introduced to the students in a reliable manner. Sustainability does not have to be an atomic process rather, having other divisions and academics in collaboration would be guaranteed to have more reliable and efficient ESD delivered to students. These changes are just suggestions but if there were to be a common consensus amongst academics it would be easier to see these changes implemented.

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