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Analysis of the introduction of Green Laboratory Certification Program at the University at Albany, State University of New York to increase sustainability in laboratories

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Analysis of the Introduction of Green Laboratory Certification Program at the University at Albany, State University of New York to Increase Sustainability in Laboratories

By

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Abstract

Universities around the world are making changes to become more sustainable including lowering energy and water consumption, reducing waste production, and looking at procurement methods. At the University at Albany, State University of New York, there is an ongoing effort to increase sustainability and climate resiliency to align with state and international goals. One of the key areas needing improvement are scientific laboratories because they have a substantially larger energy consumption than other buildings. An analysis of current practices on campus was conducted and improvements suggested from research of similar programs. This included expanding and testing a campus specific "Green Labs Checklist" to measure and aid participating laboratories. Meetings with university officials and leading companies were conducted to increase participation and gather data. An audit was conducted of the Research Foundation procurement over one year for campus laboratories. To adopt sustainability practices the laboratories need additional education and support; including hiring employees to oversee implementation and continuously adapt the program to current standards. This needs to be a university wide effort with endorsement from key campus officials.

Acknowledgments

I would like to thank my committee members: Andrei Lapenas, Indu Lnu, and Mary Ellen Mallia, for their guidance and support throughout this process. I am grateful I was able to work on this project and be part of creating measurable change at my university. My graduate cohort, professors, and campus researchers have all been helpful encouraging my curiosity and focusing the endless stream of ideas I have. I appreciate my family and friends who have provided me with endless support, encouragement, and love.

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Introduction

Despite decades of research and knowledge about climate change, our global emissions are still higher than where scientists indicate they should be. To reduce greenhouse gas emissions, stabilize the planet's temperature, and protect biodiversity, each industry sector needs to make large changes. The focus of this research is sustainable scientific laboratory use and the process to update existing laboratories. The purpose of this research is to apply these techniques to the labs at the University at Albany, analyze the current methodologies, and seek ways to reduce energy, water use and waste. This will decrease resource consumption, financial costs, and provide a more resilient campus in line with the university's *Climate Action and Sustainability Plan*.

One of the largest advocates for humans to make sustainable progress is the United Nations (UN). This organization has promoted technological and systematic changes that mitigate climate change over the last two decades. Currently, the organization is overseeing the implementation of the Sustainable Development Goals (SDGs), 17 goals adopted in 2015 to address social, economic and environmental challenges.[8] The University at Albany aligned the targets embedded in its 2020 *Climate Action and Sustainability Plan* with these goals.[30] In order to foster industry action, the UN created the Race to Zero campaign to get industries on board with international goals.[36] Policy changes are needed but take a large amount of time to be enforced. In the meantime, it will be most efficient for industries to begin acting as if these policies are already in place.

Two of the key sectors that need changes are the biopharmaceutical and technology industries. Both industries rely on laboratories for research and development and manufacturing. Laboratories are 5 to 10 times more energy intensive per square foot than typical office buildings. Specialty laboratories, including clean rooms, have been found to use 100 times more energy per square foot.[19] Humans have become highly dependent on these industries for products we use every day. Consumers have become accustomed to single-use items, and this is the same in most laboratory settings.[26]

Background

As a public research institution, the University at Albany strives to implement state goals and adopt other public targets, including the Sustainable Development Goals. This is evidenced by the campus's *Climate Action and Sustainability Plan*, adopted on April 22, 2020.[30] The six goals, each of which was aligned with the SDG's, identified in this document for the university to achieve by 2030 are:

1. Ecological Literacy
2. Impactful Research
3. Equal Access
4. Community Leadership
5. Carbon Neutrality and Climate Resiliency
6. Culture of Sustainability

The SDGs that are most applicable to this research project are #4: Quality Education, #9 Industry, Innovation, and Infrastructure, #12 Responsible Consumption and Production, and #13 Climate Action.[9] Additionally, it addresses several of the actions listed in the campus *Climate Action and Sustainability Plan*. Under Impactful Research, subgoals intend to increase research on United Nations Global Goals and increase externally funded sustainable research. Adapting our laboratories to correspond with more sustainable practices better positions them for these funding opportunities. Increasing Equal Access in laboratories requires increasing diversity and opportunity for nontraditional staff members. Under Community Leadership, there are subgoals to increase sustainability-related efforts on a local scale. These could be applied to the research groups on campus because some act as small communities.[30] Carbon Neutrality and Climate Resiliency may be the most applicable goal for this research project because the intention is to reduce energy usage and carbon emissions. Laboratories are the most intensive energy consumers of an academic building and present the best opportunity for this goal to have a widespread campus impact. Laboratories also produce a high amount of waste through experiments and single-use materials.[19,30]

The concept of green chemistry was strongly introduced to the scientific world with the publishing of "Green Chemistry: Theory and Practice" by Paul T. Anastas and John C. Warner in 1998. The book influenced an entire subcategory of chemistry and is widely accepted as a standard for practicing sustainability in scientific settings. Its first and most important tenant is the 'prevention principle". The theory is summarized as: it is best to prevent waste products from ever being created rather than try to handle them afterward.[1]

There is an extremely high level of waste produced by laboratories, with many items being thrown away as hazardous waste when there are alternative options. There have been advancements made in the sector to provide recycling and reusable alternatives for the most common laboratory supplies. Some of the changes that can be made in modern spaces are not even advancements, but a return to older styles of using reusable materials instead of disposable options. There are real reasons to protect health and safety by using disposable supplies in some situations, such as biological hazards or radiological waste.[12] However, often the most stringent measures are taken when they are not needed. The problem is largely creating a change of behavior in these environments and investing in both industrial and policy changes.[26]

Behind data centers, laboratories are measured as consuming the most energy per square foot of any sector.[26] Most laboratories are more energy intensive due to higher electricity usage and ventilation requirements. Many of these are to ensure adequate environments to protect the health and safety of the researchers. Fume hoods contain harmful fumes within a well-ventilated work area with high air change rates between 6-30 air changes per hour. Sufficient ventilation for dilution of lab air causes high energy use as the ventilation air needs to be heated, cooled and conditioned before it is introduced in the labs, only to be exhausted in less than 10 minutes. In the construction of new buildings, LEED (Leadership in Energy and Environmental Design) certifications have been used to increase the efficiency of laboratory facilities.[12]

Energy audits have been conducted on university buildings in previous research.[15,19] It is possible and feasible to introduce sustainability standards in existing structures. Changes created led to long-term cost savings. Areas of priority when evaluating an existing facility are water and energy consumption and

recycling/reuse of materials.[11] Freezers are one of the key energy drains in laboratory buildings. In laboratories, it is standard to set a freezer to -80ºC. It is unknown where this temperature was chosen from, but it is not a requirement. There is no scientific evidence of biochemical degradation by raising the temperature to -70ºC. The energy saved in a single day with this change is the same as that which would be used by a family in the same time span.[10,24]

Currently, a process is underway on campus to inventory the energy usage and update existing structures including fume hoods and freezers. There are two types of fume hoods on campus. In older buildings such as Earth Science and Chemistry, the fume hoods are constant flow. Life Sciences and ETEC facilities have fume hoods with a variable flow that is dependent on the position of the sash and proximity sensors. The hallways in the newer facilities include occupancy detection for turning off lighting.

One of the non-profit companies that have emerged to help labs become more sustainable is My Green Lab. The organization uses a combination of collecting data on sustainable methods for laboratories and providing guidance through programs tailored to higher education, pharmaceutical companies, and other sectors. They award certifications based on the percentage of identified target metrics met by each project and continue to work with those companies to increase their capabilities.[37] The organization partners with the United Nations Global Compact, working to bring sustainability to industry. Educational resources, a laboratory certification, the ACT Environmental Impact Label, and an annual Freezer Challenge are offered by the company.[25] The My Green Lab Certification program is recognized by the United Nations Race to Zero campaign as a gold standard.[36] The certification engages laboratories with professional staff members to assess the sustainability of their labs and identify areas of improvement. Over 1,300 labs are currently enrolled in the program worldwide. The UN goal is for 95% of laboratories between pharma and tech industries to be Green Level certified by My Green Lab by 2030. The entire pharma section is expected to be net zero by 2050. The My Green Lab Certification Program was chosen as an indicator of progress to move laboratories to more sustainable usage. During the

COVID-19 pandemic, 622 higher education institutions joined My Green Lab to begin creating sustainability accountability on their campuses.[16]

Additionally, My Green Lab offers programming for certification, ACT, the International Laboratory Freezer Challenge, and education materials. The ACT (Accountability, Consistency, and Transparency) Environmental Impact Label is a third-party verification for laboratory procurement, with verification conducted by SMS Collaborative, LLC. My Green Lab publishes the label and maintains a searchable database for researchers to use, including region-specific updates. Multiple procurement officers use the ACT label to aid in procurement decision-making.[25] The International Laboratory Freezer Challenge is a six-month international competition to reduce energy usage in laboratories. In 2022, over 1,200 laboratories across 27 countries participated in the challenge. The competition increases education and participation in lab sustainability by actively engaging participants. The program also gives measurable data for the laboratories to use in justification on grant applications by analyzing energy usage saved in kWh and carbon dioxide emissions reduced in metric tons.[24] The Office of Sustainability at the University at Albany registered for the 2023 Freezer Challenge to facilitate the collection of data from all campus participants. Participating in the competition is encouraged for all campus laboratories and is included in the campus certification program.[24]

Another of the key resources provided by My Green Lab is a free, educational training platform to give an overview of sustainability in scientific laboratories and create achievable goals. The training certifies participants as Green Lab Ambassadors. The program includes ongoing participation in monthly meetings with other sustainability-minded scientists.[37] In addition to the Ambassador program, My Green Lab offers a more in-depth learning platform. The Accredited Professional program is designed for scientists and other professionals who work with laboratories. It is a paid module format with six training modules. Three of the modules are currently available including Waste, Green Chemistry, and Procurement. The three modules in development are Energy, Engagement, and Water.[23]

Other organizations involved in fostering more sustainable lab practices are Kimberly Clark, Beyond Benign and Grenova. Kimberly Clark is an American company primarily focused on paper

products and both surgical and medical instruments. They offer the RightCycle Program, a recycling program for the top disposable materials used in scientific laboratories.[39] Beyond Benign is a non-profit organization focusing on providing educational resources on green chemistry and creating a more sustainable scientific community. It was founded by Dr. John Warner and Dr. Amy Cannon in 2007. One of the employees for the company is Dr. Natalie O'Neil, an alumna from the University at Albany's Chemistry Department.[4] Grenova is a company that specifically creates and validates machinery for scientific laboratories to reduce plastic waste. The goal of the company is to eliminate single-use plastics in laboratories. Pipette tips are one of the largest waste products of laboratories and the company has a pipette tip cleaning device which would allow for the transition to reusable pipette tips.[35]

Many of the changes that My Green Lab and other researchers propose can be taken by individual laboratories or facilities. The challenge for the University at Albany is the coordination of activities and providing incentives for these actions to be taken. Through increased research of the campus-specific metrics, short- and long-term goals can be created for the campus to improve sustainability in laboratories. There needs to be a top-down approach coupled with individual progress. Without the two, there will be a disconnect, and the changes made will be less effective.

Method

To establish the university short- and long-term goals and the metrics by which to measure them, three key areas of research were identified: energy, waste, and procurement. Energy is determined by using facilities data and laboratory-reported feedback on lighting, fume hoods, water, and electronic devices. Key areas of waste in laboratories are single-use plastics. Pipette tips and gloves were chosen as research topics due to their high usage and applicability to nearly all scientific laboratories on campus. Procurement was researched by conducting an audit of laboratory grant spending. The purchases made by most laboratories are through the SUNY Research Foundation.

Green Labs Checklist:

The first step of the project was to sort through pre-existing data collected. The data was in a Google Drive account across seventeen folders and three Excel spreadsheets in a OneDrive Student Account from a previous intern. The existing information was combined into a single OneDrive account under the University Energy Officer's account. The Green Lab Checklist was developed by student interns Carly Lyndsay and Andriana Lamendola working for the University at Albany, Office of Energy Management based on similar checklists in use at other higher education institutions. The Excel spreadsheet titled "Green Labs Checklist" was analyzed, and condensed where applicable, additional research areas were identified and useful links for PIs were created. When finished, the spreadsheet was introduced to PIs involved in the pilot program for the university.

The existing Excel spreadsheet titled "Green Lab Checklist" was reviewed and analyzed using knowledge of the laboratories from previous experiences. An updated version of the "Green Lab Checklist" is included in Appendix 6. The checklist has five sections: Communication, Education, & Training; Energy & Water Conservation; Chemical Use & Toxic Material Minimization; Waste Reduction & Diversion; Resource Management & Purchasing. These sections were pared down and condensed. Items of interest and key areas of improvement were noted for further research. These include

increasing awareness on campus, university asset management, freezer energy usage, water conservation, chemical alternatives, waste diversion, purchasing energy-efficient appliances, and vendor take-back programs. Additional research was conducted on the availability of green chemistry professional training, educational posters, and documents. The checklist was also compared with other existing behavioral change programs, including the Green Workspace Challenge, Environmental Health and Safety's laboratory training, and the university's Energy Campaign.

To facilitate the adoption of conservation measures, small re-positional clings were created to encourage energy savings through turning off light switches and closing fume hoods. The clings were created using bright graphics and simple wording to encourage laboratory participation. (Appendixes 1 and 2) A poster was designed to give an overview of the "12 Principles of Green Chemistry". (Appendix 3)[1] The ETEC building was canvased in the Spring 2023 term when an intern was available to go to laboratories. Twenty out of twenty-two laboratories were open and willing to have clings added to their fume hoods.

Campus specific energy costs between the Uptown Campus buildings totaled 76.6 million electric kWh and nearly $11 million in 2019. Looking at the five primary buildings with laboratories: LSRB, ETEC (2021 data), Chemistry, Biology, and Physics account for 16.5 million kWh, 21.5% of all energy usage on campus. The total spent on energy for the five buildings was $2.6 million. The LSRB had the highest energy usage of all campus buildings: 6.2 million electric kWh totaling $1.2 million. Estimates from other laboratory studies conducting sustainability initiatives range from 30- 50% in total energy savings.[13] This would result in electric energy savings between $780,000 and $1.3 million yearly. Water savings are less commonly reported as a percentage of total quantity. Many other universities have measured specific savings by changing equipment, uninstalling water aspirators, and utilizing aerators.[2] One of the items in the Green Labs Checklist is to decrease water aspirator use. The University of Alabama anticipates saving hundreds of thousands of gallons of water each year by switching to vacuum filters.[3]

Other universities have created a method to reduce excess purchasing and waste by creating and maintaining an inventory of chemicals in the departments.[17] This would be a very large undertaking by the departments and would be better suited to being managed by a central office. SUNY does have an Available Surplus Catalog for office items over $500 in value for state and Research Foundation assets, but it is infrequently used by the facility. As was shown in the purchasing audit, most office supply items (chairs, desks, etc.) are purchased new by each laboratory.[27]

One of the areas for improvement requires more involvement of student researchers to bring sustainable efforts directly to leaders of their laboratories. Multiple student-led groups have been identified as potential partners for the Green Labs project including Atomic Danes, Undergraduate Chemistry Club, UAlbany Students for Sustainability, Undergraduate Physics Society, Albany Student Press, Atmospheric Science Graduate Student Association, and the United Nations Association Chapter. This is a preliminary list of academic and service groups on campus, but any interested club could be influential. Community leadership is one of the tenets for the University's climate resiliency plan and should be further encouraged by staff and faculty.

Another option for increased student involvement is through the Living-Learning Communities (LLC) on campus. The World of Chemistry and the World of Community Service are examples LLC that could be approached for presentations and student engagement. Facility members can be identified and reached out to for potential involvement.

University Meetings:

Twelve (12) researchers had previously expressed interest in participating in the Green Labs project. This list was reviewed against current personnel, additional potential participants were added, and this group was contacted for the pilot project. Departmental offices, building managers, the Office of Sustainability, the Office of Environmental Health and Safety, and Facilities Management were identified as key players for this project.

Biweekly meetings were established to review progress and attended by a rotating number of staff including the campus Energy Officer Indu Lnu, Director of Sustainability Mary Ellen Mallia, and interns from the Office of Sustainability. Weekly meetings were held to communicate with the interns in the spring semester of 2022. PIs who had expressed previous interest in working with the Green Labs Certification pilot program were contacted.

Interns being trained by the Office of Energy Management for the campus Green Workspace challenge were asked to conduct similar audits in participating laboratories. This included the number and types of plug-in equipment, water usage, and hood practices. The author was trained to conduct both office and laboratory audits, playing a role in organizing and collecting data from student interns.

The Office of Environmental Health and Safety was identified as a key contributor to education and oversight of introducing safer chemical alternatives, disposing of old chemical and biological materials, finding suitable waste streams or methods for lab waste, and providing direct training to laboratory members. During a meeting with the office, it was recommended by the staff to use their website and campus Chemical Hygiene Plan to answer questions related to their procedures.[28] Previous interns from this project met with members of the office in May 2020 and their remaining questions were included in the files on OneDrive. Unresolved questions for further research are included in the discussion section.

Building managers for four of the laboratory buildings on campus were contacted regarding energy conservation measures to determine if lighting had been switched to LED or if T8, traditional fluorescent lighting, was still being used. Roughly half of the lighting on campus has been updated to LED. As another conservation measure, most of the building hallways use occupancy controls for lighting. In laboratories, there is a concern the lights may turn off when someone is still and conducting an experiment. However, using occupancy sensors in labs with a 30-minute time-delay post vacancy detection before lights are turned off would ensure that the lights stay on when needed but automatically turn off if the users forget to turn them off.

Facilities management oversees cleaning the buildings and lab spaces. They were contacted to discuss cleaning supplies and methods in laboratories. For common spaces, this department manages the cleaning while each lab is responsible for its workspaces. Traditional office trash in laboratories is collected by custodial staff members in the provided bins as well as dusting or wet mopping.[29] Industrial, chemical, and hazardous waste are separated by the laboratories individually for EHS disposal.[28] Facilities shared documentation on general cleaning guidelines followed by staff. It is specifically noted laboratories must be accessible for cleaning three times a week. Inaccessible labs will be skipped. Vinyl tile flooring can be stripped, waxed, and burnished through written funded work requests from laboratory occupants.[29]

In new construction, like the ETEC building, methods can be applied to create more sustainable infrastructure.[11] Inclusions for renovation decisions can include updating existing hood ventilation in older buildings and replacing supplemental laboratory equipment with more efficient models. Some of these replacements can be determined in advance, and replaced when the current equipment reaches the end of its life.[43]

Interest was expressed by members of the Chemistry Department to increase sustainability and environmental awareness in coursework. Changing course descriptions or learning objectives involves departmental and policy changes. Class content and assignments are decided by professors and could include more green chemistry and sustainability examples. The Office of International Education also offers semester-based learning experiences for students to develop sustainable skill sets and take similar courses in other countries but there are many courses and certifications offered by universities around the globe.

Another option is to allow students to add courses from other SUNY colleges as either a substitute or a supplement to their programs. Research was conducted to determine online research courses from other SUNY colleges currently offered as of Spring 2023. A list of courses available to be taken online by University at Albany students was compiled. The decision to focus on online courses was to be more inclusive to alternative students, students who cannot take courses on other campuses, and allow for a student to add a course during a normal semester on campus. Courses were searched using the Open

SUNY website using search terms “environmental science”, “sustainability”, and “climate”. Selected courses for departmental and student consideration are listed in Appendixes 4 and 5.[33]

Industry Meetings:

Meetings with organizations outside of the university were utilized throughout the research process, including My Green Lab, Kimberly Clark, Beyond Benign, and Grenova.

My Green Lab

Multiple meetings were conducted with Cristalle Ruiz, a market development representative for My Green Lab beginning in April 2022.[37] There is a fee for laboratories to sign up for the My Green Lab Certification program and have their support structure. The cost is based on the number of laboratories participating, the more laboratories on campus we have participating, the lower the cost of participation per lab. The main concern with signing up and paying for the My Green Lab Certification is the lack of campus involvement. With minimal laboratory interest participating in our pilot program, there was concern there would not be involvement in a larger project. One of the goals of the pilot project was to test the program on a smaller scale and determine campus metrics. (e.g., collecting the data on energy, waste, and procurement) This would allow the campus to be in a better position moving forward and address laboratory questions. There is still interest in joining the formal My Green Lab certification.

Other educational opportunities offered by My Green Lab are the Green Lab Ambassador certification and an annual summit. These were reviewed and the Ambassador program was included in the university’s Green Labs Certification program, giving points to laboratories that have at least one member complete the course.[23]

Kimberly Clark

A meeting was conducted between the principal researcher and Kimberly Clark’s representative Stephanie Casciato on May 3rd, 2022, regarding the RightCycle Program. Kimberly Clark collects used

gloves, gowns, and safety goggles from over 850 laboratories and breaks down the material to be repurposed as plastic pellets. To ensure nitrile strength and quality, the program only includes materials from Kimberly Clark. The recycling center is partnered with a non-profit company that employs disadvantaged workers in West Virginia.[5] Shipping costs for returning materials are the only fees for participating in the recycling program. Boxes for collection and shipment are supplied in two sizes to be used by a building or a singular laboratory. A waste metrics diversion tool, Wasted, is used to collect and distribute information to participating laboratories. At least one laboratory participating in the RightCycle program autoclaves materials determined to be hazardous waste and ships the resulting material. The company is happy to give sample gloves to laboratories interested in the program.[5]

Beyond Benign

A meeting was organized between the team members of the Green Labs project, the Chemistry Department faculty, and Dr. Natalie O'Neil. One of the main points of discussion was the Green Chemistry Commitment offered by Beyond Benign. The goal of the commitment is to have a department or school commit to expanding green chemistry in a higher education setting. The program provides a network for communication and involvement, educational resources, support with grant funding, career opportunity connections for graduate students, and measurable progress for increasing research sustainability.[32] There is interest in members of the Chemistry Department in the Green Chemistry Commitment, however, there needs to be a consensus-based agreement to sign the commitment. This will require additional organization and communication with other members of the department.[32] Beyond Benign expressed an interest in coming to campus to speak with additional faculty and students. This was discussed with the Chemistry Department and will be planned as one of their graduate-level seminars in Fall 2023.[32]

Grenova

Grenova currently offers TipNovus and TipNovusMini pipette cleaning machines. The machinery washes the disposable plastic consumables for continued use. Currently, there are only options for pipette tips but there is soon to be another device for microplates. The pipette tip device can be programmed for up to six individual settings, to correspond with a manufacturer's brand and size. An engineer from the company helps install the machine, hook up water and compressed gas sources, and presets the programs based on laboratory feedback. The machinery keeps track of the number of wash cycles completed and returns the information to Grenova to create an annual carbon-saving metric. This data is then supplied to the laboratories.[7]

The National Institute of Health and Center for Disease Control has validated the cleaning standards of the machine and determined the tips are as sterile as the first use with a new pipette tip.[6, 42] Laboratories have reported back to Grenova that their validation testing has shown increased precision with using the TipNovus because any residue from the manufacturing process can impair the new tips' precision. This has decreased the number of testing cycles in laboratories with better validation. Grenova advertises the pipette tip washing cycle can be used between ten and fifteen times without any compromise of the tips. Laboratories reporting back to Grenova have reused tips over two hundred times without any change in the tip quality.[7]

There is the extra option of using the TipLumis machine with a TipNovus. The TipLumis is a controlled storage cabinet for pipette tips to ensure sterility. The machinery can only be used with non-filtered pipette tips. There are racks to hold the pipette tips in the wash cycle that can be adjusted or customized to fit the pipette tip size. The washer can only work for one pipette tip size at a time due to the water flow specifications and customization. The wash cycle completes five different cleaning mechanisms on the pipette tips including physical and chemical removal techniques. A single wash cycle takes approximately ten minutes. The TipNovus can wash six racks of pipette tips each cycle compared to two racks for the TipNovusMini.[7]

The functionality and procedure of using the TipNovus and TipLumis were explained to three laboratory researchers in a meeting to provide clarification and answer questions. The machine would

need to be directly connected to a water line or use a 20 L Carboy. Typically compressed inert air or nitrogen is used to dry the pipette tips but the compressed gas could be another such as methanol or ethanol. The liquid waste is collected in a Carboy and can be disposed of in a normal drain safely. The wash cycle uses a stabilizing buffer and reports back to the company have shown a high enough dilution of chemicals for the liquid waste to be considered safe.[7]

After research was conducted on pipette waste and the average amount spent on the material on the campus, a cost-benefit analysis was conducted to see if purchasing or leasing a machine was feasible and the best option for implementation.

Procurement Audit:

Scientific laboratories on campus make purchases using either State funds or the SUNY Research Foundation funds. Most campus laboratories purchases are through the Research Foundation. The state-funded work is primarily for new researchers to the institution. The laboratories participating in the Green Labs Pilot program procure lab supplies and equipment through the Research Foundation. Data for fiscal year 2022 was shared with the project teams and a procurement audit was conducted on SUNY Research Foundation invoices reported to the Office of the Vice President for Research. PI names were changed in this document using a numerical system to protect privacy.

Throughout this research project, many references were made to the high-use, high-waste items being an ideal starting point for adapting laboratories to more sustainable methods. During the procurement audit, pipette tips and gloves were identified as the most appropriate items for this specific research. These materials are used in nearly every laboratory but are considered unimportant enough to be thrown out after use.[34] They represent the change individual laboratories can make in their behavior to adapt and improve sustainability. Community leadership can be accomplished if laboratories take it upon themselves to change their own behavior and actively work to increase sustainability in their labs.

Data for the audit was shared by the Office of the Vice President for Research at the University of Albany. Data was prepared in line-item invoices with details including Prime Funding Organization,

Sponsor, Award Name, Award Organization, PI (Principal Investigator), Vendor Name, Expenditure Type, Invoice Description, Expenditure Item Date, and Supplier Invoice Amount. Most invoices were from the years 2021 and 2022. There were sixteen invoices included in the data for 2020.

The spreadsheet was organized and sorted using multiple techniques. The first technique was looking at the highest-cost purchases. The second technique was to find items of high frequency or quantity purchased in a laboratory or between multiple labs. The third sorting technique was a biased search for pipette tips and gloves as they have been noted as areas of interest due to their high quantity of waste and usage.

First sorting method: Highest Cost Items

The first sorting method used the advanced sort feature and was organized by Price, Invoice Description, and Vendor Name. The first 100 items were thoroughly examined to look in depth. This accounted for $939,392.67 of RF purchases, 42.2% of the RF purchases by price. The highest purchase cost was $59,768.20 for a chromatography system and the 100th item was $3,033.60 for sequencing reagent kits. Items were identified when they were ordered by multiple laboratories and additional research was conducted to determine the type of item, the similarity between available equipment, and the justification for the item. Numbers and numbers stored by text were always sorted separately.

It is important to note the first item when sorted by price was $6,125,000.00. The item was refunded by $6,123,500.00 reflecting the actual item cost of $1,250. This refunded item is excluded from further discussion during this sorting method because it does not fall within the defined cost bracket, above $3,033.60. A second note regarding the data is that the sequencing reagent kits were also an item of high frequency purchasing by multiple laboratories.[38]

Second sorting method: PI and Vendor Repetitive Purchases

The second sorting method combined looking at both PI and Vendor data to identify when items were purchased frequently, either by the same laboratory or by separate laboratories. This was to look at repetitive purchases for cost-saving options and identify the highest-used vendors.

The second sorting method to identify repetitive purchases combined two advanced sort searches. The first advanced sort was organized by: PI Name, Vendor, Expenditure Type, and Invoice Description. The second advanced sort was organized by: Vendor, Expenditure Type, Invoice Description, and Supplier Invoice Amount. Items were noted as a frequent purchase when ordered three or more times by a laboratory in a year.

Pipette Tips:

Pipette tips were identified in the data by filtering the invoice descriptions for items containing the word "pipet" or "tip". The use of the spelling 'pipet' instead of 'pipette' allowed for both options to be included to correspond with vendor labeling. Exclusions were made for purchases solely including batteries for pipet machines and other non-pipet tip items which were filtered (e.g., "multiple" when searching for "tip"). This sorting included both disposable and non-disposable pipette options because they were unable to be separated from available data. All identified invoices were moved to a new spreadsheet for further filtering and organization.

Gloves:

Identification of disposable glove purchases was made by searching the invoices for the following terms: "gloves", "nitrile", "glv", "latex", "nylon", "neoprene", "polyester", and "HPPE". Terms were decided on based on previous work with the available data and available material types offered by common manufacturers. Identified purchases were isolated onto a new spreadsheet for organization and comparison. Items recognized as different items were removed, such as acetonitrile and latex bulbs.

Results

The majority of results came from meetings and interviews with different department members and industry representatives or from the Research Foundation audit. There are a variety of vendors and other universities already implementing sustainability in scientific laboratories and new technology is continually developing. The University at Albany has begun to make strides to be more sustainable and can follow the successful examples of other universities to further improvements. There are a handful of key players helping the university make progress, but it is not a campus wide effort. More prioritization and leadership support are needed to make this project effective and align with the university's sustainability goals.

Green Labs Checklist:

One of the materials created in this project is an updated version of the Green Labs Certification Checklist spreadsheet. This can be daunting when first examined so to aid in response rate and participation, the checklist was broken down into more manageable sections and additional resources we added.

The clings and green chemistry poster were hung in common areas of the Life Sciences building, in two PI laboratories, and distributed to the Life Sciences building manager. Fume hood clings were added to nearly all hoods in the building. Green chemistry posters were displayed on bulletin boards throughout the LSRB and ETEC buildings.

Campus specific metrics for energy usage were analyzed. An estimate of cost savings between $780,000 and $1.3 million yearly was generated based on results at other universities. This metric would involve spending money to create more energy efficiency in laboratories and does not include current projects that are underway, such as changing lighting to LED. The estimate does not include models for instituting these building changes campus wide and could be undervaluing the savings.

University Meetings:

Three PIs and the building manager of the Life Science Research Building responded with continued interest. The pilot project officially began in February 2022. Subsequent informational meetings were scheduled with additional PIs and laboratory managers both in-person and virtual. Meetings rarely had full attendance by participating laboratory management due to conflicting scheduling with lab work, teaching, and other responsibilities. The number of interested PIs fluctuated throughout the program, with two core researchers participating throughout this timeline.

There are a wide variety of colleges offering sustainability-minded courses, totaling 22 different departments between them. 59 courses across 26 colleges were identified, but it is not an exhaustive list. Many of the courses were from science-based departments, as expected, but a number were cross-disciplinary and show a high potential of involving sustainable courses in any degree program. Specific departments that were surprisingly included are Emergency Services/ Fire Administration, Mathematics, Psychology, Paralegal/ Law, and Fashion Merchandising. Some of the courses require prerequisites that are not listed on the assembled list.[33]

Industry Meetings:

My Green Lab

My Green Lab continues to be a wealth of information and resources for the university. The meetings held with Cristalle Ruiz were extremely informative and tailored to university applications.[37] Having a network with other universities and pursuing MGL certification would be highly recommended down the line. The initial focus and introduction of this research project is better suited for use with a small number of campus laboratories and the MGL certification can be used campus wide.

When the 2023 Freezer Challenge is complete in July, the data connected to the University at Albany will be analyzed.[24] Until July, the program will continue to be announced and participation highly encouraged. There is a discussion for an additional, campus-specific, incentive to be added for laboratories that participate. Ideas generated have included a participation certification by a high-ranking

campus official and a larger prize for the laboratory that shows the most improvement during the challenge.

Three members of the programming team for this pilot registered for the Accredited Professional training program. The available modules were completed. One intern completed the Ambassador certification.[23]

The first annual My Green Lab Sustainability Summit was held on May 26, 2022. This was attended by the primary researcher for this project and the recorded sessions were posted on June 9th. Previous researchers who succeeded in starting a sustainability certification on their campus using My Green Lab provided several suggestions for successful implementation, which are listed below.[22]

1. Incentives offered to laboratories or members would increase participation: examples given were recognition from the university, grant funding, and supplies.
2. Connecting the project to the highest levels of academic support showed an increase in participation.
3. A steering committee would allow for continuous feedback and improvement of the project.
4. Conducting topic-specific training sessions with researchers increases awareness and education (e.g., having a tour of the local recycling plant).
5. Increasing student education, not just with student researchers, involves the entire campus and can increase participation.
6. Multiple universities offer supply exchanges for laboratory supplies to reduce waste and excess purchasing. Creating and maintaining an inventory of supplies and chemicals also helps reduce waste.
7. Updating fume hood sashes with auto sensors and setting them to close at night or during the weekends can reduce energy usage.
8. Providing specific feedback about waste and savings instead of using scientific terminology for more inclusion and understanding. (e.g., Recycling X saves 10 trees.)

9. Switching labs to recyclable or biodegradable glove options.
10. Switching machinery off when not in use, creating a system to know who is using instrumentation at any time.

The most recent My Green Lab Europe Summit was scheduled for March 9th, 2023. Registration for the global event in 2022 was $25 but this summit was free. Members of the research team have been informed of this date and an announcement was sent to the campus community. The primary researcher attended the European Summit, and the recorded panels are available for viewing online. The next global summit will be held June 8th, 2023.[22]

Kimberly Clark

After meeting with a representative from Kimberly Clark, a discussion was held to see if the program would be a good addition to the campus Green Labs project. The initial cost for joining the program is free, with the university covering the cost of shipping the materials back to the recycling plant. The main point of concern is how viable this program would be for individual labs.[5] It is unknown how many laboratories currently use Kimberly Clark gloves that would be accepted in the program. Kimberly Clark gloves are sold by multiple vendors, including Fisher Scientific and Krackeler Scientific, which are the top two vendors ordered from laboratories.[18,41] The invoices from the vendors specify if gloves were purchased but not what brand. This is an area for continued investigation, either by communicating with laboratories or speaking with the vendors directly to see what brands are purchased.

Beyond Benign

The Chemistry Department has expressed interest in the Green Chemistry Commitment organized by Beyond Benign. The department will need to agree to participate in the commitment for it to be finalized. This will require additional staff and faculty involvement and interest.

The department has also agreed to have one of the co-founders of the organization speak to graduate students during one of the seminar presentations in the Fall of 2023. This date will be finalized

later in the Spring semester when the dates are made available. In the meantime, Beyond Benign is working with some of the Chemistry faculty to provide educational materials and support.[32]

Grenova

There are multiple options if a Grenova machine is purchased and used by the university. A TipNovusMini would be ideal for a singular lab with a high pipette tip usage rate. To involve more participants and generate more interest in the product, the larger size of TipNovus would be placed in a common area of one of the facilities. An organizational system for washing the pipette tips and scheduling could be accomplished using the same system currently used for other scientific instruments on campus. If the TipNovus is placed in a common area between laboratories, a discussion can be made to determine the top six pipette types and sizes used between interested parties. Each laboratory would have its own set of pipette tip racks to aid in transporting the pipette tips and distinguishing between clean and dirty tips.[7]

It is recommended a building or department test a pipette cleaning machine to reduce waste and save costs. The cost savings for a laboratory would increase over time with additional cycles of the pipette tips being used. For sterile pipet needs, the tips either need to be used directly after the wash and dry cycle has ended or in combination with the TipLumis storage cabinet.

5% of the items ordered by pipet invoices were for filtered pipette tips. This shows the high usage of unfiltered pipette tips by comparison, allowing washable pipette tip options to be investigated. After meeting with Grenova multiple times, a proposal for leasing a machine was offered. The total cost for the TipNovusMini system was $54,000 to be paid over 36 or 60 months. There was no shorter lease option than three years and this was decided to be too costly. The cost-benefit analysis is shown in Table 1.

Table 1: Cost-Benefit Analysis of purchasing Grenova TipNovus Mini

PI #	invoice total over 2 years (sum of	estimated yearly cost ($)	lab savings over 36 months	total savings over 36	price for TipNovus mini ($)	36 month lease ($ per month)	lease cost ($) over 36 months

	non-filter tip orders) ($)			months ($)			
13	1776.57	888.285	2664.855	5451.855	41480	1439	51804
24	1858	929	2787				

Procurement Audit:

It is important to note that laboratories are not required to purchase items noted as environmentally friendly or preference those over other options. There were multiple items noted for further discussion on whether they could be purchased in bulk quantities and distributed to the labs by a department or similar organizational method. It would be prudent to discuss with vendors if there can be an option for our laboratories to automatically be switched to ordering environmentally friendly alternatives when they are available.

There are a total of 4783 individual invoice line items, including duplicates, refunds, and invoice descriptions which include multiple purchases. There were 114 vendors between orders. 60 PIs between 16 Award Organizations were included in the data, most of the award organizations being academic departments. Expenditure types were noted as equipment or supplies, with a summary of the total cost spent for each expenditure type noted by vendors. The total amount spent on equipment was $485,391.01 and supplies were $1,743,018.68. The total included in the spreadsheet came to $2,228,409.69. When totaling costs through this audit, refunds were negated from the total price.

Pipette tips and disposable gloves were searched for separately, knowing they are items of high plastic waste with substantial research in alternatives and recycling. Searching for alternatives for these items aligns with creating a Culture of Sustainability and Impactful Research on campus.

Biodegradable and recyclable options were researched, such as the Kimberly Clark RightCycle program. The initial purchasing cost for these are frequently higher than their single use counterparts. Some of the biodegradable gloves need to be disposed of separately from other waste to control methane. Autoclaves have been used as a non-burn technique for plastic products before traditional recycling,

including gloves. It was noted in a report that chemically treated waste has the potential to off gas harmful fumes. Care should be taken to research specific laboratory solvents used to autoclave safely.[45]

Gloves are considered personal protection equipment (PPE) that are frequently overused and misused. The World Health Organization finds gloves are frequently used in situations that are unnecessary, such as while providing vaccinations. Improper use of gloves involves unnecessary spending and environmental degradation. Multiple steps are suggested to decrease glove usage and waste: providing access for proper hand washing, increasing training and education on glove usage, and providing reminders.[45]

First sorting method: Highest Cost Items

Out of the 99 highest invoice amounts, 61 of them were noted with concerns for further investigation. These items were a total of $688,856.11 (30.91%) of all purchases. The specific reasons for identification are included in Appendix 7. The most repetitive reasons were similarity to other items being purchased, similarity to items already in use by other laboratories, or lack of item description. Many items are purchased with unexplained item descriptions or ambiguous funding sources. In multiple cases, items were purchased from vendors where a similar purchase was made by a separate laboratory within the same month. This can be exemplified by both reagent kits and a chromatography device.[21] In other cases, the same item was purchased by the same lab, or an additional size was purchased in a new invoice. This is apparent when the same lab purchases the same item, in different quantities every other month.

There were several vehicle purchases made by PI 49, some of these purchases were higher than the researched item cost from the vendor. There are 6 additional purchases made by the same PI noted as "CAM Truck Follow Up" to a separate, Canadian truck body manufacturer. When researching the company and invoice description it appears to be a transferable service body to attach to the bed of a pick-up truck. The cost of one of these invoices is roughly the largest of the 6 purchases.[13]

Gas products are noted throughout all sorting methods, and account for a large percentage of both invoices and finances. Nearly all gas products are from Airgas USA, except for the two largest gas purchases. These were made by a single laboratory to Noble Gas Solutions Incorporated.

A freezer was purchased from VWR by a PI, and a second order was created for an identical model six weeks later. Not all electric machinery for laboratories has an Energy Star-rated or more efficient model. In another case, an aerosol sampler was purchased, and an identical invoice was made for another model one year later. The shipping and handling fees were charged a second time, implying a second machine was purchased.

7 out of the 61 invoices noted listed the invoice number instead of the invoice description in that line. These account for $86,051 (3.9%) of purchases, with no item descriptions or explanations given, between 5 laboratories. This does not include invoices with minimal, vague details.

Second sorting method: PI and Vendor Repetitive Purchases

1622 invoices were separated from the original 4783 invoices. This equated to 33.9% of all purchases by the number of purchases. The total for separated items was $1,006,035.47: 45.1% by cost. 51 of the PIs were included in these invoices.

This sorting method underestimated the number of items. The bias was skewed due to inconsistent labeling and invoice descriptions. The items noted were ones using the same invoice descriptions, purchased a minimum of three times. This excluded items which were noted in other invoices but not the first item listed and invoices without descriptions. For many purchases, there were additional invoices noted which were negligible in charges and the primary charge was the line item noted for future insight. For example, many companies charge ice fees to ship cold storage items. These additional charges were excluded from the organization. Specific care was taken to recognize when purchases were duplicated and refunded, causing them to be listed as three separate line items with the same date. These purchases were not included unless the item was consistently purchased on multiple dates.

Sorting by PI count (shown in Appendix 8) it is shown that two PIs each have over 100 invoices in this sorting method. PI 34 with 425, PI 4 with 160, and then the next highest count is PI 42 with 95 invoices. (Shown in Appendix 8).

PI 34's account can be attributed to the association with CAS (College of Arts and Sciences) Technical Services. This includes CAS Scientific Store, CAS Purchasing Department, CAS Machine Shop, CAS Electronic Shop, and Life Sciences Research facilities. All purchases made by PI 34 in this sorting method were to Airgas USA LLC.

PI 42's purchases were different than many of the other invoices because a large percentage of invoice descriptions were in the format "SL-####". It is unclear what was being purchased from the supplier, Integrated DNA Technologies Incorporated. On average, three separate purchases were made to the company per month.

Looking at Appendix 9, multiple vendors can be contacted to discuss increasing sustainable purchasing. The top ten vendors using sorting method 2 and from overall invoices were included in Appendix 9. These vendors include Fisher Scientific Company LLC, VWR International LLC, Krackeler Scientific Incorporated, Airgas USA LLC, and Integrated DNA Technologies Incorporated. They are the five top vendors ordered from based on the number of invoices. Fisher Scientific is ordered most frequently by PIs with 1,659 total invoices in the two years.

Some of the major vendors were researched to see if sustainability and visibility are part of their supply chain and ordering system. Fisher Scientific Company partners with My Green Lab to identify greener product choices, noting in the purchasing system using a leaf icon for consumers.[41] VWR has a search option for 'environmentally preferable' and notes items with a green leaf.[44]

Pipette Tips:

In the two years of data provided, 299 orders were made regarding pipets. This included a total of 34 PIs, 6 vendors, and a combined sum of $98,329.40 (4.4% of purchases by cost). 7 invoices were specifically noted as being refill tips, to be used in the original boxes from a previous purchase. 16 of the

invoices were for filtered pipette tips. Most of the invoices listed the size of the pipet tip ordered but did not include the manufacturer's name. (Shown in Appendix 10).

Gloves:

37 PIs out of 60 total are listed ordering gloves using this method. The total for these invoices was $37,889.72 (1.7% of purchases by cost). For each vendor gloves were purchased from, the Biology Department had the highest quantity of orders followed by Chemistry. The only exception were three orders made to Laboratory Products Sales Incorporated, which were ordered by PI 57. (Shown in Appendix 11).

These invoices were not exclusively gloves because many of the purchases are a combination of items. It is not possible to separate the cost for solely glove purchases with available invoices. The manufacturer of the purchased gloves is also not available, more data would need to be collected from individual laboratories for further decision-making.

Discussion

The focus of this research has been to identify sustainable scientific laboratory techniques, provide recommendations to update existing laboratories, and implement a campus specific laboratory program. Expanding the Green Labs Checklist to the laboratories on campus will decrease resource consumption, financial costs, and increase campus resiliency. Suggestions have been made based on this research to better align the university with its' *Climate Action and Sustainability Plan* and the UN's Sustainable Development Goals.

Green Labs Checklist:

Our pilot project operated on a small scale as a steering committee with two primary laboratories. The lab managers had direct input and participation in the planning process. The sections of the certification checklist can be used to make video walkthroughs to answer common questions. Another option is to create an online fillable questionnaire that can be completed by laboratories. This second option is similar to the questionnaire offered by My Green Lab. There is an intention to continue identifying laboratories where clings and posters can be placed. Additionally, past placement of materials should be reviewed to redistribute where needed. This will be more easily accomplished when laboratories join the green labs project on campus and are open to the suggestion.

Specific areas for continued attention are the monitoring and evaluation metrics for the individual laboratories. Evaluations are noted to be conducted at the beginning of a laboratory working with the spreadsheet and if anything changes in the laboratory. There is a lack of clear accountability for many of the items and the laboratories individually would decide who is responsible for the positions. This includes turning off equipment at night or on weekends, setting up computers or printers, sharing assets, cleaning freezers, maintaining a chemical inventory, and utilizing vendor take-back programs.

To expand the pilot project further, commitments with building managers or department chairs should be obtained to increase laboratory participation on a reasonable scale. The building manager for

the LSRB would be a good person to reach out to for this intent. They have already been involved in the pilot project and could provide insight on how to prioritize this for the researchers in LSRB.

The project could also be spread amongst multiple departments, including the Office of Energy Management, Office of Sustainability, EHS, the Office of the Vice President, building managers, and academic departments. The best results will be found when the offices work together. The point of contact can remain with the Office of Energy Management or the Office of Sustainability. Efforts should be made to include student researchers in the project, such as graduate students or upper-class students.

On a longer timescale, the pilot project can be expanded campus wide. This could begin by including all laboratories in certain buildings or departments, eventually including all laboratories at the university. With the expansion, there can be an incentive to continue participation and foster competition between laboratories. To generate prestige, university leaders and decision-makers can collaborate for certifications, recognition, and support. By providing financial incentives for participation, support should be more easily generated.

Approximately one million dollars a year would be saved by the primary laboratory buildings using energy saving protocols. There is also the potential for large water savings through innovative techniques. It is suggested the laboratories continue to take steps for water saving, both for sustainability and financial reasons. Additional campus metrics of aspirators, aerators, freezers, and other water intensive machinery in use should be itemized and researched for additional areas of water reduction.

There will be upfront costs including purchasing new, energy-saving equipment and hiring staff. When current machinery (i.e.. autoclaves, freezers, centrifuges, incubators, etc.) reaches the end of its life more energy efficient models should be purchased. Hiring new staff to implement recommendations and oversee purchases would still result in net positive cost savings.

If there was a centralized office ordering in larger quantities, such as the CAS store or one of the science departments, there would be a smaller quantity of purchases made. This would reduce shipping costs paid by the Research Foundation and would lower the carbon emissions of receiving the product. Items of interest for this method include gloves, notebooks, lab coats, aluminum foil, plastic bags, pens,

permanent markers, pipet tips, glass vials, and centrifuge tubes. These items were chosen from repetitive purchases in the financial audit and knowledge of use in many labs. Creating a policy to require checking the Available Surplus before purchasing a new item would save the university time and money.[26]

A waste audit would be beneficial for gathering baseline metrics about types of physical waste and quantities. Similar audits have been conducted by other universities and can provide structure for a campus audit. This would be a beneficial way to directly involve interns from an office or student researchers.[30] A survey of laboratories in LSRB is scheduled to inventory the brands of gloves used for further decision making. A glove recycling program or biodegradable option should be chosen and used across campus labs.

Further involvement of student-led groups on campus would allow for increased participation by both students and the laboratories they work in. There is also the potential of a student becoming interested in taking on this project full time. The first groups to reach out to are the graduate level organizations such as Atomic Danes.

University Meetings:

To increase student participation and awareness of green chemistry, further work should be accomplished to promote education and application. This includes distributing readily available materials such as stickers and posters already created on campus. Working with established non-profits such as Beyond Benign will be beneficial for increasing sustainability in courses. Additional resources and training could be used by student researchers to increase their understanding of the project and the importance of it. Beyond Benign has agreed to present on campus at a chemistry graduate seminar in Fall of 2023. This would be an ideal time to introduce the Green Labs project and spread awareness to students.

To increase education, core science courses and laboratories will need to begin to include green chemistry discussions and examples in their coursework and lectures. Additionally, student researchers on campus could participate in training offered by non-profits or governmental agencies. The EHS could be

used to offer additional resources and training for incoming science students, and student researchers, or as an annual refresher.

On a long-term scale, the University at Albany needs to include sustainability and green chemistry in the College of Arts and Sciences on a broader, deeper scale. Proposed suggestions for accomplishing this include hiring additional faculty with research focused on using green chemistry or environmental science, adding additional courses focusing on sustainability, adapting current coursework to reflect sustainable techniques, or allowing science credits to be transferred from other SUNY schools in environmental courses to promote these goals. If a student reaches out to their department asking for an environmental or sustainability course to be included in their course of study, it is highly recommended that the request is considered and approved. Suggested courses from other SUNY schools is listed in Appendixes 4 and 5.[33]

A centralized manager position should be created for leading a campus chemical inventory. This would require hiring someone under one of the science departments, an office overseeing research, or facilities. The position could also help laboratories to work with EHS to clean out old projects that no longer need to be held on to for grant purposes.

After reviewing the Winter 2021/2022 Chemical Hygiene Plan, these are the remaining questions to be reviewed with office staff for guidance:

- Are there any EHS concerns with turning off equipment or laboratory lighting at night and on the weekends?
- Is there interest in helping maintain an inventory of excess chemicals in laboratories that could be shared between labs?
- Are there protocols or requirements for cleaning out freezers of old student experiments?
- Is there a required training procedure for new researchers, staff, and students? Could sustainable practices be included as a virtual training course on their website if designed?

Industry Meetings:

The My Green Lab Certification program continues to be important for labs across the world. In the future, paying to participate in the program would be useful because they have a large network of information and intricate feedback systems. Before this can be accomplished on campus there needs to be more awareness and involvement in campus laboratories.

If there is interest in the RightCycle Program moving forward, an option is for the university to supply gloves to the participating laboratories. Requirements to receive free gloves would entail participating in the Green Labs program on campus and returning the recyclable material to a central location. An office could oversee shipping the materials back to Kimberly Clark and purchasing/ distributing gloves to laboratories. This would save laboratories money by removing the cost for one of their essential supplies. The cost for the gloves would need to be spent using state accounts.

Multiple other universities offer courses in green chemistry or environmental chemistry components. Sustainability and environmental impacts should be included in coursework when feasible. In Fall 2023 Beyond Benign is scheduled to present to the chemistry graduate students.

Short term, the departments can approve validated courses from other universities to help their students have a more diverse and robust education.[40, 46] This could be included in degree requirements or used as elective credits. Selected courses from other universities is included in Appendixes 4 and 5. It will set graduates up better for career positions to be skilled and knowledgeable in this arena.[33]

The companies chosen were helpful in getting a range of possible sustainable options for our campus laboratories. With limited time available for this project the companies we worked with were chosen from research of other university programs.

Procurement Audit:

Completing a procurement audit from the Research Foundation was useful for determining high frequency items and vendors. It is recommended to complete an additional audit on the State funded purchases.

Creating institutional controls around ordering energy efficient equipment and environmentally friendly products should be accomplished. This could be done either by policy changes for researchers to follow or working directly with the vendors to ensure environmentally friendly products are chosen whenever possible.

Education about purchasing could be addressed on a college-wide level with informational sessions virtually, in person, and displayed in common areas. For individual support, the items of the highest priority and usage would be best addressed through conversations with researchers and PIs. Laboratories could choose specific days of the month or week to place orders, create a shared file to note items to be purchased, create a list of priority items to be checked before each purchase is made to a vendor, and create a single point of accountability for vendor purchases. It would fall on the senior researchers and PIs to ensure research materials are itemized before beginning a project.

There are many items purchased regularly by PIs that could be purchased more effectively to reduce the number of shipments, reduce shipping and handling charges, and save time for researchers. Ordering items in bulk and creating a centralized pick-up location would help decrease costs and waste. A central office could order gloves, pipette tips, vials, weigh boats, and other common laboratory purchases. A possible department to manage these items is CAS, as they already use this method with gas shipments and distribution.

Purchasing in larger quantities may cause problems with a greater volume of items to store but could be addressed if multiple improvements were made tangentially, including cleaning out old materials from freezers or refrigerators, and combining shipments with other laboratories. In the case of combining shipments, the departments should investigate cost savings and space availability to order the highest quantity purchases in bulk and supply to the individual laboratories.

The vendors interacted with and purchased from most frequently should be worked with to provide institutional controls on laboratory purchases. The university can work with the vendors to ensure purchasing is most efficient, both for cost savings and shipping. Suggestions for contacting vendors is to ask for university orders to be condensed into a smaller number of deliveries, such as once or twice a

week. Researching should be done to see if shipping materials, such as ice packs, can be returned to vendors. For the PIs, the number of reduced delivery days can aid in organization, they can plan for certain days of the week to be for inventorying and putting away deliveries. If items have suitable environmentally friendly substitutes, the order change should be required.

Larger orders could be placed for items of high purchase, identified in the Procurement Audit (Sorting Method 2). A central location for storing the material would be ideal, with researchers able to request available items to pick up and make suggestions. This would save the university both time and money and would save the researchers' grant money to be used for more specific purchasing rather than mundane items required for laboratory functionality. A system could be fashioned where the university supplies basic laboratory items such as gloves or lab coats for consistency and to allow for more recycling opportunities.

Single use plastic are high waste items for laboratories to pay attention to. Recyclable, biodegradable, and washable materials are continuing to be researched. In addition to alternative disposal options there is the case for less usage to begin with. The safest and easiest way to reduce waste is to prevent initial usage. Laboratories should access where they are using disposable materials and decide if it is truly necessary or out of habit. Education is a key part of the change needed, training or informational handouts should be used to connect with all research laboratories. Creating an informational poster would be a good project for a student intern.

In the university setting, the WHO steps to reduce glove usage and waste should be investigated and applied to see when glove usage is required for projects. There is an assumed perspective by laboratories that using gloves 'can't hurt' but this is untrue. The environmental cost for products is not factored into the decision. Multiple use PPE could be considered to reduce waste but is more expensive initially in most cases.

It is an acknowledged fact that gloves are not a large product by cost for the laboratories but are high in waste. It would be reasonable to suggest a central office orders gloves in bulk at a lower cost and distributes them to laboratories. This would be tied to a recycling program where the laboratories which

have gloves given to them at no cost would be required to properly separate and return them for recycling. It is also suggested to complete an additional inventory of glove purchasing and manufacturer preferences by the laboratories to have more specific campus metrics for decision making.

Conclusion

Individual laboratories need to stop operating with minimal regard to the environmental costs of their decisions. The results of these sustainable changes are already accepted by the scientific community and are being utilized by other companies and universities. As scientists, we have the responsibility to learn and use all available data. Raising awareness and participation in the University at Albany's Green Labs certification is the basis for expanding campus wide lab sustainability. While increasing participation, tactics can be used to streamline the process and make it easier for researchers to analyze their labs. Agreements with campus leaders to provide incentives would help increase participation, such as having a campus competition, certificates given by leadership, offering supplies, or other forms of recognition.

Additional personnel should be hired to continue this project and provide a single point of accountability for different departments to connect with. The cost of an additional salary is minimal when compared to potential savings. The positions would oversee the individual laboratories and begin to introduce additional programs to raise sustainability efforts on campus: such as creating a chemical sharing program or registering with My Green Lab. It is recommended to complete an additional procurement audit on the State funded purchases of the research laboratories to compare results. A waste audit would be a beneficial, practical project to use for decision-making.

Increasing sustainability and environmental education is one of the key suggestions from this report. Multiple options have been suggested including introducing the topic in current courses, increasing research on sustainability, approving alternate courses from other SUNY institutions, and hiring additional faculties with expertise in this area. Involvement with student-led organizations on campus would help promote the project.

The primary vendors used by researchers have already been identified, and efforts should be made to create institutional controls or policy changes on purchasing and delivery. A centralized team

could be created to manage larger purchases on the research laboratories' behalf for the most frequently ordered items.

One of the most important lessons to impart on students and researchers corresponds to the 'prevention principle' of green chemistry. Waste production and financial costs can be lowered by altering the initial resource consumption. Energy savings of nearly one million dollars would be achieved by reducing energy usage in the laboratories, in addition to water and procurement savings. By increasing education, awareness, and creating additional ordering standards we can lower the overall wastefulness of our campus.

Utilizing the Green Lab Checklist and instituting the project campus wide would allow for the campus to correspond better with its *Climate Action and Sustainability and Plan* and the United Nation's SDGs. Achieving a more sustainable and resilient campus environment is beneficial to all.

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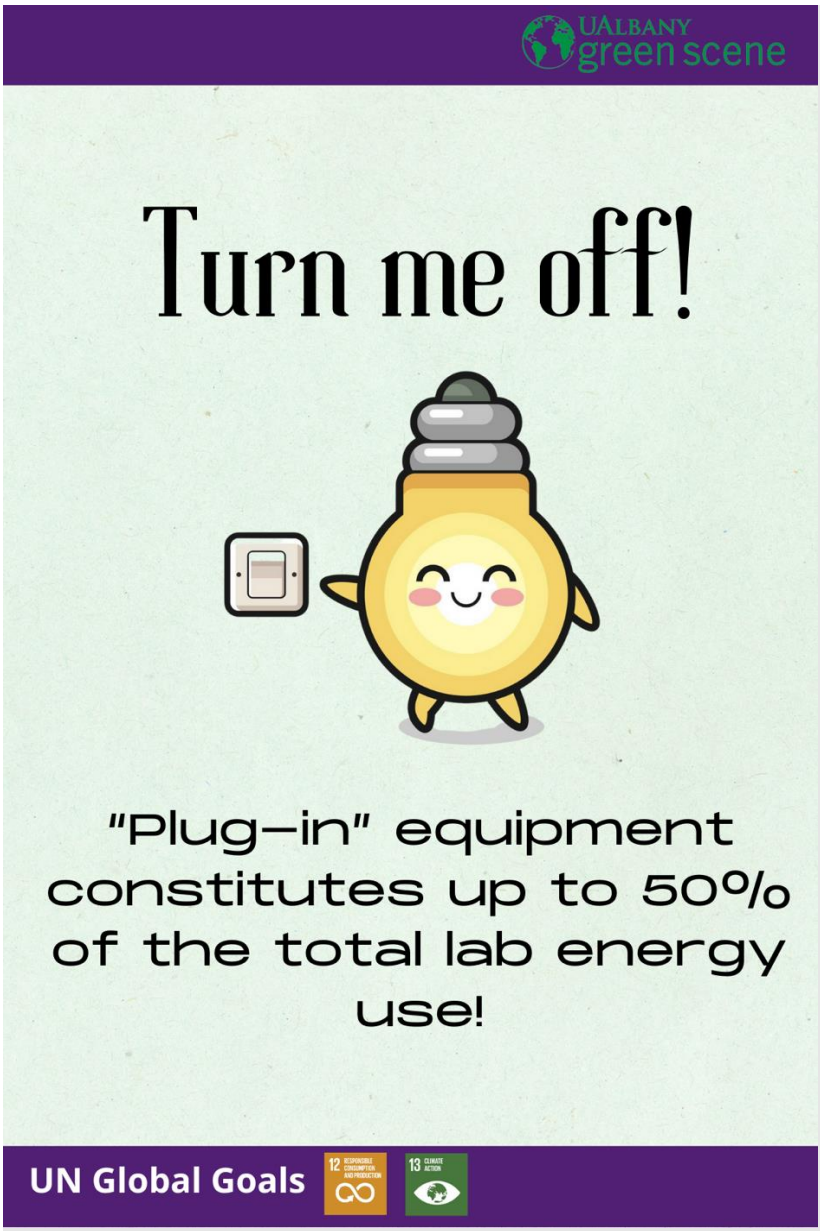
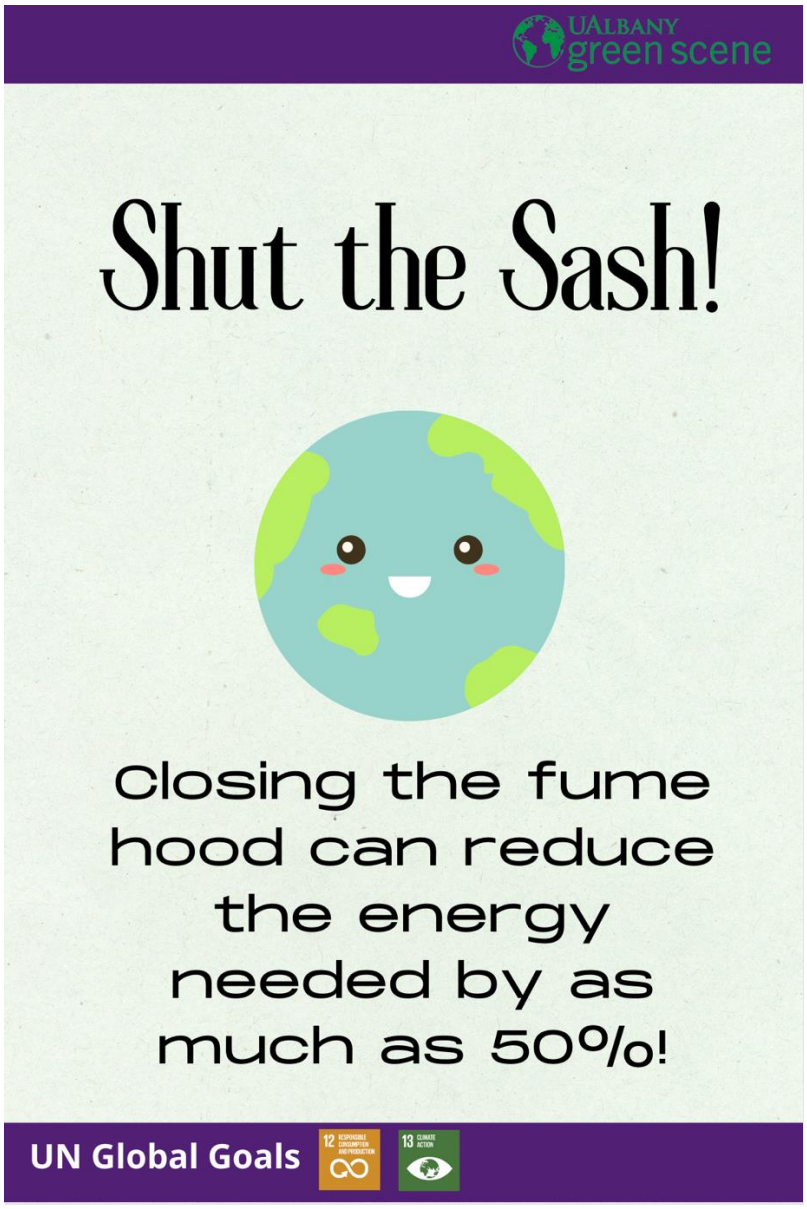
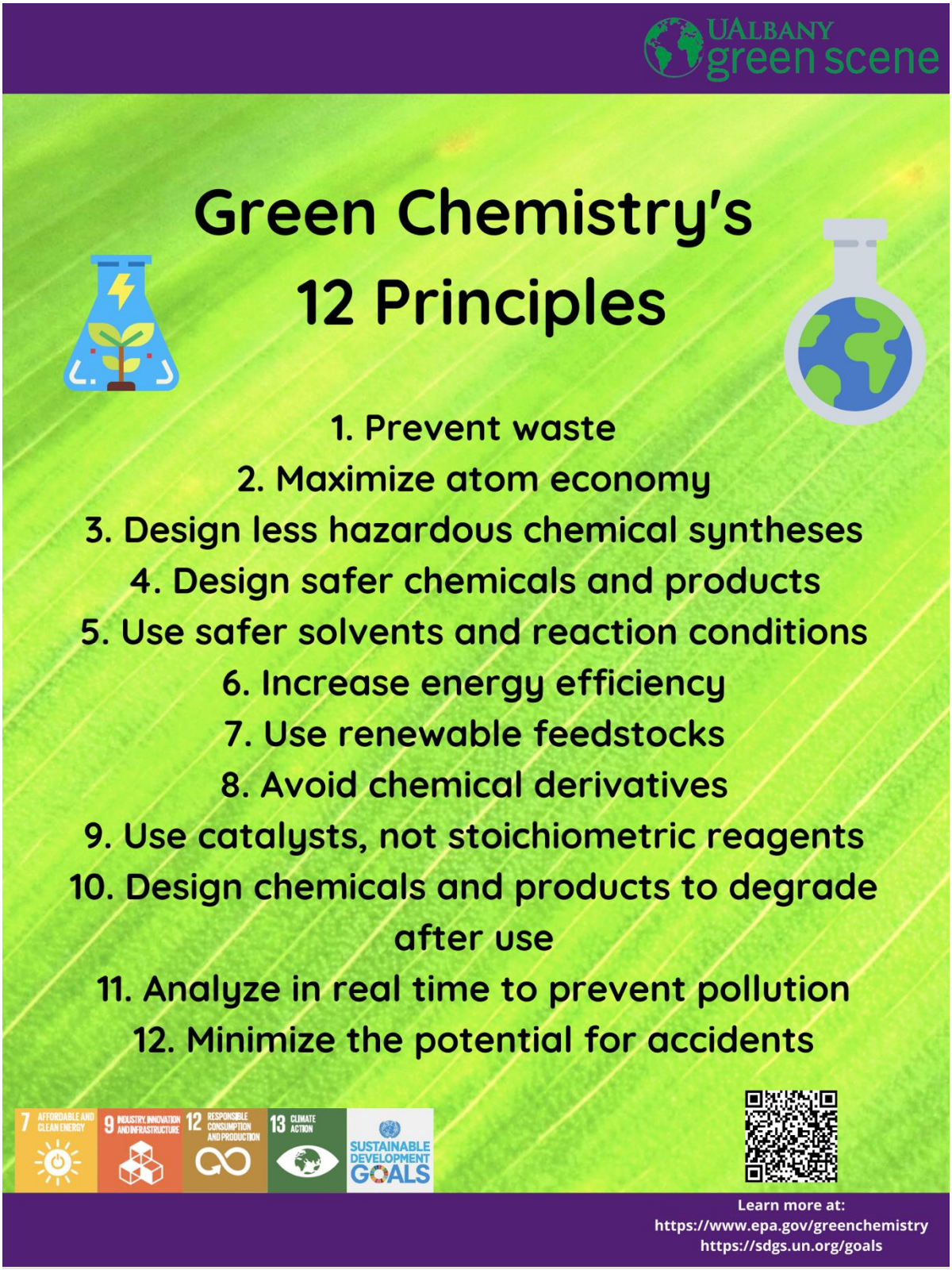
Appendix 1: Energy Saving Cling



Appendix 2: Fume Hood Closure Cling



Appendix 3: "Green Chemistry's 12 Principles" Poster



Appendix 4: Undergraduate Level Open SUNY Courses (1 of 2)

School	Course Number	Department	Credits	Course Title
Cayuga Community College	GEOL 101	Earth Science	3	Earth Science
Cayuga Community College	BIOL 208	Environmental Sciences	3	Intro to Environmental Science
Corning Community College	BIOL 1030	Biology	3	Introduction to Environmental Science and Sustainability
Empire State College	ENSC 1002	Earth Science	4	Energy: The Issues & the Science
Empire State College	ENSC 3302	Earth Science	4	Sustainable Living: Food & Energy
Empire State College	ECO 3020	Economics	4	Ecological Economics
Empire State College	ENSC 1006	Earth Science	4	Introduction to Ecology & Sustainability
Empire State College	ENSC 2000	Earth Science	4	Principles of Environmental Sustainability
Empire State College	ENSC 1000	Emergency Services/ Fi	4	Earth Science
Empire State College	ENSC 1004	Earth Science	4	Global Climate Change
Empire State College	PAFF 3003	Political Science	4	Security Implications of Global Climate Change
Empire State College	BIOL 2206	Biology	4	Winter Ecology
Erie Community College	PH 120	Physics	3	Environmental Science
Fashion Institute of Technology	FM 326	Fashion Merchandising	3	Sustainability in Fashion Merchandising
Finger Lakes Community College	BIO 119	Biology	4	Contemporary Biology II
Hudson Valley Community College	CHEM 105	Chemistry	3	Concepts in Chemistry
Mohawk Valley Community College	BI 105	Environmental Sciences	4	Environmental Science
Monroe Community College	BIO 116	Biology	3	Introduction to Environmental Science
Monroe Community College	SUS 101	Sustainability	3	Introduction to Sustainability
Nassau Community College	GSS 122	Physical Science	3	Science of Energy
Nassau Community College	GEO 101	Physical Science	3	People and Environment
North Country Community College	ENV 104 Z	Biology	3	Environ Science
North Country Community College	ENV 210 Z	Biology	3	The Environment and Society
Rockland Community College	SOC 11600	Sustainability	3	Sustainability, Society and the Environment
Stonybrook University	GEO 101	Earth Science	3	Environmental Geology
Stonybrook University	ESG 201	Engineering	3	Learning from Engineering Disaster
Stonybrook University	ATM 237	Environmental Sciences	3	World Climate and Atmosphere
Stonybrook University	PHY 237	Physics	3	World Climate and Atmosphere
Sullivan County Community College	SCI 1515	Environmental Sciences	4	Environmental Science
SUNY Brockport	PSH 405	Psychology	3	Psychology of Sustainability Issues and Practices
SUNY Brockport	REL 395	Recreation & Leisure	3	Sustainability in Recreadtion
SUNY Broome Community College	MAT 118	Mathematics	3	Mathematics of Sustainability
SUNY Broome Community College	HIS 117	History	3	World History II
SUNY Canton	ESCI 101	Biology	3	Introduction to Environmental Science
SUNY Canton	ECON 320	Economics	3	Environmental Economics
SUNY Delhi	BIOL 110	Biology	3	Environmental Issues and Sustainability

Appendix 4: Undergraduate Level Open SUNY Courses (2 of 2)

SUNY Environmental Science and Forestry	SUS 496	Sustainability	3	Introduction to Green Building
SUNY Fredonia	WRTG 374	English & Literature	3	Writing and Social Change
SUNY Geneseo	GSCI 120	Physical Science	3	Our Geological Enviromental (Lecture)
SUNY Plattsburgh	ECO 303	Economics	3	Environmental and Ecological Economics
SUNY Schenectady County Community Colleg	ENV 100	Environmental Sciences	3	Introduction to Environmental Science
SUNY Westchester Community College	PHYSC 162	Physical Science	3	Climate Change and Our Future
University at Albany	AATM 103	Environmental Sciences	3	Introduction to Climate Change
University at Buffalo	GLY 102	Earth Science	3	Climate Change
University at Buffalo	EVS 460	Sustainability	4	Leadership in Sustainability
University at Buffalo	LAW 317	Paralegal/ Law	3	The Politics of Sustainability

Appendix 5: Graduate Level Open SUNY Courses

School	Course Number	Department	Credits	Course Title
Empire State College	CAED 6040	Social Science	3	Stakeholder-Sensitive Business Models
Empire State College	MGMT 7035	Management	3	Strategic Application of Innovation & Planning
Stonybrook University	COM 605	Communication Studies	3	Environmental Communication
SUNY Environmental Science and Forestry	EST 635	Environmental Sciences	3	Public Participation and Decision Making: Theory and Application
University at Albany	HEHS 560	Environmental Sciences	3	Sustainability, Green Design and Public Health
University at Albany	HEHS 545	Environmental Sciences	3	Global Climate Change, Extreme Weather and Public Health
University at Buffalo	EVS 560	Sustainability	3	Leadership in Sustainability
University at Buffalo	LIS 581	Library Science	3	Management of Library & Information Agencies
University at Buffalo	IE 521	Engineering	3	Sustainable Manufacturing

Appendix 6: University at Albany Green Labs Checklist (1 of 9)
Adapted from existing Checklist from Office of Energy Management, University at Albany

"Green Lab Certification

Thank you for helping to make UAlbany a Greener and Safer Campus!

In April of 2020, the University adopted the "Our World, Our Future" climate action and sustainability plan. The plan identifies a diverse set of goals, including cutting campus energy use by 20% by 2023. The Green Labs Certification Program aligns with the goal to reduce energy and water consumption in University lab buildings, which account for ~20% of campus energy consumption and use three to six times more energy and water than non-lab academic buildings.

The Green Lab checklist addresses several energy and sustainability measures. Please identify the measures you would be interested in implementing in your lab. The Energy and Sustainability Offices will provide assistance with implementation of these initiatives over the Summer and Fall, and solicit your feedback to refine and finalize the checklist. Please email gogreen@albany.edu with any questions.

Your progress on each item can be tracked using the column titled "Status." Please put an "x" in the appropriate column to reflect the status of each item. The options are:

* "Y" - the action item has been completed
* "IP" - the action item is in progress
* "N" - the action item is not being pursued
* "N/A" - the action item is not applicable to your lab

The document also provides space for comments and feedback on each action item. Once you have completed the checklist, please send it to gogreen@albany.edu.

Appendix 6: University at Albany Green Labs Checklist (2 of 9)
Adapted from existing Checklist from Office of Energy Management, University at Albany

Laboratory & Contact Information	
School	
Department	
Building & Room Number	
Lab Type (select from drop down menu)	
If Other, Please Specify:	
PI/Lab Manger Name	
Number of People in the Lab	
Green Lab Lead	
Work Number	
Email Address	

Summary - Green Lab Checklist

Please use this page as a main menu to access the individual action items associated with each sub points.
The status column on this page should be filled out last, after the associated spreadsheet has been completed.

Status					
Y	IP	N	N/A		
				1. Communication, Education, & Training	
				1.1	Orientation & Training
				1.2	Reporting Maintenance Issues
				2. Energy & Water Conservation	
				2.1	Lighting
				2.2	General Appliances and Equipment
				2.3	Sustainable IT Practices
				2.4	Fume Hoods
				2.5	Freezers
				2.6	Water Conservation
				3. Chemical Use & Toxic Material Minimization	
				3.1	Compliance with EHS guidelines
				3.2	Green Chemistry Practices
				3.3	Maintain chemical inventory
				4. Waste Reduction & Diversion	
				4.1	Reycling and composting
				4.2	Reliance on Reusables
				4.3	Fieldwork
				4.4	Limit the production of waste
				5. Resource Management & Purchasing	
				5.1	Energy Efficiency
				5.2	Office supplies
				5.3	Coordination on resources

Appendix 6: University at Albany Green Labs Checklist (3 of 9)
Adapted from existing Checklist from Office of Energy Management, University at Albany

1. Communication, Education, & Training								
Status				#	Item Description	Resources	Justification	Comments
Y	IP	N	N/A	**1.1**	**Orientation and Training**			
				1.1.1	Provide orientation and continuous training opportunities to faculty/staff/students on sustainable energy efficient lab practices.			The Energy and Sustainability Offices is planning to develop a training handbook with relevant resources.
				1.1.2	Ensure that faculty/staff/students attend orientation and continuous trainings offered by EH&S on safe lab practice & EH&S guidelines	Review the list of EH&S trainings and when they are offered		
				1.1.3	At least 50% of lab members have attended a university sustainability-related event in the past year	Visit albany.edu/gogreen for a list of events		
				1.1.4	Promote the Energy Campaign in the Fall and the Campus Race to Zero Waste in the spring in a common area.			
				1.1.5	At least 50% of lab members have calculated their carbon footprint and has pledged to perform one action in their personal life	Carbon Footprint Tool		
				1.1.6	Atleast one lab member has completed the My Green Lab Ambassador training program.	My Green Lab Ambassador Program		
Y	IP	N	N/A	**1.2**	**Report Maintenance Issues**			
				1.2.1	Report maintenance issues to the building manager or Facilities Management Operation Center (518-442-3480) as soon as possible. Report any observed water leak, ventilation and/or temperature issues, lights that stay on unneccesarily, and any other energy waste on campus. Make sure faculty/staff/students have Facilities Management and Building Manager Contact information		A tap leaking at the rate of 1 drop per second will waste ~8,000 liters (approximately 2100 gallons) of water a year (USGS)	
				1.2.2	Evaluate need for central utilities, such as compressed air, steam, process chilled water, and gas to determine if central utilities are still needed. If needs have changed, inform Facilities Management. To be completed once at the beginning and if anything changes in the laboratory.			

Appendix 6: University at Albany Green Labs Checklist (4 of 9)
Energy & Water Conservation
Adapted from existing Checklist from Office of Energy Management, University at Albany

UALBANY green scene

Energy & Water Conservation							
Status				#	Item Description	Resources	Justification	Comments
Y	IP	N	N/A	2.1	**Lighting**			
				2.1.1	Turn off lights when not in use, such as at the end of the day. This includes task lighting. If necessary, label light switches with reminders to "turn me off"	Office of Sustainability is developing stickers and will make them available at no cost to labs. Contact gogreen@albany.edu for the stickers.	* Lighting accounts for 8-25% of total electricity utilized (I2SL - Best Practice Guide)	
				2.1.2	Use daylight instead of electric lights whenever possible. Turn off overhead/ambient lighting when task and/or natural light is sufficient.		* Lighting accounts for 8-25% of total electricity utilized (I2SL - Best Practice Guide)	
Y	IP	N	N/A	2.2	General equipment and appliances			
				2.2.1	Unplug or turn off non-essential or unused devices. If necessary, utilize signage to enforce this practice. Unplug and surplus any equipment/appliance that is no longer required.	Office of Sustainability is developing stickers and will make them available at no cost to labs. Contact gogreen@albany.edu for the stickers.	* The energy used by lab "plug-in" equipment constitutes 10-50% of the total lab energy use (IS2L-Energy-Efficient Lab Equipment Wiki) *This reduces vampire or phantom loads. A vampire load is the amount of energy used by appliance/ equipment when turned off but still plugged in.	
				2.2.2	Develop and implement equipment shutdown/ energy savings procedures for holidays, breaks, and weekends.	Lab manager should create a list of applicances that will be turned off for breaks and list accountable individuals.		
				2.2.3	Operate cleaning equipment only when full (dishwashers, autoclaves, etc.). Create a schedule for washing/cleaning duties	Off peak hours are 8PM - 8AM M-F and weekends.	Case in point: Per Stanford University, 60 medical-grade autoclaves consume over 93,000 gallons of water per day (3% of campus water usage)	
				2.2.4	Look into appliance/equipment sharing programs	Check the UAlbany OEM Surplus list at https://www.albany.edu/asset/surplus/AvailableSurplusCatalog.pdf. Email Michelle Baker at SUNY (Michelle.Baker@suny.edu) to be added to the sunpcsc@ls.sysadm.suny.edu listserv to see surplus equipment from other SUNY campuses. The Office of Energy and Sustainability will develop additional user-friendly resources.		
Y	IP	N	N/A	2.3	**Sustainable IT practices**			
				2.3.1	Enable sleep settings on computers and monitors, and disable screensavers. Put into sleep mode or turn off at end of day. This includes personal computers used on campus.	Change the power setting for windows computers and for Mac Computers	A desktop computer kept running with the power on for an entire year can result in ~1300 lbs of Carbon Dioxide being released into the atmosphere, requiring an entire acre of trees to offset that amount (UAlbany Sustainable IT practices). The annual power consumed by 3D screensavers at UAlbany accounts for over 300,000 lbs of carbon dioxide/year. This is the equivalent of 15 homes/year (UAlbany Sustainable IT Practices).	
				2.3.2	Enable sleep settings on copiers and printers to sleep after 30 minutes of inactivity, and put into sleep mode or turn off at the end of the day	Talk to your Technical Coordinator/ITS personnel to confirm that the IT devices in your lab are programmed to go into energy-saving mode after a period of inactivity.		
				2.3.3	Use UL-listed surge protectors in compliance with fire code requirements to turn off IT devices and other plugged-in loads at a central location	Provided by the Office of Sustainability. Contact: gogreen@albany.edu.	Energy vampires are devices that continue to use electricity even when turned off. Vampire loads are responsible for ~5% of the energy consumed in the United States. Use Duke University's Energy Vampire Calculator to prioritize which devices should be placed on the surge protector.	
				2.3.4	and copiers, and using shared devices instead	SUNY Print Initiative prohibits the use of personal desktop printers.		
Y	IP	N	N/A	2.4	**Fume Hoods**			
				2.4.1	Close the sash on fume hoods when it is not in use. If necessary, label ventilation units with physical reminders to "shut the sash".	Office of Sustainability is developing stickers and will make them available at no cost to labs. Contact gogreen@albany.edu for the stickers.	Closing fume hood sashes can cut energy usage in half and ensures the safety of lab members (My Green Lab)	

Appendix 6: University at Albany Green Labs Checklist (5 of 9)
Energy & Water Conservation (cont.)
Adapted from existing Checklist from Office of Energy Management, University at Albany

Y	IP	N	N/A	2.5	Freezers		
				2.5.1	Defrost manual defrost and partial automatic defrost freezers annually		Buildup can accumulate on the coils inside of your refrigerator forcing your unit to work overtime. If you do not regularly defrost your refrigerator and freezer, it may be difficult for the appliance to maintain cooler temperatures (10 Ways to Improve Energy Efficiency of Your Refrigerator and Freezer)
				2.5.2	De-ice freezers monthly around seals for proper close	Close the door on a piece of paper. If the paper falls, the gasket is not sealing well.	Keeping gasket free of frost and ice by brushing frost off your gasket frequently while it is easy to remove can prevent the need for expensive repairs (Univ. Colorado Boulder)
				2.5.3	Service lab equipment on a routine basis to keep it running optimally and prevent		
				2.5.4	Clean components of refrigerators/freezers, including coils, filters, and motors biannually. *Clean or vacuum filters and coils to remove and prevent dust buildup *Remove items that have fallen behind or pushed up against the unit blocking airflow underneath, on the sides, or above the unit.		Dirty coils and clogged filters make heat exchange more difficult, making the freezer less efficient (HighPerformanceHVAC.org)
				2.5.5	Turn up -80C freezers to -70C	--	Turning up the temperature can result in energy savings of ~30-40% and prolong the life of the freezer. For the majority of cases, it is safe to store samples at -70. 15 years ago, all ultra low freezers were set to 65-70C. (-70 is the new -80)
				2.5.6	Move freezers to a cooler location, when feasible.		
				2.5.7	Consider using ULT freezers in cenralized locations/core facility instead of purchasing one for the lab or as a way to reduce/eliminate freezers in the lab.		ULT freezers are large energy consumers and produce a lot of heat. The room/location where they are located should be able to easily vent off the heat to lower HVAC demand. Insufficient local HVAC capabilities can cause the building's energy consumption for the entire building to work harder, affecting ventilation and energy consumption for the entire building (Univ. Colorado Boulder)
				2.5.8	Transfer applicable biological samples from frozen storage to room temperature storage technology. Use preservative reagents that do not require cold temperatures for the storage of reagents (such as DNA, RNA)		Case in Point: Stanford University Study found than 20-25% of total sample collection could be moved from freezers
				2.5.9	Store DNA at -20C		Case in Point:University of Colorado In a study preformed by the University of Colorado, Genomic DNA stored at -20 and -80 was of good quality.
				2.5.10	In compliance with EHS regulations: * Schedule a freezer clean out every 6 months to remove expired or useless chemicals. * Label items for easy access so that doors are not left open for long periods of time. Labels must face outwards.	Review Environmental Health & Safety Policies and Procedures	* Scheduling a routine clean out will reduce excess clutter in the freezer and maintain organization. An organized freezer will reduce the amount of time the freezer door is left open, reducing energy consumption.

Appendix 6: University at Albany Green Labs Checklist (6 of 9)
Energy & Water Conservation (cont.)
Adapted from existing Checklist from Office of Energy Management, University at Albany

					2.5.7	Consider using ULT freezers in cenralized locations/core facility instead of purchasing one for the lab or as a way to reduce/eliminate freezers in the lab.		ULT freezers are large energy consumers and produce a lot of heat. The room/location where they are located should be able to easily vent off the heat to lower HVAC demand. Insufficient local HVAC capabilities can cause the building's energy consumption for the entire building to work harder, affecting ventilation and energy consumption for the entire building (Univ. Colorado Boulder)
					2.5.8	Transfer applicable biological samples from frozen storage to room temperature storage technology. Use preservative reagents that do not require cold temperatures for the storage of reagents (such as DNA, RNA)		Case in Point: Stanford University Study found than 20-25% of total sample collection could be moved from freezers
					2.5.9	Store DNA at -20C		Case in Point:University of Colorado In a study preformed by the University of Colorado, Genomic DNA stored at -20 and -80 was of good quality.
					2.5.10	In compliance with EHS regulations: * Schedule a freezer clean out every 6 months to remove expired or useless chemicals. * Label items for easy access so that doors are not left open for long periods of time. Labels must face outwards.	Review Environmental Health & Safety Policies and Procedures	* Scheduling a routine clean out will reduce excess clutter in the freezer and maintain organization. An organized freezer will reduce the amount of time the freezer door is left open, reducing energy consumption.
	Y	IP	N	N/A	**2.6**	**Water Conservation**		
					2.6.1	Use water aspirators minimally	To reduce (but not eliminate environmental impacts), keep a well-stocked dry ice condenser in line with it to trap out the solvent vapors before they go down the drain (Science Magazine). Consider alternatives like oil-free diaphragm pumps which offer deeper end vacuum capabilities and higher flowrates, minimal operating cost, and economical purchase price (Fisher Scientific)	An average aspirator pump uses at least 50,000 gallons per year (Fisher Scientific) Water aspirators are susceptible to exposing solvents to the water stream and subsequent discharge into the drain (Fisher Scientific)
					2.6.2	Check water flowrate of lab faucets and report to Facilities Management if >1.5 gallons per minute as a candidate for aerators and/or water misers.	The Office of Energy Management will train a group of students to perform energy and water audits in labs and will offer this service at no cost to the interested labs.	Typical faucets (taps) run at 4.0 gallons/minute; low-flow aerators can be installed on faucets to reduce the flow to <1.5 gallons/minute (My Green Lab)

Appendix 6: University at Albany Green Labs Checklist (7 of 9)
Waste Reduction & Diversion
Adapted from existing Checklist from Office of Energy Management, University at Albany

4. Waste Reduction & Diversion							
Status				#	Item Description	Resources	Justification
Y	IP	N	N/A	**4.1**	**Recycling and Composting**		
				4.1.1	Complete assessment of interest for recycling & waste diversion	Review Waste Diversion document. Contact the Office of Sustainability at gogreen.edu for recycling bins.	
				4.1.2	Consider reuse/recycling/salvage options for equipment that has reached the end of its useful life to divert from landfill.	Review Waste Diversion document	
Y	IP	N	N/A	**4.2**	**Reliance on Reusables**		
				4.2.1	When purchasing, prioritize reusable lab supplies over disposable ones.	If you are aware of feasible reusable alternatives to lab equipment, tools, or supplies, please list in this collaborative document	In 2015, a team at the University of Exeter calculated that scientific labs generate appoximately over 5.5 million metric tons of plastic waste
				4.2.2	Use refillable water bottles for drinks, labeled with the Fill It Forward Tag	Review Fill it Forward. Contact Office of Sustainability at gogreen.edu for free Fill it Forward tags	
Y	IP	N	N/A	**4.3**	**Fieldwork**		
				4.3.1	Maintain a strict Pack-in-Pack-out policy when doing fieldwork		"Packing out" helps protect the environment and the experiences for our community
Y	IP	N	N/A	**4.4**	**Limit the Production of Waste**		
				4.4.1	Improve experimental design to limit chemical usage and reduce waste. This can be done through the usage of microchemistry		Microscale chemistry is the reduction of chemical use to the lowest level at which experiments can be effectively performed. It offers a safer way to perform chemical experiments by using smaller quantities of chemicals. Microscale experiments are conducted without compromising the quality or standard of chemical applications in educational institutions and the experimental industry (New Hampshire Department of Environmental Services)
				4.4.2	Use less toxic, water based, or biodegradable cleaners and degreasers when possible	Safer Choice Program allows the usage of its logo on products made from safer chemicals. The US General Services Administration has several resources regarding the acquisition of environmentally oriented items. INFORM, Inc. provides a guide to environmentally friendly cleaning products and methods. See notes for links to these programs.	
				4.4.3	Limit printing in the lab space by: - Use double-sided printing whenever possible - Adjust margin settings to maximize information on the page - Use narrow-style fonts which use less ink (ie., Courier, Century Gothic, Garamond, Brush Script) - Select conservation choices, such as "fit to page" or "save ink/toner" to maximize efficiency when printing PDF documents - Establishing a bin for one-sided reprints	Refer to SUNY Print Initiative	Many simple practices can cut down on ink and excessive use of paper. Each case of paper made from recycled products saves ~ 1 tree (UAlbany Sustainable IT practices). Trees reach their most productive stage of carbon storage at 10 years of age, where they absorb 48 lbs of CO_2 per year (Urban Forestry.org)
				4.4.4	Lab members opt for virtual document sharing whenever possible.		
				4.4.5	Paid members of the lab have opted for paperless paystubs		

Appendix 6: University at Albany Green Labs Checklist (8 of 9)
Chemical Use & Toxic Material

Adapted from existing Checklist from Office of Energy Management, University at Albany

3. Chemical Use & Toxic Material Minimization							
Status				#	Item Description	Resources	Justification
Y	IP	N	N/A	**3.1**	**Compliance with EHS Guidelines**		
				3.1.1	Review University's Chemical Hygiene Plan and Hazardous Waste Guidelines and confirm lab is in compliance.	Review the University's Chemical Hygiene Plan and Hazardous Waste Guidelines	
Y	IP	N	N/A	**3.2**	**Green Chemistry Practices**		
				3.2.1	Evaluate hazardous, dangerous, or radioactive chemicals and seek to find less-hazardous alternatives	Use MIT's Green Chemical Alternatives Purchasing Wizard to obtain information on alternatives to hazardous chemicals or processes.	Choosing greener alternatives is essential to reducing the generation of hazardous waste and your exposure to hazardous chemicals (My Green Lab). "Radioactive materials accrue additional costs such as disposal, contamination surveying, and special training (NCBI- The Impact of Low Level Radioactive Waste Management Policy on Biomedical Research in the United States)."
				3.2.2	Implement the 12 Green Chemistry Principles in day to day activities Hang a poster promoting 12 Green Chemistry Principles	Review the 12 Principles of Green Chemistry Contact the Office of Sustainability at gogreen.edu for a free poster.	Green chemistry consists of chemical products and processes that reduce or eliminate the use or generation of hazardous substances (EPA-Green Chemistry). The 12 Green Chemistry Principles provide a framework for learning about green chemistry and designing or improving materials, products, processes, and systems Green chemistry takes the EPA's mandate a step further and creates a new reality for chemistry and engineering by asking chemists and engineers to design chemicals, chemical processes and commercial products in a way that, at the very least, avoids the creation of toxics and waste.
				3.2.3	Substitute mercury containing equipment with other alternatives when possible	Try using alcohol-based thermometers instead of mercury thermometers. Work with equipment suppliers to see if non-mercury-containing equipment is available. Mercury-containing equipment (including thermometers) must be disposed of through EHSO.	Mercury is a toxic and volatile chemical that produces indoor air contamination when leaked or spilled (NIH- Mercury Hazard Reduction Campaign).
				3.2.4	Use a solvent selection guide with health and safety criteria to help in selecting a solvent for a process and recycle solvents in compliance with the regulations of EHS and the principles of Green Chemistry	Review (University at Albany Chemical Hygiene Plan).	
				3.2.5	Utilize green chemistry methods, including computer simulations and micro-scale chemistry techniques when applicable.	Review MIT's Green Chemical Alternatives Purchasing Wizard for information on alternatives to hazardous chemicals or processes. Review EPA's 12 principles for green chemistry.	Green chemistry consists of chemical products and processes that reduce or eliminate the use or generation of hazardous substances (EPA-Green Chemistry).
				3.2.6	Use chemicals/reagents "first in, first out" per received dates. Add "received dates" on chemical/reagent containers and place newly received materials behind older materials in storage areas.		A "first in, first out" system avoids degradation of older chemicals and their containers and the necessity to dispose of unused, degraded chemicals.
Y	IP	N	N/A	**3.3**	**Maintain Chemical Inventory**		
				3.3.1	Label materials in compliance with EHS stipulations. These items include: * Batteries * Mercury containing items * Computer and electronic equipment * Electronic/Universal Waste is recycled including: computers, printer, laptops, batteries, A/V, CFL, CD's, audio tapes, phones/pagers, PDAs, printer cartridges		Safety is a serious subject - especially when dealing with chemical and hazardous materials. Safe practice requires that users of chemicals and hazardous materials have a knowledge of potential hazards and a readiness to maintain safe conditions. (University at Albany Chemical Hygiene Plan)
				3.3.2	Keep an up to date chemical inventory. Investigate software or spreadsheet options to increase the efficiency of this process		
				3.3.3	Submit a chemical inventory yearly to EHS		
				3.3.4	Review your chemical inventory prior to purchasing new chemicals to avoid duplication of stock.		An inventory management system minimizes waste generated from old, partially used containers, and helps to reduce overall inventory and duplicate purchases (ACS- Less is Better).

Appendix 6: University at Albany Green Labs Checklist (9 of 9)
Resource Management and Purchasing

Adapted from existing Checklist from Office of Energy Management, University at Albany

5. Resource Management & Purchasing							
Status				#	Item Description	Resources	Justification	Comments
Y	IP	N	N/A	5.1	**Energy & Water Efficiency**			
				5.1.1	Purchase LED lightbulbs for all desk and task lamps			
				5.1.2	Replace mercury or metal halide bulbs in fluorescence microscopes with LED lighting			The offices of Sustainability and Energy Management are exploring green revolving funds to pay for the incremental costs.
				5.1.3	Install LED lights in grow rooms.			
				5.1.4	Replace gas laser with solid state diode laser			The offices of Sustainability and Energy Management are exploring green revlving funds to pay for the incremental costs.
				5.1.5	Purchase Energy Star and/or My Green Lab's ACT labeled energy efficient lab equipment and appliances and EPEAT certified electronics	Look for Energy Star designation on vendor websites, view EPA's EPEAT website (link in notes). Contact the Office of Energy at ilnu@albany.edu or 518-442-3183 for help finding eligible products.	Since 1992, ENERGY STAR and its partners have helped American families and businesses save 5 trillion kilowatt-hours of electricity, avoid more than $450 billion in energy costs, and achieve 4 billion metric tons of greenhouse gas reductions (Energy Star.gov)	
				5.1.6	Use rechargable batteries in office and laboratory equipment and remote mouses (where applicable).			
				5.1.7	Purchase sterilizers with steam on demand or heat exchangers to reduce potable water used to cool down condensate			
Y	IP	N	N/A	5.2	**Office Supplies**			
				5.2.1	Purchase FSC-certified and 100% post-consumer recycled content paper as mandated by the Governor's Executive Order 4 directive. Look for items designated as being made of recycled materials by vendors	Review EO4 Specifications. Staples offers FSC certified 100% recycled content paper, model # 620016-US/CC	Purchasing recycled products reduces landfill waste, conserves natural resources and energy, and promotes the market for recycled products (EPA- Waste Wise Tip Sheet).	
				5.2.2	Purchase refillable dry erase markers			
				5.2.3	Purchase refillable ink jets and toners or ones that do not produce cartridge waste			
Y	IP	N	N/A	5.3	**Coordination on Resources**			
				5.3.1	Redistribute unused chemicals within department		In a laboratory that has not adequately implemented waste minimization programs, unused chemicals typically constitute 40% or more of the hazardous waste stream generated. Costs incurred as a result of these unneeded chemicals include analysis, storage, packaging, transport, and disposal.	
				5.3.2	Maintain an inventory of supplies and consumables for better purchasing management	Communicate with other labs to determine an effective means of coordinating shared resource opportunities.	Equipment sharing saves landfill space and reduces surplus equipment, supplies, and costs (Harvard- New Life for Lab Equipment).	
				5.3.3	Consult with Technology Coordinator prior to any purchase to ensure the new IT equipment will be supported and meet the full needs of the user		By ensuring the technology fits the needs of the user will ultimately decrease technology turnover and decrease the amount of electronic and equipment waste	
				5.3.4	Order frequently used items in bulk, consolidate orders, and/or combine order with other labs when possible		Purchasing in bulk will reduce the amount of waste associated with packaging from seperate orders, in addition to a decrease in overall greenhouse gas emissions associated with transporting the order	
				5.3.5	Share resources, supplies, and/or consumables between labs	Offices of Sustainability and Energy will investigate software or spreadsheet options to automate the coordination between labs	Making a new product requires a lot of materials and energy - raw materials must be extracted from the earth, and the product must be fabricated then transported to wherever it will be sold. As a result, reduction and reuse are the most effective ways you can save natural resources, protect the environment and save money (EPA.gov)	
				5.3.6	Before purchasing new equipment, check the house supply inventory or consider external secondary markets, whenever possible	View websites such as biosurplus.com	* See above *	
				5.3.7	Utilize vendor takeback programs	Request information from vendors for details of available take-back programs, such as Kimberly-Clark's PPE recycling program.	Take-back programs can be used for surplus supplies, gloves, ice packs, Styrofoam coolers, ink & toner cartridges, and/or packaging material	

Appendix 7: Research Foundation Financial Audit, Sorting Method 1: by cost (page 1 of 3)

Vendor Name	Invoice Description	Expenditure Item Date	Supplier Invoice Amount	Reason for further investigation
Oxford Nanopore Technologies PLC	MinION Mk 1C Basic Starter Pakc: Control Expansion Commodity; Ligation Sequer	10-Aug-2021	6,125,000.00	Items purchased by PI from Oxford vendor were primarily on two dates. Item refunded to match correct price.
Bio Rad Laboratories Incorporated	NGC QUEST 10 PLUS CHROMATOGRAPHY SYSTEM; NGC INVLET VALVE MODULE, M	08-Nov-2021	59,768.62	Duplicate purchasing, why was a new one purchased by PI 33 2 months after when PI 46 had a higher model in his lab?
Campbell Scientific Incorporated	SENSOR CABLE 20 FT PER SENSOR CABLE; MOUNTING KIT; GOODRICH FREEZING R	20-Sep-2021	52,275.00	Additional cable was purchased one week later
Central Chrysler Dodge Jeep Ram of Raynham	2022 RAM 1500 VIN: 1C6RR7GG8NS173440	08-Apr-2022	49,045.00	Truck was purchased for research. Funding is listed as "multiple sources" which seems ambigious.
Bio Rad Laboratories Incorporated	NGC QUEST 10 PLUS CHROMATOGRAPHY SYSEM; NGC INLET VALVE MODULE	07-Jan-2022	40,168.80	Duplicate purchasing
Avnet Electronics Marketing	Settlement Amount	02-Aug-2021	35,000.00	Unknown item
Campbell Scientific Incorporated	Expandable Closed Path Eddy Covariance System w/EC155 & Pump Module; Stair	22-Apr-2021	27,552.96	Purchased by another lab 1 month later
10X Genomics Incorporated	CHROMUM NEXT GEM SINGLE CELL KIT V 3.1, 16 RXNS; TUBE DYNABEADS; LIBRAR	29-Aug-2022	23,588.00	Frequent item purchased by laboratories
Mightex Systems	Invoice: INV8895363	15-Oct-2021	22,990.00	Unknown item, company makes spectrometers
10X Genomics Incorporated	Chromium Next GEM Chip G Single Cell Kit, GEM Single cell 3'LT Kit, GEM Single Ce	24-May-2021	22,464.00	Repetitive
10X Genomics Incorporated	CHROMIUM NEXT GEM CHIP G; CHROMIUM NEXT GEM SINGLE CELL 3; CHROMIUI	20-Sep-2021	22,464.00	Frequent item purchased by laboratories
Campbell Scientific Incorporated	Expandable Closed Path Eddy Covariance System w/EC155 & Pump Module; Stair	10-May-2021	21,984.00	Atmospheric monitor? What was this used for?
Snell Equipment Incorporated	KUBOTA TRV-X1100CWL-A UTILITY VEHICLE; KUBOTA K7731-99620 FRONT WOR	31-Aug-2021	16,886.22	What was this needed for?
Noble Gas Solutions Incorporated	250 LITER LIQUID HELIUM DEWAR AIR PRODUCTS LIQ HELIUM VOL: 250; HAZ MA	10-Mar-2022	12,500.00	1 of 2 gas purchases outside of the 425 orders to Airgas USA
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V.25 (150 CYCLES; 75 CYCLES); FREIGHT	27-Sep-2021	12,134.40	
Dell Marketing LP	PowerEdge R750 Server System Service Tags 2032VH3	12-Oct-2021	11,795.75	Can computer servers be more sustainable, look into more
Fisher Scientific Company LLC	RDE486DQ22-STP REVO ULT PROMO	29-Aug-2022	11,790.00	Purchased sustainable option
Illumina Incorporated	NextSeq 1000/2000 P2 Reagents (200 cycles) v3; freight	02-Aug-2022	10,291.12	Similar to another purchase

Appendix 7: Continued (page 2 of 3)

VWR International LLC	INV X18181244 VWR FREEZER ULT LW TEMP RACK	08-Jul-2021	9,970.57	Same order placed one month later
VWR International LLC	INV X18181244 VWR FREEZER ULT LW TEMP RACK	26-Aug-2021	9,970.57	Matching order one month earlier
Fisher Scientific Company LLC	NANODROP ONE H2 2021 PROMOP PR-1 CONDITIONING KIT	20-Aug-2021	9,876.24	Not sure if there are sustainable purchasing options
Noble Gas Solutions Incorporated	Acct: 06681 INV: 01259615 100 Liter Liquid Helium Dewar Air Products Liquid He	06-Sep-2022	9,860.00	2 of 2 gas purchases outside of the 425 orders to Airgas USA
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V2.5; FREIGHT	14-Jul-2021	9,100.80	Repetitive
Brechtel Manufacturing Incorporated	AUTO COLLECTOR WITH 38 VIAL HOLDING CAROUSEL AND CONTROL SOFTWARE,	13-Jul-2022	8,605.00	Could these be used with reusable tubes? Why was a second machine purchased one year later?
Brechtel Manufacturing Incorporated	AUTO COLLECTOR WITH 38 VIAL HOLDING CAROUSEL AND CONTROL SOFTWARE,	14-Jul-2021	8,455.00	Duplicated one year later
Biosynthesis Incorporated	S-20000 LOT 10011D; SHIPPING	06-May-2022	8,400.00	Unknown item
Les Industries Fibrobec Incorporated	CAM Truck Follow Up (1) Dodge Ram 1500 6.5' 2022 02-1602 Wild 6 with side d	08-Apr-2022	7,690.00	Why are there 6 of these for different prices?
Electronic Business Products Incorporated	LANIER IMC4500; SR3260 FINISHER; BU3090 BRIDGE UNIT, PB3280 PAPER BANK,	26-May-2021	7,675.90	Laser color printer. Is this for the individual lab or for a department?
VWR International LLC	INV X18181213 FETAL BOVINE SERIUM HI PREMIUM	27-Jul-2021	7,368.00	Repetitive
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V2.5 (75 CYCLES); FREIGHT	15-Oct-2021	6,336.00	Repetitive
Nikon Instruments Incorporated	ECLIPSE TS2-FL MAIN BODY; POWER CORD; TS2-W 10X EYEPIECE; T1-SNCP PRECE	15-Mar-2022	6,315.00	Microscopes can be LED or metal halide illumination. An LED model was purchased
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V2.5 (150 CYCLES)	14-Dec-2021	6,067.20	Repetitive
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V2.5 (75 CYCLES AND 150 CYCLES)	18-Jun-2021	6,067.20	Repetitive
Abclabtory Scientific Company Ltd	Inv# INV-R1313065	30-Jun-2022	5,861.00	What was this invoice for? Is there a certain amount, where if a price is met the items purchased have to be included in the receipt and the need for it explained?
Fisher Scientific Company LLC	PIPETMAN CLASSIC	29-Sep-2021	5,564.72	How many pipets were purchased? They look to be ~$700 on the website
Illumina Incorporated	NextSeq 1000/2000 P2 Reagents (100 Cycles) v3; freight	12-Jul-2022	5,474.56	Repetitive

Appendix 7: Continued (page 3 of 3)

Illumina Incorporated	NextSeq 1000/2000 P2 Reagents (100 cycles) v3; freight	28-Jul-2022	5,474.56	Repetitive
Airgas USA LLC	HELIUM IND LIQ 250LT	06-Oct-2022	5,454.00	Repetitive
Takara Bio USA Incorporated	NUCLEOSPIN 96 RNA 4 X 96 PREPS (4)	03-Aug-2021	4,902.48	Repetitive
Fisher Scientific Company LLC	RAINBOW PACK; SUPERSCRIPT IV RVRSETRNSCRPTSE	05-Oct-2021	4,872.78	What is the rainbow pack of? What quantity was purchased? Seems like a large amount based on company pricing
Fisher Scientific Company LLC	SUPERSCRIPT IV RVRSETRNSCRPTSE	06-Oct-2022	4,734.80	Repetitive
Metkinen Chemistry Oy	Inv 2122 for PO R1306068	06-May-2022	4,600.00	Unknown item
Metkinen Chemistry Oy	Inv 2122 for PO R1306068	06-May-2022	4,600.00	Unknown item
Metkinen Chemistry Oy	Inv 2122 for PO R1306068	06-May-2022	4,600.00	Unknown item
10X Genomics Incorporated	Chromium Next GEM Chip G Single Cell Kit, GEM Single cell 3'LT Kit, GEM Single Ce	24-May-2021	4,400.00	Repetitive
Bio Rad Laboratories Incorporated	BioFrac Fraction Collector; freight	07-Jan-2022	4,396.00	Were other options looked into? It looks like it uses a lot of specialized microtubes
Fisher Scientific Company LLC	SUPERSCRIP IV RVRSETRNSCRPTSE; POWERUPSYBRGREEN, SUPERSCRIPT IV RVRSE	08-Aug-2022	3,551.10	Repetitive
Airgas USA LLC	HELIUM IND LIQ 250LT	18-Jun-2021	3,506.41	Repetitive
Airgas USA LLC	HELIUM IND LIQ 250LT	12-Aug-2021	3,506.41	Repetitive
Airgas USA LLC	HELIUM IND LIQ 250LT	14-Oct-2021	3,506.41	Repetitive
VWR International LLC	INV X18181213 AGAR BACTO 10KG	29-Jul-2021	3,486.22	Repetitive
Illumina Incorporated	Nextseq 1000/2000 P2 Reagents 300 cycles v3; freight	03-Aug-2022	3,411.26	Repetitive
Fisher Scientific Company LLC	DRY VAC SYSTEM 115V	28-Jan-2022	3,387.57	There don't seem to be energy efficient models for dry vacs. Fisher does not note which options are more 'green'.
Integrated DNA Technologies Incorporated	STARRSEQ-G45A-ENH	11-Jul-2022	3,298.70	What is this?
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V.25 (150 CYCLES; 75 CYCLES); FREIGHT	28-Sep-2021	3,168.00	Repetitive
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V2.5 (75 CYCLES AND 150 CYCLES)	14-Jun-2021	3,168.00	Repetitive
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V2.5 (75 CYCLES); NEXTSEQ 500/550 HIGH C	27-Jul-2021	3,168.00	Repetitive
Illumina Incorporated	NEXTSEQ 2000 P3 REAGENTS (100 CYCLES); FREIGHT	09-Mar-2022	3,131.14	Repetitive
Illumina Incorporated	NextSeq 500/550 High Output Kit v2.5 (150 cycles)	28-Feb-2022	3,109.44	Repetitive
Illumina Incorporated	NextSeq 500/550 High Output Kit (150 and 75 Cycles); freight	13-Sep-2021	3,033.60	Repetitive
Illumina Incorporated	NEXTSEQ 500/550 HIGH OUTPUT KIT V2.5 (75 CYCLES); NEXTSEQ 500/550 HIGH C	27-Jul-2021	3,033.60	Repetitive
		sum	688,856.11	
		total $ purchases for all	$2,228,409.69	

Appendix 8: Research Foundation Financial Audit, Sorting Method 2: PI Repetitive Purchases

Top 6 PIs by invoice quantity

Row Labels	Count of Vendor Name
PI 34	425
PI 4	160
PI 42	95
PI 35	83
PI 56	67
PI 24	63

Appendix 9: Research Foundation Financial Audit, Sorting Method 2: Vendor Repetitive Purchases

Top 10 vendors from repetitive purchases

Row Labels	Count of Vendor Name	Sum of Supplier Invoice Amount
Airgas USA LLC	477	111889.84
Fisher Scientific Company LLC	426	174584.22
Krackeler Scientific Incorporated	252	72490.41
VWR International LLC	115	61873.27
Integrated DNA Technologies Incorporated	97	12155.95
Illumina Incorporated	49	113085.36
Greenfield Global USA Incorporated	31	13591.25
Life Technologies Corporation	19	1739.98
Laboratory Products Sales Incorporated	18	6359.74
10X Genomics Incorporated	16	78940.06
Health Research Incorporated	14	4135.37

Top 10 vendors from all invoices

Row Labels	Count of Vendor Name	Sum of Supplier Invoice Amount
Fisher Scientific Company LLC	1659	599827.33
VWR International LLC	938	270143.44
Krackeler Scientific Incorporated	586	158471.64
Airgas USA LLC	517	111823.76
Integrated DNA Technologies Incorporated	313	71931.34
Life Technologies Corporation	101	53205.92
Illumina Incorporated	52	117283.63
Chemgenes Corporation	42	12170.03
Bio Rad Laboratories Incorporated	38	120575.38
Greenfield Global USA Incorporated	34	14615
Laboratory Products Sales Incorporated	31	16842.04

Appendix 10: Research Foundation Financial Audit, Bias Sorting: Pipet tips

Row Labels	Count of Invoice Description	Sum of Supplier Invoice Amount
Krackeler Scientific Incorporated	112	39418.12
Fisher Scientific Company LLC	86	34256.33
VWR International LLC	78	18214.65
Laboratory Products Sales Incorporated	16	4530.82
Integra Biosciences Corporation	6	1536.58
Amazon Capital Services Incorporated	1	372.9
Grand Total	**299**	**98329.40**

Appendix 11: Research Foundation Financial Audit, Bias Sorting: Gloves

Row Labels	Count of PI	Sum of Supplier Invoice Amount
Amazon Capital Services Incorporated	**1**	**27.08**
010 Biology	1	27.08
Fisher Scientific Company LLC	**47**	**14367.85**
010 Biology	13	3622.57
010 Chemistry	11	3314.79
010 Envir & Sust Engr	9	3212.67
010 Psychology	5	1225.78
010 Physics	5	224.67
010 Biomedical Science	2	745.57
010 The RNA Institute	1	961.8
010 Atmospheric and Environmental Sciences	1	1060
Krackeler Scientific Incorporated	**19**	**8111.18**
010 Biology	13	6579.32
010 Chemistry	4	1379
010 The RNA Institute	2	152.86
Laboratory Products Sales Incorporated	**3**	**721.79**
010 Chemistry	3	721.79
VWR International LLC	**40**	**14661.82**
010 Biology	14	5361.88
010 Chemistry	13	4529.7
010 The RNA Institute	12	4484.21
010 President's Office	1	286.03
Grand Total	**110**	**37889.72**